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Integrating art into science education: a survey of science teachers' practices

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ABSTRACT

Numerous case studies suggest that integrating art and science education could engage students with creative projects and encourage students to express science in multitude of ways. However, little is known about art integration practices in everyday science teaching. With a qualitative e-survey, this study explores the art integration of science teachers ($n = 66$). A pedagogical model for science teachers' art integration emerged from a qualitative content analysis conducted on examples of art integration. In the model, art integration is characterised as integration through content and activities. Whilst the links in the content were facilitated either directly between concepts and ideas or indirectly through themes or artefacts, the integration through activity often connected an activity in one domain and a concept, idea or artefact in the other domain with the exception of some activities that could belong to both domains. Moreover, the examples of art integration in everyday classroom did not include expression of emotions often associated with art. In addition, quantitative part of the survey confirmed that integration is infrequent in all mapped areas. The findings of this study have implications for science teacher education that should offer opportunities for more consistent art integration.

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1. Introduction

The courage to imagine the unimaginable is a valued trait for both artists and scientists. The definition of 'art' as 'something that is created with imagination and skill and that is beautiful or that expresses important ideas or feelings' in Merriam Webster conveys many of the reasons why including artistic processes into science might be valuable: firstly, creativity and imagination are required in science to form mental images of investigated entities, often invisible to the eye such as electrons or atoms, and visualising or expressing these images to others is a requirement for the development of science (Hadzigeorgiou, Fokialis, & Kabouropoulou, 2012); secondly, the ability to address and express emotions and ethical and moral issues is important in understanding the decision-making and argumentation processes of science emphasised in science topics related to socio-scientific issues (Zeidler, Sadler, Simmons, & Howes, 2005) and sustainable development (Eilks, 2016). Multiple modes of expression do not have only a potential to teach about

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scientific literacy, but could also open up science for poorly performing students, e.g. for those behind in linguistic capabilities (Reif & Grant, 2010). Furthermore, arts enable inspiration and novelty as well as develop cognitive and social growth, enhance creativity, capture attention through novelty, reduce stress and make teaching more enjoyable in general (Sousa & Pilecki, 2013).

Science integration has traditionally meant integration having to do with mathematics, engineering and/or technology, which has led to approaches such as STEM education in the United States (Czerniak & Johnson, 2014). However, there are signs of a change. Recently, there has been discussion of including art to STEM and move to STEAM education (Sousa & Pilecki, 2013). Indeed, the amount of STEAM-related articles that report interventional studies of art and science integration have been on the rise (Grant & Patterson, 2016).

However, these intervention studies are usually conducted in settings that favour art integration. Furthermore, the target group in these studies is dominantly elementary and college level students. In these settings, the instructor is trained to the task and is provided with equipment and enough time to integrate art. Everyday science lessons that integrate art, especially in secondary and upper secondary levels (ages 13–18), rarely have these elements. Recent priorities of national educational policies promote integration (Finnish National Board of Education, 2014; Next Generation Science Standards, 2014). For example, the new Finnish National Core Curriculum, integrated and multidisciplinary learning are set as a common goal and emphasis is on transversal competences in instruction of all subjects. Furthermore, each school is required to organise at least one multidisciplinary teaching module each year. This enables science teachers to integrate art for science teaching in high school and upper secondary levels more than before. Due to curriculum demands to integrate across a wider range of discipline areas, there is an increased need for more research in the area of integration (Czerniak & Johnson, 2014).

Even though research papers discuss many promises of art integration, the current realities of art integration in science education have not been mapped. In order to realise these promises, more research is needed in designing art integration viable for everyday science lessons. Therefore, the aim of this study is to understand science teachers' art integration in order to support the design of viable art integration for regular science lessons in the future.

2. Theoretical background

Integration in educational context has various meanings (Czerniak & Johnson, 2014). In this study, integration is outlined as a process between art and science and therefore it is possible to draw from the definition of interdisciplinary. Lederman and Niess (1997) define interdisciplinary as a blending of different subjects by making connections between them, but still having the subjects as identifiable entities. Connection making between art and science is discussed in terms of knowledge and experiences that can highlight characteristics of both disciplines.

Knowledge integration is valuable for learning. The importance of integrated knowledge is rooted in constructivist learning paradigm based on the principle that new ideas are integrated into existing knowledge frameworks. On concrete level this means e.g. that abstract concepts learned in school are linked to authentic phenomena, themes or contexts to support learning. Knowledge integration is also an issue of curriculum design. Ideally, curriculum integration could mean that learning experiences are organized around big ideas such as conservation, pollution, politics and economics in order to unify fragments of knowledge (Beane, 2016). In the process, connections are made in knowledge across disciplines supporting the learning of both disciplines. The curriculum integration for secondary and upper secondary levels can then be implemented, e.g. as thematic units, inquiry or problem-based learning projects (Burnaford, Brown, & Doherty, 2007).

Knowledge integration is a cognitive process. Linn, Eylon, and Davis (2004) suggest a knowledge integration approach (KI approach) in science education. They elaborate the integration process by clarifying that ideas need to be added to the pool before making connections and afterwards there has to be self-monitoring and evaluation in order to select and promote the most useful connections. Shen, Sung, and Zhang (2015) draw on KI approach in their framework for interdisciplinary reasoning and communication to illustrate that these integration processes are often social. Their framework adds to the definition of integration by distinguishing between differential and commonality integration. In *Differential integration*, ideas are organised from different disciplines to a connected whole in a complementary manner. In *Commonality integration*, a common set of knowledge is singled out across disciplines, which might lead to competition in which concepts enter the common core.

Knowledge and experience are deeply intertwined in learning. Important groundwork on the notion of experience was done by the pragmatist John Dewey (1934/2005, 1938). Drawing from Dewey, Kolb and Kolb (2012) created a theoretical framework of experiential learning theory for learning from experience. In the experiential learning theory, experiences are perceived through bodily senses during activities. These sensations then enable reflection and are then assimilated or distilled into abstract concepts that can then be actively tested. Developed abstract concepts then enable more possibilities to select action for subsequent learning cycles. Both knowledge and skills are acquired in the process (Kolb & Kolb, 2012). Here, perception during an activity phase plays a key role. What is perceived is influenced by e.g. a teacher's instructions, the previous experiences and the students' knowledge. Therefore, the perceptions made from educational objects can be very different in science and art lessons. As a crude example, observing a pot of melting snow could be perceived as a transformation from solid to liquid or a transformation of visible to transparent. And yet at the general level, close observation is a valuable trait in both for scientific (Next Generation Science Standards, 2014) and for artistic habit of mind (Winner, Goldstein, & Vincent-Lancrin, 2013).

If knowledge and skills are rooted in experiences, an important question arises: are students able to *transfer* the learning between art and science? Transfer is defined as the ability to apply knowledge and skills to new contexts (Dori & Sasson, 2013). In principle, it is valuable to explore the possibilities of transfer, because generic transferable skills are needed to be successful in any domain (Taber, 2016). However, transfer is known to be difficult for students (Bransford, Brown, & Cocking, 1999) due to specific non-general nature of skills and knowledge (Perkins & Salomon, 1989). Billing (2007) suggests that transfer can be fostered, e.g. when general principles of reasoning are taught together with self-monitoring and with sufficient examples of problems and context of application. Dori and Sasson (2013) model near and far transfer, suggesting that the need for support increases depending on the differences and similarities in tasks, disciplines involved and cognitive skills required (Dori & Sasson, 2013). Therefore, if art and science are recognised as dissimilar disciplines, students will need more support in transfer between disciplines. Shen et al. (2015) see transfer and integration as profoundly interrelated processes. They clarify on the differences of integration and transfer by suggesting that in integration, ideas are compared and contrasted in a similar level of priority, whilst in transfer 'one takes an idea or an explanatory model from primary discipline and applies it to other disciplinary context'.

The evidence related to the effects of art integration implies that unsupported transfer has very limited possibilities. In a large-scale review, Hetland and Winner (2001) investigated the hypothesis that being infused with art impacts the learning of non-art skills or knowledge. The results were presented on three different levels of causality.

- Reliable causal relationships were found to be in strong correlation between (a) relationship between listening to music and spatial-temporal reasoning; (b) learning to play music and spatial reasoning and (c) classroom drama and verbal skills.
- Slight causal links were found in (a) learning to play music, and mathematics and (b) dance and non-verbal reasoning.
- No reliable causal links were found in (a) arts-rich education and improvement on mathematical or verbal scores, (b) arts-rich education and creative thinking and (c) learning to play music and reading.

In general, the academic performance between the art and non-art infused groups is not significantly different (Hetland & Winner, 2001). However, art integration is reported to have a positive effect on the success of disadvantageous students (Robinson, 2013).

One important aspect to add to the understanding of an experience related to art and science integration is emotion. Emotion has often been considered as integral part of art. Historically, the feeling of beauty has contented for many as the main purpose of art. Nowadays, the emotions associated with art have a wider range from beauty to anger, to horror or disgust. Considering the emotions related to an experience in art and science integration aligns with the study of aesthetics. Indeed, adapting the definition of aesthetics from Shimamura and Palmer (2012) that covers knowledge, sensation and emotion seems to align especially well with the previously stated descriptions of experience and learning. However, aesthetics is not only a property of art. The notion of aesthetics has been used to understand and enrich experiences in science education as well. Drawing from aesthetics, Dewey suggested that art could provide a special type of 'an experience' that has a sense of completeness of its own due to build-up, resolution and anticipation, like in drama (Pugh & Girod, 2007). Aesthetic understanding has been argued to contribute to the understanding of science and science education (Girod, 2007). Indeed, the feeling of beauty or completeness can be associated with art, nature and (scientific) ideas alike (Shimamura & Palmer, 2012). Lin, Hong, Chen, and Chou (2011) report that integrating aesthetic understanding into reflective inquiry promotes conceptual understanding and attitude towards science. However, Pugh and Girod (2007) remind us of the fact that providing transformative, aesthetic experiences all the time is difficult and that teachers should focus on teaching only some of the concepts in an artistic way. They continue to suggest that collaboration with teachers and researchers is needed to explore the dynamics of these experiences.

In contrast to art education, it has been suggested (Alsop, 2005; Zembylas, 2005) that science education often emphasises cognitive aspects and neglects emotion although emotion and cognition are interrelated in science learning. In this study, we follow Zembylas (2005) and use emotion instead of a more general term, affect, because emotion emphasises performative and bodily aspects of experience and therefore aligns better with action and the aspects of perception of experience. Whilst the previous research in emotions and science education has been dominated by attitude research and its influence in learning (Alsop, 2005), there has also been substantive amount of research conducted on the areas that more directly address emotions such as anxiety, enjoyment and its relation to interest and confusion (Sinatra, Broughton, Lombardi, Pekrun, & Linnenbrink-Garcia, 2014). The role of emotions as an instructional enhancement and as a hindrance is especially relevant in areas of science education that deal with controversial issues (Sinatra et al., 2014) such as socio-scientific issues (Zeidler et al., 2005). Since art is used to express feelings and ideas, it is not surprising that methods drawn from art have been suggested when dealing with controversial issues in science education. For example, Ødegaard (2003) proposes that the drama can be used to learn not only about science concepts, but also about the interaction between science and society and the nature of science. She points out that divergent interest and ethical conflicts are essential in decision-making process, as is also shown in good plays and dramas. The need to address multiple perspectives, ethics and decision-making processes is central in education for sustainable development and it seems natural that art and drama have been suggested (Eilks, 2016) as one of the methods when connecting science education and education for sustainable development.

The evidence related to positive emotional outcomes of the integration experience is widely observed in both disciplines. Czerniak and Johnson (2014) review some of the affective gains observed in science integration programmes that mention enhanced interest, motivation and attitude towards science and towards school. Studies of art integration programmes observe motivational and social growth of different student groups, teachers and even schools, suggesting that certain art activities can promote students' engagement, self-confidence, self-control, conflict resolution, collaboration, empathy and social tolerance (Burnaford et al., 2007; Robinson, 2013). One explanation to increased motivation with art integration is the fact that art enables multiple ways to express and explore content. This enables students who are not as fluent with the discipline-specific expression to be recognised by others for their successes leading to academic motivation (Robinson, 2013). To some extent, the same explanation applies for art and science integration in general.

However, one needs to proceed with caution with art integration. In a recent meta-analysis, Winner et al. (2013) argue that there is far too little research on the impact of art education on students' outcomes of creativity, critical thinking, persistence, motivation and self-concept, which prevents the making of too strong conclusions about these outcomes. They summarise that there is evidence of the claim that art education enhances these skills in the context of art, but there is no evidence on the transfer of other subjects including science. However, they argue for art education in its own right, because artistic habits of mind are valuable and there is suggestive evidence of the fact that art matters in innovation. They conclude that these students' outcomes depend on the way arts (and science) are being taught and they request more research on pedagogical models and attitudes related to art integration.

2.1. Integrating art into science education

Art integration includes different forms of art that help to address content in multiple ways such as literature, drawing/painting, drama, music and sculpture (Reif & Grant, 2010). Integration can occur through multiple art forms or with just one, with the help of artists or art teachers, and some art integration projects can permeate the whole school curriculums (Burnaford et al., 2007).

Russell and Zembylas (2007) discuss some of the challenges of art integration for teachers, related to self-efficacy and to the structure of the school day in traditional school systems. It is understandable that science teachers feel that they are out of their comfort zones when integrating art, since science teachers are trained to teach certain disciplines and are not usually prepared to teach integrated approaches, or artistic processes in particular (Bequette & Bequette, 2012). However, there are possibilities to alleviate these challenges by providing sufficient teacher education or influencing the traditional structure of school days, so that the art and science teachers would have more time for team-teaching or time for collaborative planning (Russell & Zembylas, 2007).

To illustrate some of the many possibilities of art integration available for science educators (Table 1), case studies that integrate art specifically into science education are reviewed here. Reviews of art integration methods and practices in other subjects can be found elsewhere (see e.g. Burnaford et al., 2007).

The listing of scientific content only is natural because these activities are mainly reported publications that focus on science education. Furthermore, only few of the studies quantitatively compare the learning in arts and non-arts cases. For example, Crowther, McFadden, Fleming, and Davis (2016) compare the learning of science content through videos with and without music. They reported that the group who saw videos without music performed better in a posttest right after watching the video, the group who had music on their video out-performed the other group in a delayed posttest. A more detailed analysis, which would focus especially on integration between art and science, was not found by the researchers and this type of meta-analysis should be conducted in the future.

3. Research design

The purpose of this study was to understand science teachers' art integration in regular lessons. A qualitative survey was developed based on the previous reviews of integrated science education (Czerniak & Johnson, 2014) and art integration (Burnaford et al., 2007; Winner et al., 2013). Qualitative part of the survey was emphasised, because no previous models focussed on integrating especially art and science integration were found.

3.1. Research questions

The research question that guides this study is: how is art integrated in science lessons? This question is divided into three more specific sub-questions that can be investigated:

Table 1. Previous case studies that report art and science integration.

Arts	Subjects involved	Task descriptions	Science topics
Design	STEAM	Engaging students with functional design processes	Engineering process (Bequette & Bequette, 2012)
Paintings	Chemistry	Experimental activities on dyes and colours, and information about chemistry in paintings	Chemistry concepts (Kafetzopoulos, Spyrellis, & Lymperopoulou-Karaliota, 2006)
Photography	STEAM	Students do inquiries of how science relates to aesthetic properties or students build their own pinhole cameras	Inquiry, chemical kinetics and optics (Stamovlasis, 2003)
Drawing	Mathematics and physics	Students are introduced to art as a way of expressing mathematics and science. Students write and draw to express their ideas	The abstract concepts of contemporary physics (van der veen, 2012)
Concept cartoons	Physics, chemistry and biology	Students discuss (and occasionally draw) concept cartoons which introduce characters who represent different abstract scientific ideas or arguments	Chemical bonding (Ültay, 2015)
Comics	Biology	Comics are used to engage students	Viruses (Spiegel, McQuillan, Halpin, Matuk, & Diamond, 2013)
Sculpture (glass, metal and ceramics)	STEAM	Collaborative projects with artists	Concepts of protein structure and folding (Gurnon, Voss-Andreae, & Stanley, 2013)
Literature	Biology	Students write short stories related to science	Enhances scientific literacy (Ritchie, Tomas, & Tones, 2011)
Poetry	Chemistry	Students read, analyse and write poems	Atomic radius and ionisation energy (Araújo, Morais, & Paiva, 2015)
Drama	Physics and biology	Role plays and physical simulations	Electrolysis of water (Saricayir, 2010) Learning about socio-scientific issues and nature of science (Ødegaard, 2003)
Dance and movement	Science and mathematics	Kinesthetic activities and dance.	Geometry (Moore & Linder, 2012)
Music	Science, chemistry and physics	Listening and analysing science content songs	Science topics (K-12) (Crowther et al., 2016) and various topics of chemistry (Last, 2009)
Film and cinema	Science	Videography	Videographic investigations of energy geography (Graybill, 2016)

- What forms of art are integrated in science lessons?
- How often are different forms of art integrated?
- How to describe art integration in science teaching?

The lack of reviews in art and science integration enabled only very rough hypotheses in relation to the research questions. The hypothesis was that there is art integration in all forms of art based on the coverage provided by previous case studies. It was suspected that integration is equally rare in all the different fields of art, because integration was not specifically emphasised by the previous national curriculum and previous research suggested that science integration has focussed on other disciplines. Since only few examples of art integration were to be expected to exist in teaching practice, they were expected to be exceptional or characteristic and therefore prospective for description of art integration.

4. Methodology

The data was collected with an e-survey during November and September 2015. Sixty-six lower secondary (ages 13–15) and upper secondary level (ages 16–18) Finnish science teachers took part in the survey. The respondents had Master's-level university degrees and they were quite experienced as science teachers and they had the proficiency to teach one or two of the sub-disciplines of science: physics, chemistry, biology or geography. These disciplines were often coupled with the proficiency to teach mathematics.

The questionnaire was sent through channels such as Facebook groups and mailing lists, which require either submitting or following or previous cooperation with in-service teacher education. Therefore, the results might overtly present opinions of the teachers who are active and are interested in getting the latest information as well as developing their education.

4.1. Questionnaire

The results discussed here were obtained as a part of a larger survey about science teachers' perceptions about integrated education and arts integration practices. The results of teachers' perceptions of integrated education are reported elsewhere (Haatainen, Turkka, & Aksela, 2017). The survey collected background information (sex, major and minor subjects being teached, experience, etc.). The questionnaire contained one section which specialised integration with a specific subject, which in this case was art. Because, no previous instruments about art integration in science education were found, participants were asked to give an open-ended example of art integration. The design of the rest of the items in the survey on art integration in science education mapped the extension of art integration which included questions about the frequency of integration and question about the possibilities of integration. Here, the possibilities of integration were seen to be related to the extension of integration. The rough classification to different forms of art and the possibilities (and therefore hinderances) was based on the previous research on arts integration in education (Burnaford et al., 2007; Reif & Grant, 2010).

The questionnaire was piloted within a focus group consisting of science education researchers, which then led to minor changes in the questionnaire.

4.2. Methods

The explorative design of qualitative content analysis means that the focus is on inductive category formation (Mayring, 2014). In this study, exploratory statistical analysis (Cohen, Manion, & Morrison, 2013) was also used to further quantitatively explore the extent of art integration. Quantitative and qualitative methods were mixed in order to provide deeper understanding of the phenomena (Creswell, 2013).

Exploratory statistical analysis was used to describe the data related to the extension of art integration. This method presents and describes data and is mostly concerned to see what the data itself suggest. Frequencies were calculated and presented as table for easier interpretation in order to reflect them to the hypotheses. These statistics do not make inferences or predictions but simply report what has been found (Cohen et al., 2013).

Qualitative content analysis is a systematic, rule-bound procedure that develops categories, which are coming from the material itself, not from theoretical considerations. Although it is somewhat impossible to avoid the preconceptions of the research in any analytical process, the inductive category formation aims for a description based on the material itself without bias owed to the preconceptions of the researcher. However, it has to be noted that preconceptions are also a necessary part of the research process as hypotheses generation (Mayring, 2014).

The inductive category formation followed the steps suggested by Mayring (2014). The criterion for the categories was 'a way to integrate art into science teaching'. The data that did not fit under this definition could then be left out from the coding. These consisted of empty answers and negative answers such as 'I do not integrate' and clauses that made no sense in terms of art integration in science education. The level of abstraction that could answer to the research question was understood to be that of a pedagogical model. This level of abstraction could then support the design of art integration in future. Only after this, the text was coded.

4.3. Coding

The smallest units of coding were considered to be a proposition given in the context of the open-ended question 'Give an example of how you integrate art in your science lessons'. Some paragraphs proposed several examples of art integration and were therefore coded separately. The coding procedure starts by going through the material and formulating categories near to the text and by the selected level of abstraction. For example, the proposition 'animation' was first formulated as a mutual activity in order to achieve the target level of abstraction. For each new proposition, it was checked if it could be subsumed into an existing category, if not a new category was formulated.

When only few new categories were appearing the category system was revisited to see whether the category system could answer the research questions, e.g. if the category system was too general or too specific. Each time the definitions of the categories were changed the coding process was started from the beginning. After several rounds of inductive category formation a two-category system with three subcategories each emerged, where two main categories were integration through content and integration through activities.

The examples were categorised as art integration based on an activity, if they consisted of verbs and nouns that described action that made sense as a pedagogical activity. For example, analysing, compare, inquiry and drawing. These activities were categorised as *science activities* and *art activities* or *mutual* based on the surrounding context in the following way:

- *Activities were categorised exclusively scientific if* they appeared with descriptions that elaborated the activity as science, e.g. analysing scientific properties or drawing a graph about a phenomenon. Science activities were applied to the context of art and they most often targeted a work of art, which was measured for its scientific properties. For example, 'students calculating the mass of air inside a bronze sculpture' was categorised as science activity.

- On the other hand, *activities were categorised as artistic if* the descriptions elaborated them as making art, e.g. writing a poem. In art activities, science content was often used as the topic. The targeted science content was e.g. chemical reactions or socio-scientific issues. For example, one of the teachers described 'A play about the environmental effects of different ways of producing energy.'
- Some of the examples demonstrated activities, which could be considered both artistic and scientific. These *mutual activities* did not declare a discipline-specific target for the process and could be categorised as a part of both science and art lessons. For example, inquiring snow and drawing. Also, the idea of visualisation leaned towards this category as drawing and illustrating was used to target general entities such as theory, tasks and thinking. When visualisation targeted molecules or other entities of science, the example was considered as a science activity.

Other examples were categorised as art integration based on the content**.** The links between the content were established either indirectly through a theme or an artefact or with a direct link between the content in the two disciplines.

- *Art integration through a theme* – category suggested a somewhat larger, a more general theme, topic, phenomenon or a big idea that could be approached from both disciplines. The themes were broader such as symmetry, sound, snow, colour and light. These themes were not considered to be at the theoretical core of the disciplines as such although they could enable direct links to the theoretical core. For example, light and sound mentioned as such could be understood as a theme, but music and optics as core contents. The broader themes enabled larger projects such as in the following example: '*The project colorful chemistry, during which we were introduced to paints, painting (arts), dyeing glass and fabrics, photography …* '
- *Art integration through an artefact* – category was based on artefacts that had both scientific and artistic characteristics and could in this way illustrate a connection between art and science. These artefacts could be machines, objects or works of art and could be either perceived or discussed in lessons or outside school in museums or in the environment. Here especially paintings stood out as objects that were simultaneously art and could illustrate geometry or beautiful (scientific) phenomena in nature and could enable discussing the science involved in investigating paintings. For example, 'Paintings about the bridge of a moon in a Light-discipline' and 'Plato's objects' and 'Leonardo Da Vinci's incredible machines' were categorised as integration through an artefact.
- *Art integration with a direct link* – category elaborates which two concepts, ideas or domains between art and science are connected. No wider theme or concrete artefact was required to mediate integration. These links could then be more specific such as connecting Fibonazzi's series to golden ratio or more vague such as music and wave physics. There was some overlap with the integration through a theme category as in some cases that stated a link between two domains; the other domain could also be understood as a theme from the perspective of science education. For example, 'music and sound discipline' (a course in Finnish physics education) was categorised as a direct connection, because music is a core domain within art, not a theme like sound would have been. Also, 'redox-reactions are connected to etching in graphics' was categorised as having a direct link.

4.4. Inter-rater agreement

The final coding of all the material used the category system described above. Two inter-raters participated in the verification of the final coding to add to the reliability of the results (Mayring, 2014). The final inter-rater agreement after discussion was substantial as indicated by Cohen's Kappa coefficient of .946.

5. Results

5.1. Extent of arts integration

Science teachers reported infrequent participation in arts integration (Table 2). Little more than one-fourth of the teachers organised science and art integration in smaller units during classes, or in larger units such as projects or courses on art integration. Approximately half (53%) of the science teachers experienced that the atmosphere in the school supported art integration.

Experiences about possibilities in art integration divided opinions in a similar manner as science teachers reported that they do not have time (45%) or enough knowledge (52%) to integrate arts. Majority of the science teachers agreed that they would like to have more material on art integration (73%).

The following section of the survey mapped the frequencies of using art for the purposes of science teaching (Table 3). The general trend in the results was the fact that those who included art in their teaching were the minority in all categories. First three questions mapped the presence of art in general. The frequencies of use of art pieces or practices as context where science could be taught or as points for discussion in classroom were dominated by those who never pursued this type of integration. The rest of the questions were related to frequencies of different forms of art. Drawing and painting were the most frequent art practices as 12% of the teachers reported that this was used even more than 1–2 times per course. In comparison, literature, drama and digital art yielded 0–2% for frequent users. The majority of teachers reported that they never included art in the ways suggested in the questions. For example, 70% of teachers reported that they never used literature as a part of science teaching.

5.2. Nature of arts integration practices

Science teachers' examples of art integration fall into six categories (Table 4) with two main categories based on activities and content. Each category demonstrated different aspects of making connections across science and art. The six categories could explain the majority of sample. Furthermore, it was found informative that only one example stated collaboration

Table 2. Science teachers' participation in science and art integration.

Questions (options to answer were yes/no)	%/($N = 66$)
I organise science and art integration on my classes (alone or in cooperation with others)	28
I organise (or participate in organising) courses or activities which integrate science and art	27
The atmosphere in our school encourages integrating art and science	53
I do not have enough time to organise integration of science and art	45
I do not know enough to organise integration of science and art	52
I would like to have more material to help me integrate science and art	73

Table 3. The frequency of integrating science and art.

How often do you employ the following in your classes? ($N = 66$)	Never (%)	Once a year (%)	1–2 times during a course (%)	More frequently (%)
Works of art as context	36	35	20	6
Methods of art as a context	42	27	20	8
Talking about the connection between art and science	39	35	15	8
Talking about art and science in a bigger picture (e.g. a phenomenon)	59	21	11	5
Creating projects that include art	56	24	12	5
Fine art activities (e.g. drawing, painting)	36	27	18	12
Drama activities (e.g. bodily exercise or a performance)	47	32	17	2
Digital art or video activities (digital narratives, producing videos)	52	27	18	0
Literature activities (writing poetry or creative writing)	70	20	6	2

Table 4. The frequency of categories of accepted art integration examples.

Label	Number of cases ($N = 65$)	Frequency (%)
Activity of science	9	14
Activity of art	18	27
Activity for both	13	20
Content through a theme	4	6
Content through an artefact	12	18
Content with a direct connection	9	14

with an art teacher and there was only one example of art integration that implicitly enabled a way to explore students' affective dispositions by requesting students to write an essay or draw something about a topic: 'mathematics in my life'. Emotions or feelings were not explicitly brought up in any of the examples of art integration.

6. Conclusions

The quantitative mapping of art integration suggests that teachers use various forms of art in science lessons, but art integration is infrequent. The Fine arts stood out as being more frequent than others. This was clarified by the examples of art integration, where drawings were used to illustrate concepts of science and that paintings could easily illustrate ideas of mathematics and sciences. Here, it should be noted that although teachers often suggested drawing graphs or molecules as art integration, drawing is an established practice in science education and can hardly be said to be art integration unless it has other qualities that characterise art such as imagination, expressing important ideas and feelings or aesthetics. The infrequency might be partially explained by the lack of time, knowledge and materials a teacher reported in relation to art integration.

The category system that emerged from the data creates a pedagogical model for art integration in science teaching. The two main ways to connect art and science are based on content and activities (Figure 1). These approaches are sometimes intertwined and sometimes used separately or subsequently during science lessons.

In *activities integration,* the experience of doing something is emphasised. Teachers engage students with drawing, analysing, etc. to provide an experience that helps the students to connect art and science. The activities can be roughly divided into science-based,

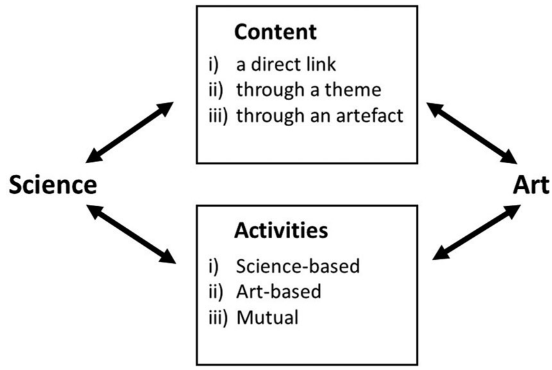

Figure 1. The framework for art integration in science teaching.

art-based or mutual. In principle, teachers use the activity from one domain, where something is done on the concepts, ideas or objects from the other domain to make a connection between disciplines. In the case of science-based activity such as calculating the volume of a statue, the purpose of the activity appears to be transfer as it is all about applying science to the context of art (Dori & Sasson, 2013). On the other hand, in art-based activities that target science content, e.g. chemical reactions, the objective of the experience is unlikely to be the transfer of art skills, because these are examples of science lessons. The objective is more likely to be a positive emotional outcome. However, research is needed to understand the objectives behind these activities.

The mutual activities were not bound by disciplinary-specific content. The advantage of these activities is then that they enable learning that is not bound to disciplinary content but allows it, when necessary. This suggests that these mutual activities are used to develop thinking skills, which can be useful in various contexts. One has to keep in mind that the transferability of these skills is dependent on the support of transfer and the need for support increases if the distance between disciplines increases (Dori & Sasson, 2013). Nevertheless, if the need for support is adequately considered, these mutual activities are prospective for developing generic transferable skills.

Content integration emphasises the constructing knowledge by elaborating how ideas and concepts between the two disciplines are connected. This can be understood as a process of knowledge integration (Linn et al., 2004), implying that an integrated core (Shen et al., 2015) can be established from the connections. Content integration was found to be related to themes, artefacts and direct links related to colours, light, sound, patterns and geometry. One possible perspective that unifies this integrated core is perceiving and understanding something that is subjectively beautiful and therefore connects to aesthetics (Shimamura & Palmer, 2012). Furthermore, illustrating how the content of art and science is linked could in itself convey a feeling of wholeness for students and therefore provides an aesthetic experience (Pugh & Girod, 2007). Therefore, aesthetic themes are found to be an important piece of integrated core between art and science. In future designs, this integrated core should be negotiated between a more diverse group that includes art specialists and/or teachers. According to Shen et al. (2015), the negotiation process itself is valuable, because it develops a deep understanding of the integrated common core and supports transferring it into different disciplinary contexts.

In teaching practice, content and activities are intertwined. Activities can provide observations or sensations that enable reflection and abstract thinking that lead to content integration similar to the experiential learning cycle (Kolb & Kolb, 2012). Whilst integrating art and science only through activities or only through content teachers operate with less components and integration might be easier. However, more consistent and, therefore possibly more aesthetic (Pugh & Girod, 2007), learning experiences could be enabled by intertwining these approaches.

The observed infrequency of art integration has implications for in-service and pre-service teacher education that align with implications reported in other studies. Russell and Zembylas (2007) report that sufficient training in using integrated approaches is needed in order to enable meaningful experiences with art integration for both teachers and students. This study can contribute to relevancy of art integration training for the teacher by pointing out the viability of some ways of art integration: the findings of this study imply that mutual activities, such as inquiry and visualisation, and integrated core based on aesthetic themes are ways that science teacher have used to connect art and science. The framework created in this study elaborates the many possibilities of connecting activities and content, and can guide consistent designs of novel and development of the previous cases of art and science integration in the future. However, when designing teacher education for art and science integration one should lean to previous research to see which specific combinations of science topics and art forms have been suggested to work. For example, when learning about how science and society interact, one could draw from drama (Ødegaard, 2003). Furthermore, Bequette and Bequette (2012) suggest that meaningful integration ensues when artist and scientist sit around the same table. This could be promoted within teacher education e.g. by organising workshops that highlight the viability of art and science integration for both art and science teachers. In addition, the study implies that ability to express emotions through art integration is not adequately utilised by the science teachers. Sinatra et al. (2014) suggest that teacher education should provide activities that enable critical evaluation and reflection on students' and teachers' emotions especially when addressing emotions related to controversial topics. Indeed, it seems that teacher education for art integration should address the role of emotions in more explicit way instead of expecting that reflection emerges naturally.

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