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Amplifying the "A" in STEAM Education

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Murray State University Honors College

HONORS THESIS

Certificate of Approval

Amplifying the "A" in STEAM Education

Grace Marie Floerke
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AMPLIFYING THE "A" IN STEAM EDUCATION

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Abstract

This paper discusses the importance of teachers implementing STEAM education in the classroom. Previously, science, technology, engineering, and mathematics (abbreviated as STEM) education was used as a tool to prepare students to excel in career fields that are projected to grow in the near future. However, recently the acronym was changed to STEAM to add "the arts" to the original acronym. It is imperative that the arts are seen as an equal to STEM, as they can complement and enhance the goals STEM is trying to reach. Since not all students possess the same interest, ways of learning, or abilities, it is vital that teachers do the best they can to reach all of their students through their curriculum. Though the task may seem daunting, there are countless ways that the arts seamlessly fits into STEM. In this paper, four middle-school appropriate lessons that merge the disciplines of STEAM are provided. The first lesson combines an aspect of humanities with science. The second lesson combines an aspect of visual art with an aspect of technology. The third lesson combines an aspect of theater with an aspect of engineering. And the fourth lesson combines an aspect of music with an aspect of mathematics.

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Introduction

Education specifically focused on the disciplines of Science Technology, Engineering and Math has been shortened to the acronym "STEM." The purpose of this educational emphasis is to prepare students for careers that are becoming more relevant and numerous in the world. More recently however, the tetrad of science, technology, engineering, and math, was granted a fifth member: arts. There is no specific date for the initiation of this update, but STEM is slowly starting to become STEAM. Unfortunately, many would consider the "A" to be out of place. Science, technology, math, and engineering all cohesively fit like puzzle pieces, often overlapping with one another. Since these careers are seeming to become more relevant, these disciplines have been pushed onto students in attempt to prepare them for the future. This is great, as the goal of teachers is to prepare students for the world they will make. However, STEM, as it stands, is incomplete. The addition of "A" in the acronym STEAM is a response to the inadequacy in STEM education to meet the needs of all students. The arts encourage critical thinking, creativity, and teach expression in ways that traditional STEM material does not. By properly implementing the arts, educators can reach a broader audience of students through a lens of the arts, while enhancing the initial goals of STEM education. There is no one right way of implementing STEAM education, but it is important that teachers utilize different aspects of the arts in their pedagogy to best differentiate their instruction, therefore enabling more learning to occur.

This document was written to encourage teachers to incorporate the STEAM into their classrooms in order to increase the likelihood of success for all of their students. I have crafted four different examples of lesson plans that intertwine one branch of the arts with one branch of the original STEM subjects. These lessons are engaging for students and allow them to discover

solutions in a way that is meaningful. Having students produce knowledge back to the teacher is an excellent way of summative assessment that draws from their own wells of knowledge and is supplemented by the new information. In these sample lessons, I have found ways to teach science in the form of humanities, technology in the form of visual art, engineering in the form of theater, math in the form of music at the middle school level. Using similar strategies, teachers can better prepare all students for modern society in which STEAM is becoming ever more significant.

History of STEM Education

Congressional acts and government programs have played major roles in the United States Education System since its founding. Though direct attention to STEM education may date back to the first Congressional meeting, there are a few specific cases that truly took hold of how STEM education was practiced in the country. Two of the most crucial acts were ratified nearly a century apart: The Morril Act of 1862 and the National Defense Education Act of 1958.

The Morril Act was proposed by Vermont Representative Justin S. Morrill with the intention of more effectively utilizing public lands for farming, as well as provide the ability for those who worked on the farm to seek higher education (Duemer, 2007). The law primarily focused on agriculture, landowning, and how taxes would be paid for the distribution of land, but in terms of education Morril, in his own words, aimed to "open college doors to farmers' sons and others who lacked the means to attend the colleges then existing" (Morrill Act,1862). Section 4 defines how these funds should be divided, in powerful terms, concerning education:

> That all moneys derived from the sale of the lands aforesaid by the States to which the lands are apportioned, and from the sales of land scrip hereinbefore provided for, shall be invested in stocks of the United States… and that the moneys so invested shall constitute a

> perpetual fund, the capital of which shall remain forever undiminished… to the endowment, support, and maintenance of at least one college where the leading object shall be, without excluding other scientific and classical studies, and including military tactics, to teach such branches of learning as are related to agriculture and the mechanic arts, in such manner as the legislatures of the States may respectively prescribe, in order to promote the liberal and practical education of the industrial classes in the several pursuits and professions in life.

This act pushed for agricultural education in higher levels, but on a larger scale, this was one of the first big pushes for guaranteed funding of a specific STEM discipline in higher education. At this point in history, the United States had already established a public school system, but there was no mandate for states to have a publicly-funded school with programs geared toward science, engineering, and military tactics. Without STEM programs in higher education, the knowledge cannot effectively be passed down nor implemented in comprehensive education Without the Morril Act, many Universities and their benefits to the United States would not exist today.

More recently, one of the most prominent pushes for STEM education in the United States occurred in the late 1950s. Precisely, the day that changed it all was October 4, 1957. The day the Union of Soviet Socialist Republics launched the world's first artificial satellite *Sputnik* into the thermosphere was the day the United States Education Department received a wakeup call to upgrade science education in the country (Wissehr; Concannon, 2011)**.** Prior to this event, Science and math education had been abated due to the recent world wars. The military was in need of technicians, scientists, doctors, engineers to help the war effort, a majority of them being university professors and staff who had been given more money to aid in government projects.

There remained an unfilled void: a lack of science educators. Consequently, the student numbers lacked due to the insufficient number of teachers in the nation (Lathan, 2020).

Though presidents such as Harry Truman had attempted to address these issues in the past, there was no doubt that the United States was falling behind in education dominance. After Truman's presidency had adjourned, Dwight D. Eisenhower saw it his duty to revamp the education system to meet the needs of an ever changing, ever evolving—technologically speaking—world. The National Defense Education Act of 1958 was passed in attempt to bridge this gap between the States and Soviets (National Defense Education Act, 1958). In section 101 paragraph 2 of the General Provisions, the National Defense Education Act states the following:

> We must increase our efforts to identify and educate more of the talent of our Nation. This requires programs that will give assurance that no student of ability will be denied an opportunity for higher education because of financial need; will correct as rapidly as possible the existing imbalances in our educational programs which have led to an insufficient proportion of our population educated in science, mathematics, and modern foreign languages and trained in technology.

Because of this act, science, mathematics, and technology education were not only encouraged, but given more government funding as well. Public universities pushed these disciplines into the foreground of higher education focus. Though the modern-day acronym STEM was not used until the early 2000s, the National Defense Education Act was one of the first to put a spotlight directly on science and math in United States education.

The first acronym "SMET" started to appear in the 1990's, but Judith Ramalay, former director of education and human resources for the U.S. National Science Foundation changed the acronym to the more pleasant-sounding "STEM" acronym in 2001 (Christenson 2011).

Currently, the United States is nearing the end of a five-year plan enacted in 2018 titled the "STEM Education Strategic Plan." This plan had set three major goals: to build strong foundations for STEM literacy, increase diversity, equity, and inclusion of STEM for all Americans, and to prepare the STEM workforce for the future (Office of Science and Technology Policy, 2020). Over 180 programs have been put in place in the United States by a wide variety of agencies in order to help achieve the goals of STEM in America.

STEAM and Its Significance

In recent years, a new addition to STEM has been made. One of the first STEAM models was created by former PhD student George Yakman, whose goal was to create an integrated curriculum for education (Yakman, 2008). STEAM is the newly-created acronym that adds "the arts" into the original STEM acronym. To some, the arts may feel out of place with the rest of STEM. The four original fields are very closely intertwined, while the arts may seem an outlier, but according to Yakman, "We now live in a world where; you can't understand Science without Technology, which couches most of its research and development in Engineering, which you can't create without an understanding of the Arts and Mathematics" (Yakman 2008). The arts give way to a side of learning that is not often reached through STEM alone. Though STEM work gathers research, data, and solutions to problems dealing with advancing society, the arts can greatly enhance how that data is communicated. The playwright Oscar Wilde once wrote "Life imitates Art far more than Art imitates life" (Wilde, 1891). What he means by this is that life is unknowingly seeking means of expression, and art is a beautiful and convenient way of doing so. According to Susanne Langer in "The Cultural Importance of the Arts," the word expression has two meanings: to let out our feelings, or the presentation of an idea (Langer, 1966). Teaching students different avenues of expression and communication will increase the

ability for information to spread. The arts allow students to connect material to personal experience and emotion. When material becomes personal and memorable, more learning occurs. Separating the arts from STEM separates the information STEM brings from one of the most efficient means of expression. Using arts in education can be linked to more memorable learning. Research from the Journal of Mind, Brain, and Education shows that "arts integration naturally incorporates activities that are likely to bring about potential benefits for long-term memory" (Rinne; et. al, 2011).

The original purpose of STEM education was to prepare students for the careers that would become ever-important in our technologically advancing future. According to the US Bureau of Labor Statistics, STEM jobs are projected to grow 10.5% between 2020 and 2030 ("STEM Demand," 2021). It is imperative that teachers are encouraging more students to look into these growing fields as they are becoming more necessary. Not only are the job fields growing, they are also higher-paying. In 2020, the median annual wage of STEM occupations was $89,780 (US Bureau of Labor, 2021). By encouraging more students to look into higher paying jobs, we could potentially lower poverty rates in the United States, which, according to the most recent census, is 11.4% of our population (Shrider et al., 2021).

One audience that STEM teachers need to put more emphasis on reaching is women. The United States Census shows that women make up nearly half the workforce, but are only making up 27% of STEM workers (Martinez; Christnacht, 2021). There are many possible reasons for the percentage gap, but a lack of interest is not one of them. In recent years, women have made gains in some STEM occupations, but women are still very far behind in crucial fields such as computer work and engineering.

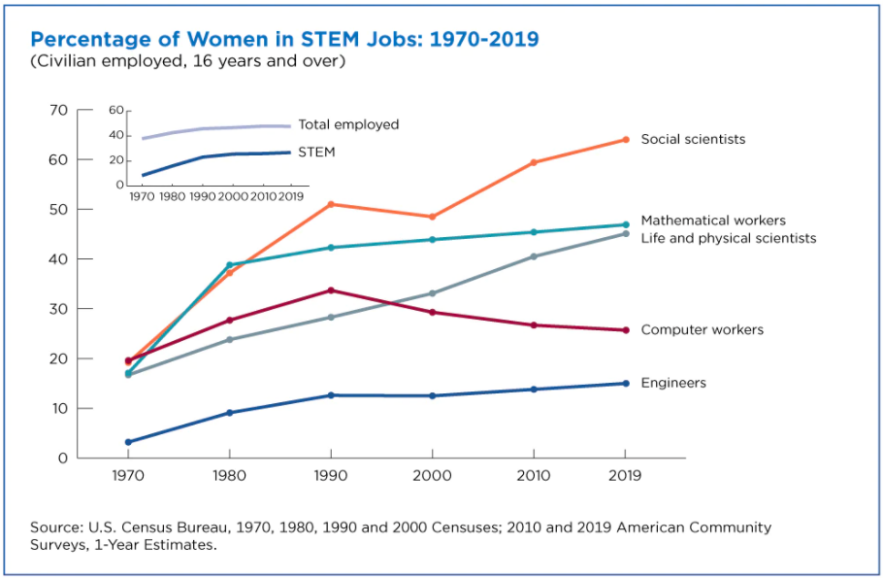


Figure 1. Data from the U.S. Census Bureau shows the percentage of women in different STEM occupations, indicating that <30% of computer workers and engineers are women.

National Girls Collaborative Project shows that nearly three-fourths of middle school girls express interest in STEM, but less than half of a percent of high school girls pursue computer science. These are specific examples, but they do not negate the fact that there is a clear disparity between the number of girls who show interest in STEM at a fairly young age and number of women who actually pursue STEM-related professions. One reason for this may be due to societal pressures that are put on women such as body image. A study by Elizabeth Daniels and Rachael Robnett looked at the relationship between objectified body consciousness (OBC) processes and adolescent girls' interest in STEM. Their findings show that the amount of stress coming from body shame could be linked with a relationship between social media behavior and STEM attitudes in middle school girls specifically (Daniels; Robnett, 2020). This may be due to a lack of exposure in childhood and adolescent years. There are also societal stereotypes that boys are better than girls in topics like math or science. Research from Carol Dweck, social and developmental psychologist from Stanford University, shows that these

stereotypes can inhibit women to have a growth mindset (Hill; et. al, 2010). In media, women are less often depicted as highly intelligent characters, which makes them seem rare. This imposes a bias among young girls, potentially discouraging them from STEM careers (Mazenko, 2016). Since people are exposed to more media at a younger age than past generations, this is affecting women at crucial identity-defining ages. Knowing this, teachers can use media and artistic ideas within STEAM to encourage more women to pursue STEM fields despite the negative stereotypes and biases they may face.

However, not every student is going to become an astrophysicist, a civil engineer, or a financial advisor. Not every student is, or needs to be, passionate about the traditional STEM fields. Society still needs artists, graphic designers, humanitarians, architects, actors, musicians, and so on and so forth. Nonetheless, this does not change the fact that the world is advancing, and teachers need to best prepare all students to succeed in the world in which they will live. Using STEAM as a framework for teaching, students will learn transferrable skills like critical thinking and creativity. In a study about STEAM instructional programs in Canada from the *Journal of Research in Innovative Teaching and Learning*, C. Liao is quoted saying that "the STEAM programs in this study teach character-building skills, such as 'critical thinking and problem solving; collaboration and communication; and creativity and innovation'" (Bertrand; Namukasa, 2020). These skills are vital to being a citizen in general. No matter what field a person chooses to pursue in life learning critical thinking, problem-solving, creativity, communication skills, and collaboration—all of which are encouraged through a STEAM education model—will foster well-rounded individuals who will be able to benefit themselves and society around them.

STEAM's Connection to Creativity and Critical Thinking

STEAM education has been shown to have positive effects on creativity. In one study from the Journal of Technology and Design Education developed an effective STEAM activity that showed an increase in verbal and figural creativity in a group of 7th grade girls in Istanbul, Turkey. In this study, titled "Exploring the effectiveness of STEAM design processes on the middle school students' creativity," a control group of students were taught purely based on the curriculum in a science textbook, while another group were taught the same material with different STEAM-focused lessons. The results showed a significant difference, favoring the variable group, in verbal and figural creativity (Ozkan; Umdu Topsakal, 2019).

In this paper, and in casual conversation, I often use terms like critical thinking and creativity interchangeably. STEAM encourages both creativity and critical thinking. Though there is overlap between the two terms, there is a distinction. One is a noun and the other is a verb. Better yet, creativity is an idea, whereas critical thinking is an action. The problem lies in the fact that these concepts are not easily defined.

The most cohesive definition of creativity I have found comes from F. Barron, author of "The Disposition Towards Originality" and M.I. Stein, author of "Creativity in culture." Barron did not truly define creativity, but defined originality. Simply put Barron states that originality should be uncommonness, while creativity is "adaptive to reality" (Runco; Jaeger, 2012). The reason for this distinction is that it eliminates works that are uncommon but random. Creativity is done purposefully. Stein, on the other hand, contribution defined the idea of novelty. In his words, if a creative product is "novel," it "did not exist previously in precisely the same form…" and the extent of its "novelty" depends on "the extent to which it deviates from the status quo [as well as] the nature of the problem that is attacked" (Runco and Jaeger). Stein explains that

originality and novelty are fundamental for creativity. Putting these two ideas together, we can infer that creativity requires a purposeful uniqueness. It is important to note that creativity is not about judgement. Creativity itself does not have to do with making judgements on value, but simply whether or not it is deliberate and inimitable.

When it comes to critical thinking, there is also debate on the definition. The University of Louisville points this out, and has chosen to adopt Michael Scriven and Richard Paul's definition of critical thinking ("What Is Critical Thinking?," 2021). They define critical thinking as the following:

> Critical thinking is the intellectually disciplined process of actively and skillfully conceptualizing, applying, analyzing, synthesizing, and/or evaluating information gathered from or generated by observation, experience, reflection, reasoning, or communication, as a guide to belief and action.

Though many may consider critical thinking as just logic and reasoning, there is more to the process. Logic may come into play in critical thinking and decision making in, but critical thinking itself is not necessarily synonymous with logic. It is about taking in information, processing, and forming a set of principles on which to act. Dr. Kenneth Petress from the University of Maine at Presque Isle states that critical thinking is also vital in the arts. He provides the examples such as making choices in structuring of music, repeating skill in order to improve, and understanding that judgement is often coming from those with less expertise than the artist producing a work, to show critical thinking's role in the arts. (Petress, 2004)**.**

Creativity is the conceptualization of new ideas, while critical thinking is the application of these ideas. The lessons presented are, on their own, creative, but students are critically thinking when applying their new ideas. The creativity encouraged through STEAM leads to

more critical thinking. As defined before, creativity is not about judging whether the ideas are useful, practical, or even objectively "good." Creativity is simply about originality and meaning in thought. This is where critical thinking skills come into play. Students analyze the creative ideas they have envisioned and judge whether they are useful to the topic at hand through critical thinking.

Using the arts in STEM education gives knowledge from a new angle, allowing students to find new solution sets and view options that would not be available with a traditional STEM curriculum. Therefore, by giving students supplemental information to analyze, in this case, from an arts-based source, idea, or perspective, allows students to think more critically. In the context of this argument, students may be producing knowledge that may be creative in its own right, but by being presented STEM information though an unconventional artistic lens, students apply critical thinking to come to a solution.

Time for Application

STEAM education is extremely important for the development of students' minds, as well as career choices. However, there is not a clear-cut-curriculum or set of guidelines for how this education should be carried out. Nonprofit organization such as Project Lead the Way have come up with their own curriculum outlining ways that teachers can implement STEM into middle and high school classrooms (Stohlmann et al., 2012)**.** However, it is noted in this article that teachers were not fully confident in their abilities to teach the STEM material due to their lack of knowledge in the subjects. Not only is it important that we increase STEAM material for students, but it will also raise another generation of teachers to pass on more STEAM knowledge to their future students. Different curriculums for STEM education, like NGSS, STEL, and ISTE have been proposed. However, a curriculum may be confining to teachers, and what's more

important is that the arts are integrated with STEM during instruction of a lesson. The content is important, but the way in which the lesson is taught does not necessarily need to be confined to a strict curriculum. Setting limits for instructional strategies can potentially set limits on the audiences the lesson reaches. Curriculum is important for establishing a baseline of knowledge, but the method of the instruction can vary from educator to educator.

The following four lessons I have created are combinations of science and humanities, technology and art, engineering and theater, and math and music. Though I chose these duos specifically, that is not to say that aren't pairings of technology and theater, science and music, engineering and art, et cetera. That being said, many teachers may not know exactly how to manipulate the arts in STEM activities. Partially, this is due to the lack of research showing practical implications of integrating specific branches of the arts with specific branches of STEM. Based on the pairings I have chosen, I have found one article with a concrete example teaching ethics of science in a Colorado School that has data showing a positive impact on students' critical thinking skills (Zillox; Smith: Mitcham, 2016). I have found two articles concerning the benefits of theater in improving social skills and sciences (Burke; Wessels: McAvella, 2018)(Hartigan, 2012). Three sources detailing the rise and progression of digital art and technology have been shown to improve motivation for learning in the classroom (Unrath; Mudd, 2011) (Black; Browning, 2011)(Cress 2013). For the connections between music and math, there are many parallels at higher-level education, such as using complex ratios to determine to tone frequencies(Shah, 2010), but I have also found two articles detailing math-music integrated curriculum at an elementary, and specifically third-grade, levels (Courey; Balogh; Siker; Paik, 2012)(An; Tillman; Boren; Wang, 2014).

While there exists some research about practical examples of integrated topics, this integration is often light, especially in the middle school environment. Though these results are few and far between, this does not negate that bridging the aspects of STEAM provides educational benefits. Since there is not a plethora of examples out there, teachers must find creative ways in which to incorporate a variety of arts with each of the original STEM disciplines in order to encapsulate the benefits from multiple branches of the arts. In the following sections of this paper, I have written narratives of different possible lesson plans doing such. It is important to note that none of these lessons have been formally tested in a classroom environment. This is partially due to the COVID-19 pandemic interfering with formally testing this in classrooms, as to not make schools uncomfortable in an unprecedented time. However, the point is not to show empirical data on the lessons themselves, but to give an example of what STEAM may look like in a middle school setting. Teachers are free to try any of these lessons. Based on my previous classroom knowledge, the following lessons are concrete examples of how I think STEAM could be implemented in a classroom setting.

Conscience Behind Science: Combining Science and Humanities

When most people think of the arts, the common examples of music, theater, or visual arts come to mind. Though I do incorporate each of these examples in other lessons, I wanted to integrate one branch of the arts with science specifically. Humanities, unfortunately, can often be pushed aside as a branch of the arts. Not only does humanities strongly influence the creation of different facets of the arts, but it should also have a hand in scientific decisions today. More explicitly, the humanities subcategory of ethics can be extremely advantageous for scientific discoveries, and, when ignored, the absence of ethics can reveal detrimental consequences of scientific advancement.

With that being said, this is an example of combining humanities with science. This lesson incorporates students' ability to research a controversial topic, analyze the information, and critically think to devise an argument for that topic. In multiple middle school standards, students are required to analyze data and apply it to different scientific topics. In this case, students are not only applying critical thinking to topics of science, but topics of ethics as well.

Necessary Prior Knowledge:

1. How to teach controversial topics: It is a teacher's job to guide students through controversial conversations in a respectful manner. Dr. Gomez of Murray State University explains this concept in "Embracing the Controversy: Challenging Students Through Meaningful Dialogue" that can be summarized in a few steps (Gómez, 2019).
    a. **Teach the concept of privilege**: Students must know that they have unique privileges and experiences that allow them to view the world based on their knowledge. (Since this topic may be hard to understand, using an analogy like Ableism may help students get the idea)
    b. **Explain disagreeing without being disagreeable:** After explaining what privilege is in this context, explain that privilege is not inherently "bad." Each person has different views on the world based on their personal experience. Some students will have differing opinions based on their own privileges and/or lackthereof, which will call for some classroom disagreements. Establish a culture of respect. Instill the values of respecting other opinions, and the ability to hold a different view without condemnation of another.

c. **Start small:** Use a scaffolding technique that allows students to warm up to being able to openly disagree with their classmates. If students do not comfortable stating their opinion on more trivial matters, then they will not be able to share their opinion on real ethical issues.

2. Lincoln-Douglas Debate Format: After allowing students to form justification for their defense of a topic, make sure the debate has rules and does not turn into a competitive argument. The goal of these discussions is not to "win" but to critically think about the ethics of science. One way to do this is to enforce a Licoln-Douglas debate speaking format (Roberts)**.** More specifics on these terms can be found at https://www.speechanddebate.org/wp-content/uploads/Intro_to_LD.J.Roberts.7.5.27.pdf , but this is the basic format and time restrictions on a debate.

   a. Affirmative Constructive- **6 minutes**
   b. Cross-examination by Negative- **3 minutes**
   c. Negative Constructive- **7 minutes**
   d. Cross-Examination by Affirmative- **3 minutes**
   e. 1st Affirmative Rebuttal- **4 minutes**
   f. Negative Rebuttal- **6 minutes**
   g. 2nd Affirmative Rebuttal- **3 minutes**
   h. Preparation time between all speeches and cross examinations- **4 minutes**

Start the lesson by breaking students off into groups of 4-6 students. There must be an even number of groups so that each debate has one affirmative and one negative side. Instruct students prepare an argument over a simple topic. These topics could be anything from simple

"would you rather" questions to debating foods such as pancakes or waffles. This allows the students to become comfortable expressing their opinion in a debate setting. Have two or three pairs of groups debate these topics using the Lincoln-Douglas format. This will allow students to get comfortable with speaking in turn, learn how to form rebuttal arguments, and sharpen their overall debate skills.

After allowing students to discuss simple topics, then explain that they will apply these debate concepts into their science classrooms. Allow students to pick their topic from a list provided, making sure that each issue has a supporting and opposing side. Below is a list of potential 12 debate topics for students to choose from for this lesson:

1. Is scientific animal testing necessary?
2. Should humans continue to keep animals in zoos?
3. Is genetic engineering of humans ethical?
4. Should human cloning be legal?
5. Should ecocide be a crime?
6. Is there one solution to climate change that is best?
7. Should science try to recreate organisms that have gone extinct?
8. Are GMO's healthy for people to eat?
9. Can vegetarianism save the earth?
10. Should people trust homeopathic medicine more than modern medicine?
11. Is obesity a disease?
12. Is solar power the best form of energy?
13. Should we ban nuclear power?
14. Is artificial intelligence replacing human intelligence?

15. Is colonization of Mars a good idea?

Many of these ideas came from the following websites, both of which are great tools to use.

https://www.myspeechclass.com/debate-topics-teens.html#environmental_debate_topics

https://owlcation.com/academia/80-Science-Debate-Topics-for-Students

https://research.com/education/debate-topics-for-college-students#3

After choosing a debate topic, groups must form a claim for their argument, and start gathering data to support their claim. Give students between one and two days to get together and construct a cohesive argument. After the analyzation period has passed and groups have formed their case, two groups will start the formal debate process. By following the Lincoln-Douglas format, both groups will debate while the rest of the class analyzes the arguments from both sides and decide which argument is the strongest based on the data presented. Stress to the students that there is no "winner" in these arguments. As stated before, goal of these discussions is to think critically about the role ethics plays in scientific discovery and research. Students must choose the most successful debater not based on their own opinion, but by which side presented the soundest argument.

Implications

There is no limit to how many times this lesson could be taught. It is important for students to know that scientific decisions have consequences. Though students may be interested in learning new things and support an advancing world, students must also realize that advancement does not always equal a positive outcome. By teaching this lesson, students will produce knowledge from their own research about their topics, and apply that knowledge to drawing their own conclusions. Many of the presented issues are prevalent today, but with increasing technology, the issues may become more ubiquitous in their futures.

Teaching students to listen to both sides of a controversial issue also strengthens their ethics. Middle school students are shaping their future identities, and allowing them to have ethical discussions in the classroom provides a safe space for self-discovery. Allowing students to expand upon shaping their moral compasses is crucial for their psychological development. This lesson is a great way to teach students how to investigate data about the world around them, while at the same time challenging their own beliefs in a healthy fashion.

Below is a rubric stating how this lesson would be evaluated. As stated before, students are not judging the "winner" of the argument based on opinion. Their grade should reflect their ability to look at scientific data and create a sound argument. The ethics are there to enhance the lesson and provide an outlet moral, cognitive, and psychological development.

Class Debate : Conscience behind Science				
Teacher Name: **Ms. Floerke** Student Name: _____				
CATEGORY	4	3	2	1
Respect for Other Team	All statements, body language, and responses were respectful and were in appropriate language.	Statements and responses were respectful and used appropriate language, but once or twice body language was not.	Most statements and responses were respectful and in appropriate language, but there was one sarcastic remark.	Statements, responses and/or body language were consistently not respectful.
Information	All information presented in the debate was clear, accurate and thorough.	Most information presented in the debate was clear, accurate and thorough.	Most information presented in the debate was clear and accurate, but was not usually thorough.	Information had several inaccuracies OR was usually not clear.
Rebuttal	All counter-arguments were accurate, relevant and strong.	Most counter-arguments were accurate, relevant, and strong.	Most counter-arguments were accurate and relevant, but several were weak.	Counter-arguments were not accurate and/or relevant
Use of Facts/Statistics	Every major point was well supported with several relevant facts, statistics and/or examples.	Every major point was adequately supported with relevant facts, statistics and/or examples.	Every major point was supported with facts, statistics and/or examples, but the relevance of some was questionable.	Every point was not supported.
Understanding of Topic	The team clearly understood the topic in-depth and presented their information forcefully and convincingly.	The team clearly undestood the topic in-depth and presented their information with ease.	The team seemed to understand the main points of the topic and presented those with ease.	The team did not show an adequate understanding of the topic.
Time Limit	The team spoke within the time limits laid out in the Lincoln-Douglass Debate format. Students were respectful and ended their turns at	The team spoke within the time limits laid out in the Lincoln-Douglass Debate format most of the time. Students were respectful but tried to	The team DID NOT often speak within the time limits laid out in the Lincoln-Douglass Debate format. Students often spoke much longer than	The team DID NOT speak within the time limits laid out in the Lincoln-Douglass Debate format, often interrupting the other team and speaking
Ethics	Students put in great effort to show defense of the ethical portion of the debate, and backed up their claim with scientific evidence.	Students put in some effort to show defense of the ethical portion of the debate, and backed up their claim with some scientific evidence.	Students put in little effort to show defense of the ethical portion of the debate, and backed up their claim with statements that were not scientific in nature.	Students only defended the ethical portion of the debate based on personal opinion and DID NOT defend their claim with scientific evidence.
Date Created: **Dec 08, 2021 02:30 pm (CST)**				

Figure 2. Conscience behind Science Debate Grading Rubric.

Creations meet Computers: Combining Technology and Art

One lesson to combine art and technology is by teaching students about a particular artist or style, having them create a work in that style, and allowing them to create a website and other social medias for the artwork in question. In previous lessons, students will be taught about four different art styles of the 20th century: Fauvism, Cubism, Surrealism, and Pop Art. Students will then create and personify their own artwork inspired by one of the styles, giving it a name, backstory, and personality. The students will then create one "social media account" for their artwork as well as a website.

Necessary Prior Art Knowledge:

1. Fauvism: One of the first breaks from Impressionism in the early 1900s, Fauvism was an art movement classified by bright colors and distinct brush strokes, displaying a somewhat unnatural image. Some notable Fauve artists include Henri Matisse, André Derain, Maurice de Vlaminck, and Kees van Dongen among other (Rewald; "Fauvism", 2004).

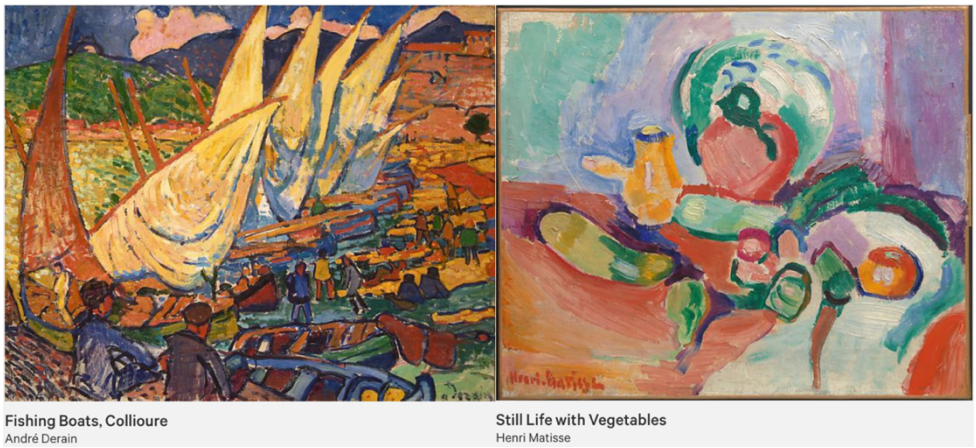


Figure 3. Two paintings by André Derain and Henri Matisse, respectively, illustrate the characteristics of Fauvism art style.

2. Cubism: This art style was created by Pablo Picasso and Georges Braque in the late 1900's and early 1910's. Cubism embodied the idea that art should not always mimic nature by depicting images with geometric shapes. This was used to emphasize the two dimensions of a canvas. Other Cubist artists include Fernand Léger, Juan Gris, and Jean Metzinger (Rewald; "Cubism", 2004).

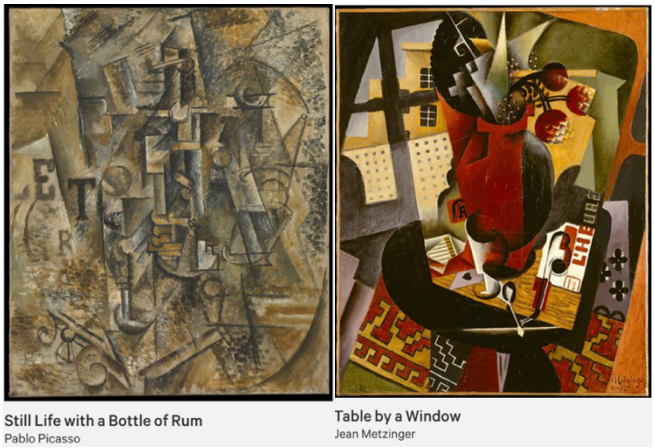


Figure 4. Two paintings by Pablo Picasso and Jean Metzinger, respectively, illustrate the characteristics of Cubism art style.

3. Surrealism: Originating as a literary movement, surrealism is an art style that encapsulates dream-like scenes and the limitlessness of the imagination. The literary portion of the Surrealist movement began in the late 1910's, but visual arts grew popularity in the 1920's, 1930's and beyond. Some well-known surrealist artists are Max Ernst, André Masson, René Magritte, and Salvador Dalí (Voorhies, 2004).

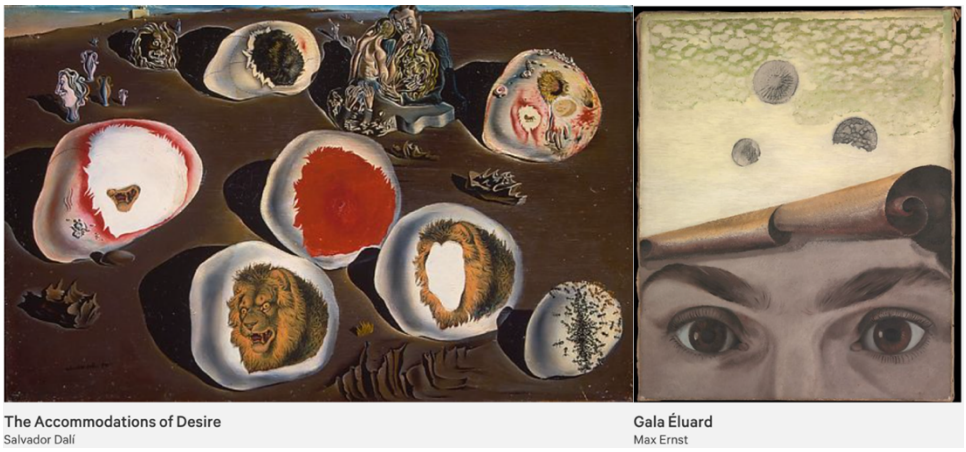


Figure 5. Two paintings by Salvador Dalí and Max Ernst, respectively, illustrate the characteristics of Surrealism art style.

4. Pop Art: Having both American and British roots, the Pop Art movement of the late 1950's and 1960's was fueled by the different social justice and political movements in the world. The art was known for bold, primary colors depicting everyday items and well-known media imagery. It provided a huge contrast to the abstractness of past art movements in the 20th century. Popular pop artists consist of Andy Warhol, Debora Kass, and Roy Lichtenstein (Walker Art, *Andy Warhol*; "Pop Art"; Walker Art, *Roy Lichtenstein*).

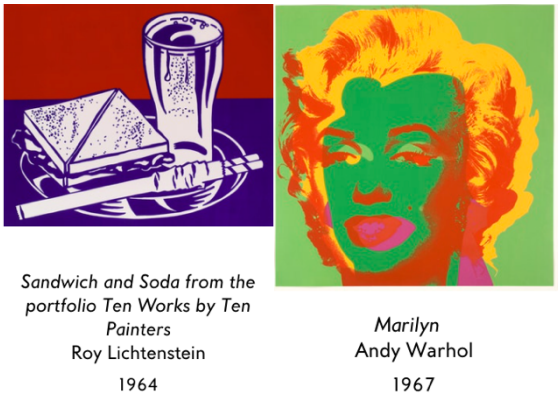


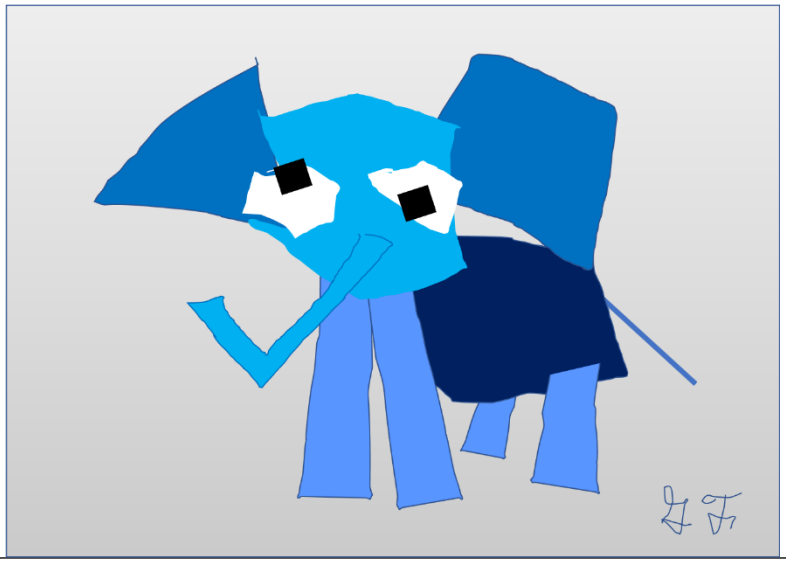
Figure 6. Two paintings by Roy Lichtenstein and Andy Warhol, respectively, illustrate the characteristics of Pop Art style.

After being taught a brief history on each of the four art types, students will be allowed to create an artwork in the style of their choice. As teachers it is important to have an even spread across all the art types to ensure that each art style is sufficiently talked about.

After creating their artwork, students will bring their artwork to life! Students will need to provide a name for their artwork, a backstory or biography, as well as different examples of art that they are similar to. They can interact with other artworks in the class. Students will then take a picture of it. This picture will be used in their own website and possibly their tweets. Using weebly.com, students will make a free website showcasing their art's personality. Using prankmenot.com, students will create fake Twitter tweets or Facebook statuses for their personified artwork. They have free creative control over the entire project, as long as they meet the requirements for each portion of the project.

There are three portions to this project: the artwork, the website, and the social media. Students have creative control in this assignment, but there is criteria that they must meet.

For the artwork itself, they must create a piece of art that is inspired by one of the four styles. The student's artwork can be in any appropriate media. Examples of this could be acrylic paint, watercolor, pen and ink, oil pastels, colored pencil, pencil, or even clay sculpture. The piece can depict any classroom-appropriate image that they desire, so long as it shows that they understand the aspects that make up each art style. Creativity should not be stifled, but the goal of the assignment is that students show effort and engagement while producing knowledge based on what they have just leaned. Here is an example that can be found at https://msfloerkeart.weebly.com/:



This work of art is titled Bluephant. Bluephant was created in the style of cubism and depicts a completely blue elephant. She likes the simple things in life and doesn't believe that she should be in a fancy museum. She wants to see simple people who are inspiring like her. Therefore, she wants to live in a more ordinary place, like a coffee shop.

Figure 7. This artwork titled "Bluephant" was created as an example for what a student's artwork and simple description could potentially look like.

After creating the artwork, students will bring it to life. Students will give the artwork a personality, backstory, and likes/dislikes. They will show what it would be like if this artwork used social media. Using prankmenot.com, students will create fake Twitter tweets or Facebook statuses for their personified artwork. Prankmenot.com is a website where students can generate a realistic-looking fake tweet or Facebook status. Students can choose a profile picture, body text, and date posted. Students will generate at least three tweets or Facebook statuses from the point of view of their artwork. They can interact even with other artworks in the class. The only requirements for these posts is that they are classroom-appropriate, show the artwork's personality, and have a date that is relevant to the time period in which the art was created. For

example, if the student's artwork is in the style of Fauvism, the date of the post must be relevant to the time of Fauvism, which would be somewhere around 1900s-1910s.

Finally, the student will incorporate both their artwork and their social media into their website. Students will design a basic website using weebly.com in any way they wish. Weebly is a free, user-friendly website creation tool that is useful for showing students what goes into building a website. The website may have any aesthetic or design that the student wishes. The website requires only a few aspects. It must have at least four tabs on their website. One tab must be a home tab, stating the artworks name as well as other images of known artworks in the art style they have chosen.

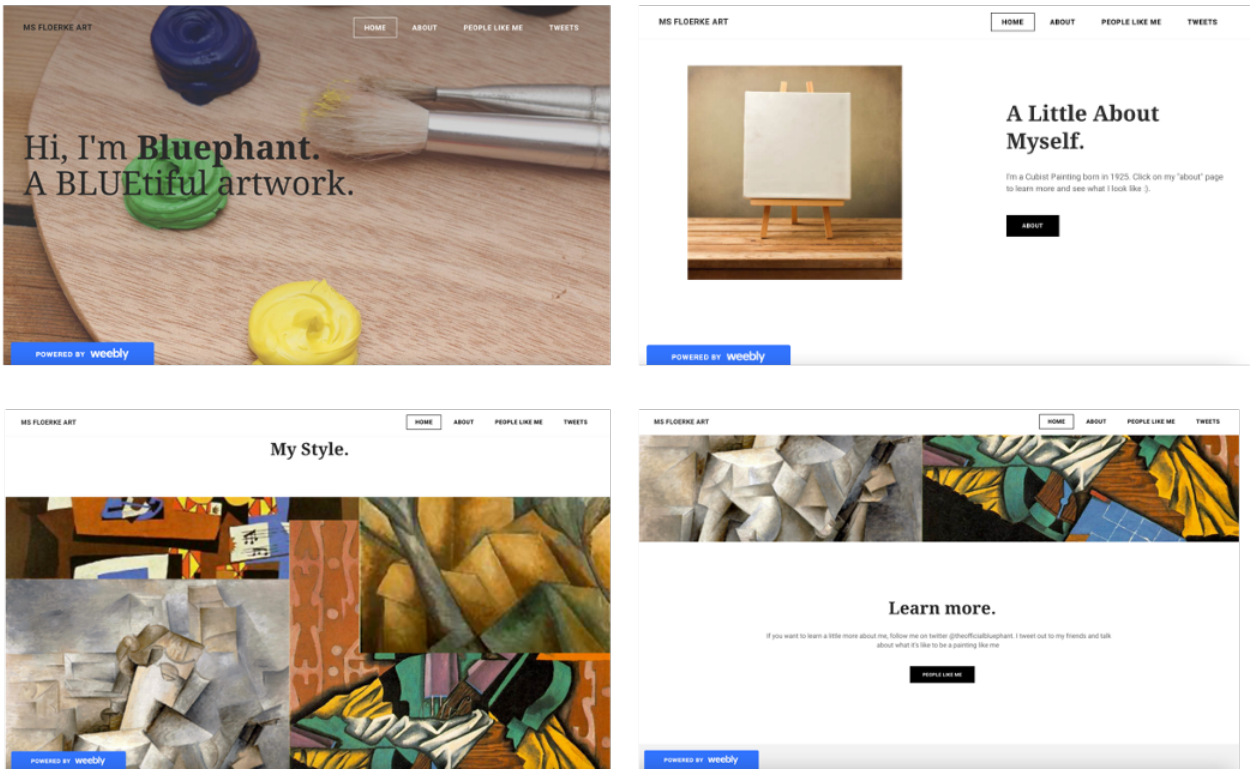


Figure 8. Screenshots from the "Home" page of the sample website.

There must be an “about” tab. This tab must have a picture of their artwork. As well as a small biography.

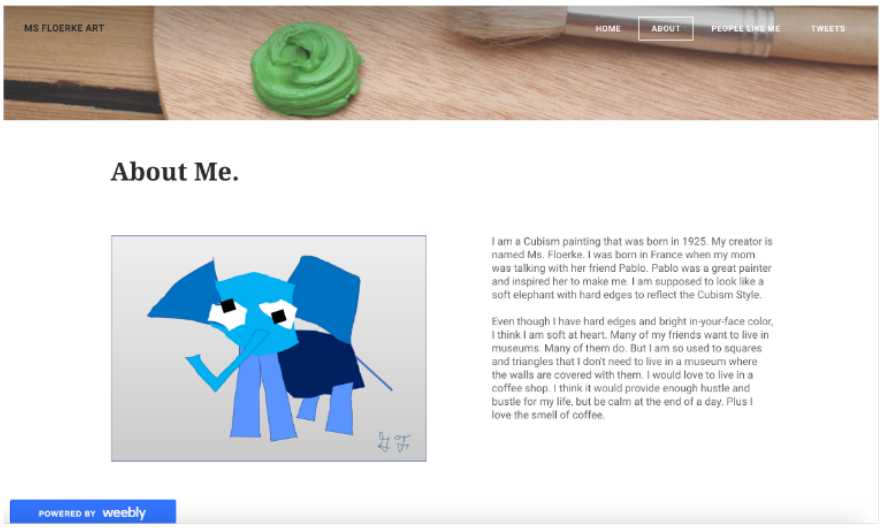


Figure 9. Screenshot from the "About Me" page of the sample website.

The third tab should be a “people like me tab.” This tab will showcase at least different artworks in the style of the student’s choice. These artworks could be famous artworks, or it could include other classmates’ works in the same style.

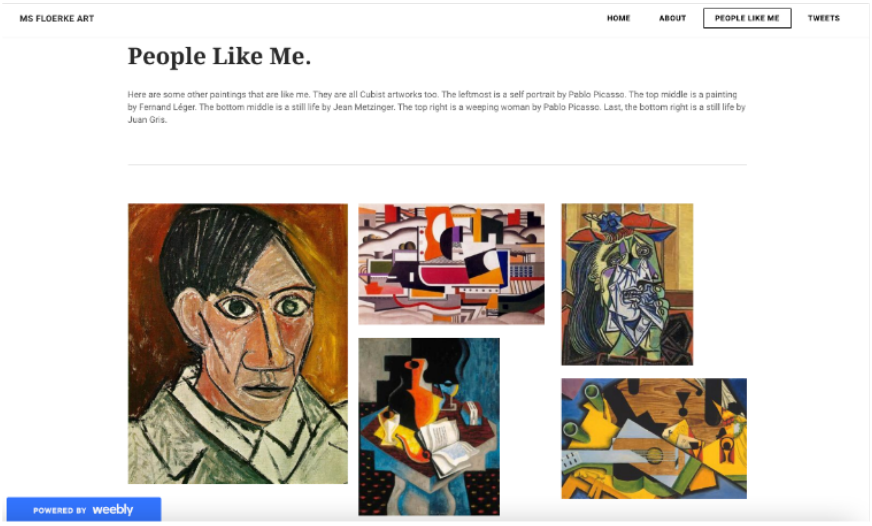


Figure 10. Screenshot from the "People Like Me" page of the sample website.

The last tab will be a tab with screenshots of their fake social media posts. These were created earlier but will be posted on the website so the student and teachers can find them in one place.

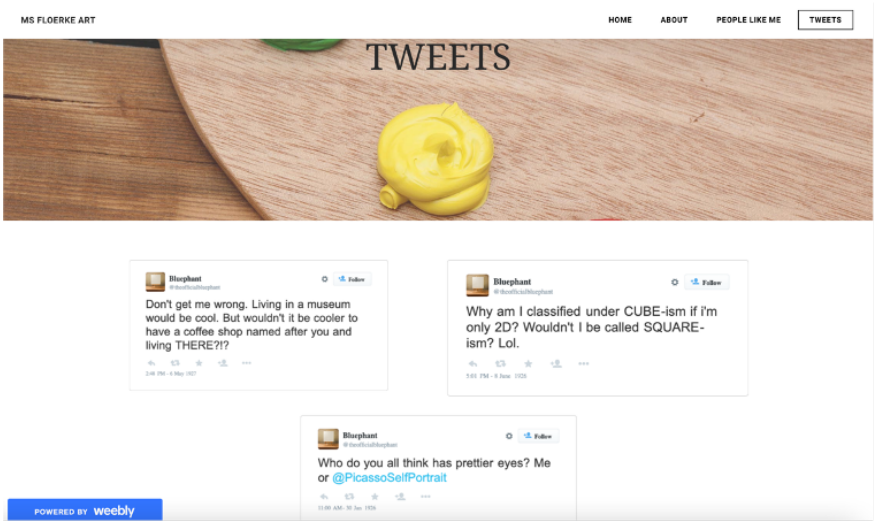


Figure 11. Screenshot from the "Tweets" page of the sample website.

Implications

This lesson could apply to any style of art. Allowing students to create their own work in the style off another allows students to be creative in how a piece is constructed. It also allows them to have a personal connection to the material they are learning about. They are also critically thinking when they take the newly-learned information about the art and decide how to interpret that in a digital format. This could even be taken a step further into technology by having students “sell their art.” They could collect information on the cost of different artworks in their style, and log it into programs like Microsoft Excel, Students could even calculate the average selling price their artwork by using functions in the software.

Students participating in this lesson will not only learn aspects of art history, they will also learn advertising skills like creating a website. When students pursue higher education, oftentimes they will need to create a portfolio or presentation of their work in a website or other

nontraditional presentation format. Oftentimes, these skills are not taught in schools. By teaching students how to have an understanding of the building of a website at a younger age, we are better preparing them for future education experiences. This lesson also ties in social media that students use daily. This teaches that social media can be used for educational purposes, as well as makes a connection from curriculum to personal interests. Students develop a more meaningful connection to the material, therefore allowing them to have a more memorable learning experience.

Below are two rubrics stating how this lesson would be evaluated. The first rubric evaluates the artwork itself, while the second rubric evaluates the website. The artwork should not be judged based off of an individual's artistic talent. The grade should be given based on the students ability to understand the art style they have chosen and ability to represent that in their artwork. The website should be graded on its content, containing the elements laid out in the rubric. If the website has the elements laid out in the rubric, it accurately assesses the knowledge gained from the lesson based on what the knowledge the student produces within their website.

Creations Meets Computers: The Website

Teacher Name: **Ms. Floerke**

Student Name: _____

CATEGORY	4	3	2	1
Home Tab	The Home Tab contains 4 of the following 4 aspects: (1) the name of the student artwork, (2) pictures that relate to the topic or art style studied, (3) the type art	The Home Tab contains 3 of the following 4 aspects: (1) the name of the student artwork, (2) pictures that relate to the topic or art style studied, (3) the	The Home Tab contains 2 of the following 4 aspects: (1) the name of the student artwork, (2) pictures that relate to the topic or art style	The Home Tab contains 1 of the following 4 aspects: (1) the name of the student artwork, (2) pictures that relate to the topic or art style studied, (3) the type art
About Tab	The About Tab contains both a picture of the student artwork and a biography from the point of view of the artwork. The biography states an accurate	The About Tab contains both a picture of the student artwork and a biography from the point of view of the artwork. Either the biography DOES NOT state	The About Tab contains both a picture of the student artwork and a biography from the point of view of the artwork. The biography	The About Tab is missing both a picture of the student artwork and a biography from the point
Like Me Tab	The Like Me Tab contains at least 4 pictures of artworks from the same era and style of art. Each painting is identified by title and artist.	The Like Me Tab contains at 3 pictures of artworks from the same era and style of art. Each painting is identified by title and artist.	The Like Me Tab contains at 1-2 pictures of artworks from the same era and style of art. Each painting is identified by title and artist.	The Like Me Tab DOES NOT contain any pictures of artworks from the same era and style of art.
Social Media Tab	The Social Media tab contains at least 3 tweets or facebook messenger chats are on the website. Each post is classroom appropriate, contains the artwork name, contains a historically accurate date, as well as shows insight to artwork\'s personality as described in the biography.	The Social Media tab contains at least 3 tweets or facebook messenger chats are on the website. Each post is classroom appropriate, contains the artwork name, and SOME posts contains a historically accurate date, and somewhat shows insight to artwork\'s personality as described in the biography.	The Social Media tab contains at least 2 tweets or facebook messenger chats are on the website. Posts are still classroom appropriate, but are missing the artwork name and historically accurate date, and show little insight to artwork\'s personality as described in the biography.	The Social Media tab contains less than 2 tweets or facebook messenger chats are on the website. Posts are NOT classroom appropriate, missing a historically accurate date, and DO NOT show insight to artwork\'s personality as described in the biography.

Date Created: **Dec 07, 2021 09:39 pm (CST)**

Creations meet Computers: The Artwork

Teacher Name: **Ms. Floerke**

Student Name: _____

CATEGORY	4	3	2	1
Recognition of Work	Student can accurately name 4 works and their artists in the style they have chosen.	Student can accurately name 2 works and their artists in the style they have chosen.	Student can either accurately name and describe at least 2 works OR accurately name 2 artists in the style they have chosen.	Student is not able to name or describe any works or any artists in the art style they have chosen.
Reflection of Art Style	Student can give multiple reasons for choosing techniques, materials, colors, or other aspects to create their piece. The artwork clearly shows connection and understanding of the art style	Student can give some reasons for choosing techniques, materials, colors, or other aspects to create their piece, showing loose connection and understanding of the art style studied.	Student struggles to give reasons for choosing techniques, materials, colors, or other aspects to create their piece, indicating a lack connection and understanding of the art style studied.	Student cannot describe connection between the content of their piece the art style studied.
Time/Effort	Class time was used wisely. Much time and effort went into the planning and design of the artwork. It is clear the student put their best effort into their piece.	Class time was used wisely. Student could have put in more time and effort into their piece.	Class time was not always used wisely, but student did put some effort into their piece.	Class time was not used wisely and the student put in no additional effort.

Date Created: **Dec 07, 2021 08:33 pm (CST)**

Figure 12. Both Creations meet Computers Art and Website Rubrics.

Simple Ma-scenes: Combining Engineering and Theater

A major concept of engineering is the design and building of structures and machines that make aspects of life easier. Many examples of this can be seen in our daily lives. As these tools are often taken for granted, students can learn to better recognize the machines that enhance their everyday activities. Through this lesson students will learn to build their own machines, and incorporate them into a skit. Students will exhibit critical thinking by constructing their machines through unconventional materials, and will show creativity by conceptualizing a scene in which to use the machines.

Necessary Prior Knowledge:

1. Simple Machines: There are six simple machines that must be taught prior to the lesson. Simple machines are, according to Encyclopedia Britannica "any of several devices with few or no moving parts that are used to modify motion and the magnitude of a force in order to perform work" (Editors of Encyclopaedia Britannica)**.** The following definitions of the simple machines are all adapted from Britannica.
    a. Pulley- Similar to a wheel an axel, a pulley is a wheel with a cord on its rim. This chord allows it to change the force direction in order to lift heavy objects.
    b. Lever- A lever is a bar that sits atop a fulcrum used to lift heavy weights. By placing a heavier object or stronger force at one end of the lever, the other end may be lifted.
    c. Wheel and Axle- Consisting of a circular frame revolving around a rod, a wheel an axel allows for greater amounts of weight to be raise or moved.

d. Wedge- A wedge is often used to split or tighten an object by using its tapered edge to move force in a sideways direction.

e. Inclined Plane- An incline plane is a sloped surface used to lessen the amount of force to raise a heavy object.

f. Screw- Screws are often cylindrical objects that are twisted into another material primarily for fastening.

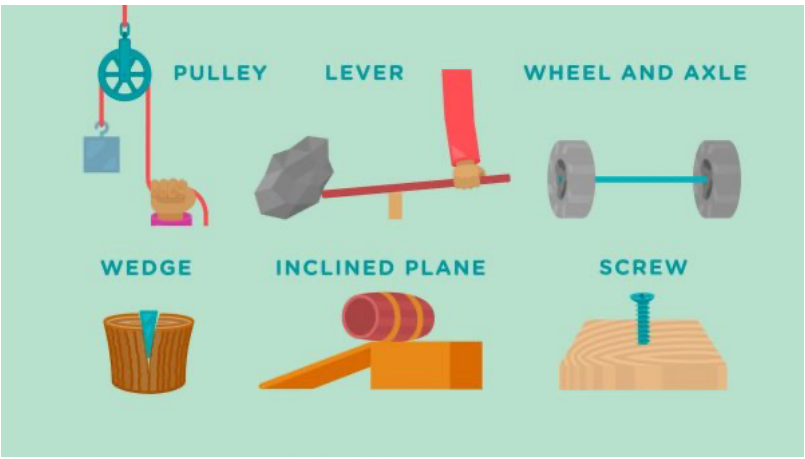


Figure 13. Image of the six basic types of simple machines (Genius Generation).

For this lesson, students will build their own simple machines using the list of materials that will be provided by the teacher. Materials may include, but are not limited to, items such as:

- plastic cups/paper cups
- paper plates, pencils
- yarn
- building blocks
- decks of cards
- paper
- water bottles
- jars with lids
- glue, tape
- paper
- paper towel/toilet paper rollers
- tissue boxes
- scissors
- shoe boxes

- chopsticks, skewers
- PVC pipe
- tinker toys

Similar to the art in technology lesson, students have creative control in this assignment, but there are criteria that they must meet. Students will be split into groups of four to six students to guild their simple machines. There are only two criteria for this lesson. First, each group must build at least four of the six simple machines using household items provided in the classroom. Second, after constructing these machines, students will write a three-to-seven-minute skit that incorporates their simple machines in a way that makes sense in the context of the scene. The skit may be about anything that they desire—albeit must be classroom appropriate—and each student should have a role within the scene. However, the scene should not be a tutorial on how to use simple machines. The way in which the machines are incorporated should be relevant to the story of the scene. Below is a sample scene with the list of simple machines and descriptions provided.

<u>Simple Machines:</u>

- Simple machine 1: pulley- using a string and empty soup cans that are attached to the corners of a PVC pipe arch. A pully will lift a sheet of paper, simulating lifting blinds on a window.
- Simple machine 2: lever- chopsticks can be a lever when they are squeezed
- Simple machine 3: wheel and axle-. A shoebox will have two toilet paper rollers on the bottom. Skewers will go through the hole of the rollers, and one paper plate will be on each of the ends of the skewers. This will make a cart that will roll.

- Simple machine 4: screw- inside the box, there's a water bottle with sticky notes in it. The lid of the water bottle cap acts as a screw that keeps the notes inside.

Roles

Student 1: Tyler

Student 2: Jessie

Student 3: Alex

Student 4: Mom

[actions]

Scene

[Starts with Tyler lying on the ground sleeping. Jessie and Alex are both using chop sticks to pick up sleeping Tyler's hair, laughing as they do not wake up]

[Mom enters the scene and sees both children pulling a prank]

Mom: Alex! Jessie! What do you think you're doing?

[Tyler wakes up]

Jessie: MO-Om! It was going so well They didn't even notice.

Tyler: What are you guys doing in here?! I was TRYING to sleep!

Mom: Why would you want to sleep today? It's going to be such a good day! I mean it's not EVERY DAY you get to turn 13!

Tyler: What?

Alex: Did you really forget it was your birthday, stupid?

Mom: Hey, be nice.

Alex: What? Just because he's older doesn't mean he's still not stupid.

Mom: You go get out of here. [Alex exits] Tyler, honey. It IS your birthday! You're finally a teenager. Aren't you excited?

Tyler: … [Tyler turns around to fall back asleep on his other side]

Mom: Well come on now, it's time to get up. You still have to go to school today. The sunrise is pretty this morning. You should see it! A beautiful way to start your day.

[Mom uses the pulley to pull up the blinds made of soup cans and paper]

Jessie: Mom, I'm still tired and that's super bright.

Mom: The sun is bright, Jessie. Get used to it. Look I have to go make your special birthday breakfast. But you only get it if you get up and go to school. [Mom leaves the room]

Jessie: [Jessie starts to leave the room with mom, but then turns back to Tyler] Are you okay bro?

Tyler: [tyler speaks muffled with his head in his pillow] I'm fine. Go away.

Jessie: Why are you lying?

Tyler: I'm not Jess. Go away.

Jessie: Yes you are. I know you're lying when you don't look at me.

Tyler: [Tyler jolts up and yells] I SAID I'M FINE, OKAY? NOW GET OUT OF MY ROOM!

Jessie: Dang. Someone woke up on the wrong side of the bed this morning. Sor-rY. [Jessie starts to leave]

Tyler: Wait. [Jessie stops] Look I'm sorry. I just don't want to be thirteen.

Jessie: [Comes back in the room] Why not?

Tyler: I… I don't know. It just seems stressful. I am going to go to high school next year and I'm scared. I'll be the youngest one in my grade. I won't know anybody. I'm a loser. I can't be a kid

anymore. I don't know who to talk to about it. You and Alex are both younger than me. Now Mom says I have to be a good example. I don't want to let you down and I'm scared I will.

Jessie: You won't do that. You're a good big brother. And hey, I'm not far behind you. I know Alex is 3nd grade, but I'm in 6th. Eventually we'll be in high school together.

Tyler: That sucks.

Jessie: Why?

Tyler: Not only am I going to be the weird kid, but then I'll be the weird kid with the even weirder little sibling.

Jessie: What if I'm the *cooler* sibling?

Tyler: Great. That makes me feel SO much better.

Jessie: Look Tyler. I think it's time you get your birthday gift from me and Alex.

Tyler: Is it like last year's gift where you guys wrapped up one of my old shirts and said you got me a brand-new shirt even though I wore it 3 days before that?

Jessie: No. But that was a good one. Hold on. [jessie Shouts down the pretend hallway] ALEXXXXXX! BRING THE GIFTTTTT!

[Alex walks in pushing a make-shift cart with an old T shirt covering an object on top of it.]

Alex: Ta-DA!

Tyler: Why is it on a cart?

Alex: For dramatic effect!

Tyler: Do you even know what that means?

Alex: No. Jessie told me to say it.

Tyler: [Tyler takes the covering off the gift and sees a plastic water bottle with a bunch of folded up sticky notes in it. A note on the outside of the bottle says "To Tyler."] What's this?

Jessie: Well. I could tell that you were upset about something last week. I didn't know this was it. But I wanted to remind you that you are a great brother. So Alex and I made a bunch of little notes reminding you why you're a great brother. I guess the gift had good timing. Just take one out and read it when you are sad.

Tyler: Thanks guys. Love you both. [They all give awkward fist bumps]

Mom: [Mom yells from the edge of the room] BIRTHDAY PANCAKES ARE READY!

Tyler: Come on. Let's go to school. [all three exit]

[The End]

Implications

This lesson is extremely versatile and could be taken in further directions. Students will have to critically think about the materials they have been given in order to construct a simple machine of their own. By requiring students to do only four of the simple machines, pressure is taken off of them. This also allows for diverse results to occur. One group of students may make an inclined plane out of different materials than another group of students. This also allows students to test the designs of their products before demonstrating them in a skit. Much of engineering deals with building prototypes and trial and error processes. Students are testing the effectiveness their simple machines just as civil engineers test bridges for weight capacity.

The theater aspect of this lesson encourages student collaboration and confidence. The ability to speak in front of an audience and convey a message can be very beneficial for communication skills. Theater is an enjoyable and safe way to both teach and entertain. When students use creativity to brainstorm plotlines for their short skits, they are applying what they have learned to concepts they already know or express interest in. This lesson could be taken further by allowing students to compare their skits to different scenes in movies. Students could

observe different simple machines that are used by the actors in movies they have already established a connection with. Engineering can be seen in the world around them as well as in fictional settings. It is important that students recognize that the engineering aspects of designing, testing, and manufacturing solutions can be seen all around them.

Below is a rubric stating how this lesson would be evaluated. Some students will be better writers than others. This lesson should be graded on the student's ability to create functioning simple machines with the materials provided. This lesson should also take into account how the machines fit within the context of the student's skit. Grading them on contextualizing their work incorporates the understanding of providing context in a theatrical production.

Simple Ma-scenes Grading Rubric				
Teacher Name: **Ms. Floerke** Student Name: _____				
CATEGORY	4	3	2	1
Number of Simple Machines Used	Student uses 4 simple machine props that show considerable work/creativity and which make the	Student uses 3 simple machine props that show considerable work/creativity and which make the	Student uses 2 simple machine props that show considerable work/creativity and which make the	Student uses only simple machine prop that show considerable work/creativity and
Machines in Context	Each of the 4 machines in the skit had a function and clearly fit into the context some aspect	Most of the 4 machines in the skit had a function and clearly fit into the context of some	The majority of the 4 machines in the skit DID NOT clearly fit into the context of some aspect of the	The implementation of the machines seemed incomplete or chaotic with no clear plan. They were
Construction and Function of Machines	Great care taken in construction process so that all machines are neat, attractive and function properly	Construction was careful and accurate for the most part, but 1-2 machines could have been refined for	Construction accurately followed the plans, but 3-4 machines could have been refined for a	Construction appears careless or haphazard. Many details need refinement for a strong or functional
Collaboration with Peers	Almost always listens to, shares with, and supports the efforts of others in the group. Tries to keep people	Usually listens to, shares with, and supports the efforts of others in the group. Does not cause	Often listens to, shares with, and supports the efforts of others in the group but sometimes is not	Rarely listens to, shares with, and supports the efforts of others in the group. Often is not a good
Time-Limit	Presentation is 3-7 minutes long.	Presentation is 2.5-3 minutes OR 7-7.5 minutes long.	Presentation is 2-2.5 minutes OR 7.5-8 minutes long.	Presentation is less than 2 minutes OR more than 8 minutes.
Date Created: **Dec 07, 2021 07:33 pm (CST)**				

Figure 14. Simple Ma-scenes Grading Rubric

Coordi-notes: Combining Mathematics and Music

One lesson to combine mathematics and music is by comparing music notes to points on a graph. By fifth grade, students should be able to plot points on a Cartesian grid, as this is written in fifth grade standards. By sixth grade, students should be learning how to solve equations and expressions with the variables in them.

Necessary Prior Music Knowledge:

1. Basic note values:
    a. whole note- accounts for four beats in one measure of 4/4 time signature
    b. half note- accounts for two beats in one measure of 4/4 time signature
    c. quarter note- accounts for one beat in one measure of 4/4 time signature
    d. eighth note- accounts for ½ of a beat in one measure of 4/4 time signature
2. Basic rest values:
    a. whole rest- accounts for four beats in one measure of 4/4 time signature
    b. half rest- accounts for two beats in one measure of 4/4 time signature
    c. quarter rest- accounts for one beat in one measure of 4/4 time signature
    d. eighth rest- accounts for ½ of a beat in one measure of 4/4 time signature
3. Measures: sometimes referred to as a bar, a measure is a specific amount of beats played that is determined by the time signature.
4. Time Signature: represented by a one number placed on top of another, a time signature indicates how many beats are in a measure, as well as the value of each beat. Here are three examples:
    a. 4/4 time would indicate that there are four (top number) quarter notes (bottom number) can fit in one measure.

b. 3/4 time would indicate that there are three (top number) quarter notes (bottom number) that can fit in one measure.

c. 6/8 time would indicate that there are six (top number) eighth notes (bottom number) that can fit in one measure.

Start the lesson by showing students a simple equation to solve for "X". After students of solve for "X", Emphasize that **variables have value an equation**, that they are worth a certain number.

Next, show students the following four different types of musical notes.

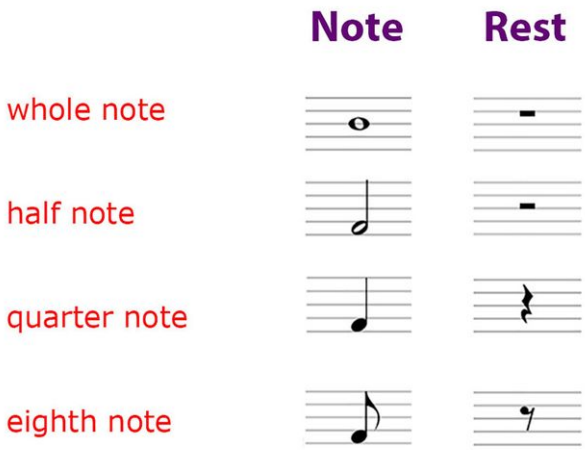


Figure 15. Music note names and symbols are detailed above (Pinterest).

The teacher should explain what each note looks like as well as how many beats each note accounts for. Then compare the fact that like variables that have value in an equation, Music notes have value within a measure.

Next, the teacher should show a simple coordinate system. Using this system, the teacher can explain that the left-right distance determines the x-value, while the up-down distance determines the y-value. After reexplaining these terms, a teacher may show a music staff. The number of beats that have passed in a piece of music will determine how far left or right the note

is. The note name will determine how far up or down. After explaining these relationships, overlay the Cartesian graph over the music staff. This will show the relationship between the x-coordinate and beat, as well as the y-coordinate and note name. Major vertical gridlines will account for one beat. However, horizontal gridlines will account for two notes. Since each line and space corresponds to a different note on the staff, each note will be 0.5 units away from one another.

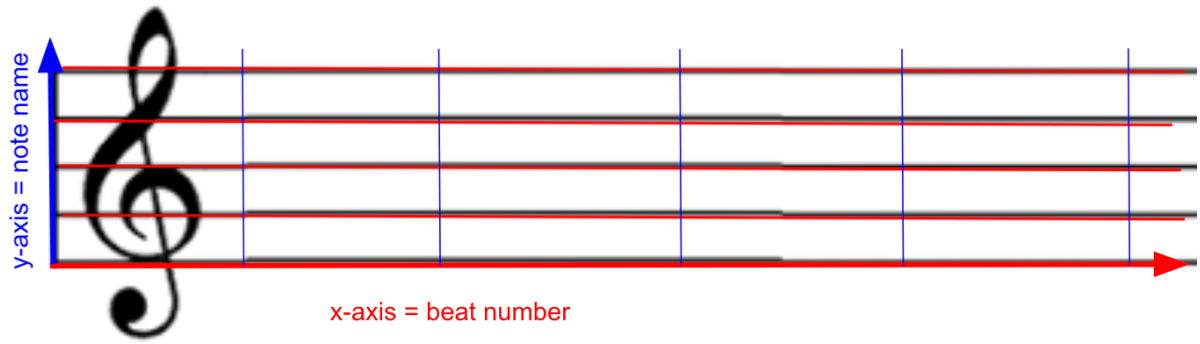


Figure 16. An x-y coordinate grid can be overlaid on a music staff to show similarities in graphing and music notation. The red lines indicate the note name, and the blue vertical lines indicate the beat number. This is inspired by an image in "An Exploration of the Relationship between Mathematics and Music" (Shah 2010).

The next exercise will teach students to "graph" music notes by using their knowledge of music they had just gained. Students should receive handouts of the rest and note values that have been taught, as well as an image identifying different note names.

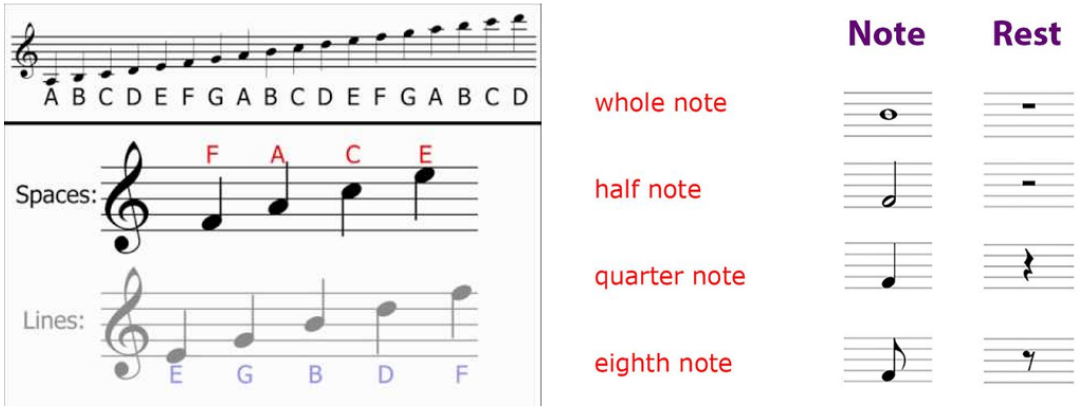


Figure 17. Image would potentially be used as a handout during the lesson. The image on the left details the letter names and position of notes (Youtube/musictheoryguy). *The image on the right is the same as Figure 12.*

Students will be able to identify coordinates of different notes on a staff, just as they would as if they were graphing standard ordered pairs.

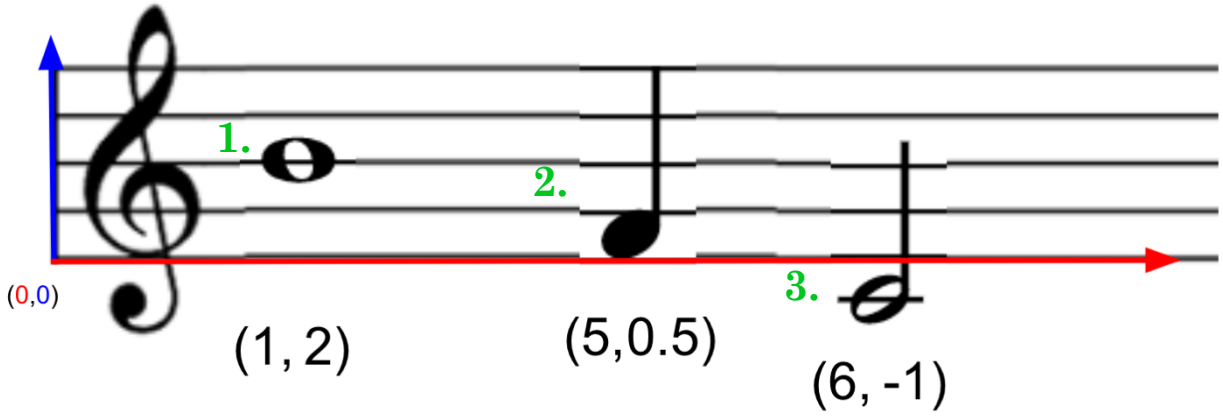


Figure 18. A set of three sample problems for the math and music lesson with answers below each note.

In order to determine the coordinates of the first example note, students will need to identify which beat number the note is on, as well as which line. Indicate that the origin of this "graph" is the bottom left corner of the staff. The bottommost line on the staff is y = 0.

To start, students should identify the coordinates of note **"1."**. Note **"1."** starts on the first beat, so its x-coordinate would equal one. The note is also two lines up the staff, so the y-coordinate would equal 2. This would mean that the ordered pair for note **1.** is (1,2). Second, students will identify the coordinates of note **"2."**. Note **2.** starts on beat number 5. Since note **1.** accounts for 4 whole beats, the next note would start on beat five, indicating that the x-coordinate would equal 5. Note **2.** is one space up the staff. Each line accounts for two notes and each line is worth one. This would mean that one space on the graph stands for 0.5. The y-coordinate, in this case, would equal 0.5. This would mean that the ordered pair for note **2.** is (5,0.5). The last sample problem has students identify the coordinates of note **"3."**. Note **3.** starts on beat number 6. Since note **1.** accounts for 4 whole beats, and note **2.** accounts for one whole beat, the next note would start on beat six, indicating that the x-coordinate would equal 6. Note **3.** is one line below the staff. Since the bottom line represents y = 0, one line below the staff would call for the y-coordinate equaling -1. Taking this information, the ordered pair for note **3.** is (6,-1).

After completing the three sample problems with teacher assistance, students would now work solo or in groups (whichever is most conducive to the specific learning environment) to find the coordinates of each note in a song.

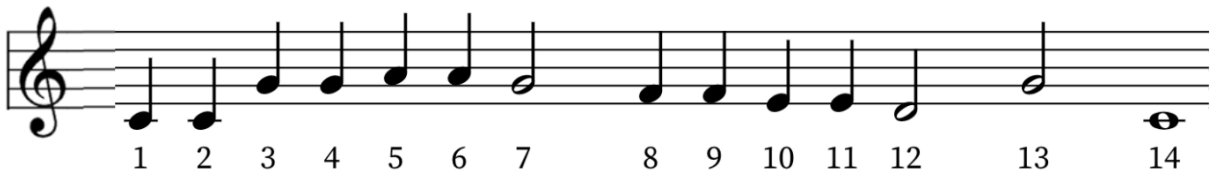


Figure 19. A set of 14 sample problems for the math and music lesson.

It is important to take into consideration the lack of time signature. Instead of starting each measure over, make the songs one long measure. On a music staff, each measure mark indicates a new set of beats. By neglecting measures, students will not be confused by beat number for x-coordinates.

The song above shows a variation of "Twinkle Twinkle, Little Star." Repeating the exercise in the warmups, students will name the coordinates of each note in the song by identifying beat numbers and location on staff. Students will also use the handouts given to correctly identify the note name for each note. Lastly, students will name the note value (ex. whole, half, quarter) for each note present. Answers to the song above are the following:

1. (1,-1), C, quarter
2. (2,-1), C, quarter
3. (3, 1), G, quarter
4. (4, 1), G, quarter
5. (5, 1.5), A, quarter
6. (6, 1.5), A, quarter
7. (7, 1), G, half
8. (9, 0.5), F, quarter
9. (10, 0.5), F, quarter
10. (11, 0), E, quarter
11. (12, 0), E, quarter
12. (13, -0.5), D, half
13. (15, 1), G, half
14. (17, -1), C, whole

Implications and Evaluation

This lesson could be taken another step by providing coordinates and assigning students to notate a song based on the coordinates given. Students could also find sheet music for the melody a short song that they know and find the coordinates to that song. This concept could also be used to teach slope-intercept for by graphing ascending and descending scales on a graph.

By teaching this lesson, students who do not understand math may understand an aspect of math by their knowledge of music. This also allows students to think critically about the music they listen to, relating the melodies they hear in songs to math they are learning in class. From a music perspective, this allows students to learn and practice the needed skill of counting when reading music. In order for notes to be played at the right time, students must have an understanding of the value of each note type, as well as consistency of music notes. This helps students who are arts-minded understand aspects of math, as well as helps math-minded students have a deeper appreciation for music.

Below is a rubric stating how this lesson would be evaluated. The grade scale assesses students' ability to recognize notes on a staff, to count note values in a song, and to accurately graph ordered pairs.

Coordi-notes Rubric

Teacher Name: **Ms. Floerke**

Student Name: _____

CATEGORY	4	3	2	1
Accuracy of Ordered Pairs	All ordered pairs are written in (__,__) notation and correctly paired with the corresponding notes in the song.	Most ordered pairs are written in (__,__) notation and correctly paired with the corresponding notes in the song, with the exception of 1 or 2.	Ordered pairs are NOT written in (__,__) notation, but are correctly paired with the corresponding notes in the song.	Ordered pairs are NOT written in (__,__) notation, and are NOT correctly paired with the corresponding notes in the song.
Accuracy of Note Names	All note names are correctly labeled and corresponding to the notes in the song.	Most note names are correctly labeled and corresponding to the notes in the song with the exception of 1 or 2.	Some note names are correctly labeled and corresponding to the notes in the song, with more than 2 and less than 8 being incorrect.	Majority of notes are NOT correctly labeled and corresponding to the notes in the song, with more than 8 being incorrect.
Accuracy of Note Values	All note values are correctly identified for each of the corresponding notes in the song.	Most note values are correctly identified for each of the corresponding notes in the song, with the exception of 1 or 2.	Some note values are correctly identified for each of the corresponding notes in the song, with more than 2 and less than 8 being incorrect.	Majority of note values are NOT correctly identified for each of the corresponding notes in the song, with more than 8 being incorrect.

Date Created: **Dec 07, 2021 06:20 pm (CST)**

Figure 20. Coordi-notes Grading Rubric

Conclusions

Education with focus on the original STEM disciplines dates back to the country's founding, and acts such as the Morril Act and NDEA have increased momentum for the subjects in question. As technology advanced in the past, it is continuing to advance in the future. Teachers must be willing to adapt to changing times in the ways the approach their material, teaching strategies, and students as well. STEM was the past, but STEAM is the new frontier for education. It should be emphasized that STEAM is successor of STEM, and has been made only to add onto STEM education, not detract from it. Adding the arts does not time away for the original four facets, but enhances their assets. Though STEM has its benefits, STEM alone was not reaching the needs of all students. Many students who do not think in a way that is commonly referred to as a "left-brained dominant" are not currently receiving the benefits that science, technology, engineering, and math education have to offer simply because the manner in which they are taught is not suitable for them. As teachers, we cannot exclude an entire learning style of students. On top of that, teachers can use STEAM to encourage more women to pursue their STEM interests that are evident at a young age. The arts call for an inclusive material, which can help eliminate potential bias, allowing more young women to feel confident in their academic capabilities. Integrating the arts in STEM will help us bridge the gaps between these groups of students that are pushed aside from STEM education. Through STEAM, student who may have been slightly interested in STEM can be encouraged to follow their passion, and students who are not interested in STEM-related futures will still reap the benefits such as critical thinking and creativity through participating in engaging STEAM lessons.

As stated before, these lessons were not conducted in physical classrooms due to the widespread COVID-19 pandemic. In my opinion though, this only leaves room for the lessons to

grow. My hope is that teachers read these lesson plans and expand upon them further since I was unable to do so myself. The lessons I have written draw from scientific, engineering, mathematical, and technological knowledge in a way that incorporates the art without taking away from the STEM material being presented.

Teachers bear one of the most difficult tasks of any profession by preparing students to find answers with means that do not yet exist to problems that the world has never faced. The arts encourage creativity, and critical thinking skills in both arts-minded and STEM-minded students. The STEAM lessons in this paper reach broad audiences of students through engaging, student-centered, and entertaining lessons with principles that can be applied outside of its intended middle school audience. The arts help people understand emotion, relationships, structure, all in different ways. The arts without ideas within STEM principals are incomplete, and STEM without creativity is complacency. Without modifying the original STEM disciplines, less students will pursue STEAM, which will decrease the amount of people working in associated fields. This will slow down societal progress as well as potentially cause for more unemployment. Using lessons that integrate the ideas of STEAM will inspire students to pursue more STEAM careers; for the students that choose not to follow a STEAM path, the techniques that have been taught in these lessons can be applicable to everyday life. In order to foster passions of all students, we must include the arts in STEM, and STEM in the arts.

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