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CUR Focus on the Web

A New Approach to Teaching Ethics in General Chemistry

As part of summer undergraduate research, students from several two-year colleges in Illinois visit Illinois State University (ISU) for an intensive ten-week research experience. The program (known officially as the NSF Undergraduate Research Collaborative STEM ENGINES program) is a joint effort involving primarily the seven campuses of the City Colleges of Chicago, William Rainey Harper College, Oakton Community College, the College of DuPage, and ISU. Other participating institutions include Youngstown State University, Chicago State University, and Hope College. The goals of the program's project are to:

(1) Identify and recruit promising young scientists from two-year colleges into the STEM disciplines, especially students from traditionally under-represented groups;

(2) Train two-year college students to become effective practitioners of science;

(3) Instill in these students the confidence to pursue science as a profession;

(4) Encourage them to complete their undergraduate and graduate STEM education; and

(5) Transform the cultures of participating two-year colleges by embedding intensive research experiences during the academic year and the summer into their curricula.

As part of this summer program at ISU, the Fellows (as we refer to them) engage in an introductory course entitled Responsible Conduct of Research and Ethics that is specifically designed for this group. As part of this course, the Fellows are assigned a project, the most recent of which involved the Fellows developing a series of modules that use "clickers" to gauge students' reactions to ethical scenarios in scientific research. One goal of this project was to develop modules that would be used during the regular academic year for a 120-minute laboratory session in General Chemistry. Moderators that teach these laboratory sessions would then evaluate the modules to see if they could serve as an introduction to classroom discussions focusing on ethics in science. Another goal was to see if we could increase student engagement in discussions involving ethics.

Embedding useful and effective aspects of education about research ethics in entry-level undergraduate courses is often difficult in the sciences. Most faculty members are not trained, and therefore, are not comfortable teaching about this "gray" area. Yet faculty members are partly responsible for introducing students to scientific misconduct (Montes et al., 2009). Roald Hofmann has been quoted to indicate that courses in ethics as well as discussion groups should be a part of the education of all scientists (Cardellini, 2007).

Before the Fellows began their project, ISU faculty members and STEM Fellows had Susan Schelble, a member of the American Chemical Society's Ethics Committee, visit ISU to present a workshop on the use of "clickers" in ethics training. Schelble's clicker workshop, with 26 participants, provided a good basis for the Fellows' subsequent project. After outlining the work of the American Chemical Society's National Ethics Committee, she had the audience use clickers to respond to various scenarios and case studies dealing with professional and research ethics. (For details, see http://portal.acs.org/portal/acs/corg/content?_nfpb=true&_pageLabel=PP_TRANSITIONMAIN&node_id=1795&use_sec=false&sec_url_var=region1&__uuid=402c89c0-19a2-45bb-87c7-020bad99bf19. This Web site also provides useful links to other ethics resources.)

An example Schelble presented at the ISU workshop was "The Case of the Dangerous Doc":

> *Professor M does synthetic organic chemistry. He has been modestly successful over the years, developing a reputation for producing difficult-to-synthesize fine chemicals. Unfortunately, he has also developed a reputation in his department for unsafe laboratory conditions; several students working in his lab have had serious accidents resulting in permanent disfigurement. After the last incident, the university finally buys out his contract to terminate his appointment. Professor M starts up a contract synthetic lab in an old creamery in a nearby small town. He advertises in the university newspaper for part-time student help, specifying his need for chemistry majors. His former faculty colleagues are pretty sure that his new facility has inadequate safety equipment.*

This scenario was followed by three multiple-choice questions that addressed the concept of 'what should happen':

1) What should the chemistry faculty do in this case? (Recognize that the students are unaware of Professor M's past.)

A) Issue a blanket warning to all undergraduates by email; detail Professor M's past history in the department.

B) Go to Professor M's new facility and offer to perform an independent safety audit.

C) Contact the student newspaper with their concerns and try to prevent future ads.

D) Quietly spread the word verbally about Professor M's past history with safety.

E) Do nothing—what happens off-campus is not the responsibility of the faculty.

2) What should be the response of the university administration to the current solicitation for student employees? (Assume the concerns of the chemistry faculty have been confirmed.)

A) Direct the student newspaper to refuse future advertisements from Professor M.

B) Contact Professor M and inform him that he is forbidden to solicit students as employees.

C) Contact the local zoning board and other appropriate government bodies and inform them of Professor M's current operation and history.

D) Do nothing, out of concerns of litigation by Professor M.

3) What should the department/university administration have done about the safety issues and accidents prior to terminating Professor M?

A) Ignore those instances when no blood was spilled. Issue a mild reprimand for the rest.

B) Require Professor M to attend and pass re-education seminars on laboratory safety.

C) Agree with Professor M that the students were at fault in all cases.

D) Have Professor M conduct safety seminars for the department.

E) Keep a complete written account of each incident in Professor M's personnel file.

STEM Fellows and Dr. Jones at a 'victory lunch' following the final STEM clicker project presentation.

Individual workshop participants then "voted" anonymously using the clickers and could see rapidly how others in the room reacted. Once the final "votes" were shown on a screen, Schelble, serving as the moderator, opened the floor for discussion. Lively discussion involved both faculty members and students asking questions, and some even volunteered how they voted and why they made that decision. As the workshop progressed, students became very willing to indicate how they voted and why. Several times Schelble was asked to tell the audience what the "right" answer was, and she was able to gently indicate that there very well could be multiple "right" answers. Our Fellows quickly realized that the interesting discussions allowed them to see the ethical questions and possible answers in a more complex way. Although the workshop was geared to chemists, much of the content is relevant to any scientist.

Following this activity, the STEM Fellows had informal discussions about this workshop for several days, and the comments indicated that they came away with a very favorable impression of the value of such discussion. As teams of 2-3, the Fellows then began their summer ethics project. Since one goal was to determine if the students could become more engaged in ethics, we encouraged them to consider their target audience (General Chemistry students) as they developed their modules. Each team was encouraged to develop 3-4 modules. Eleven Fellows developed some examples from their own points of view to make ethics more real for other chemistry students; the modules they produced have now been used in an Introductory

Chemistry Lab. Following the development of their modules, the STEM Fellows presented their modules to the other teams of Fellows who then used clicker voting to respond. The use of clickers has the distinct advantages of allowing anonymity and producing rapid results (Duncan, 2005). Voting can also just be done on paper, however.

The major areas that the STEM Fellows selected for their clicker examples focused on plagiarism, cheating, lab safety, sexism, racism, and favoritism. Below are some of the examples of their work followed by the responses from the STEM Fellows (with Jones as moderator) as well as the responses from the subsequent work with the General Chemistry students (Ferrence as moderator). An example of their work was the "The Unusually Sexist Professor":

> *Brooke is a student in Dr. Smaller's General Chemistry class. For the midterm evaluation, Dr. Smaller gave a writing assignment based on a chemistry article. The students all had three full weeks to complete the assignment. Dr. Smaller stressed that there would be no excuses for late work. Jacob was in the same class as Brooke. He was in the hospital for two of the three weeks and couldn't finish the assignment on time. He talked to Dr. Smaller, once he got out of the hospital, about his condition and his inability to complete the assignment in one week. Dr. Smaller was nice to him but didn't say clearly that she would extend the date.*
>
> *The Monday the assignments were due, Jacob and Brooke didn't have theirs ready. Jenny, Tom, and Marc from the same class also didn't complete the homework. All five of them went to talk to Dr. Smaller after class. She gave additional time to Tom, Jacob and Marc to complete the homework with no penalty and gave a whole letter grade penalty to Brooke and Jenny. Jenny and Brooke had noticed that in class Dr. Smaller usually agrees with what the boys say and congratulates them more than she congratulates girls. They decided to talk to Jacob, Tom, and Marc about how they will finish up the assignment and found out they had no penalty and an extra week to finish the work. The girls reported this to the chair of the Chemistry Department.*

This scenario was followed by a multiple-choice question that asked what the students thought had happened after the complaint was made

> *What do you think happened? (What decisions are commonly made in those situations?)*
>
> *A) Dr. Smaller was suspended for a month and the girls were also allowed time to finish their homework.*
>
> *B) Dr. Smaller was given a warning and all of the students were given an A on the assignment.*
>
> *C) Dr. Smaller was given a warning and required to attend ethics training; the students were given the appropriate penalty for late assignments.*
>
> *D) The Department Chair talked with Dr. Smaller about her behavior in the class; Dr. Smaller allowed the girls one more week also to finish the assignment and all students were told to keep quiet about this whole situation.*

Both groups of students largely believed that option D would be what would occur in such a situation. However, the General Chemistry students did not feel that any of the above responses were "good" solutions to the problem and would have preferred to have different options available to them. This situation allowed the moderator to indicate that not all situations have "ideal" solutions and the best of the available options must be chosen. Additionally, the moderator was able to discuss the gray areas of ethics, which is what makes ethics training so difficult. The General Chemistry students showed a great deal of maturity and were not naïve about the problem. They knew it would be difficult to punish a professor, felt that the situation should be kept quiet to prevent the university's reputation from being harmed, and were also concerned about fairness to other students. They would have liked to see the professor go through ethics training to modify her behavior instead of suspending her.

Through this student feedback we felt that the students were very engaged in learning ethics, not as a set of rules, but as a process that should be examined and, after discussion, lead to general agreement. Students were not required to sit and take notes while a professor lectured—they were able to engage each other in lively discussions. The ability to question each other helped the students to gain a new perspective and learn how to conduct themselves professionally during a discussion (listening intently, supporting a suggestion with facts, being respectful of the position of others).

Table 1: Student Response Data for "The Unusually Sexist Professor"

Group	A	B	C	D
STEM Fellows	0	2	1	6
Percentage of Fellows (%)	0	22	9	55
General Chemistry Students	1	2	7	12
Percentage of Students (%)	4	9	32	55

Table 2: Student Response Data for "Chemical Splash"

Group	A	B	C	
STEM Fellows	4	3	2	
Percentage of Fellows (%)	36	27	18	
General Chemistry Students	6	15	1	
Percentage of Students (%)	27	68	4	

Another example from the STEM Fellows was the "Chemical Splash":

> *An undergraduate student was working on an experiment in a hood. When she removed the reflux condenser, the solution bumped and splashed on her face. In spite of the fact that the student was wearing goggles, the solution managed to go past the seal and into her eyes. On that day, she was in the lab by herself. When the chemical got into her eyes, she could not open them, so she was struggling to find her way to the eyewash and safety shower. Eventually, she found her way there. Then another student saw her and called 911.*
>
> *The doctor could not save her eyes. He mentioned that her eyes would have been saved if she could have washed them or gotten to the hospital earlier. When asked, her lab supervisor said he did tell her to read all the safety instruction when she first started working for him. However, he had also mentioned he had never trained her or explained about the proper way to operate things in the lab.*

This scenario was followed by a multiple-choice question:

> *Who do you think should be held responsible for this incident?*
>
> *A) The Lab supervisor is responsible. He should have trained and reminded her to properly position the sash.*
>
> *B) The student is responsible for this because she should have read the instructions and put the hood sash farther down. She also should have checked MSDS for the chemical she is working with and taken the right precaution.*
>
> *C) The university is responsible for the way the lab is designed; the safety shower and eyewash are not easily accessible. Additionally, the hood should have a lock that prevents the sash from accidentally being raised more than the recommended height.*

Overall, both the Fellows and later the General Chemistry students felt that people should be responsible for their own safety and should not rely on others (e.g., the instructor and/or university) to look out for them. However, the moderator asked a follow-up question about how the students' parents would respond if it had been them hurt in a chemical accident. The unanimous answer from the General Chemistry students was that their parents would blame the instructor for the incident and hold him responsible. (This question was not posed to the STEM Fellows.)

The General Chemistry students also provided feedback on the structure of the clicker system. They enjoyed the atmosphere and discussions that the clicker system provided. There was a sense of excitement in the class period that used the modules, and both the faculty member and teaching assistant felt that the students, as a whole, ended up engaged in the activity. There was little passive behavior by the class. Students also felt there should be a "right" answer to each situation and were somewhat distressed when an answer was not provided to them. However, this allowed the moderator to emphasize that ethical issues do not have an exact answer and depend on the circumstances surrounding the situation. Overall, the students enjoyed this method of teaching and discussion and indicated that they would like to participate in similar exercises. They felt that they were able to learn and expand their thinking in order to look at situations from multiple viewpoints.

From the "clicker" voting by the General Chemistry laboratory students (with 22 students), the most-selected responses were similar to those given by the STEM Fellows. This suggests, based on student responses, that the General Chemistry students appear to make the same ethical decisions as more advanced students.

The students who were at Illinois State University for the STEM program in 2009 were diverse ethnically, racially, and by gender (2 males and 9 females). Due to their various backgrounds, the STEM students had different viewpoints on ethical situations that allowed for the development of interesting discussions. Through these conversations, they developed a deeper understanding of the complexity of ethical issues, along with an increased ability to cope with these situations.

We think that the clicker technology is an important tool to engage young scientists in the responsible conduct of research. The clicker-response modules designed by the STEM Fellows would be easily adaptable to different learning environments with only small modifications. Faculty members (moderators) guiding students using clicker technology should have a small amount of training so that they know how to engage the students in discussion without leading them to particular conclusions or appearing to take sides.

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