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POINT OF VIEW

Arts in science education[1]

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Abstract: Combining the arts and standard curricula together can create a richer and more lasting learning experience for students who believe that learning science is boring in classes. It is suggested that study of the arts should be accepted as an essential part of achieving success in work. To this end, the most important action will be coordinating efforts of scholars from various areas to allow arts education for science students to become an evidence-based field. It is our contention that while the sciences seek to find answers to the most fundamental questions about our physical world, we need to find a place for the arts within the curriculum and within the process of scientific investigation. The arts should be applied in science education in a manner that considers the culture of each community. Those who are actively engaged in arts should be able to better manage their scientific projects and be able to better communicate and think. The main goal of arts in science education is to give students the opportunity to express their thoughts and feelings in the context of their different cultures and also to understand science through the lens of their creative activity in arts.

Key words: arts, science, creative, education, culture.

Résumé : Combiner les arts et le programme scolaire standard peut créer une expérience plus riche et plus durable pour les étudiants qui croient que l'étude des sciences en classe est ennuyante. Nous suggérons que l'étude des arts devrait être acceptée comme une partie essentielle de la réussite. À cette fin l'action la plus importante sera de coordonner les efforts des intellectuels de différents domaines pour permettre aux étudiants en sciences d'avoir une formation en arts. Nous sommes convaincus, alors que les sciences recherchent des réponses aux questions les plus fondamentales concernant notre monde physique, que nous devons trouver une place pour les arts dans leur programme et dans le processus de recherche scientifique. Les arts introduits dans le programme scientifique devraient refléter la culture de la communauté. Nous pensons que les scientifiques s'impliquant activement en arts, devraient être mieux capables de gérer leurs projets scientifiques et de mieux les communiquer. Le but principal des arts dans l'éducation scientifique est de donner aux étudiants l'opportunité d'exprimer leurs pensées et leurs sentiments dans le contexte de leurs différentes cultures via la lentille de leur activité créatrice en arts. [Traduit par la Rédaction]

Mots-clés : arts, science, créatif, éducation, culture.

1. Introduction

One of the most important aims of education is to develop more knowledge, skill, and ability. Students of the 21st century are very different from the students of the past. This requires educators to think continuously about how to change their teaching to empower and engage modern students, which makes educational innovation important. Research [1] has shown that what students learn in the arts may help them to master other subjects, such as reading, math or social studies. Students who participate in arts learning experiences often improve their achievement in other realms of learning and life. For example, an analysis [1] of multiple studies confirms the finding that students who take music classes in high school are more likely to score higher on standardized mathematics tests. One explanation is that musical training in rhythm emphasizes proportion, patterns, and ratios expressed as mathematical relations. The arts nurture a motivation to learn by emphasizing active engagement, disciplined and sustained attention, persistence, and risk taking, among other competencies [1].

The arts are a great learning tool for students to increase their motivation according to their interests and abilities. Art also provides diverse opportunities for communication and expression. Our question is how exactly teachers can fit the arts into science education by considering the culture.

2. Understanding science through the creative process in the arts

Psychologists have shown that toys are crucial for the development of such high-level skills as decision-making, socialization, and creativity [2]. A toy such as the Tippe Top was a physics puzzle that fascinated at least two Nobel Laureates: Niels Bohr, who helped figure out the structure of the atom, and Wolfgang Pauli, best known for the Pauli exclusion principle, both famously studied the Tippe Top to figure out what made it flip itself. Although the physics behind it is very complicated, designing Tippe Tops in several colors and forms can help to explain the composition of colors, symmetrical or asymmetrical motions, and moments of inertia [2].

How can this toy be used in science education, and what is the role of art? We can ask students to build several types of Tippe Top to investigate the parameters affecting its turning, or to explore the mixture of colors. They also can build a magnetic Tippe Top to check out new styles of spinning tops and also compare those that

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Fig. 1. Borujerdi ha House in central Iran. [Colour online.]

are a little unusual. In all of these experiments the main part is the art of building the Tippe Top to help students to find the science behind it.

A new way to investigate simple periodic motion, such as that of a pendulum, as well as chaotic motion, is to ask students to build their own dolls with arms and legs attached to a rotating connector. The dolls can be built of paper, nanomagnets or any other materials. To investigate the parameters in this motion it is necessary to make the dolls in different shapes. Because students think differently, all these toys will help them to show their individuality in solving problems with their creativity in arts.

3. Scientists and creative arts

In earlier times, in the absence of technology, "nature" was the laboratory of scientists like Plato, Aristotle, Michelangelo, and da Vinci. The study and observation of the world around them, often referred to as "nature", or "the natural world," was their source of inspiration, truth, and wisdom. Using this laboratory, Plato and Aristotle laid the foundations for much of modern physics and mathematics, as well as more "artistic fields," such as esthetics, ethics, and political science. da Vinci was a painter and sculptor, but was also an engineer, inventor, and anatomist. Michelangelo was also a painter and sculptor, as well as a poet, but also an engineer, anatomist, and architect [3].

Niels Bohr was struggling to reimagine the structure of matter. By analyzing the radiation emitted by electrons, Bohr realized that science needed a new metaphor [4]. As Bohr said, "When it comes to atoms, language can be used only as in poetry". Bohr's discerning conviction was that the invisible world of the electron was essentially a cubist world. What Bohr maintained was that the form they took depended on how you looked at them. Electrons weren't like little planets at all. Instead, they were like one of Picasso's deconstructed guitars, a blur of brushstrokes that only made sense once you stared at it. So the art that looked so strange was actually telling the truth.

Having pieces that are connected to each other occurs in an example in which Calder's composition artistically shows the physiology of the cells of an area that are selectively responsive to motion and its direction. Viewed from a distance, the separate pieces of the mobile appear as static spots of varying sizes. But as the pieces move in different directions, each one stimulates only the category of cell that is selectively responsive to the direction in which the spot is moving [4].

4. Finding the nexus of arts and sciences in our everyday life

In our society, those who have been educated in different universities and different sciences cannot easily communicate with each other on their subject, and the schism between the sciences and the arts is the main reason. Climate change and its effects have severe consequences for our environment, so reducing energy use in buildings is one of the most important ways to reduce humans' overall environmental impact. There are several elements to the design of buildings, and architects should consider the use of more sustainable materials. By considering several parameters, such as weather and culture, an analysis of every step in the construction of a building, from the paints used on the walls to the type of ventilation system, give a clearer picture of how architects can design the best building.

Our ancestors, by studying the environment, identified the principles of geometry, the physics of forces, and its mechanisms to build their buildings using their creativity. Many centuries ago, they succeeded in building examples of the most splendid buildings and innovative architecture.

- Borujerdi ha House in central Iran (built in 1857) is an excellent example of ancient Persian desert architecture with a windcatcher that functions as a solar chimney (Fig. 1).
- The bath of Sheikh Bahai and Menar Jonban in Isfahan. In the former the water temperature was kept steady for over 250 years by a small candle burning below the water reservoir [5] and the latter (built in the 14th century) had special features so that if either of the minarets is shaken, the other minaret will vibrate as well (resonance).
- Choga Zanbil Temple is a Zigorat with a height of 62 m and a length of 105.20 m for each side of the first floor. Even after 3000 years it is in good condition. The architecture of ancient Iran provided it with a portable water treatment system. The water was brought to the system through a network of canals constructed on scientific principles. Then, by passing the water through various layers of sand, gravel, and coal, and a certain percent of salt and lime as bactericides, the treated water was transmitted to smaller basins through nine narrower canals from under the main reservoir (vessels law principle, as when the liquid settles, it balances out to the same level in all of the communicating vessels regardless of the shape and volume of the containers). This system was man's first system for water treatment [6].
- The Pasargad Palace in Shiraz, the oldest imperial capital city of the world (Fig. 2), is one of the most splendid buildings in the world. It has innovative architecture, and even after 2500 years the columned hall is amazing for its incredible height and the specific distance of the columns from each other [7].

It is interesting that in ancient times both art and science always were involved in architecture.

5. The arts help to understand scientific concepts

As Einstein noted: "The greatest scientists are artists as well" [8, p.245]. It is clear that artists enable people to visualize the sciences in different ways or to apply new ways of thinking. In scientific

Fig. 2. Pasargad in Shiraz. [Colour online.]

Fig. 3. Physics experiments by building the aparatus and taking a photo, doing experiments using their own aparatus, and interpreting the results (experiments in AYIMI tournaments). [Colour online.]

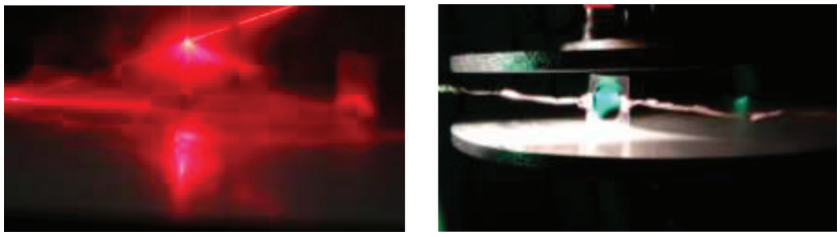
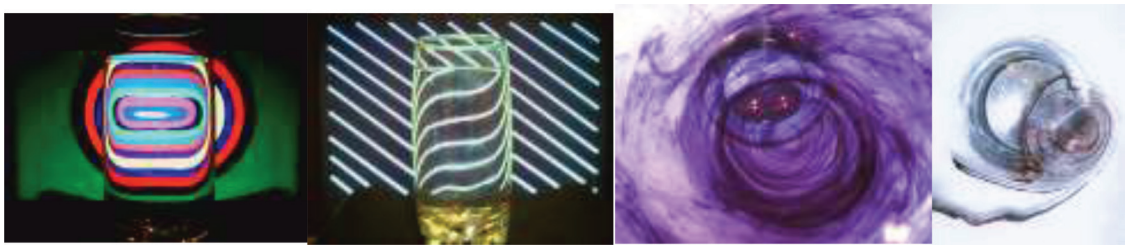


Fig. 4. Making real lens and circulation in water, in situ experiments combined with art. [Colour online.]



communities we can encourage students to solve problems by seeing connections between different scientific fields, and arts and culture (Fig. 3). For instance, in our physics education, students are asked to look carefully at nature and everything around them in their everyday life. Then by using art they can illustrate their observations and interpret their main ideas, or analyze real scientific problems using their own creative approaches. Students who found that learning physics was boring for them, now find the beauties of physics along with its complexities.

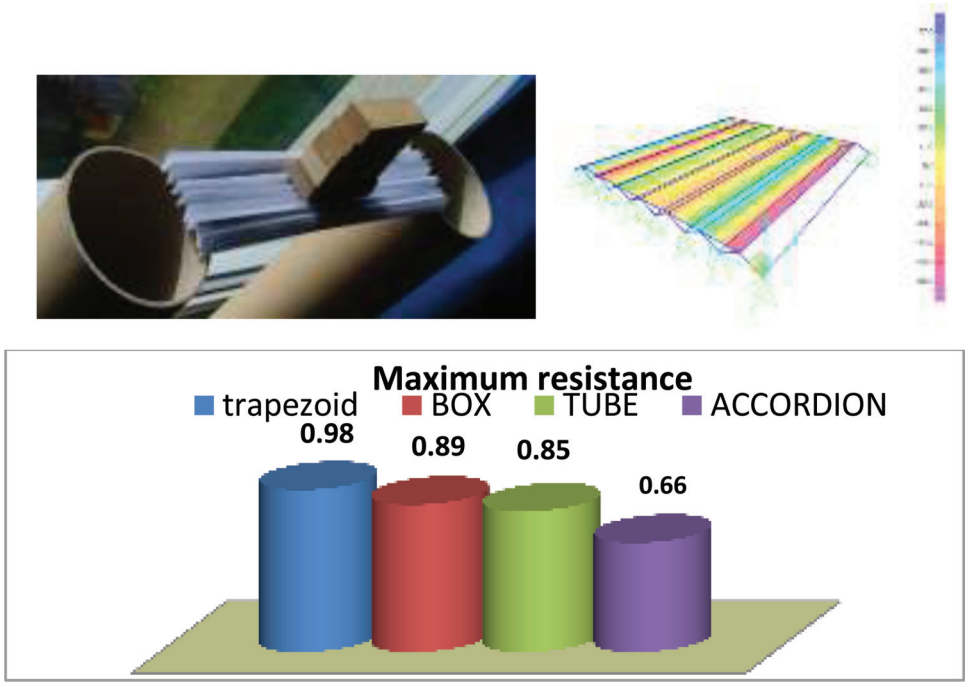
It is, however, very important to compare the arts in different cultures because we can discover how different instruments can be applied in solving the same problem. There are several local outreach programs in AYIMI to middle and high schools that expose all students to the wonders of different sciences using the arts. Arts in science education inspires students to look carefully, to think deeply, and to design a model, such as "Physics in Nature," which directs students to use art in science to get more capacity to create meaningful ideas.

6. How to guide students to learn science from their own creativity in art

To learn science using art requires collaboration between the teacher and students. This collaboration consists of two stages. In the first stage, the experienced teachers, who are asked to participate in scientific challenges with their students, are guided to hold inquiry workshops. These workshops focus on promoting

Fig. 5. Students describe a volcano eruption and explain how it changes the ocean's floor using their experiments. [Colour online.]

Fig. 6. Paper bridge experiment and data analysis (experiments in AYIMI tournaments). [Colour online.]



students' skills in solving problems while considering their abilities in building devices and setups. In the second stage, teachers present outcomes of this collaboration to develop students' learning using their creativity in art.

Students try to present their solutions in the workshop where it is often difficult to see their work as a research program among young students. Students show their own in situ experiments, the real data and analysis in the workshop to convince the visitors (Fig. 4 and 5).

Modeling a bridge using a single sheet of paper to find the stresses, forces, and the maximum resistance against weight, helps students think as a designer to construct a paper bridge and investigate the relevant parameters. The details of one's own learning process are demonstrated in the process of designing and observation. In this case students observe how art provides them with a basis for understanding (Fig. 6).

Arts subjects can develop a positive attitude to help to change our lifestyles to those that conserve nature. Students can be asked to find methods for the creative recycling of materials and for the design of buildings to reduce greenhouse effects and conserve energy or even produce more energy. They can then present them in workshops and defend their projects and exhibit their art to attendees. It is a way to make connections between humans and their environment to understand and discuss important environmental issues and find the best solutions. This connection not only makes classrooms pleasant and interesting, but also helps students to understand the role of art in environmental protection.

6. Conclusion

How are arts and science related to each other? How does art help students remember scientific concepts better? We believe that education, creativity, and empathy strengthen any community and that there is no border between science and arts, but we also believe that local culture should be considered. Scientists that lived many years ago were not only accomplished in their scientific field but also in arts. Arts in science education offers a new model for 21st century teaching to help the shift from human labour to mechanical labour based on human imagination and novelties so it should be considered that:

- science and arts can impact to each other; and
- problems cannot be solved alone just by science and arts can help to find the solution too.

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