Encouraging Creative Expression in a Scientific Context
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To be published in the "Reflections from the Classroom", a University-wide publication, in Spring 2010.

The Backdrop

I am an assistant professor in the Department of Physics and Astronomy and for my first 3 semesters at KU I have taught large introductory astronomy classes. Introductory science classes at the University level provide the last opportunity for many of our students to be exposed to science, and that in a society where science plays an increasing role in public discourse and decision making. This has important implications for our responsibility as teachers. We must try our best to lead the students along a path that encourages critical thinking, problem solving, and synthesis of diverse information into a coherent message. There are well established paths, however imperfect, towards reaching these goals. Indeed, there is a large body of research demonstrating quantitatively that this is best accomplished by actively engaging the students and making them the center of the learning experience. No less important, but with a much less clear path towards success is how to engage students to a degree that they enjoy the subject matter and how to enable them to represent their knowledge of it when they leave the classroom. Even more challenging is to have them develop the skills to explain this knowledge in such a way that non-scientists, their friends and family, can understand it.

This latter point is a sticky one. As scientists we often want to teach students to think like us and communicate their knowledge in the way we do. We do this because we want them to experience being a scientist, if even for a semester. But, do we not also have a goal of that the our students learn to communicate effectively about what they have learned? And in that case, is a research paper or lab report truly the best medium? What if students could achieve the same level of engagement, exercise their critical thinking skills, and learn to synthesize multiple pieces of information, but at the same time communicate their knowledge in a manner that was best suited to their own strengths. This essay describes one such attempt to address these questions.

The project

I drew inspiration from work being done by Christopher Impey at the University of Arizona, by Daniel McIntosh at the University of Missouri, Kansas City and from discussions with Dan Bernstein and Barbara Anthony-Twarog in my own department. I implemented a project in my introductory class in the Fall of 2009 that would focus on understanding and communicating the recent successes that astronomers have had in discovering planets around other stars. The students were tasked with reading a set of four popular-level articles and answering a set of questions that required them to combine their knowledge and drawn their own conclusions, with the assistance of any additional articles that they could find. As a final element I told them that the information had to be communicated in a way that their friends or family could understand, and using any medium of their choice. They were given complete freedom.

The project came in two parts. First was a 1-page proposal, in which the students submitted their additional references, described what they would do, why it was suited to their personal strengths, and some obstacles that they envisioned in their implementation. My hope was that this would allow them to think about what their project would actually entail, before realizing too late that it was impractical. I graded these on a rubric but as I have only minimal grading support and no TA for 150 students I did not given individual feedback. Rather I tried to find common threads and spent some time in class with general suggestions and an exhortation to talk to me if they had specific questions. The second part required them to hand in the projects themselves. I allowed electronic as well as physical media and allowed teamwork, although the teams needed prior approval and a clear description of the contributions of each member.

The results

The challenge in grading was to take these very diverse projects and evaluate them based on completeness of content, accuracy, demonstration of synthesis, and effectiveness of communication. My grading rubric was adapted from the meta-rubrics of the American Association of Colleges and Universities (AACU), which provide a framework for how to evaluate work based on general criteria, e.g. problem solving, critical thinking, communication. As this was at heart a science assignment, the most weight was given to content, and only 1/4 was given to the effectiveness of communication. The students were given the rubric with the assignment.

I received 118 projects, of which 5 were team efforts. Although the quality varied I was impressed with many of the projects, especially with those that used non-traditional media most effectively. Among these were a poem, an outstanding 1-act play, a rewritten version of Alice's Restaurant - performed and set to music, a well-developed board game, two movies, a painting, a fully constructed Facebook network of friends, and two web high quality sites. Despite their creativity, not all of these received the highest marks, mostly because they lacked the necessary elements that were required in the rubric. In fact, some of the highest scores were not particularly creative, but were highly effective at using their chosen medium, e.g. a research paper. In addition to the projects received above I was given powerpoint presentations, scrapbooks, brochures, children's movies and books, short stories, term papers, and comic strips.

In evaluating the projects, a common thread was that many students did not know how to footnote or properly reference their work. It was also clear that many students think that condensing all of your material into a set of loosely connected bullets in a powerpoint presentation somehow magically improved its effectiveness. In fact, powerpoint slides are meant to accompany an oral presentation and are not normally a good way to express written material. Likewise, there were many students who were very creative and artistic but failed to use their chosen media to express the requested information in an understandable fashion.

Looking back I: Successes

Despite the modest (10%) contribution of this assignment to the final grade, I was struck by the large effort that some students put into their projects, presumably far more effort than some of them put into studying for their exams. This served as an indicator that this assignment was indeed successful at engaging the students more than was possible with normal coursework.

It also engaged a broad audience - the top performers were not limited to the best students in the class but also included those whose performance in other aspects of the course was lackluster. These same students were often very creative and obviously felt that this was their opportunity to shine. These were exactly the students I was trying to reach with the assignment and I was pleased to see some of them putting forth so much effort, and so effectively. One goal of this class is to get people excited about science and give them the ability to communicate their excitement and knowledge to a larger audience, in effect turning them into ambassadors - albeit entry-level ones - of science. For at least some of the students I think the assignment accomplished these objectives.

Finally, as intended, the project gave the students a chance to practice their skills at synthesis and there were indeed those who combined and interpreted the material in a way not encapsulated in the assigned articles.

Looking back II: Shortcomings

The major obstacle in the implementation of this assignment was the large grading burden. I received 118 projects and grading them took me 5 days. I have no TA support in this class and my undergraduate grader was not advanced enough to assist in the grading, leaving the burden to fall upon myself. Aside from taking far too much time to be sustainable, the load also prevented me from giving individualized feedback. This directly hampered the effectiveness of the first part of the project, whose purpose was to give the students a chance to think through their strategy and get comments back on their ideas before embarking on the final project.

I had expected that the degree of synthesis and effectiveness of communication - two rather high level expectations - would be the main discriminator among the students. To the contrary, the largest difference between how students performed was the degree to which they completed, in any form, the required elements of the assignment. While creativity and deliberation were involved in designing many of the projects, there was not strong evidence that a majority of the students moved past regurgitation and onto critical evaluation of the information.

Despite my best intentions, my rubric was not as effective as I would have liked. There were items that were not independent of one another and in some cases, my abstract idea of what would be a good rubric item did not translate into an effective discriminator.

Looking back III: Future implementation and challenges

The overall quality of the projects would undoubtedly have been better if the students had been given more opportunity to practice the necessary skills. In the future I will give short assignments early in the semester that will prepare them for synthesizing the information from multiple sources. As an example, students could read short articles and be asked to draw their own conclusions and present them in class. These would not necessitate individualized feedback, but could provide the fuel for in-class discussions, something that is possible even in a class of 150 students. I would also like to give the students more concrete examples to demonstrate what I would like to see in various phases of the assignments. For example, it was clear to me that certain media were seldom effective, powerpoint-type presentations being at the top of the list. In the future I might consider banning such presentations altogether, or giving past examples of "good" and "bad" uses of this medium.

The risk with limiting students expression is that it could pigeonhole them into my concept of a project, and thereby limit their ability to explore their own strengths. To counter this, a possibility that I am interested in exploring is collaboration across disciplines, specifically with those in the arts and communication, to determine how communication of science concepts can best be accomplished with non-traditional means.

A major obstacle to implementing this project was the grading burden. Indeed, it will not be possible to do this assignment again without a significant change in this arena. Luckily, there are remedies. A simple one will be to require group work. This approach would require some means of insuring that everyone pulls their own weight, but this obstacle is faced in all group assignments and is not insurmountable. The most straightforward, but also the most expensive, solution would be to have a TA to assist in the grading, implementation, and feedback process.

Assessment of learner outcomes is key in measuring the effectiveness of such an assignment. While it appeared to me that the engagement of the students was increased, it would be more useful to have a quantitative metric that could encapsulate this information. I currently employ nationally standardized pre and post-class diagnostic surveys and in future semesters I envision also asking my students to answer questions that address how their attitudes towards science have changed. Comparing this against other instructors nationwide will provide some measure of how well my assignment accomplished its goals.

Final thoughts

Among the challenges in introductory science classes are how to engage students, how to inspire a long-term interest in the field, how to increase their long-term retention of the knowledge acquired in the class, and how to enable them to communicate these new insights to their peers. This assignment was challenging, both for me and the students, but I think it addresses all of these areas. The burden, especially that of grading, is extreme, but as I have addressed above, these obstacles can be mitigated.

By using non-traditional means of representing knowledge and of exercising critical thinking skills, it may be possible to change the way in which we instill in students an appreciation of science and an ability to carry out a scientific discourse on their own terms.

In general I received positive student feedback from this project. Opinions were diverse but one student highlighted some of the strengths and weaknesses of such a project in the comments below. While enthusiastic, this student was not a spectacular achiever but wrote a wonderful poem for the project that did not get top notes only because he did not address all of the required elements.

"Well, I loved the project because of how creative it is. The only thing I would change is making the project more creative by not allowing people to write papers. I understand that that idea may go against your idea of everyone communicates differently, however, college students write papers all the time, so, I say, bring on the creative juices. I mean how awesome is it to be required to mix math and sciences with the arts? In my opinion, that project was one of the best requirements that has ever been asked of me in a class."