

Arts Integration in STEM



How can the arts illuminate the STEM field, or the other way around?

As a biology, engineering, and geometry teacher at a public arts school in Boston, I explore this question daily. In fact, we math and science teachers at Boston Arts Academy call ourselves the STEAM team, which stands for—you guessed it—science, technology, engineering, arts, and math. Many people might wonder why teachers would bother integrating the arts with STEM. I do, too, especially when we've seen so few examples of deep arts integration in education. After all, how much does a student really get out of making a pretty poster or reciting a rhyme?

As an artist at heart, however, these questions percolate a little longer in my mind. I like to ask, how could a dancer interpret fractals, or a musician explain

Pascal's Law? Designing curriculum with these cross-disciplinary connections is not as foreign as it sounds! I use the arts to tackle challenges that all teachers face, such as student engagement, differentiating for all learners, and teaching collaboration skills in project-based environments. Any teacher can use these arts integration strategies!

Increasing student engagement

One way I've successfully engaged my biology students in claim-evidence-reasoning practice is through mock patient interviews at the end of our neurology unit. Properly scaffolded, students get to demonstrate their understanding of neurological disorders through theatrical expression. For example, as student-physicians, they practice questioning patients, gathering evidence, and defending their diagnoses (see Figure 1). As student-patients, they figure out how to coherently express symptoms of a neurological disorder, such as retrograde or anterograde amnesia, aphasia, or prosopagnosia.

this day as a way to show me how much they have learned about the brain, and they get to express their learning creatively! I sit amongst the physicians as patients enter our office one by one. Students acting as patients take a seat in the center of our classroom, where all physicians have access to question and perform tests on them. I only occasionally facilitate with questions if the dialogue needs a bit of a push in a certain direction.

Preparation for Patient Interviews

Instructions: Write a piece that expresses a day in the life of this patient. First, choose a neurological disorder that this person lives with. Address these two questions:

1. What would it be like to wake up and do their morning routine? What would it be like to navigate complex social situations, such as the first day of school?
2. Imagine them visiting the doctor's office for the first time; what would they say? What questions might the doctor ask?

You may choose any of the following formats:

Journal entry	Patient interview script	Dialogue	Comic strip
Storyboard	Movie script	Monologue	Short story

Figure 2. The night before mock patient interviews, students complete an assignment that prepares them to represent a patient empathetically and accurately.

One challenge with brain disorders is distinguishing one from another. For example, a person diagnosed with anterograde amnesia is unable to form new memories, while a person diagnosed with prosopagnosia has trouble recognizing faces. Complex questions arise, such as: if a patient does not recognize you, is it because they don't remember your face, or they don't remember having met you at all? In these cases, I prod the students to ask ever-more specific questions or perform cognitive tests on the patient. I have seen my students ask patients to draw an image on the board from memory, or even pull in other students to test a patient's facial recognition abilities. It is great fun to see what they come up with to test and rule out diagnoses!

Differentiating for all learners

Another great teaching challenge that I address with arts integration is differentiating for all students in a heterogeneous learning environment. I have found that arts integration is especially powerful for learning when it is coupled with student choice (see Figure 3). When given options in their learning, students can engage with the material on their own terms. You can think of this as the ‘low threshold’ in the phrase ‘low threshold high ceiling’ commonly used amongst math teachers.

Mini Project options: (about 1 hour each)	Full project options: (about 2-4 hours)
<i>Make a Kahoot quiz.</i> 20 questions minimum	<i>Make a film of transformations.</i> Can be a YouTube lesson that you teach. Can be a news anchor interviewing the different transformations. Can be a stop-motion animation of transformations – try the app “Stop Motion Studio”
<i>Annotate an existing dance with its transformations.</i> Find a dance on YouTube, then, describe in what sequence transformations are used.	<i>Make a choreographed dance.</i> Perform or film it. Include subtitles for extra credit.
<i>Take pictures of transformations/tessellations you see in everyday life and in nature.</i> Create a film or slideshow of these images.	<i>Create a transformations board game.</i> Must include playing pieces and instruction manual.
<i>Create tessellation artwork.</i> Expect to spend 1-2 hours on it; include color.	<i>Compose and perform a song</i> You may also film the song
<i>Create a comic explaining the transformations.</i> Use a site like www.bitstrips.com .	

Figure 3. Students choose a combination of projects to demonstrate their understanding of the geometric transformations. They may choose two mini-projects or one full project.

For example, at the beginning of the geometric transformations unit, I let students decide how they wanted to demonstrate their understanding. Dancers interpret dilations, translations, reflections, and rotations in short choreographed pieces. Visual artists illustrate these four concepts with captioned comics (see Figure 4). Musicians wax poetic about the geometric transformations. However the ideas are expressed, each student engages in the same material but in very different modes. As you might imagine, creating rubrics for each of these projects

would be a total time drain. So I don't sweat it. The purpose of these options is for students to demonstrate a conceptual understanding of the transformations—not the technical details of how to execute them on paper, which I might assess with a traditional paper-and-pencil quiz. Through these projects, students can therefore meet the material on their own terms. When projects are due, we also get to build community by presenting and appreciating each other's work!

Reflection

*Reflection is taking a shape and moving it completely opposite.
Like looking in a mirror, or in this case, twins.
The shape keeps its size and form, but faces the opposite way to
the original*



Figure 4. A freshman uses her visual arts skills to illustrate 'reflection.'

Teaching students to work together on complex projects

Another great pedagogical challenge: how do we teach students to work together on complex tasks? Many of us choose to assign students to specific lab roles such as recorder, materials manager, reporter, and so on. I have seen teachers take this scaffold a step further with group contracts. These strategies are useful and, I believe, necessary for some class assignments like time-sensitive labs. However, they can also stifle organic interactions by taking important decision-making opportunities out of students' hands.

One answer I've developed to this dilemma is through my biology students' "Central Dogma Choreography" project. I give students one week to create a three to five minute film that represents the flow of cellular information from DNA to RNA to protein. The week's work serves as both a learning activity and summative assessment, since students have to identify and fix any misconceptions that arise throughout the choreographing process. In order to encourage complex group work, I add an additional challenge to the mix: students must work together as a class to produce just one film.

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When I introduce these parameters, hands immediately shoot up. Will we want narration? What about music? Who is going to act, and how will we physically represent DNA, the nucleus, transcription and translation on film? I allow students time to brainstorm their vision individually and then share out as a class (see Figure 5). Once those ideas start to congeal, other problems arise: who's on props? How can we synchronise our choreography and music if they will be recorded separately? I let these questions pop up organically, just to the point where students are interested, but don't have all the answers yet. When given a good balance of scaffolding and artistic freedom (more on scaffolding below), my students tackle the challenge with great zest! I think the most important part for them to understand is that they need each other to succeed, and that each person will and is expected to contribute a valuable skill. I therefore make sure students spend time thinking about how they envision themselves contributing to the project, and have them share these ideas publicly.

Central Dogma planning

Name:

<i>Item/Notes</i>	<i>To do/when</i>	<i>Who's on it?</i>
Equipment – cameras? Microphone?		
Setting – out/inside?		
Props – ??		
Choreography (general overview)– ??		
Narrator – ??		

Do Now: How do you envision using your ART in our DNA choreography project? How can you contribute your artistic talent?

Visual Arts

Music

Dance

Theater

Figure 5. Students brainstorm their project visions and potential contributions.

Some people might be wondering at this point how we avoid a situation where a only few students are doing all the work. With this in mind, I give students a set of options to work from, and ask them to envision how their choice would make the class's product come together (Figure 5). Some students may step up as directors and choreographers, while others choose to record music or write lyrics. Others feel more comfortable behind the scenes with props. Whatever their role, they have chosen it and have time to think about how their contribution is essential to the project.

Our extended debriefing process is central to making this week work. I need all students to be on the same page when we discuss our progress, contributions, and expectations each day. There are three main strategies I use to ensure students are ready to work the moment they enter class. First, I set aside time

each day for students to think about and articulate their design decisions with each other. At the beginning of each class, students look at the calendar of remaining days along with a list of potential tasks (see Figure 6). The 'Do Now' assignment is to write in the tasks they want to prioritize for the following days. We spend the first 20 minutes of class setting goals and organizing roles, which is facilitated by their Do Now (see Figure 6). My second strategy is to have student leaders facilitate these class debriefs. When students lead their peers, it creates an environment where peers start holding each other accountable. Finally, I require student debrief sessions to start with shout-outs to each other. This sets a positive tone before we get into nitty-gritty details of what needs to be done as the deadline looms. Through this extended debrief process, students practice listening to each other and compromising on important decisions.

I've actually been surprised to see that the theater students don't necessarily demand to direct or act in the film. While they are willing to take on these roles, I have been pleased to see people step up and step back as they negotiate their responsibilities with each other. This past year, a trio of directors emerged: a musician, a thespian, and a dancer. A visual artist worked on the voiceover narration, and the rest of the students fell into filming, props, music recording, and editing.

I always stop the students' work 20 minutes before class ends for clean-up and a whole-class debrief. This student-led discussion is intended to figure out what adjustments will need to be made. With the deadline looming and idea implementation in full swing, students learn accountability, complex task management, and cooperation skills.

Final Project Calendar

Do Now: Use the calendar below to figure out and fill in *what* we need to do and *when*.

Today (80 mins)	Wednesday (105 mins)	Thursday (80 mins)
Tonight	Wednesday night	

Some reminders: PowerPoint Upload to YouTube Record Narration
 Film Translation Stitch scenes together (edit video) Record music?
 Edit narration and music over video

Figure 6. Students prioritize the work they think should be done that day in a blank calendar. I modify the reminders on the bottom based on their previous day's accomplishments and their stated goals.

Yes but...how?

I can imagine a few readers wringing their hands at this point. No rubric? Letting students run the show for a whole week? What if the patient interviews get derailed with irrelevant questions or overly exuberant acting? As you might imagine, integrating arts into academics asks teachers to relinquish some control over their classrooms. This is scary. As a type-A planner, I get it. There are days when I fret over how to manage the creative process—are they goofing off, or do they just need space to think outside the box? Or, are these two processes in fact mutually exclusive? The reality is that there are days when I don't think explicitly about big STEAM projects because I need to focus on standardized testing. For me, though, the risks are totally worth it. My goal is to use the arts to improve

my teaching in three ways: increasing student engagement, differentiating for multiple learning abilities, and teaching team-work skills. In fact, I feel that I am just scratching the surface of STEAM teaching. There are endless directions I could explore. For example, I could use common language with the arts faculty to teach growth mindset. In some ways, it is easier for students to track their own growth over time in their arts practice. How, then, can I help students recognize that their growth is not limited to the arts, but is present in whatever they choose to practice?

So far, I have used the arts as a currency to engage my students in math and science. Another STEAM avenue to explore is how and when to apply scientific thinking to the arts. I wonder what might happen if STEM skills cross-pollinated the arts world. What kinds of design connections could students make if we asked them to think like engineers when creating an arts piece? Or could students use their arts to take a stance on public issues, such as urban planning, genetic engineering, and space exploration? With STEAM thinking, the possibilities are endless!

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Angela Lou, a 2012 Knowles Teaching Fellow, is a part of the STEAM department at Boston Arts Academy in Massachusetts. She teaches biology, geometry, and engineering, in addition to leading an advisory and co-teaching a reading and writing class. Reach Angela at angela.lou@knowlesteachers.org.