

The organization of secondary education builds upon the specialization introduced in elementary school: instead of one teacher teaching many topics, students move from class to class, taking mandatory and elective courses. This structure reflects how our society views topics of knowledge. We think of math as being very different from music, even though many studies have shown that music education increases math skills, and music is mathematically structured (harmony, time signatures, tuning, etc.). Similarly, our culture holds science and art to be radically different fields. The left brain-right brain dichotomy is a popular myth with absolutely no scientific backing, which helps bolster the idea of analytical thinkers (scientists) vs creative thinkers (artists) (Nielsen, Zielinski, Ferguson, Lainhart, & Anderson, 2013). At her TED Talk, the famous astronaut Mae Jemison had this to say about how we teach art and science:

If we keep thinking that the arts are separate from the sciences, and we keep thinking it's cute to say, "I don't understand anything about this one, I don't understand anything about the other one," then we're going to have problems...When these concepts underly our teaching and how we think about the world, then we have a problem, because we stymie support for everything. By accepting this dichotomy, whether it's tongue in cheek, when we attempt to accommodate it in our world...we're messing up the future. Who wants to be uncreative? Who wants to be illogical? Talent would run from either of these fields, if you said you have to choose either, and then they're going to go do something where they think, "Well I can be creative and logical at the same time" (2002).

Placing sharp boundaries around disciplines is artificial and not a reflection of how knowledge works outside of school. By utilizing interdisciplinary teaching, students are better able to recognize bias, overcome preconceptions, engage in critical thinking, tolerate ambiguity, and learn in a deeper and more meaningful way (Science Education Research Center, 2012). According to The National Council

for Teachers of English, "educational experiences are more authentic and of greater value to students when the curricula reflects real life, which is multi-faceted rather than being compartmentalized into neat subject-matter packages" (Science Education Research Center, 2012). This lesson reflects how learning works outside of the classroom. Connecting art to science not only enhances learning about art, but students who have trouble interfacing with scientific concepts might have an easier time if they can relate it to something they already enjoy or understand, such as art. Similarly, a student who enjoys science, might be able to gain a greater appreciation of art and history through this lesson.

In *Picturing Science, Producing Art*, Caroline A. Jones and Peter Galison claim that, "...art [and] science...are historically and culturally embedded. Neither practice has unique and absolute purchase on 'reality', and neither is alienated from history as its rhetoric might imply" (Jones & Galison, eds., 1998, p. 3). Bringing art and science together is nothing new; the two disciplines share a common history. During the Renaissance, the zeitgeist of humanism helped shape both fields (and our idea of what a well-rounded education is) into what they are today. The educated elite sought to explore the natural world, to better understand humanity's place in it. People began to catalogue and illustrate the known world, as well as collect specimens for *Wunderkammern* (cabinets of curiosity) to show off to guests. Objects were collected for their novelty and beauty, as well as scientific study. Artist polymaths like Leonardo da Vinci and Michelangelo not only made great contributions to art, but anatomy, architecture, optics, and engineering. Cross-pollination continued into the 18th and 19th centuries, with the equine anatomical work of George Stubbs, and the motion photographs of Eadweard Muybridge. In the 20th century, the physicist Niels Bohr was inspired by Cubism, and it shaped his work on wave and particle duality theory (Lehrer, 2008). This rich, shared history between art and science is key to understanding contemporary art and why many artists use technology and scientific discoveries in their artwork.

This lesson appeals to multiple senses, because students can create their final work in whatever medium they like: drawing, painting, sculpture, movement, sound, etc. To put it in Multiple Intelligence terms: Art-making is inherently Visual-Spatial, Intrapersonal, and Kinesthetic; but this project can also appeal to individuals who identify with the Naturalistic, Verbal-Linguistic, Interpersonal, and Musical categories. Digital *Wunderkammern* exposes students to a variety of audio-visual media, as per Dale's Cone of Experience: we watch an educational film, we collect still pictures, etc. However, most of the lesson involves direct experiences: creating a webpage, arranging the class *Wunderkammer*, photographing, sketching, creating artwork, etc. The lesson also utilizes a variety of categories of Bloom's Revised Taxonomy: Students analyze and evaluate the images they find online to collect ones they find interesting, they analyze connections between objects when creating the class *Wunderkammer*, they evaluate the work of their peers a number of times during the lesson and give feedback, and finally they apply previous artistic skill and knowledge to solve the problem of creating a new piece of artwork.

Facilitation Theory is a humanist educational theory which calls upon the teacher to not be an instructor of skill or knowledge, but a facilitator of learning. It aligns well with student-centered learning practices. The theory was developed in the 1960s by the great psychologist Carl Rodgers. He was inspired by Dewey's writing, as well as his own experiences in clinical psychology. Rodgers is responsible for person-centered therapy, which flew in the face of psychoanalysis and other therapist-centered psychotherapies of the mid 20th century. According to Rogers:

because of the continually changing atmosphere in which we live, we are faced with an entirely new situation in education where the goal of education, if we are to survive, is the facilitation of change and learning. The only man who is educated is the man who has learned how to adapt and change; the man who has realized that no knowledge is secure, that only the process of

seeking knowledge gives a basis for security. Changingness, reliance on process rather than upon static knowledge, is the only thing that makes any sense as a goal for education in the modern world (Zimring, 1994, p. 415).

Rogers wrote that attitudinal qualities were what made a teacher an effective facilitator. The core attitudinal qualities are realness, prizing, and empathetic understanding. Realness concerns being honest with your students. It is incredibly important to have a human relationship with your students to create a safe and respectful learning environment. Rogers believed that teachers who adopted the traditional persona of the authoritarian teacher discouraged interest in and respect for learning. The second quality, prizing, is having a non-possessive caring for your students; acknowledging that your students are fellow human beings with emotions, hopes & dreams, etc. The last quality, empathetic understanding, is the ability to understand your students' human condition: their attitudes about learning, their home life, their emotional states, etc. (Smith, 2014). In research done by Rogers and others, students in facilitative environments were more creative, engaged in higher-levels of problem solving, had better attendance rates, reported that they enjoyed lessons, and showed greater independence and initiative-taking behavior (Zimring, 1994, p. 420).

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