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Chemistry in Art: Crossing the Curriculum

Question

I like to think that if I had not gone to the Art Institute of Chicago during August, I would have figured out my chemistry class curriculum on my own. But, I doubt it. My visit to the museum's teacher resource center introduced me to the connections between art and chemistry. And talking to the caretaker at the center led me to thinking how I could exploit these connections with my students.

During the Renaissance, artists had to be chemists. The need for new paints to express their visions forced many artists to become proficient with mixing natural materials into pigments and binder systems. The artist's visions were often limited by the materials available to them. Today, the bonds connecting both disciplines remain as strong as ever. Artists are constantly working within a wide variety of materials created through chemistry. Therefore, an artist must be a technician in understanding the boundaries and uses of all the materials available for his work.

However, the average school's curriculum regarding art studies and chemistry does not stress this connection. Students usually must take either subject, but little attempt is made to connect the two. The textbook, "Art in Chemistry; Chemistry in Art," by Barbara Greenberg and Diane Patterson, details a year-long course in chemistry with strong connections to art instruction. The authors fuse specific artwork and art projects with the set curriculum of chemistry to enhance the

students' understanding of the main chemical concepts. They attempt to interest both the technical and aesthetic notions of chemistry by tying the two disciplines together. Students should hopefully come away with an understanding that artistic visions can be expanded by the technology and materials available to the artist.

Greenberg and Patterson's instruction are based on a combined art and chemistry course that they prepared for eighth graders. The authors included extensions and topics that could adapt their plans for a high school-level course. Since I would not be team-teaching chemistry on a high school level, I felt I could adapt their ideas to my own plans and produce a curriculum with a heavy emphasis on chemical topics. The connections between both subjects can be easy to see. Since chemistry topics can be difficult for students to perceive, I felt Greenberg and Patterson's approach gave a clear path to the students' understanding. By emphasizing the connections between both art and chemistry, students would come to see chemistry in a new and interesting manner.

Background and Context

By September 2005, I was teaching my fourth year at Flushing High School. While I enjoyed teaching chemistry, I found the department's set curriculum limited me and bored my students. It did not achieve good results on the Regents Examination and needed to be changed.

Beginning in 2001, the New York State Board of Regents changed the topics covered on the Regents' examination. Previously, the examination tested basic chemical theory with a strong linkage to mathematics. It explored the connections between chemistry principles and industrial applications. In changing the curriculum

in 2001, the Board of Regents re-directed the nature of study from industrial to conceptual. The examination focused was on the physical setting of chemistry, especially how it interacts with everyday life. The examination still included industrial applications, but considered them as a corollary to the overall theme.

Chemistry became part of a three-part Regents curriculum, titled "The Physical Setting" which became required for a high school diploma in New York State. Students had to pass a course and Regents examination either in Earth Science, Chemistry, or Physics along with an introductory Living Environment examination. Chemistry had been an elective study for upper classmen. The new requirements for graduation meant that more of the students in the high school would be assigned chemistry courses. To compensate for this change, the Regents dropped many of the mathematical aspects of chemistry from its curriculum and indicated that chemical topics and concepts should be emphasized in instruction.

As expected, a large influx of chemistry students occurred in our school. While we had 174 students take the Chemistry Regents examination in June, 2001; 356 took the test in June, 2002; 523 took the test in June 2003; and 343 took the test in June 2004. Initially, scores on the Regents examinations plummeted and as a result, the percentage of students passing the Regents examination dropped from 40 % in 2001 to 17% in 2002; 20% in 2003, and 25% in 2004. The passing rate was 23.7% in June 2005.

Both the increase in the number of students assigned to chemistry classes and the changed emphasis of the Regents curriculum were definitely factors in the drop of the passing rate. However, I felt the curriculum and teaching had not adapted to these changes. While it is true that the mathematics was deemphasized,

the attitude and habits developed during the time that it was emphasized still strongly influenced by how teachers continued to teach chemistry. While chemistry now joined a system of learning topics, it was still being taught as a separate discipline. Instead of connecting chemical principles with other systems, chemistry teachers continued to isolate chemistry.

This approach turned off students. Even without its mathematics, chemistry can be a daunting subject for students. The chemistry curriculum did not connect it to life and earth systems as the Regents board had hoped. As a result, students were surprised by the new Regents examination which now includes essay readings and questions connecting chemical principles to real life situations. I believe this is one reason that the scores on the Regents examination dropped.

After teaching earth science in middle school, I had little practical experience in teaching chemistry when I started at Flushing High School in September, 2001. As a result I followed the department's curriculum and lesson plans. Also, following the curriculum would not make waves in the department, especially since I had not yet achieved academic tenure at the school. I did no better than the other teachers' passing rates on the new Regents examination. Only about 12 percent of my students passed Regents examinations in my first year and the number rose slowly to about 20 percent over the next few years. I realized that something had to change in my approach to the teaching of chemistry, or I would never see my students get above mediocrity in passing rates on the Regents examinations.

Three years after I began teaching at Flushing High School, changes came in which gave me the opportunity to change my approach to teaching. First, the assistant principal retired which brought a different administration into the

department. Second, I received tenure which made me more open to changing the way I approached teaching Chemistry. Finally, I attended National Science Teachers Association conventions which gave me an opportunity to sample ideas and teaching styles focusing on science inquiry rather than rote knowledge of facts and figures. I began incorporating more inquiry into my teaching plans and approached the learning of chemistry through discovery. This approach led to interesting lessons for the students.

Meanwhile, the school changed the schedule of students' science classes from Living Environment (9th grade) to Chemistry (10th grade) to Earth Science (11th grade) to Earth Science for 10th graders first and then Chemistry (11th graders). The department also required that chemistry students pass the first year Mathematics Regents examination before being assigned to Chemistry class. This limited the number of students and upgraded the ability of the students taking the Chemistry Regents examination.

Tools

I planned my Art in Chemistry curriculum as a one-year course with subjects chosen to fit the Regents curriculum topics. My art topics were (1) Color; (2) Painting Surfaces; (3) Clays and Glazes; (4) Jewelry Making; (5) Photography; (6) Art History; and (7) Chemical Hazards in Art; and (8) Art Restoration. In each of these units, the projects would be tied into chemical principles taught in class. Overall, I wanted 20 art projects and two chemistry demonstrations. The chemistry textbook assigned to the class supplemented these units. No book on art instruction was supplied, but I photocopied articles and other material for the students.

I was assigned to teach two classes of Chemistry under an annualized year of study. This would mean that I would have the same students through both semesters of the school year. In all, about 45 students would remain in both classes throughout the whole year. The students represented different academic levels and abilities.

Teaching Chemistry and Art

My first unit was on color. I included lessons on the meaning and nature of color and color reactivity. One of the projects included preparing a color wheel with 12 hues as well as producing a chart determining the light and dark values of the colors and learning about the significance of each hue and degree of color. This tied in with our studies of the electromagnetic spectrum of visible light divided into separate colors. The students then learned that the colors they see were the result of certain atoms being excited by the application of energy. I defined light and color in terms of specific electromagnetic energy produced by specific atoms. The students could use this connection to understand atomic structure and the role protons, neutrons, and electrons play in the properties of matter and energy.

After color, the students produced pigments for oil- and water-based paints. The students prepared most pigments using ionic solutions derived from reactions involving organic and inorganic substances. Producing the colored pigments taught the students about (1) chemical change, (2) how atoms combine to make molecules, and (3) chemical formulas and equations. The students also learned such laboratory skills as how to filter and decant, use a Bunsen burner, and work safely in the lab.

Once they developed pigments, the students tested them binders for oil paints, water paints, and egg tempera. They prepared paints by combining the

binders with the pigments. This project taught solutions, suspensions, colloids, and physical changes.

The students learned about painting surfaces and the chemistry involved in producing images. I organized a field trip to the Metropolitan Museum of Art in order to give them examples of how paint and painting surfaces are determined. We compared oil painters such as Goya, Durant, and Rembrandt with Impressionists such as Monet, Manet, Gauguin, and Van Gogh. We viewed modern art by Pollock, Lichtenstein, Picasso, Mondrian, and Rothke to give another view of paint and surface. The students viewed a show focusing on how Van Gogh composed his paintings and listened to curators explain the significance between his work and materials.

The students conducted chemical experiments in the procedures for stretching canvasses and producing a water color paper. They produced gesso, which is similar to fresco painting. Teaching this section, I showed Michelangelo's use of fresco in producing the Sistine Chapel paintings. The students discussed the difficulties of producing this work along with its advantages and disadvantages over canvass and paper as a surface. The students also reported on the painting of the Sistine Chapel in relation to the chemistry known in that time.

The final project for this unit involved making paper from sawdust. We used this unit to discuss acid and base chemistry. The breakdown in wood fibers to be stretched into paper also taught the students chemical decomposition reactions and the shaping of organic molecules.

After the first few units of study, I felt that I was promoting art instruction as the primary topic, rather than supplementing the chemical education with art. Both

the students and I enjoyed the art and working with projects in the laboratory. However, I felt that learning the art took away from the time I could have spent in the classroom reviewing chemical concepts and formulas.

My original plan would have had the chemistry class run in conjunction with a class in art application. I never did get full cooperation from the art department. In addition, none of the chemistry students enrolled in art instruction, all my work with art and chemistry had to be accomplished in the 45-minute chemistry class period. This made the unit's schedule run longer than expected. If I continued at the same pace as I had been teaching, I would not cover all the topics required for the Chemistry Regents examination. Either I would have to cut the art instruction and concentrate more on chemistry information or continue the curriculum and accept that some topics would not be covered in class.

I decided to save time and review the next two units, Ceramics and Jewelry Making, quickly stressing the chemistry information. These topics covered the curriculum topics such as relative weights, mole concepts, and simple unit conversions. The jewelry making unit covered metal and acid reactions, intramolecular bonding, and redox reactions. Finally, I had to substantially change the unit on photography because the different chemicals and other materials were just not available. I substituted more readings and demonstration activities to cover the curriculum topics such as light-sensitive chemicals, oxidation-reduction reactions, and organic compounds.

I did combine some art instruction with chemical experiments in the last two units in my curriculum. Art History and Restoration looked at the ability of art forgers to take similar materials and produce copies of great and near-great art. The

students studied how radioactive emissions can be used in producing radioactive dating of artwork. They also used spectroscopy to distinguish different hues of color paint to make matches between the forged work and the original work. The students' writing project focused on preserving and restoring works of art, including the cleaning and restoration of the Sistine Chapel ceiling.

In the last unit, Chemical Hazards in Art, I presented lessons on chemicals used in art which included topics of toxicity and proper use of materials. The lessons provided examples on corrosive metals and the hazards the metals presented. I also reviewed the dangers involved in improperly handling chemical bottles and test tubes.

Data

Overall I completed about half of my original curriculum. There were many chemical topics that I needed to cover. I rushed through the missing topics in the last two weeks which forced me to squeeze in new information without much review time. I asked the students to take on a lot of information in the curriculum and accept it at face value.

I did not like the way the course ended and I feel that the reason for the changes was a lack of confidence I had in my new curriculum. As a result of my fears that I would not be able to finish all the curriculum topics on time, I went back to a system that caused problems in the previous tests.

When I reviewed the work accomplished during this year's accomplishments with the students I still believe the effort gave me an advantage. The course curriculum allowed me to become more flexible with my lessons and tie them into something that students enjoyed. The increase in interest from the students carried

over to a more superior projects and better performance on tests and quizzes. Often I found the students putting in extra time and work to complete their projects and make connections with other areas in chemistry.

At this year's Regents examination, my students performed better than last year's class. About 31 students qualified and took the Regents examination with 11 students (35 percent) passing with a score above 65 out of 100. Nineteen students (61 percent) scored above 55 out of 100. However, I cannot determine an accurate numerical comparison with last year's class because of different circumstances between this year's class and last year. I did not have the complete roster of students for an entire year like I had this year. Our school has just begun to annualize the rosters. I will be able to continue my study next year and create comparisons in numbers between the classes.

I did ask students at different times during the year to fill out a set of questionnaire on their opinions regarding the curriculum. These questionnaires showed that about 37 of the 45 students who filled out questionnaires enjoyed the work in the classroom and felt it was worthwhile to learning enough chemistry for the Regents examination. The students explained that the art instruction made learning Chemistry more fun and interesting. They said they enjoyed working on projects and continuing on specific tasks that lead to something being produced. About 70 percent of the 45 students who answered the questionnaires said they felt they understood the topic better than if they had learned it through common classroom experiences. The students also answered that they could see the connection between the science and the art instruction and understood the importance of materials to the production of arts.

There were students (about five in total) who claimed that the combined curriculum did not help them understand chemistry any more than any other form of instruction. Most of them said they felt the additional art instruction distracted their ability to concentrate on the science and left them feeling that neither subject was explored properly. These students also said they did not like the way the material had to be rushed at them near the end because the art projects had taken up so much time earlier. They said that more time should have been spent early on the chemistry so that this problem did not occur later in the year.

Although a group of students did not like the idea, I still felt that I had succeeded in some small ways in changing my form of instruction. I also felt that I had made a new start in changing my teaching style by connecting the two subjects.

Analysis

In reviewing the year, I formulated three cautions for teachers attempting an integrated curriculum:

1. **Simply tying chemistry experiments with art instruction is not enough. Teachers must incorporate a variety of lessons based on the connections between art and chemistry.**

When I started the year I had a lot of energy for producing the art projects and introducing the chemistry involved. I soon found out that the tendency among students when confronted with new information is to take all information at equal value. The students were confused at first as to how much importance I was applying to learning art. After all, the course was chemistry. I did not emphasize

exactly how much weight I would give to the art projects in terms of grades and assessments, therefore the students did not grasp the connections I was making between the two. When it came to studying for tests or producing reports, the students valued the art instruction as much as the chemistry they were producing.

2. **Teachers integrating different subjects into one curriculum must stress this question, "Where are we going with all this?" Unless they establish a clear goal at the beginning, teachers may during the course of a year emphasize learning points that do not support the students' achievement.**

I have to say that learning and instructing students in art projects was a lot of fun. I found it very invigorating and it gave me, the teacher, a new angle to how the subject should be seen. There was too much of a temptation to concentrate on the art instruction and leave chemistry as a connection to the art. When I teach this next year, I will determine what will be emphasized in the class and watch that I do not lose the way in teaching the two subjects.

One focus that I want to explore in the future classes is determining how much chemistry my students know before they begin study and then try to determine exactly how much they understand the chemistry after the year has ended. This past year I concentrated on the Regents examination as my only measuring stick in determining their understanding. Next school year, I plan to assess the students more deeply on the topics and explore their entire knowledge of the subject.

Having worked through an entire school year of teaching with this method, I believe that the best course for next year will be to focus more attention on backward planning in my lesson units. I believe that if I determine what I want my students to

understand at the end of their art projects will help not only them to stay focused on learning, but it will help me to determine how to arrange the projects within lessons to achieve the level of understanding that I would require with the students. I plan to incorporate the ideas from the book "Understanding by Design" by Arthur Wiggins and Jay McTighe, in my lesson planning along with Greenberg and Patterson's ideas.

3. To make integrated subjects work, teachers must have the confidence to continue it throughout the year despite pressure to cover topics for the Regents examination.

Because I finished the curriculum early in the year I did not have the opportunity to see if the art instruction would stay with the class throughout the year and help them understand the subject better. I had planned for it to last the entire year, but I lost confidence at a crucial point. I believe the decision was a sound one at the time, because of the oncoming Regents examination. Still, I wonder if I ended it too early. Next year, I will try to make better plans for the curriculum and pay more attention to the schedule of classes to make it last all year.

My original question was to see if I could connect the study of chemistry with art instruction and use the strengths of both and the clear connections between the subjects to give the students in my chemistry class a deeper and more profound knowledge of the subject. However, I did not do the necessary research on this idea before I started. Instead, I spent the majority of my time in lesson planning and relying on Greenberg and Patterson's book and my own experiences in teaching the curriculum in past years. This was a mistake that I wouldn't make again. The combining of two subjects produces problems that can only be overcome by a clear

predetermination of what could occur during the year. I know now the problems, but with more research into the working of the two subjects I might have avoided the problems which cost me the full completion of my original concept.

4) **Connecting different subjects does not cover all topics equally well. Teachers must maintain an awareness of which topic fits their need and which don't fit when they attempt to integrate subjects.**

I found that when I attempted to cover all chemical topics with art projects but I found that not all topics lend themselves to connecting to the art instruction. I felt that the requirements of these topics could only be covered by common classroom practice and drill. It was tempting to think I could extend the art projects to cover the material, but many topics can only be dealt with in memorizing information.

In their book, Greenberg and Patterson establish clear division between what is art in scope and what is chemistry in practice. The authors lay out a plan to create a combined chemistry and art curriculum that addresses both subjects. I thought that since I was only responsible for teaching chemistry, I could cover the art instruction aspects nominally and concentrate on the chemical topics. But I found that you cannot introduce a type of art expression and not spend time discussing the reasons for its existence. This requires careful planning and "custom-fitting" of topics so that the proper amount of time could be spent on these topics.

Policy Recommendation

1. **Integrated curriculum should not be carried out by a single teacher. Team teaching may be required to truly integrate subjects into a single curriculum.**

I believe I gave my course a major disadvantage by not communicating better with the art instruction teachers in our school. I believe that if I had made more of an effort to explain my plans I would receive more help in planning and implementing my art projects. I believe I was at a disadvantage this school year without the ability to connect with art teachers to help me prepare instruction. I felt at times that I did not understand the art instruction as well as an art teacher would. As a result, I felt like I did not have the ability to cover the material properly. I believe this also led to my making the classes longer and the schedule slower.

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