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RESEARCH ARTICLE

Artistic Photography for Science Teaching: Preschool Teachers Creating Photographic Metaphors to Represent Scientific Phenomena

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Abstract: Digital photographs are commonly used for science instruction since they can facilitate meaning-making and can draw students' interest and attention. However, it appears valuable to explore teachers' own creations of digital photographs, *e.g.* by using their portable mobile phone devices, to illustrate scientific phenomena as well as to create metaphorical representations of these phenomena, which this study calls 'photographic metaphors'. In this direction, this study qualitatively examined preservice preschool teachers' (n = 42) artistic photographs and photographic metaphors. Furthermore, it examined teachers' views on using such an arts-based approach through qualitative content analysis of their questionnaire reflections. The findings revealed that teachers created a variety of photographic metaphors having linguistic and conceptual features. Furthermore, they found such an approach engaging and effective for science teaching. However, challenges often arose since teachers created inaccurate or vague metaphors in several instances. The findings inform teacher education designers in implementing arts-based approaches in science, specifically through artistic photography.

Keywords: arts-based approaches in science, artistic photography, photographic metaphors, preservice teachers, preschool education

1 Introduction

Arts-based approaches have been recently highlighted in educational reports for science education (European Commission, 2025; NASEM, 2018). The dynamics of integrating arts in science instruction are numerous, both regarding students' cognitive skills in science and students' affective variables such as interest and engagement (Odegaard, 2003). Integrating arts-based methods can assist learners in expressing and developing their science identities, including students coming from underrepresented groups in science (Chappell, 2024; Varelas et al., 2024). Furthermore, arts-based methods may activate multimodal semiotic systems which are not restricted to text, such as visuals, movement, sound, music and gestures (Varelas et al., 2022; Woodard et al., 2023). As concerns instructional practices, arts-based approaches entail opportunities to model scientific phenomena through various representations (Nipyrakis, 2025; Nipirakis & Varela, 2025).

One of the art forms that appears promising for science education is photography. Photographs have been used both for research purposes in terms of collecting data on the participants' settings, activities and artefacts (Jornet, 2014), but also as a teaching tool. Particularly, using digital photos, such as the ones used in science-related digital picture books, can contribute to increased student understanding in science and positive attitudes towards learning (Tang et al., 2024). However, using visual representations in science teaching is not new since photos and animations are widely used in science textbooks, especially the recent years (Tang, 2023). What appears to be underexplored, though, is the implementation and exploration of teachers' own creation and use of artistic photographs for science teaching purposes. The reasons behind such an approach are numerous. On the one hand, examining teachers' use of digital pictures can provide information regarding their design teaching practices (Nipirakis & Varela, 2025). On the other hand, photography can act as a means to show others how we see ourselves, our perceptions and views of important issues, which can further influence policy and can challenge the existing societal views and norms (Avraamidou & Martins, 2022; Wang, 1999). Such an approach is adopted in the 'photovoice' methodology and has been used in a wide variety of purposes, such as promoting decolonising pedagogies (Cook, 2015) or raising awareness regarding environmental issues in urban environments (Kalaitsidaki et al., 2022).

Nevertheless, there are limited studies that explore teachers' own creations of artistic photos in order to provide representations and explanations of scientific phenomena. Such an approach deviates from common practices of teachers receiving ready photographic resources, *i.e.* through textbooks or on the internet. The significant difference is that teachers, by creating their own photos, are given increased agency and opportunities to design their own teaching in artful ways. Furthermore, several researchers stress the importance of using embodied resources, such as conceptualised schemata from our everyday experiences (Kersting & Steier, 2018; Niebert et al., 2012; Treagust & Duit, 2015). In this light, teachers' own artistic photos can draw upon such resources from teachers' own experiences and cultural backgrounds. Moreover, given the increasing popularity of smart mobile devices such as mobile phones for educational purposes (Papadakis & Kalogiannakis, 2017), the utilisation of mobile phones' photographic functions can provide an accessible and fruitful method for teachers and students to use artistic photography for teaching and learning science; a statement that needs to be explored.

Specifically, due to the potential of the arts to model phenomena and to provide metaphorical representations that can provoke thinking (Dawson & Lee, 2018), this study implements the art of photography in order to create and convey metaphors for science teaching. Metaphors and analogies have a long history in science education, while in many cases these two instructional tools are used interchangeably (Duit, 1991; Thomas, 2006). Both of them offer representations that can facilitate science understanding (Lancor, 2018). Based on the defining characteristics of metaphors discussed in the literature, a metaphor compares entities from two domains: the 'target' domain which is the phenomenon that we are trying to explain through modelling, and the 'source' domain, which is the more familiar entity used to characterise, clarify or amplify the target (Thomas, 2006). However, contrasting analogies where this comparison is made explicit and both the similarities and differences are discussed, metaphors make this comparison implicit. Specifically, metaphors point out an absurd connection between the two entities, often entailing some aspect of surprise or anomaly, hence highlighting the differences between the two entities and inciting the mind to search for their similarities (Duit, 1991; Treagust & Duit, 2015). Nevertheless, the differences between analogies and metaphors are mostly rhetorical and not cognitively significant, since they both have sense-making and illustrating goals (Wuppuluri & Grayling, 2022).

Based on the above defining characteristics stated in the literature (*e.g.* Duit, 1991; Katz, 1998; Treagust & Duit, 2015), this study implements a definition of a metaphor as 'an implicit comparison of entities, which is literally false and entails some aspect of surprise'. For example, let's consider the phrase "the nucleus is an energy giant exactly because it is a dwarf in size" (Trachanas, 2018). On the one hand, the words 'dwarf' and 'giant' literally make no sense when talking about the nucleus, while on the other hand, their paradoxical use of these terms for the nucleus provokes surprise in the reader's mind, which causes them to try to find similarities between these terms and the properties of the nucleus *i.e.* having high energy levels because short-wavelength vibrations take place in its small size. This mental process, activated by the metaphor, is intellectually engaging and motivating, and can promote science understanding.

Metaphors can be viewed as a theoretical device that allows the discovery of new features both regarding the phenomenon under study and the formal language used to describe it (Levrini, 2002). In fact, according to Gurney (1995), "a metaphor is a basic component of language itself", especially when expressing abstract phenomena which we do not fully understand; 'black hole', 'big bang', 'light waves', to name a few (Gurney, 1995; Lancor, 2018). Hence, metaphors are viewed not only as a facilitating tool, but also as a necessary tool to express and communicate these abstract scientific phenomena, not only to the public, but also among scientific communities.

However, despite the facilitating role of metaphors, it is important to keep in mind the arising challenges, such as students confusing the metaphor with the actual phenomenon, or that the students may focus solely on the features of the phenomenon highlighted in the metaphor (Kampourakis, 2016). Given the fact that the use of metaphors can serve as a lens for interpreting empirical data and examining meanings (Levrini, 2019), there appears to be a need to carefully scrutinise the creation and use of metaphors by teachers for their appropriateness and validity. This can shed light on teachers' views and practices on using metaphors for instructional use, particularly through the use of artistic photography, which will be henceforth referred to as 'photographic metaphors'. Moreover, the aesthetic aspects of the metaphors are also deemed important in order to perceive the meanings and the creative aspects that the metaphor aims to convey (Contini & Giuliani, 2022). Hence, there appears to be a need to examine if and how artistic photography can generally be an appropriate and effective means for creating metaphorical representations for science teaching.

Particularly, the research questions of the study are:
(1) How do preservice preschool teachers use artistic photography to teach science through photographic metaphors?
(2) What are preservice preschool teachers' views on using artistic photography for teaching science through photographic metaphors?

The findings of the study aim to provide insights into the dynamics of integrating artistic photography in science education, particularly as a means to convey scientific meaning through the use of photographic metaphors. This can inform the teacher education literature both in terms of exploring preservice teachers' views on making and using artistic photography in science education and in examining the ways that preservice teachers use photographic metaphors as an instructional tool.

2 Methods

2.1 Context

The study was conducted during a science education undergraduate course at the Preschool Education Department of the University of Crete in Greece. The course is mandatory and it is part of the first-year curriculum for preservice preschool teachers. The overall structure of the course is presented in Table 1. Particularly, the preservice teachers received instruction on theoretical and methodological aspects of science education, while they were also introduced to models, analogies and metaphors through participatory discussion, definitions and examples. Subsequently, they were given the opportunity to deliver optional essays, including a worksheet and lesson plan on a science topic of their choice. In the 11th session, the preservice teachers were introduced to artistic photography, namely i) definitions, categories, and examples, ii) literature review on their use and significance in science education and preschool education, iii) principles of technical operation of photography and equipment such as types of lenses, iv) photometry, and v) photographic synthesis. A demonstration of the operation of a DSLR camera took place in class, as well as a demonstration of photographic cameras integrated in smartphones.

Table 1 Implementation of the Study

Weekly session	Context	Deliverables
1-5	Theoretical aspects in science education (learning theories, students' misconceptions, inquiry-based teaching, models of instruction)	
6-7	Lesson planning	Individual worksheets and lesson plans
8	Instructional tools (models, analogies, metaphors)	
9-10	Arts-based approaches in science education	
11-13	Artistic photography for science education	Individual artistic photography essays Classroom group activity

2.2 Artistic Photography Essays

The teachers were called upon to use their smartphones or cameras to photograph a scientific phenomenon related to their chosen topic in their lesson plan. Additionally, they were called upon to add descriptions of the scientific phenomenon represented in the photo, as well as justifications of how and why they made this photo from an artistic point of view, *e.g.* in terms of photographic synthesis or exposure. Subsequently, they had to include a second photograph, which could serve as a metaphorical representation of the aforementioned phenomenon under study, and describe the metaphorical connection between the two by justifying their choice, like an 'artistic statement' of the photo. Teachers were also allowed to use a combination of two pictures/stop motion in case they wanted to demonstrate motion. It was also made possible for teachers to use a photo from other sources or the internet in one of the two photographs, *e.g.* in cases where the phenomenon couldn't be photographed by themselves, such as a volcano; however, it was set as a prerequisite to have at least one photograph created by themselves. They were also allowed to change the topic upon wanting to, by justifying their choice. Collaboration with other people or experts in artistic photography was made possible as long as they describe the assistance received for their assignment.

2.3 Classroom Group Activity

During the 12th session, a classroom group activity took place in order to familiarise teachers with artistic photography and photographic metaphors, and to assist them in carrying out their essays. Particularly, teachers who were attending the lesson were divided into groups of 2-5 participants, and were called upon to photograph a scientific phenomenon of their choice, describe the phenomenon they photographed, and explain how and why they made the photograph this way, similar to their assigned essay. The teachers were allowed to leave the class for 35 minutes and search for phenomena outdoors, since the academic classroom is located within natural surroundings. Furthermore, they were called upon to attach or describe a second photo, which could be metaphorically used to describe the scientific phenomenon under study, and justify the metaphorical connection between the two.

2.4 Participants & Ethical Approval

Participants were 42 preservice preschool teachers who voluntarily participated in delivering creative essays and questionnaire responses. The participants signed consent forms for participating in the study, while the study was approved by the Ethics Committee and General Assembly of the Pedagogical Department, numbered 651/9-04-2025. The participants who declined to participate were not included in the study, and their group deliverables (*i.e.* their classroom group activities) were also excluded.

2.5 Data Collection

Data collection of the study includes teachers': a) individual artistic photography essays (n = 42 teachers), b) classroom group activity deliverables (n = 21 teachers into 7 groups), c) pre-questionnaire (n = 17) open responses regarding teachers' understandings of models, metaphors, and analogies in session 11, right before the implementation of artistic photography, d) pre-questionnaire (n = 31) and post-questionnaire (n = 29) open responses regarding teachers' views and experiences with artistic photography, e) worksheets and lesson plans (n = 34).

2.6 Data Analysis

Teachers' photos were analysed through visual data analysis techniques (Cohen et al., 2009), specifically through inductively-made categories that were relevant to the fundamental characteristics of metaphors, as described below. On the other side, teachers' reflections and descriptions were analysed through qualitative content analysis (Mayring, 2015) and were also used to corroborate the interpretation and analysis of what we see in the photograph, hence increasing the concurrent trustworthiness (Cohen et al., 2009).

Particularly, teachers' artistic photography essays were qualitatively analysed based on the following categories: a) the science topic under study, and the relevance to the science topic they had chosen in their conventional lesson plans, b) the extent to which scientific phenomena were properly and accurately described, based on the content of the photograph and the descriptions provided, c) the perceived aesthetical quality of the photograph based on principles of photographic synthesis/framing and photometry shared in class, d) the metaphor used and described. Specifically, the metaphor was coded according to: di) the extent to which it entails surprise by using a three-level scale: no surprise/surprise/big surprise, dii) the features of the metaphors used, namely the characteristics of the metaphorical connection, which were described by teachers. For example, some teachers mentioned emotional connection in the description of their metaphors, others used linguistic connection in terms of using a similar term in other contexts, while others used personification of the phenomena. All metaphors were coded according to one or two features, based on the analysis of the photograph and the description provided for clarification and corroboration. The analysis of the classroom group activity deliverables followed a similar pattern as described above.

Regarding teachers' views, descriptive statistics (average scores and standard deviations) were used for the closed-ended responses of the questionnaires in order to gain insights into the overall perceived interest/competence of the group of teachers. The open-ended responses were qualitatively analysed through qualitative content analysis. Particularly, inductive codes were created from teachers' responses to each question, while the codes were further revised and grouped into broader categories.

3 Findings

3.1 Science Topics for Artistic Photography

The teachers created photographs of phenomena and photographic metaphors in a variety of science topics. The most frequent patterns included i) light phenomena (n = 10 teachers), *e.g.* rainbow, sunset, sunrise, shadows, ii) changes of states of matter (n = 7), such as water cycle, solidification, iii) weather phenomena (n = 5) such as thunder, rain, wind, iv) natural disasters (n = 4) such as volcanos, earthquakes, tsunamis, v) topics from traditional science curricula, such as gravity (n = 3), heat (n = 3), floating and sinking (n = 2), electrical circuit (n = 1), oscillations (n = 1), and vi) irrelevant/non-scientific topics, such as geographic location (n = 1). Hence, we could infer that artistic photography was used both for topics that are common to preschool education, but also for traditional science topics which would be rather taught in higher student grades.

Even though in most cases (n = 25) of photographic essays the teachers maintained the same science topic with their lesson plans, in several cases (n = 14) the teachers changed the topic. Indicative arguments that they used to justify the change are, first, that those topics were more interesting or easier for the photographic essay than the first ones. Second, that they personally found those topics more interesting and creative, and third, that they already had photographic materials on those topics that they liked. Consequently, we can infer that although photography provided a fruitful space for representing a variety of science topics, it also affected teachers' selection of science topics, since many teachers prioritised the ones that teachers liked more or that would be represented in a better way according to their point of view.

3.2 Aesthetic Aspects of Artistic Photography

The teachers delivered photographs, most of them created by themselves using their mobile phones, while they also used photos (n = 10) from the Internet, as they mentioned. Analysing photographs from an aesthetic point of view, although most photos depicted well the phenomena under study, a series of common challenges were noted. Some of the most prominent challenges related to photographic synthesis, since in many cases (n = 10) the frame included too much of an area (*e.g.* sky) which was not needed and would rather not assist the viewers in focusing on the phenomenon. Putting the phenomenon under study in a strong focal point (*i.e.* according to the rule of thirds) was also neglected in some cases since some teachers tended to centralise too much the object under study. Another common characteristic was that teachers tended to use a portrait orientation (*i.e.* having greater height than width for the photo) even for landscape photographs. Even though this aspect ratio is not considered natural for human vision, this could be explained in light of teachers having extended experience with using mobile phones and social media, where portrait orientation is the norm. Additional challenges related to having some parts of the phenomenon cut from the frame or having a background that distracts from the object/phenomenon of interest. Similar challenges appeared in the analysis of teachers' group activity in the classroom. Some indicative examples of coded challenges are presented in Figure 1.

(a) (b) (c)

Figure 1 Examples of indicative coded challenges in the aesthetics of the photograph: a) issues on the frame (*i.e.* too much sky), horizon misalignment and portrait orientation, b) photos of plants with a distracting background and portrait orientation, c) distracting background when presenting boiling phenomena.

3.3 Photographic Metaphors

3.3.1 Teachers' Pre-conceptions of Metaphors

In this section, the focus is shifted to the photographic metaphors created and described by teachers. First, we can see from the analysis of teachers' pre-metaphor questionnaire responses that some teachers came up with limited conceptualisations of a metaphor before the artistic photography sessions. Particularly, 4 teachers made reference to defining characteristics such as the use of a source and a target domain, and 3 teachers mentioned a comparison between them, which is literally false. Only one teacher mentioned the implicit character of this comparison, and one teacher mentioned the element of surprise. On the other hand, 7 teachers confused the meaning of the term 'metaphor' with the meaning of 'transfer', which is the literal translation of the word in Greek, also used in the context of science. As regards examples of metaphors, 4 teachers provided accurate examples of a metaphor, while 4 teachers provided partly accurate examples which were rather expressing an analogy instead. Hence, we can infer that a deep understanding of a metaphor, its characteristics and its similarities and differences appears demanding, even after receiving instruction about them in previous sessions. The fact that most teachers were first-graders with limited experience with instructional tools, or the lack of doing more practical exercises on metaphors during this course, could interpret these shortcomings.

3.3.2 Features of Teachers' Photographic Metaphors

The photographic metaphors that teachers created were coded into 15 different features, the most prominent of which are presented as follows:

(a) *emotion* (n = 17 coded themes), where the phenomenon was metaphorically represented through the expression of an emotion. For example, a teacher represented heat through the embrace of a couple in love, or an earthquake with a person being emotionally distressed after a sad event. However, it appeared common in this category to create photographic metaphors that vaguely represented the scientific phenomenon, by representing no reasonable connection between the source and target domains, such as representing rain droplets with tears when a person is crying. We could hypothesise that such use could lead to students' misconceptions, such as connecting rain with sadness, which does not actually contribute to understanding the phenomenon.

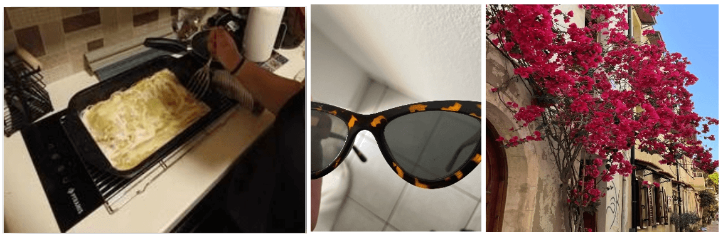
(b) *personification* (n = 9). The phenomenon was represented through an action or state of a human person. For example, T25 created a photo of some friends playing the 'telephone game' where a message is being transmitted from one to another to represent heat transfer. *"The (whispered) word begins from the first person and is being said to the next person step by step. In the same way, heat is transferred from one molecule to the other, so that makes the phenomenon more understandable."* [T25]. Another teacher used a photo of a baby which is being fed in order to represent photosynthesis in plants. *"Kids do not grow out of the ground, but they also need light, food, clean atmosphere and hydration in order to be strong and happy."* [T31].

(c) *linguistic* (n = 9). The metaphor relates to using the same word/term in a different phenomenon; hence, the connection was made by using the same word having a similar meaning but used in a different domain. For example, it is common when teaching photosynthesis to refer to it as a process where plants create their own 'food'; hence, T39 created a photo depicting a meal that she cooked herself to eat, as shown in Figure 2a. *"In the same way that plants transform carbon dioxide and water with the assistance of light into their food for themselves, I also cooked food that I used to feed myself"* [T39]. Similarly, T7 used a photo of a bougainvillaea 'exploding' like a volcano by bursting into bloom, as shown in Figure 2c.

(d) *content* (n = 8). The connection between the source and target domains was made through experiencing a similar phenomenon; hence, the properties or the results of the phenomenon were used to connect the two phenomena. For example, the fogged sunglasses in Figure 2b restrict our vision, and that was used to explain the limited vision we end up having during dust storm phenomena, such as in Figure 1a. *"As when our sunglasses get fogged up, we cannot see clearly, the same occurs when there is African dust in the atmosphere, where it somehow obscures our vision"* [T16].

(e) *material use* (n = 3), where the connection between the two domains was made through the reference to the same object, *e.g.* photographing droplets in order to explain what phenomena take place in a rainbow.

(f) *philosophical* (n = 3). A more abstract idea was used to explain what occurs in the scientific phenomenon. For example, T21 used the indecision of a human who vacillates between two options to model the phenomenon of an oscillating pendulum (a swing). *"The metaphorical connection between the two photographs is that as the swing oscillates, this human cannot decide which door to open and enter."* [T21]. T17, on the other hand, used a picture of a poppy growing on a part of a road with asphalt to demonstrate plants' growth, but also to interpret that phenomenon with feelings of hope and self-sacrifice.



(a) (b) (c)

Figure 2 Examples of photographs used in a metaphorical way by teachers

3.3.3 Challenges in Creating Photographic Metaphors

Although teachers became creative in using a variety of photographic metaphors, in several cases the metaphors they used were coded as inaccurate (n = 3), where there is no direct conceptual connection between the source and the target domain. For example, one teacher made a connection between the sunset and a long-lasting friendship with her pet that lasts the whole day, a connection which does not directly contribute to the meaning-making of the scientific phenomenon. Furthermore, 12 metaphors were coded as vague, which means that the connection between the source and the target domain was not well-established. For example, one teacher photographed boiling water to showcase the change of state of matter from liquid to gas, and then she photographed a rainy landscape to showcase the complementary process in the water cycle. Hence, a metaphorical connection that would contribute to understanding the first phenomenon was not quite apparent, we could say.

Scientific inaccuracies while describing phenomena and photographic metaphors were coded in 7 instances, such as the use of the term 'air' for describing wind, or using the term 'boil' for describing evaporation phenomena. Notably, we can infer that analysing teachers' descriptions of their artistic photographs, we can also gain deeper insights into their understandings and misunderstandings of science content knowledge.

Further challenges relate to teachers using similar phenomena in both the source and the target domain in 8 cases, something that we could not expect to contribute much to facilitating students' understanding. For example, T38 used an image of an apple tree and made reference to the image of an apple falling on Newton's head in order to explain her first photo which demonstrated a bottle of water falling to the ground due to gravity. Even though the two phenomena can be connected, we cannot expect that the source domain would be more familiar to students than the target domain; hence, the efficiency of the metaphor here could be deemed restrictive.

3.3.4 Further Characteristics of Photographic Metaphors

Concerning the element of surprise, most metaphors incorporated surprise (n = 22) or big surprise (n = 10) in their metaphors, hence making use of this feature for drawing students' attention to the phenomena. However, in 10 cases, the element of surprise was not apparent, such as when introducing photographic metaphors for the same scientific phenomena/domains, as described above.

On the other hand, teachers used photos of themselves or their friends and relatives (n = 9) to embody phenomena and make representations that would facilitate science meanings. For example, one teacher photographed herself where she was protecting her body under the table in a room setting where an earthquake would have taken place, while another teacher photographed a person and her shadow to demonstrate the creation of shadows.

3.4 Teachers' Views

3.4.1 Teachers' Prior Views on Artistic Photography

Most preservice teachers mentioned no prior experience with artistic photography (n = 16) or had experience with it only for entertaining purposes (n = 7). They rated their prior experience in artistic photography as 4.42/10 (STD = 1.92), their perceived competence as 6.42/10 (STD = 2.06) and their interest as 7.48/10 (STD = 2.13) in artistic photography. When they were called upon to describe the main features of artistic photography, their responses focused on colours and light (n = 9), the skills, experience and passion of the photographer (n = 7), the object/theme that we photograph (n = 6), the expression of emotions (n = 5) and ideas/innovative ideas (n = 4), creativity (n = 3), aesthetical beauty (n = 3), to depict reality (n = 2), as well as technical aspects of photography such as the angle of view (n = 4), focus (n = 2), quality (n = 2), background (n = 1), the camera, and knowing how to use it (n = 3), *etc.* On the other hand, elaborated views on catching the viewer's eye/attention (n = 2), photometry, or photographic synthesis appeared scarce.

3.4.2 Teachers' Post-Intervention Views on Artistic Photography

Teachers' main post-questionnaire reflections on the affordances of artistic photography for science teaching are shown in Table 2, while the main perceived challenges are shown in Table 3.

Table 2 Perceived advantages of using artistic photography for science teaching

Advantages of using artistic photography for science teaching	N
Drawing students' interest/attention/focus on the phenomena	8
Increased understanding of science	5
Visualisation of science phenomena	4
Facilitates inquiry/students making hypotheses and questions on what they see	3
Makes teaching more interesting/ pleasant	2
Direct contact with live data	1
Facilitates students tracing details	1
Develops instructors' skills in photography	1
No response	10

Table 3 Perceived challenges of using artistic photography for science teaching

Challenges of using artistic photography for science teaching	N
Difficulty in photographing/demonstrating the scientific phenomenon of interest well	7
Technical aspects (angle of view, good capture, clarity, setting of objects)	6
Lack of equipment (*e.g.* camera)	2
Didn't know what phenomenon to photograph	2
To make the phenomenon understandable	1
To understand the scientific meaning	1
May disorient students from the lesson	1
Need concentration	1
No perceived challenges	6
No response	10

As we can see from Table 2 and 3, the preservice teachers identified several advantages of artistic photography related to science learning; however, many teachers considered it demanding to provide elaborated photographs to represent the scientific phenomena they wanted to teach.

As regards the educational value of using photographic metaphors, the preservice teachers found that as an approach that can facilitate science understanding (n = 8 teachers), and connect abstract concepts with more familiar ones (n = 2). As one teacher mentioned, *"it helps since the children are introduced to a phenomenon in a more creative and understandable way"*.

Photographic metaphors were deemed to be a multimodal tool that can visualise phenomena and activate multiple semiotic systems that are not limited to text. Particularly, one teacher mentioned *"Artistic photographs are very helpful since it is something visual that most people understand and conceptualise"*, while another teacher wrote *"They are very important since they make science more understandable in cases one does not learn just by reading texts, but also sees that"*.

Moreover, teachers found that method interesting both for the children (n = 3) but also for them and in general (n = 3). *"I find that as a smart strategy to draw students' interest concerning the scientific phenomenon under study"*, stated one teacher. Advantages were also mentioned specifically in terms of science teaching (n = 4) since it was deemed useful, effective, and a simple way, having a different type of teacher-student interaction. *"I think the kids find it a more interesting way than simply being taught in a standard way, because this way they have a different interaction with the teacher and the artistic photos bring kids more 'close' to the* *phenomena"*. Teachers also mentioned the development of skills (n = 3), such as creative thinking, imagination, reflection, and analogical thinking.

On the downside, three teachers expressed some concerns, specifically related to the metaphors being difficult to be understood by kindergartners (n = 2), hence it might end up confusing them. One teacher stated *"I consider that the use of photographs as metaphors/analogies wouldn't be understood by children at the age of 5 and 6 years old. It would be more understandable in ages where the children would have been taught and would have the ability to perceive what a metaphor is"*. Even though we could consider this concern legitimate, we feel the need to discern children's ability to learn a phenomenon *with* a metaphor, from children fully comprehending *what* a metaphor is, which certainly requires more elaborate thought. Furthermore, one teacher stressed the importance of the metaphor to be specific and focused as a prerequisite in order to make the phenomenon understandable.

4 Discussion

This study examined the integration of artistic photography in designing science teaching through the creation of photographic metaphors. Particularly, it examined teachers' views and instructional design practices in creating their own photographs of scientific phenomena and photographic metaphors to explain these phenomena. The main findings are discussed as follows.

First, in regard to science topics, we can see that artistic photography can provide a fertile space for creating and communicating metaphoric representations in several topics, many of which were related to common topics of Preschool Education, as well as indicative curriculum topics for upper grades. Although many scientific phenomena were quite abstract and, as teachers mentioned, it was difficult to illustrate, the teachers used several embodied resources from their everyday surroundings, or even photos of their own bodies and facial expressions, to represent scientific meaning through visual metaphors. Hence, the teachers made good use of their creativity, but also multimodal and aesthetic ways of representation. This finding speaks to the dynamics of using artistic photographs crafted by teachers to familiarise students with the scientific phenomena under study.

Furthermore, analysing the features of the photographic metaphors created by the preservice teachers in this study, we came across different types, such as linguistic metaphors, content-focused metaphors, object-oriented metaphors, representations through emotions, and personifications. Several researchers have already discussed the existence of different types and interpretations of metaphors, especially distinguishing linguistic metaphors from conceptual metaphors (Treagust & Duit, 2015; Contini & Giuliani, 2022). However, an inspection of the efficiency and appropriateness of such types of metaphors is needed. For example, Kallery & Psillos (2003) have suggested that the use of anthropomorphism and animism by preschool teachers should be used with caution, since it may cause cognitive and emotional problems to children. It should not be deemed easy for children to understand the metaphorical connection implied by the personification, while at the same time maintaining the focus on explaining the phenomena and not deviating to vague or generic impressions from the photograph. Further studies regarding the types of photographic metaphors and their learning outcomes for young children could shed light on these aspects.

Moreover, this study explored teachers' challenges both in understanding as well as in implementing metaphors. It appeared that in several instances, teachers misused metaphors, such as creating vague connections between the source and the target domain, or using similar phenomena for both the source and target domains, often lacking the element of surprise that would motivate the viewer. We can interpret this finding, first, by the traditional difficulties that preschool teachers face in science knowledge (Kallery & Psillos, 2003) and in designing science teaching (Nipyrakis, 2024). Second, this finding may reflect the fact that understanding and using metaphors is a demanding endeavour, in the same way that it appears demanding for students as well (Niebert et al., 2012). Third, designing teaching which makes good use of metaphors could be considered a skill that needs developed pedagogical content knowledge, something that could not be expected from first-grade preservice teachers in our case.

The study findings also stress the importance of aesthetic aspects when developing metaphorical representations (Contini & Giuliani, 2022), which, in our case, concern aesthetic aspects in creating artistic photographic materials. As findings reveal, some preservice teachers' photos had shortcomings in terms of quality or framing, which we could hypothesise might limit students' focus on the phenomena under study. Even though photography is a common social media activity for young people and young children nowadays, training on principles and techniques of artistic photography is recommended if photography is to be implemented for educational use, *i.e.* deviating from common uses of photography as just capturing moments and life experiences. Teachers need to understand how artistic photography differs from common photography practices and how it can be used to facilitate science understanding. Framing, photographic synthesis of objects to be photographed, experimentation with different angles, zoom, light and much more can enhance teachers' abilities to create teaching material with artistic photography. Future studies could also examine photo editing or even adding photographic effects to create enhanced photographic materials for educational use. Such an approach relies on developing teachers' Technological Pedagogical and Content Knowledge (TPACK) and skills (Mishra, 2019), specifically related to TPACK on effectively implementing digital photography in science education.

Furthermore, given the increasing exposure of young children to smartphones and cameras (Paradakis & Kalogiannakis, 2017), as well as to photograph-based social media, it also appears valuable to carry out educational interventions that make good use of such tools and approaches. A more sophisticated use of such technological tools can highlight the educational potential of mobile devices and could argue against the existing sceptical stances of many parents against technology (Alexandraki & Zaranis, 2023).

Notably, regardless of the challenges that preservice teachers faced, they provided positive reflections regarding the integration of artistic photography for science teaching, and most of them considered it appropriate to use photographic metaphors for facilitating children's meaning-making in science. It appeared that artistic photography is a motivating approach for both students and teachers themselves, according to teachers' reflections. Future studies could examine this finding for teachers of primary or secondary education. Furthermore, the effectiveness of such an approach for student learning needs to be examined.

Limitations of the study relate to the small number of participants and the fact that no interview data were obtained since no participants volunteered for the interview at the end of the semester. Even though the analysis of diverse data sources was used to increase trustworthiness, the data were not analysed by a second coder in order to minimise researcher bias and to examine the inter-rater reliability. Also, given the fact that the course was in lecture mode, attendance in class was not mandatory; therefore, not all participants who delivered essays were present in the classroom session or delivered questionnaire responses in class. Even regarding the teachers who completed the questionnaires, a non-negligible percentage of them did not provide articulated responses on open questions, probably due to survey fatigue. Future studies with seminar/laboratory courses, which would include focus groups and/or interviews, could provide deeper insights regarding teachers' views on photographic metaphors and their reasoning for creating these metaphors.

This study contributes to the literature examining the use of metaphors as instructional tools, but also to the literature that has been examining visual means such as digital photos and animations. However, what appears distinctive in our case is that teachers are given the opportunity and the agency to create their own digital photos by using their creative imagination and their everyday mobile devices, often their own selves and bodies too, to model and represent scientific phenomena for their students. This signifies the potential of customised artistic photography, while the impact on teaching students remains to be further explored.

5 Conclusion

This study advocates the use of the art form of photography for designing science teaching. It demonstrates the potential of using mobile phone cameras to create artistic photographs for illustrating scientific phenomena, but also for creating and conveying metaphorical representations of these phenomena. Teachers' reflections and practices provide empirical findings regarding the dynamics of photographic metaphors, but also the challenges that may be posed by such an approach. Overall, artistic photography appears as another arts-based method to motivate students and provide embodied and multimodal representations for science teaching. Such an approach can inform teaching practice in preschool settings, mainly through the creation and use of digital photos by teachers. Even though in some cases preschool children could be rather considered too young to handle mobile phone cameras themselves, we can hypothesise that they are still familiar with mobile devices due to their parents' common use of mobile phones and cameras at home, and the generally increasing use of mobile devices in young children's daily lives (Papadakis et al., 2021).

Therefore, the study offers implications for practice since, according to teachers, such an approach can facilitate students' science understanding and can foster student motivation towards science. Moreover, it has implications for research since assigning teachers to create their own photographs and photographic metaphors can assist researchers in gaining insights into teachers' understanding and use of metaphors, their science content knowledge, and their TPACK skills, such as using their mobile phone devices for creating and using digital photographs for educational use. Implications for teacher educators rely on creating interdisciplinary approaches in teacher preparation sources. Particularly, this study provides recommendations for teacher educators to support teachers in creating and using their own teaching materials, digital photos in our case, which generally fall within the 'teacher as a designer' approach (Psillos & Kariotoglou, 2016) in teacher education. Using their everyday portable devices together with their artistic inspiration to enhance their teaching appears as a feasible and promising way towards that direction.

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Conflicts of Interest

The author declares there is no conflict of interest.

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