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SCIENCE INTEGRATED WITH AESTHETIC EXPRESSIONS FOR BETTER UNDERSTANDING OF SCIENCE SUBJECT MATTER

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Teachers have to create a variation of learning situations to increase the understanding for theories and abstract models in science. We have experiences of combining aesthetic expression with science in pre-service teacher programme for more than ten years and have seen the benefits of embodying abstract theories with dance, art, music or drama and better understanding of science subject matter. The integration of science and aesthetic forms of expressions have support in the Swedish curriculum both for preschool and the compulsory school and it is therefore important to include exercises using aesthetic expression in the teacher education program. The purpose of the workshop was to give examples of how art can be used to study phenomena in science. The workshop was divided into three parts. In the first part the participants were doing different exercises embodying concepts in physics and creating relations with each other. In the second part the participants in groups constructed a kinetic mobile. In the third part, the participants reflected and discussed their experience and understanding of phenomena during the workshop. Examples of assessments of the construction process were presented. Here we also present the planning and theoretical background to the work with aesthetic expression of science.

Keywords: aesthetic expression, integrating art with science, learning outcome

INTRODUCTION

Every student is unique as well as every learning experience is particular in its own way and therefore is conducive to a joint future where our common agreements affect our habitual experience of the world. Martha Graham, innovator of modern contemporary dance expressed the concept of uniqueness and the ability to partake actively (Halprin, 2003);

There is vitality, a life force, an energy, a quickening, that is translated through you into action and because there is only one of you in all time, this expression is unique.

And if you block it, it will never exist through any other medium, and will be lost.

As a teacher it is crucial to have the opportunity to create a variation of learning situations in order to deepen, broaden and crystalize the understanding especially addressing complex phenomena and abstract concepts together with models and theories.

John Dewey pointed out the importance of achieving experience in order to acquire knowledge, a sort of “experience through learning” (Pugh & Girod, 2007) which can be understood as an embodied integrated knowledge received through active participation. In Canada *Learning through the arts* was created as a national educational program (Smithrim & Upitis, 2005). This program showed an evident increase both in student engagement in other subjects than art as well as a higher level of motivation in learning. Visual and

performing arts called *Arts-Infused Learning* has been found to be important for different subjects, besides art in school such as language, math, science, and history/social studies courses (Lorimer, 2011). It was shown that using art in order to understand complex phenomena in science increased student's concentration of the exercise as well as their understanding (Lorimer, 2011). It was also noted that *Arts-Infused Learning* encouraged intercultural collaborations and trans-disciplinary understanding. Music has also been described to successfully integrate other subject where young children in preschool could better understand the meaning of different concepts (Economidou Stavrou, et al., 2011). Education of artists together with pre-service teachers in teacher education also showed the advantages of integrating different professional disciplines as well as different disciplines in art together with the subject matters. These types of student collaboration increased their enthusiasm about teaching and it broaden their perspective on learning in and outside the classroom (Ketovuori, 2011).

SUPPORT IN CURRICULUM

In Sweden students in pre-school and compulsory should learn to express their knowledge in using art. In the curriculum of Swedish preschool this is expressed as

The work team should give children the opportunity to develop their ability to communicate, document and describe their impressions, experiences, ideas and thinking processes by means of words, concrete materials and pictures, as well as aesthetic and other forms of expression (Skolverket a, 2011, p. 11)

Further, in the aims of the subject biology, physic and chemistry in the curriculum for compulsory school:

Teaching should contribute to pupils developing the ability to discuss, interpret and produce texts and various forms of aesthetic expressions with scientific content (Skolverket b, 2011, pp. 105, 120, 135).

Therefore, it is important to include this type of activity as well as knowledge of the art itself to be able to use these tools to create a diversity of learning situations. This skill described in the Reporting Guidelines for

International Teaching Placement for professional development of teachers used during placement express:

Commands and uses various communicative abilities (for example, body language, drama, music, pictures).

EXPERIENCES FROM TEACHER EDUCATION

At Södertörn University the science teachers have worked together with artists in teacher education during the last 15 years with the purpose to create an education from a more diverse intercultural perspective. Disciplines of Art such as dance, art, drama and music have been used, e.g., to visualize hydrogen bonds between water molecules by dancing, forces and balance in producing kinetic mobiles, details of biological material by drawing, drama exercises showing the pump of blood and digestion and singing songs about the cycle of water creating clouds and rain. In 2011 Södertörn University teacher education hired a group of artists in order to teach what was now mentioned as Aesthetic Learning Processes. Examples of aesthetic expressions in 2- and 3-dimensions in a science course for pre-service preschool teacher is shown in figure 1. During the aesthetic exercise students recalled the content of the science course with examples like frictions from shoe soles on ice, insulation of a snow and the effect of gravity on a door hinge. They then created a world where night and day, planet system, seasons or the phases of moon also should be included (fig. 1). After the course, two years later, the students were evaluating the course by answering questions like:

Describe how Aesthetic learning processes have supported and/ or enhanced your understanding of different phenomenon, concepts and abstract models?

Here are a few randomly picked answers:

“Through talking around the concepts and making a conclusion at the end of the session”.

“Through giving knowledge a different and new dimension”.

“Through the process and creative thinking outside the box during the art-making process I have gained a deeper understanding.”



Figure 1. Closing of workshop with artefacts created by pre-service preschool teacher students

“Go beyond the theories, express my thoughts not only through written text. I have learned to share my thoughts and to be openminded toward others”

“Aesthetic learning processes have supported to transfer our theoretical knowledge into practical action”

“I have understood the meaning of different concepts especially the difficult one. Practicing practical exercises that reveal what we are reading have developed my understanding of different areas. And learning each other's learning ”

THEORETICAL BACKGROUND TO THE STRUCTURE OF THE WORKSHOP

Intermodal theory – modalities of imagination

Joseph Beuys argued that “Everyone is an artist” and we all strive for coherence, connection and *Beauty* as we struggle to construct meaning, direction and shape our lives, in our habitual world experience. *Beauty* as the term is used in the understanding and the implementation of *Intermodal theory* refers to a distinct response to an artistic act and/or an artwork that stirs us and which we associate with *Beauty* (Knill, 2003). The response has a bodily origin, which sometimes describes as ‘moving’, ‘touching’ or ‘breath-taking’. Most languages suggest this sensory effect even if we do not always experience the effect literally. The notion of *Beauty* is closely linked to the phenomenon when a ‘quite-right’ image emerges as a felt sense, an image that matches and resonates with the psychic condition of the individual person or group working together on the shaping and constructing of knowledge inherent in the subject matter. This is followed by a shift in awareness often experienced and described as a sharpened understanding and change in the notion of time and the conception of the learning process. This shift is often linked to a shared ‘aha’ -moment or experience. The phenomenon occurs whether the experience of *Beauty* is intensely joyful and pleasurable or is characterised by pain,

confusion and perplexity (Knill, et al., 2005). The contrary quality to an embodied *Aesthetic response* (fig. 2 left) would not be the idea of ugliness but rather dullness and an apathetical inability to respond (Knill, 2003).

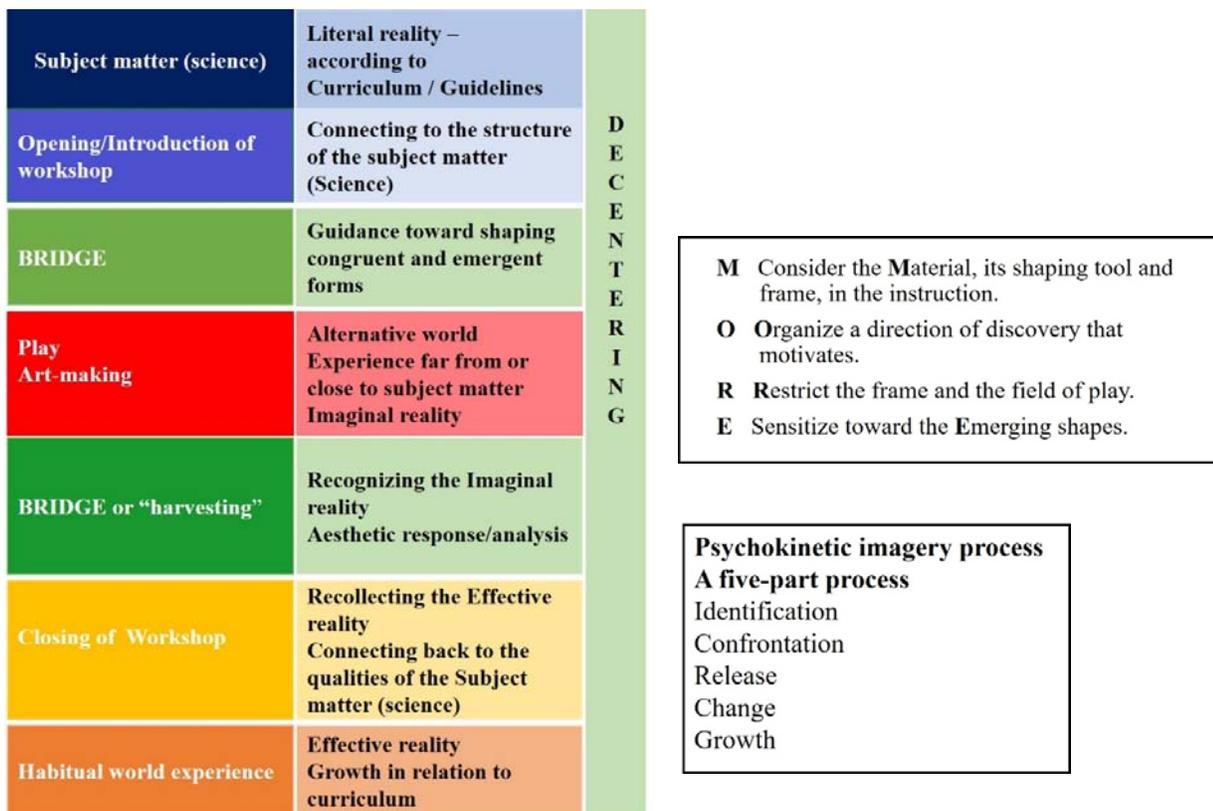


Figure 2. A structural didactic map of Aesthetic Learning Process (ELP) to the left, MORE – guidelines of intermodal work process (Knill, et al., 2005) upper right and Intermodal arts model (Halprin, 2003) lower right.

We sometimes have a preconceived notion that very well may situate us in the narrow manner of thinking and acting that marks the helplessness around a ‘dead-end’ situation. This position may originate from both imaginary and/or actual external factors such as the number of students, the timetables, the surroundings, social- and economic conditions, various disciplines and subject matter and the ability to reach the goals and quality of the curriculum. Focusing on the problematic situation has a tendency to produce more of the same and tends to worsen the situation. On the other hand, a *Decentering* induced attitude (fig. 2 left) and approach moves away from the fixed position offering a variety of possible and unexpected solutions. *Decentering* is used in order to slow down, find balance, stability and flow. In order to leave the time-sequence of literal reality controlled by a linear game-structure to a circularity movement of improvisation and play full of coincidences and synchronicity. The phenomenon of play is experienced in the ‘doing as if’ and in the here-and-now connected to all *Alternative world experience* (fig. 2 left). This phase is always framed by an entrance and an exit. The characteristics of all the ‘in and outs’ of the *Alternative world experience* are at the same time aspects of *Decentering* and contributes to the *Range of play*, the area of unconstructed movement of body, feelings and thoughts. Whereas creativity is often explained as an ability that allows people to discover a new solution to an old problem, *Art-making* is a multitude of perspectives, which alters into new knowledge. When provided with *Range of play* (fig. 2 left) the situational restrictions experienced by preconceived, stereotyped and normative thinking are contrasted.

However, restriction in the field of play is essential and may lead to further discovery and depth of subject matter. Restriction in for example constriction of material or time together with distinct and direct guidance providing directions of exploration in order to sensitise towards what is being experienced makes for a deeper understanding (Knill, et al., 2005).

Various theories of *Imagination* explain that imagination is not totally controllable; it is predictable only in its unpredictability. We can distinguish three realms of imagination: the dream space – (phantasy), the daydream and the artistic activity/play. The artistic activity combines the dream space and the daydream as the force of longing, which belongs to imagination as it yearns for the moment to manifest itself in the real world. The difference between imagination and phantasy is the embodiment of materiality with the former and the immaterial quality of the later (Levine, 1992).

The artistic activity is always a shared experience, in between group members, within a community and/ or individual, the tools and the materiality of the *Emerging shape*. The sharing happens not only through verbal description and communication but also through multiple sensory modalities (Knill, 2003).

Any art discipline, because of its connection with imagination, can evoke and find further expression in any other modality of imagination. Among all art disciplines we find a variety of sensory channels and imagination modalities. For example, within the visual arts the sensorimotor and tactile senses are engaged when we paint and a painting communicates not only through the visual image, but also through other imagination modalities. A painting may evoke a rhythm and a sound from which a story appears that depicts an act and a dance unfolds. In a similar way a poem can evoke sounds and movement (Knill, et al., 2005).

To educate in an integrated way one therefore must allow a synthesis that sharpens the sensory modalities seeing that the human instinct is multisensory.

Aesthetic Learning Process

An Aesthetic Learning Process based on *Intermodal Theory* (fig. 2) always consists of a five-part process. At the ESREA- conference 2017 our workshop was designed with the conference in mind and therefore with a focus on the middle parts of an intermodal Arts model process. The framework was the setting of the conference itself using the pre-understanding and predisposition of the participants as an agreement of shared literal reality (Knill, 2003; Halprin, 2003). This was the ethical starting point for the workshop at ESERA.

An Intermodal Expressive Arts five-parts process

The first part (identification) begins with an opening of the workshop by introducing the theme or subject matter, connecting these to the framework, in which the distribution of time is included and *Literal reality* (fig. 2 left), which can be described as a static and limited yet a familiar situation and cognizance (Knill, et al., 2005).

The second part (confrontation) is the BRIDGE. This phase is where the guiding and sensitising toward the qualities and characteristics to the theme and/ or subject matter happens. This approximation is done in an organized, clear and distinct direction of discovery using corporeal expression as a medium on the path to a broader and deeper awareness and adding layer on layer. The responsiveness and perception is thoroughly investigated both individually and together with others. It is equal important for the participants to start to discover one another as well as the subject matter or /and theme. It is also during this part where the *Range of play* must establish a good enough spatial room for movement of body, feelings and thoughts (fig. 2).

The third part (release) consists of the *Alternative world experience*. This phase cannot start until the *Range of play* is sufficient in scope, depth and balance. The phase of *Art making* and *Play* is ready to begin provided

that an agreement has been reached in regard to the materials, tools, oneself and the other participants. Then the Art making takes place - shaping the emerging forms. When the shaping act is followed by a shift in awareness often experienced and described as a sharpened understanding and change in the notion of time and conception of the learning process. The *Imaginal reality* (fig. 2 left) is an active part of the driving force in both receiving and welcoming of the emergent form.

The fourth part (change) is the BRIDGE again, but in this phase the crossing is from the *Alternative world experience* and *Art making*. In this step it is crucial to recognize and create awareness of the *Imaginal reality* and its motivation to co-exist. A good way of reaching a level of understanding is the *Aesthetic response* and *analysis*, which are both significant parts of *Harvesting* (fig. 2 left).

The fifth part (growth) is recollecting the *Effective reality*, connecting back to the beginning evaluating and reflecting over the process from the first step to the last. (Knill, et al., 2005).

An *intermodal arts model* is used during and within every sequential step as the *Aesthetic learning process* moves through the five part-work processes, looping, descending and ascending in-between and between the three levels of awareness and response, *the Mental level, the Physical level and the Emotional level* (Halprin, 2003). The three levels are equivalent significant components in the driving force behind this sometimes astute and exhaustive faculty that grasps, perceives, differentiates, distinguishes, integrates and conceptualizes the complexity of forms and patterns throughout and within the entire work process of *Aesthetic Learning* (Halprin, 2003) (fig 3).

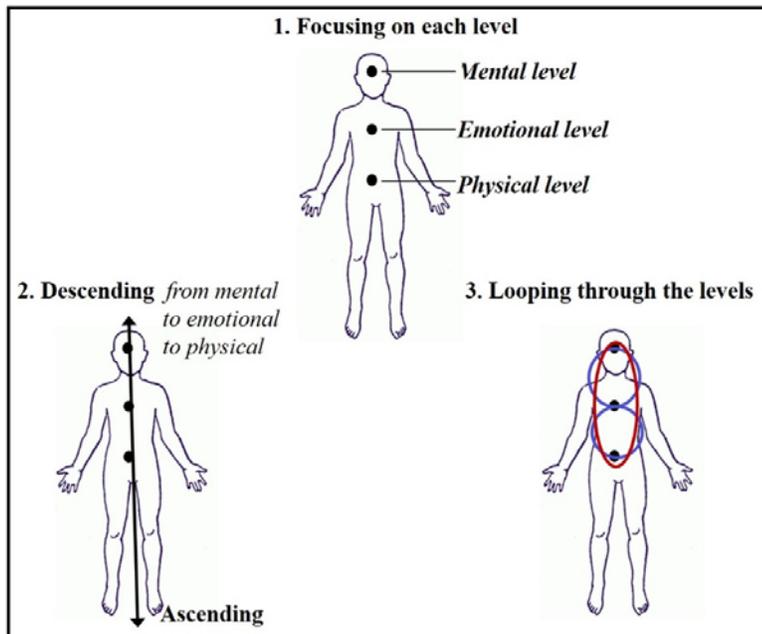


Figure 3. Three levels of awareness and response (Halprin, 2003).

WORKSHOP

The workshop at ESERA -17 was directed by an art- and a science teacher and included examples of phenomena in science integrated with art performances in order to create deeper understanding through the construction of artefacts.

We constructed the workshop based on the setting of the conference as being a context of shared participation. We therefore incorporated the topic from one of the Conference Keynote speakers; the pivotal moment and we focused our work as a sort of play in three acts; the opening, the middle and the closing act. The mental image being a stroke out of a poem *Lifting Belly* by Gertrude Stein; “..a rose is a rose is a rose..” as a form of direction of discovery (fig. 2 upper right and fig. 3). The work was carried out in three main parts:

Part 1. Opening and introduction to the workshop followed by Bridging.

In the first part the participants were doing different exercises embodying concepts in physics and creating relations with each other. Exploring the *Range of play* – organically forming groups of four quartets.

Part 2. Art-making

In the second part the participants constructed a kinetic mobile in groups of four.

Part 3. Bridging and *Harvesting*.

In the third part, the participants reflected, discussed and analysed their experience and understanding of different phenomenon, which had been addressed during the work process.

Altogether, 16 persons from different countries participated in the workshop.

First part

In order to achieve experience of concepts in physics such as gravity, friction, density, equilibrium and forces by aesthetic expressions, the workshop started with the participants standing in a circle in the centre of the aula. The following steps were improvisational work on the floor. Movements were done to feel gravity and to find the equilibrium in their own bodies (fig. 4 left). The instruction was to focus their own awareness as they moved and felt the space and the concept of “sliding” and then imagine and ask themselves if “sliding” has the colour of white, black or more a greyish nuance in between the white and the black. The next step was to find the spot where they sensed and felt the colour of “sliding”. After finding the spot, the next step was to turn to the person, whom at the moment was physically closest to them and share what they had become aware of during the exercise. We then went on to explore other concept such as “heavy” and “light” in the similar manner. The participants told their impression of the concepts to the person next to them and finally to all members of the group. Examples of descriptions were: “black, it is fast in the dark when driving”, “white - all colours together when it spins quickly”.

The next instruction was to collect a piece of large white cotton sheet, a black crayon, a white crayon and a white panel with canvas structure. They were told to find and prepare a drawing area in somewhere in the aula - a place that made them comfortable enough. The following step was sensitizing towards the materials as well as to the surroundings by taken the white crayon in one hand and the black crayon in the opposite hand. Letting the crayons transform into dancers and themselves into world-renowned choreographers famous for creating choreographies representing different pivotal-moments. (This connects the work in progress to the outer framework of the conference and particularly to the topic raised by one of the Keynote speaker). They were then told to breathe and let the body, arms and torso get heavy as they opened their listening (ears) while they were instructed to close their eyes and let the dancers start dancing using the white square panel with structured canvas surface. The group members were instructed to share with another member of the group and then come together in the respective quartets observing and comparing their dance drawings within finding connections and similarities between their respective “blueprints” of the various choreographies (fig. 4 right). The blueprints of the dance were then used in opening up the second part of the workshop, the *Art-making* and construction of the quartet’s kinetic mobile.



Figure 4. Participants expressing different concepts in physics using their body (left) and crayons and panel.

Second part

The participants in groups of four used their blueprints to build a kinetic mobile. The instructions were to construct the mobile in at least two levels with two wooden sticks using the material presented on a table (fig. 5.) All material was carefully planned to have different physical properties for example material with different elasticity such as rubber bands and to awake imagination. The mobile should also contain hanging things. The instruction was also that each person should think what the mobile tells them and the group was supposed to give it a name (fig. 6). This phase of *Alternative world experience* often draws group members closer to one another creating and bonding with a closeness in the relationships emerging during this phase. The relationships emerging are several, in between group members, in between the subject matter and the physical artefact leaving preconceived notions aside. The last step of in the *Art-making* and an *Alternative world experience* is *Aesthetic response*, the reflections were first done individually and then in small groups.



Figure 5. Material presented on a table.

Third part

We reconnected and reflected upon to the second and first part through *Aesthetic analysis* over the shared and achieved experience, recollecting the *Effective reality*, the learning and the altering of perspective and new insights that has taken place during the one-and-a-half-hour Workshop.



Figure 6. Example of kinetic mobiles constructed in the workshop.

Comments from participants:

Amazing that we created something from our mind.

Art is linked in the same way as curiosity in science.

Warming up is good to let go of the conference.

Needed several steps – not until we drew the dance – and I let go of the idea of doing right and wrong.

It takes a while before the thought comes.

I have never thought that I could create something like this along with people I do not know.

With such activities you can distinguish patterns.

It was an important and informative piece of the instructions about the hardness of the pen, 6B - I realized then that different hardness on pens can be investigated in chemistry and that the different grind of the canvas panel structure gives different results.

For the final evaluation of the exercises two questions were presented:

-What moment during the workshop awoke your curiosity or surprised /amazed you?

What new knowledge or experience will you bring with you?

“A surprise that came from the meanings that emerged.”

“The black and white sequence. Then my mind opened for your instructions. I think I needed some time to disconnect from the reality of the conference.”

“Bringing me an unexpected context. Not understanding the purpose, I opened up, it wakened my inspiration – with reduced experience like that can wake up hidden ideas.”

“White movement above is invisible.”

“I started to be very curious when we had to find the good place on the line between the grey and the white colour. My body decided for me what was the best place for me”

“The necessity to find a dialogue between the authenticity (defined by our own body) and the truth (defined by the science).”

PERFORMANCE ASSESSMENT OF PRACTICAL EXERCISES

The Swedish curriculum in the subjects of science have changed from being centred on reproducing facts to performance of skills when students should show their ability to use their knowledge in a context. One example is from the curriculum knowledge requirement in physics for grade E (passable) year 9 (Skolverket b, 2011, p. 127):

- Pupils can compare results with their questions and draw simple conclusions with some connection to the models and theories of physics. Pupils apply simple reasoning about the plausibility of their results and contribute to making proposals on how the studies can be improved.
- Pupils have basic knowledge of energy, matter, the structure and development of the universe and other physics contexts and show this by giving examples and describing these with some use of the concepts, models and theories of physics. Pupils can apply simple and to some extent informed reasoning where phenomena in daily life and society are linked together with forces, movement, leverage, light, sound and electricity, and show easily identifiable relationships in physics.

The teachers must create different learning situation to train these skills and to make it possible to assess performances. One possibility to assess practical exercises is to use an assessment rubric, here created from the knowledge requirements in physics in the Swedish curriculum for compulsory school and student’s examples (Skolverket b, 2011). Such rubric is also useful during exercises integrating science subject matter with aesthetic expression where knowledge can be visualised (Mutvei & Mattsson, 2013).

	Sufficient	Good	Better
Use of theory	The student draws simple conclusions partly related to models and theories in physics. <i>(Gravity is the force that pull the weights down)</i>	The student draws conclusions based on models and eories in physics. <i>(Moving the string along the stick will move the equilibrium.)</i>	The student draws well founded conclusions out of models and theories in physics. <i>(The heavy weight on the short arm will balance the longer stick with the light weight like a lever.)</i>
Improvement of the experiment	The student discusses the observations and contributes with suggestions of improvements. <i>(If one put a heavier weight on one side it will compensate for the short arm.)</i>	The student discusses different interpretations of the observations and suggests improvements. <i>(The mobile is not hanging straight. It might be due to that one should take away the weight or move the string to get balance.)</i>	The student discusses well founded interpretations of the observations, if they are reasonable, and suggests based on these improvements which allow inquiries of new questions. <i>(The string stick due to friction and it is difficult to let it slide. We should look for other material that has lower friction)</i>

Explanations	The student gives simple and relatively well founded explanations. (<i>You need less force when you use a screwdriver if you hold it in the handle furthest away.</i>)	The student gives developed and well founded explanations. (<i>You will not need so much force when you cut the hedge if you use the hedge cutter with the longest handles.</i>)	The student presents theoretically developed and well founded explanations. (<i>You can move a heavy stone if you use a skewer with a long handle. The pivot point will be close to the stone having a short distance.</i>)
Relate	The student gives examples of similar processes as in the exercise related to questions about physical phenomena (<i>When I walk with my shoes on ice I have low friction. This is like when we measured how much force we needed to pull a box on different surfaces.</i>)	The student generalizes and describes the occurrence of similar phenomena in everyday life as in the exercise (<i>Design of mobile cases and shoe soles has to do with the need to create materials that have low or high friction.</i>)	The student discusses the occurrence of the phenomena observed in everyday life and the use of it and its impact on environment, health and society. (<i>It is important to use tires with structure on your car in winter to get higher friction otherwise you might have an accident.</i>)

By formation of a rubric for performance assessment with possible student answers provide opportunities for the teacher to participate in practical exercises in physics integrated with aesthetic expression. The teacher can investigate the knowledge of the students by listening to their discussions and how they solve problems while creating artefacts. The assessment rubric is a valuable tool for the teacher to evaluate their teaching and to give students more precise feedback (Mutvei & Mattsson, 2013).

SUMMARY

The participants of the workshop performed designed practical aesthetic activities as examples on how to reach a deeper, wider level of scientific understanding with several perspectives and layers of experience and knowledge. The workshop also gave examples of how to plan, implement and assess outcome of aesthetic learning activities in order to promote the development of the students' science knowledge content.

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