



UMS: Fall 2017 Case Study in the Sciences

UMS believes that experiences with the performing arts can enrich and enliven academic inquiry across all disciplines. We are committed to creating uncommon learning opportunities for students and faculty, both in and outside the classroom. Through our Course Development Grants and Classroom Ticket program, we support faculty from across UM's disciplines in the integration of performance into their courses.

Collaborating with our Campus Engagement Specialist, faculty creatively incorporate music, theatre, and dance events into their syllabi. This is one of two detailed case studies of UMS performances integrated into science courses in Fall 2017.

Orchestrating a Musical Understanding of Chemistry

Ginger Shultz: Assistant Professor, Chemistry
Brian P. Coppola: Professor, Chemistry

Shultz and Coppola, who collaborated on this Course Development Grant project, share an interest in Chemistry Education. Shultz conducts educational research aimed at understanding the teaching and learning of college level chemistry, and Coppola is Associate Chair of Educational Development and Practice as well as Arthur F. Thurnau Professor.

THE COURSE

Ginger Shultz and Brian Coppola worked with UMS's Campus Engagement Specialist to incorporate performance into Organic Chemistry I (Fall 2017). A total of 1400 students, mostly first-years and sophomores, take the course, which consists of 350- to 400-student lecture sections as well as GSI-led discussions and an array of other learning resources. Many students take Organic Chemistry I as a pre-health requirement—an experience that sparks the interest of some, inspiring them to become chemistry majors. Anyone registered for the course may elect to do a program of supplemental instruction, participation in which earns them Honors credit; about 10% of students choose to join this cohort. They meet for an extra two hours each week with a section leader (a junior or senior who previously excelled at the course) and a group of up to twenty other Honors students. A media-based project is often among their term assignments; these have included visually enhanced podcasts, instructional videos, and web sites. It was this Honors cohort of about 140 students who participated in Shultz and Coppola's UMS performance-based project.

WHY INCLUDE PERFORMANCE IN A CHEMISTRY CLASS?

Although the Chemistry Department encourages educational initiatives, taking a group of Organic Chemistry students to the theater is “not something that typically happens in science.” However, Shultz was eager to meet the challenge of the UMS Course Development Grant application and contacted Coppola, who coordinates the Honors cohort, to collaborate on the project. Because some of the previous semesters' Honors students had approached their media projects through music—for example, creating songs as part of a video or podcast—Coppola considered the UMS opportunity a good fit.

Shultz and Coppola had overlapping goals for including performance in Organic Chemistry I. Most importantly for Shultz, she wanted to nudge students away from the “get-an-A mindset.” “Organic chemistry requires creativity; designing and building a new molecule requires creativity,” says Shultz. She envisioned using attendance at a UMS performance as an opportunity to ignite that creativity, providing students an opportunity to explore the relationships between music and organic chemistry. Coppola also saw value in such an exploration: “I personally support the idea of the connection between science and X, X written as broadly as possible. I just believe it is a really interesting and useful thing that can be a part of these students' educations—to perhaps first think that it's just too weird, that there is no connection, and then to find that there is one. Because they have searched it out, found it, and made the argument, which ultimately, isn't a pre-existing answer. That's what I think is the most important thing; the world doesn't come with pre-existing answers. We construct them. So what is the connection? Find it. Make it.”

In that way, the project not only spoke to the creativity

that interested Shultz; it represented a pedagogy that appeals to both instructors. Different from using existing knowledge to answer a question, students would have to produce something, to make something that wasn't there before (not coincidentally, a capacity that definitions of both “creativity” and “research” share). “This allows students a chance to create explanations,” says Coppola, “Just learning something on your own is half of the story; the other half is being able to tell someone else about it.” That “someone else” is an important part of the equation, too, as the supplemental media project for Honors students historically has had a peer-to-peer instructional aspect to it. “Making these media projects is fun, for some people, but it also needs to have a purpose,” Coppola explains. “For example, the video explanations of old exam problems [a previous Honors media project] got turned back to the whole class and became a learning tool. If students wanted to check their answer, they could go to the video and

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have a peer walking them through the explanation.” Shultz and Coppola intended to maintain this aspect of the project, ensuring that both the process of making this music-based media project and the resulting product would have implications for learning.

Shultz had a final goal in mind for her students' attendance at a UMS

performance: to rethink the scientist's identity. She hoped the experience might prompt them to consider questions like What does it mean to be a chemist? and What do chemists do? and perhaps reimagine their answers. “So often Organic Chemistry is just this trial, something they have to do to get a good grade. I wanted them to see that it's something cool, to change their perspective,” says Shultz.

THE SOLO ASSIGNMENT

With a UMS Course Development Grant in hand, Shultz and Coppola experimented with many iterations of the assignment before settling on the “SOLO project—Singing Octaves and Learning Organic: Using Musical Performance to Teach Organic Chemistry,” appended to students' Honors packet. For the SOLO project, Honors students could choose one of five UMS musical concerts in October and November (Amir ElSaffar's Rivers of Sound Orchestra, Daniil Trifonov, Sphinx Virtuosi, Zakir Hussain & Dave Holland, and China NCPA Orchestra); tickets were provided at no cost to the students, using Course Development Grant monies. Shultz planned for a faculty member or section leader to be at each concert, available for a post-performance talk with students who attended that night. The assignment prompted, “You will work in a group with two or three other students to produce a media project that combines organic chemistry and some aspect of the musical performance that you attend. The primary goal of each project is to teach a fundamental aspect of organic chemistry in a

peer to peer mode. The way you use music, or something about the musical performance, is up to you. And you are encouraged to be creative!” Shultz and Coppola offered a few examples of what that project might look like—a video or Powerpoint slide presentation explaining a chemistry problem, an interview with a musician/scientist—but encouraged students to come up with their own ideas. A project timeline established dates for drafting a project plan, sharing progress with discussion groups, and finalizing SOLO projects.

THE SOLO PROCESS

Having given students so much agency regarding the project, and not knowing exactly how the process would unfold across the semester, Shultz found that she and Coppola had to “fly by the seat of our pants.” The logistics of communication were challenging. Because not all the Honors students were in her lecture group, when she wanted to share an idea about the SOLO project, she talked to Coppola about it. He in turn talked to the section leaders at his weekly meeting with them, and they brought the idea to the Honors students. The section leaders also kept Coppola apprised of students’ progress in their weekly sessions—an opportunity to make sure that they were on track and fulfilling the criteria of the assignment. Ultimately, the section leaders came to fill creative and instructional roles comparable to Coppola and Shultz’s; agency was as much a part of the SOLO project for them as it was for student participants.

Because the assignment was somewhat “out there” for a Chemistry class, Shultz expected some pushback. However, the only objections formally registered with faculty came from students who wanted to alter the shape of the project—for example, students wanted to work alone rather than in a small group, or make a musical project that didn’t connect to a specific UMS performance. To be sure, many students were uncertain, but one section leader, junior Kaitlin McKernan, observed that no one was really reluctant: “They were just like, ‘Oh wow, how am I going to do this?’ It was out of their comfort zone of just having what’s right and wrong for Organic Chemistry.” For some, however, McKernan reported “They think it’s cool. They’re just surprised not to have an assignment that tells them do this and this and this.”

Fortunately, most sections had a mix of students, including many with musical backgrounds and a few who, as Coppola describes, “take it as just another creative opportunity and run with it.” That mix was critical for the peer-to-peer learning that Shultz and Coppola envisioned for the process. During the weeks leading up to the completion of SOLO projects, portions of each Honors section were run like a studio course, with small groups showing iterations of their projects to their peers for feedback. Section leader senior Jack Gatti explains that the students in his section formed their small SOLO groups based on their friends and social cliques; as a result, his groups had a mix of students with musical backgrounds and those without. Two of the small groups in McKernan’s section were comprised entirely of students with no musical experience, but they

were able to get input and help from the other groups in the section.

THE SOLO PROJECT

Although Shultz and Coppola had included in the assignment prompt some examples of how students might approach the project, few students followed those examples. Most created short videos that reflect the unique intersections of their group members’ interests

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and backgrounds with the concerts they saw. All videos were posted on youtube, and during exam week, Coppola sent links to a few of them to the entire Organic Chemistry I class.

The range of completed SOLO projects is broad, including musical

explorations of the chemical makeup of rosin and nylon used for violin strings, enactments of chemical reactions with students playing the parts of the molecules that bond and split (set to music heard in concert), original songs and raps explaining chemical reactions, and many more. Project titles include “The Benzene Song,” “Organic: The unexpected marriage,” and “Time for Stereochem.” Shultz observes, “The videos indicate that they thought carefully about how to teach the content in a coherent way using performance, and about what would be useful to include. For example, with the stereochem video, they broke down the different scenarios in which this idea is applied.”

The creativity that Shultz sought to ignite was also amply evident in the finished SOLO projects. One group in Gatti’s section made a connection between unstable transition states and unstable chords that want to be resolved. Inspired by pianist Daniil Trifonov’s particularly expressive playing, they modelled a chemical reaction in which a high energy chemical intermediate (in this case, a carbocation) must undergo a favorable reaction to a lower energy product. Using a recording of Trifonov, they represented this process musically with a dissonant chromatic chord as the carbocation that resolves to a consonant chord at the end. Another group, who attended the China NCPA Orchestra concert, drew on one group member’s own expertise playing a traditional Chinese instrument to explore the parallels between musical notation and chemistry’s symbolic representation. The students observed that chemistry has its language just as music does and, accompanying themselves on the Chinese instrument, sang some of the rules of chemical nomenclature.

Students faced a significant challenge in the assignment’s requirement to connect their projects in some way to the specific performance (exacerbated for some by the fact that not everyone in their group had attended the same concert). In McKernan’s section,

“One group said that in the performance they saw, there was a piece in the key of A-flat, and that the song ‘All of Me’ by John Legend is also in that key. Then they made lyrics to explain stereo chemistry to the tune of ‘All of Me.’ It was a very small link to the performance.” However, McKernan goes on to note, “But people enjoyed watching the video, and they made a three-and-a-half minute song with lyrics. It was one of the better things in my class.”

Evaluating the final products proved to be a challenge of its own for the section leaders because there was no formalized rubric. The Honors grading scale for the course allows for Outstanding (O), Satisfactory (S), and Unsatisfactory (U), with an S average needed to earn the Honors designation. Gatti explains his grading process: “The main criterion they had was that it needs to unite the performance they saw and some kind of organic chemistry concept. That was the minimum to get an S, in my opinion. It was kind of vague and I didn’t want to disrupt anyone’s grade with this project, so I didn’t give any U’s for it [McKernan concurs]. But I ended up giving two O’s and two S’s because the overall presentation was just a lot more engaging to watch. That sounds super-subjective, but it was kind of clear if you saw the projects.”

IMPACT ON STUDENTS

The creativity that Shultz hoped to inspire in her students is evident in the array of final projects that demonstrate unexpected ways of thinking about chemistry. The group that assigned elements to musical notes (the note G is oxygen, for example) and then generated a molecule based on a phrase of Beethoven’s Grosse Fugue, did so because of the requirement to connect chemistry to the Sphinx Virtuosi concert they saw. (Their video goes on to demonstrate that molecule in an E2 reaction.) Gatti echoes Shultz when he observes, “Science involves thinking about problems in a way that other people haven’t in order to arrive at an answer. This project...forces them to think about things from another angle. It’s a really great exercise in creative thinking, even if they don’t maybe see the value in it immediately.”

At least for some students, the SOLO project helped them revise some of their understandings about identity—about what they can do in a chemistry class and particularly about what the roles in the classroom are. Shultz recounts, “When I went to the performance and I sat down, there were a few students who were in my section that I was able to talk to and they were like, ‘Oh, Professor Shultz, you’re here.’ They were excited that I was there and that was really cool.” One student approached Shultz in the lobby after the performance to relay her pleasure at having identified on stage the instrument she herself plays, and her excitement about the project. Shultz says, “She articulated to me that she’s really struggled here in the classes like this one that are so huge, where you begin to feel anonymous. It’s hard to connect with the faculty member, and she felt like this activity really helped her to do that, and it

had this personal connection for her.”

The requirement to attend a concert of international-caliber music was an impact in itself, broadening students’ perspectives that are sometimes narrowly defined by disciplinary expectations. Gatti observes, “There’s a tendency in first year students to be on a really focused, ‘blinders-on’ track. ‘I don’t really need humanities.’ It’s a good opportunity to experience something cultural, even if they don’t unite it with organic chemistry. We gave them a ticket to this thing they wouldn’t have seen otherwise. ...maybe it will inspire them.” McKernan agrees, “Especially because a lot are freshmen. I came in and didn’t know about UMS and all the cool performances the university has. It gets them out of the mindset that I’m just here to go to classes.” One student adds, “I appreciate having to go to a concert. How cool is that? I have to go see the greatest pianist of our time (Trifinov) for my chemistry class.” There was also acknowledgement of the diversity of UMS’s programming, and the opportunity to hear music they wouldn’t otherwise: “We don’t have a lot of exposure to Eastern music [like Amir ElSaffar] here and I learned something, so I thought it was really cool. And I think a lot of other people had the same reaction to it.”

In addition to those anticipated impacts, students lit upon numerous unexpected insights, simply because of looking at organic chemistry in relationship to music. While some of these insights represent a deeper understanding of an idea presented in class, others are wholly original, as demonstrated by the student observations excerpted here:

- “If you’re stumped on an exam question, it could be you’re not looking at it right. The symbols on the page, you could literally be thinking of them from the wrong perspective. This assignment reminds you to look at things differently.”
- “Professor Coppola says the image of the molecule on the page is not the molecule; it’s just a representation. It’s analogous to how the score is not the music, what you hear in the performance.”
- “A lot of this course is brute force. You do a hundred problems so you’ve seen every kind of problem before the exam. It’s like music; it marries brute force and creativity. You have to practice and practice and practice. And you know what sounds right because of all that brute force repetition, whether it’s music or molecules.”
- “We saw Rivers of Sound, which is jazz and Middle-East music, so we chose to do a [chemical] reaction with a lot going on because the music has a lot going on, with different cultural layers.”
- “On the exam, you’re asked to answer in the same aesthetic as the problem is given. Chemistry can be aesthetically pleasing...In my head, the atoms are personified.”

WHAT THEY WOULD DO DIFFERENTLY

Despite all these impacts, the project did not fare well in students' end-of-term evaluations of the course. The activity was rated lowest of the projects they were given over the term, and it was the only one "below average" (below 3 on a 5 point scale). In Coppola's estimation, the students' dissatisfaction may have come from the requirement to connect their projects to a specific UMS performance: "From the get-go it was a challenge to think about how we turn the performances that they see into something meaningful for the class...However, if the connection is to take my innate musical abilities and interests and find ways to merge those things together, if I redefine the project as using the free ticket to a UMS performance as a way to inspire people about music so they can then do something with that inspiration, but not necessarily take the Chinese symphony performance and try to meet it together with chemistry, then this [would have been] a raging success." Nonetheless, it was that particular challenging requirement that inspired student insight—a reminder that student enjoyment and comfort are not always synonymous with learning success.

Coppola would also have liked to see a bigger impact in terms of how the SOLO project worked as an instructional tool for other Organic Chemistry students: "I sent out five or six examples [youtube links] of what they [the Honors students] made to the entire class, and I got zero feedback. I'd like a little deeper connection in terms of using them pedagogically, the way we've used other supplemental projects."

Shultz would revisit the way the activity was framed for students, citing the convoluted chain of communication as problematic: "The advantage of me introducing it to a class is that I would maybe be able to frame it for students and what it was really all about...I wondered how much of it was this dilution of the message, where Brian and I are really excited about it and we tell these leaders about it—and he talked to the leaders way in advance and got them excited about it and talking about it—but it's still this filtered message that gets down to them [the students]." In addition, the debriefing she had planned a faculty member to do after each performance—an important opportunity for students to contextualize what they had seen and heard—didn't happen because of logistical constraints.

Gatti observes that the students could use more guidance on how to give meaningful input to each other in the "studio" phase of the project: "They don't really know how to give that kind of feedback. They do it with their homework all the time, a formalized peer review process where you improve it before you turn it in. But this was out of their comfort zone, people weren't so clear on how to do this."

Going forward, Shultz holds fast to the importance of giving students agency but also accounting for their different pedagogical needs: "What we thought was a lot of agency could have been more for some students. And maybe some students need that scaffolding, some students need the structure. I'm thinking about how you structure an assignment like this in such a way as to give

those students who want to run with it the freedom to run and have agency with it, as compared to students

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She concludes that the UMS project was "an awesome thing," not least because it demanded that her students expand their notions of chemistry: "I think students take science courses often because they expect a certain experience and they expect everything to be

cut and dried and A+ B+ C. When you change that model, it's weird for them. There's an adjustment period for them to accept that it's okay in science to do something a little different."

¹Instructors might implement arts advocate Liz Lerman's "Critical Response Process" (<http://danceexchange.org/projects/critical-response-process/>) or the Kennedy Center ArtsEdge guidelines (<http://artsedge.kennedy-center.org/educators/how-to/tipsheets/art-crit-made-easy>) to facilitate meaningful classroom feedback on projects like these.
