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In the Classroom

Progress in Practice: Teaching and Learning with Case Studies

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Cases are well-written vignettes, usually expressed as dilemmas, that allow the reader to engage ideas along emotional and intellectual dimensions.

The formal analysis of case studies is a standard educational experience for students of business, medicine, and law. Published in 1954, McNair and Hersum's description of the use of the case method at the Harvard Business School marks the beginning of the modern age of this structured teaching strategy [1]. Harvard has maintained its leadership in the area of case instruction in

*Individuals involved in curriculum design often introduce new, modified, or applied ideas about instruction that span from classroom methods to philosophies of education. In this series, we examine progress in chemical education that is related to actual practices, and where many recommendations have originated from areas in higher education that exist alongside of and overlap with chemistry. Rather than an exhaustive review, we will select examples, background, and vocabulary that may either invite interested newcomers to explore a different area in their teaching, or provide language and precedent for individuals who wish to contextualize ideas they have developed independently.

—Brian P. Coppola, Series Editor

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business [2], and over time the use of cases has been adapted to many areas, including addressing issues of teaching and learning in education [3–6]. Case studies are also generally recognized as a highly effective way for faculty, research scientists, and graduate and undergraduate students to examine topics in research ethics in a classroom setting [7–10].

Cases are well-written vignettes, usually expressed as dilemmas, that allow the reader to engage ideas along emotional and intellectual dimensions. Anticipatory scenario building is an important strategy for success in learning [11] and has even been suggested in the context of the evolution of cognition [12]. Well-crafted cases anticipate scenarios that a learner might eventually face in situations that do not allow time for careful deliberation before an action (a decision) is required. In a monograph published by the American Association for Higher Education (AAHE), "Using Cases to Improve College Teaching" [4], Hutchings outlines the core characteristics of "cases" that are independent of their individual contexts.

Cases are authentic

Cases tell a credible story (having "the ring of truth"), and in doing so the reader can easily identify with the situation being described and can be drawn into the situation as a participant might have been.

Cases provide concrete details

The information must be present from which the reader can make real judgments or engage in a meaningful debate, otherwise the situation becomes too conditional on information that is not provided. The richness of a dilemma is made clear by providing the reader with a well-written set of facts that anchor the imagined situation.

Cases draw their power from the narrative format

A well-written case foreshadows, alludes, and causes the reader to draw inferences. The dilemma being presented generally represents an unusual situation, so cases will often be naturally compelling stories because the situation unfolds in an unanticipated way—especially when the initial clues misdirect the reader.

Cases are open-ended and deliberately ambiguous

Ambiguity is not lack of clarity for an effective case study, but rather the description of a paradoxical situation. One hallmark of a well-crafted dilemma is to clearly convey how

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the benefits gained by different stakeholders are in conflict with each another. A case is supposed to cause the discussion of conditional options along many possible lines of inquiry rather than to solicit single, best answers.

Bunce raised the issue of using case studies in undergraduate chemistry education in 1955 as a way to evoke "understandings and appreciations [about chemistry] not developed by studying facts and principles in logical fashion" [13]. He viewed these as stories to complement the historical case method for science instruction developed by Conant [14]. Another publication advocating the case method did not appear in the *Journal of Chemical Education* until Jones described its use with high school chemistry students in 1975 [15]. Only a few other authors have explicitly suggested the use of case studies in chemistry education [16, 17], and then as a way to provide meaningful contexts in which to motivate the interest of students in chemistry, such as with pharmaceutical and industrial situations. The notion of situated contexts has reemerged in the textbooks (and programs) created by the American Chemical Society called *Chemistry in the Community* and *Chemistry in Context*. In addition, the upcoming profusion of "instructional modules" for chemistry instruction are all based on integrating chemistry into a narrative and often socially relevant situation. In another sense, many authors have used the term "case study" colloquially, meaning "an example of" a phenomenon that they wanted to illustrate [18–26], as in "the case of DDT" or "a case study on molecular hydrogen calculations."

Case studies are *virtual events*; they rely on the imagination of the readers, their identification with the situation, and a candid self-assessment by the readers about how they would actually respond. Cases are usually very specific to the situation of the readership. For example, cases that rely on the experiences of a research director are not generally accessible to undergraduate students. Cases are also intended for group work, relying on both oral and written communication skills. Students, or any other readers, must extemporaneously formulate ideas and express them, and they must also use critical listening skills. Another useful practice is to have groups of learners develop and refine their own cases. Cases produced locally are invariably based on personal experiences and correspondingly allow their writers an even deeper reflection (even catharsis) on unresolved events in which they were a participant.

There are different models for how to structure group work. In our structured study group program [27] for first-year Honors students, case studies in research ethics are

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included in the first-and second-term curricula and allow us to study scientific practice in addition to factual information. We have rewritten cases found in Kovac's [11] *Ethical Chemist* to better reflect the context of our first-year students. During the last month of the second term, the students produce their own ethics cases, usually drawn from their experiences at the university. Over a four-week period, three cycles of editing and peer review for both the content and the composition are included with the weekly group meetings.

The following written directions are provided to the students:

In the following examples, situations arise as case studies. In each case, there are a number of imbedded issues that are meant to provoke discussion. The purpose of these cases is to have you consider the ramifications of these situations before you might actually encounter them. To discuss cases, participants should consider the following "leading questions":

1. What are the possible courses of action for the different individuals involved in this situation? What ethical questions are raised by each alternative? Another way of approaching this question is to consider who benefits from a given course or action and who is harmed, including any local group (a research group or department, for example), a larger group (such as other members of the professional society), as well as the general scientific or social culture.

2. What principles can be used to decide which action is the best? Many times, there is no clear cut decision ("clear-cut" equals "all-win"). The realities of social situations and the seemingly natural tendency to "get along" can cause the persistence of clearly poor judgments.

3. Having decided which course of action is the best from an ethical point of view, are there practical considerations which might make this strategy difficult to implement?

4. To whom might you turn for advice on what to do in this case? One of the benefits of case study analysis, in my opinion, is to remind individuals that they often take on too much responsibility when they do not have too, and when the decisions have already been encountered by my other like themselves, in the context of an existing system of rules.

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We also provide the following explicit instructions on how to structure the group work.

Case Studies Done in Focus-Group Format

Every group of about 5–7 participants should have a facilitator/leader who moderates the conversation and keeps the discussion on task. The facilitator should be familiar with the cases so that issues that are not raised by the group are considered. The facilitator should also ensure that everyone participates, feels comfortable with their participation, and also gets their point across. One of the participants should act as the recorder. The recorder keeps notes on the issues and options raised by the group, provides a summary to the group once a consensus is reached, and reports the group's position to the larger audience when necessary ("In our group, we...").

Outline of roles and timing of group work:

1. Divide into groups with a facilitator.
2. Assign/Elect recorder for Case 1.
3. One individual from one small group reads the case to the entire room.
4. About 10 minutes of deliberation within the groups:
   - What issues relate to the context of the case?
   - What possible suggestions or resolutions are possible? Explore a full spectrum.
   - What consequences are there with each option? Who are stakeholders and what is risked?
   - ...and, what are the benefits?
   - Recommended a course of action and conditions for satisfactory resolution.
   - The recorder continually restates and clarifies the group's thinking.
5. About five minutes of whole-room discussion led by one of the facilitators; reports from groups to gather the unique set of responses; bottom line reflections.
6. Choose new recorders and class reader and go to the next Case.

Case Studies For Undergraduate Chemistry

The following cases have been used with groups of 15-25 first-year Honors students in the structured study groups. The first two cases have been modified from Kovac's casebook and the third one was created to follow from them.

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Case 1: Data Points

You are an undergraduate research student engaged in the study of substituent effects on the rates of reaction of a particular class of compounds (changing parts of the molecular structure and observing the effect). Based on what you have been told by your faculty advisor, you are expecting that the rate constant will vary linearly with the increasing polarity of the substituent. After performing a careful set of triplicate experiments, you go to your research director with a graph of rate constant versus polarity. With the results of 10 different systems plotted, 8 of the 10 fall nicely on a straight line, but 2 points are well above the line. Your research director is convinced that the two "deviant" points are in error and strongly recommends that you repeat those cases. What should you do?

1. Do you repeat only the two "deviant" measurements?

2. Do you repeat all the experiments?

3. Are there circumstances under which you simply omit the two points that do not fall on a straight line? After all, the majority of the cases actually fit the desired model.

4. Independently, you examine three other examples from samples that were left over from the previous undergraduate researcher on this project. All of them are also well off the line. In fact, your results agree with the data written in that student's notebook. How do you address these results?

Case 2: Expectations

As a undergraduate research student in a major chemistry department you are carrying out a series of experiments designed to verify your research director's "pet hypothesis." She expects that a series of molecules whose substituents vary in a regular way will produce a useful new method for controlling the outcome of a certain chemical reaction. You have carefully studied a large number of reactions and, to you, the data look random. But each time that you show your advisor the graph she asserts that she sees the desired trend emerging and sends you back into the laboratory to perform more experiments under another set of conditions. While it seems clear to you that the expected correlation just doesn't exist, your advisor continues to insist that it does and provides a number of theoretical arguments to support her claim. What do you do?

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Case 3: Other Expectations

You are still an undergraduate research student in the laboratory described in Case 1, except this time you share a laboratory with a graduate student who is doing work on an analogous project. Curious about the outcome, you actually work up your colleague's data independently (it is late one night while you are waiting for the automated sample collector to finish its job, and the notebooks are sitting open on the desk that you share). You are convinced, after just a few minutes looking at how the data has been handled, that the part of the data that appeared linear was manipulated to give that result, and the only three authentic points are the ones off of the line.

a) How do you proceed?

b) What if your lab-mate is a senior undergraduate who has been working in the laboratory for three years and has a publication with the research advisor. How does this affect your options? What if the notebook is that of a post-doctoral student (a Ph.D. from another school doing work in your research group)? What if the student worker is your research director's daughter?

Case Studies Used in Training Graduate Student Instructors

Our use of case studies has extended to the training of graduate student instructors, a program for which I share responsibility each year. The training of graduate assistants in our *Structure and Reactivity* courses has been a challenge because of how different these courses are from their own experiences in introductory chemistry.

In this year's training program, instead of simply talking to the new graduate students about "professional behavior and ethics," I organized the group of trainers (experienced graduate students) to create a set of case studies that were discussed by the new graduate students in a facilitated focus-group format. This method was better than the seminar like alternative in every respect.

We are following up on this year's program in a number of ways. About three weeks into the term, a two-person team from our Center for Research on Learning and Teaching conducted a debriefing of both the new graduate students and the seven graduate student trainers to get candid feedback on the use of cases and the overall training experience.

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About six to eight-weeks into the term, we will ask the new graduate students to submit some cases based on their teaching experiences in the department. A group of experienced graduate students who are in a chemistry teaching and learning seminar that I conduct will take responsibility for helping the first-year graduate students refine their cases. In my experience, this will also provide our new graduate students with the opportunity to reflect on their overall graduate experience in a way that will be useful for the department.

About 10–11 weeks into the term, we will hold a 2–3 hour session (comparable to the final one used in the training program) where the new graduate students will consider a select group of five to six cases that they have created.

The following cases are representative of the ones used in the 1996 program (created by the author or together with the graduate student indicated next to the title of the case).

Case 1: The Case of the "A" Student
You are the graduate instructor of a first term organic chemistry laboratory that asks you to use a series of qualitative assessments (record-keeping, attendance, level of engagement) as the basis for grading. The first formal feedback to your students happens at midterm. Students that meet the nominal expectation are supposed to earn a "B" grade, while demonstrated independence and initiative are the stated criteria for assigning higher grades. A premedical student reacts quite strongly to your evaluation of her work as a "B+", and she demands that she should get an "A". After all, she argues, she has completed every assigned task, has come to every period on time (and stayed for the entire 4 hours), and always has good results. When you reviewed her work, on the other hand, you found that her notebook was confusing and hard to follow, and that she lacked a solid theoretical basis for her laboratory work as well as a lack of common sense in handling materials.

What range of responses is appropriate? What responses are inappropriate? What assumptions can you make about this situation? What behaviors on your part during the term would influence how this situation might unfold?

Case 2: An Observation (with James Zimmerman)
You are a first-year Graduate Student Instructor (GSI) who, with two of your colleagues, is proctoring an examination in a large (350-student) room. The class is

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taking their first examination of the term and, as you are moving around the room, you notice a student seated in the back of the room. He seems to be looking at you whenever you scan the section where he is seated. As you move closer, you see that this student has placed a small piece of paper in his calculator cover, which is sitting off to the side. During the first half of the exam, you keep an eye on this student. Although you never explicitly see him using this slip of paper, you know that the students were not allowed to bring anything into the test besides their calculator and a pencil or pen.

What options and obligations do you have in this situation?

Case 3: Outside of class (with David Johnson)
You are a first-year GSI who teaches four discussion sections in a large introductory chemistry course. While passing through campus on your way to get lunch one day, one of your students spots you and has questions concerning an exam. The explanations are going to be a bit involved. Do you invite the student to join you for lunch so you can field these questions?

One Friday evening, while you are out with your friends (most of whom are other GSIs in the program), you visit a local bar. One of your students is there and offers to buy you a drink. Do you accept this offer?

Instead of offering, your student has already ordered your favorite drink for you (you did mention this in class, after all), and it is delivered to your table by one of the waitstaff.

You are out with your friends on another evening, and the group stops in at a coffee shop. While your friends are ordering, you see one of your students studying for an upcoming exam. You stop by and offer the student some encouragement. After you field an impromptu chemistry question, your student turns the conversation to a new movie you are interested in seeing (you did mention this in class, after all) and asks whether the both of you might not go to see it together tomorrow night. Do you accept this offer?

Case 4: Dissin' the Course (with Eric Monson)
You are a first-year GSI. A student from someone else's discussion section sits down with you during your open office hours and asks for help with the review questions for the exam, which is coming up the day after tomorrow. Answers, scratched notes, and calculations fill the small stack of paper she pulls from her folder, so you can tell she has

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already put some effort into trying to solve the homework herself. As you begin to go over her work with her, however, you immediately recognize that she is having fundamental problems with many of the questions.

> Confusion runs deep on an oxidation-reduction question. Trying to get her on the right track you say, "Okay, the reaction they're asking about here is very similar to the one you all did in the laboratory. Can you describe to me what happened there, either from things they've been going over in lecture, or from your discussion section about this laboratory?"
>
> As she is paging through her notes, she mumbles, "Well...", but you can see she hardly has anything written down about any of this.
>
> "Have you been going to lecture?"
>
> "Yeah, I try to, but the lecturer is so boring and she can't teach this stuff! We all sit there and try to listen, but she's just confusing us! And, then, during discussion, nobody knows what's going on, but our TA just stands there...he tells us to do our best and then just writes out the answers to the questions at the board. We don't even know if what we're saying is right or not and he doesn't really help us at all!"

Just before you reply, you reflect on your own instruction and you think to yourself just how much you agree with her assessment of this course.

Case 5: The Instructor in the Next Lab

You are a first-year graduate instructor in a first-term laboratory course. Your teaching laboratory is adjacent to that of a third-year graduate student, and the set-up of the labs is such that three large windows allow both of you to keep a full view into each other's lab room. Although this third-year student spends most of his time seated in a chair with his back to his class, reading journals, he appears to be responsive to his students' interruptions. Because you can see through the window, you also note that there are fairly detailed directions written on the chalkboard, including descriptions of the anticipated results that were meant to be discovered by the students (according to the way that the activity was described by the faculty member in charge of the course).

What are your options and obligations in this situation? What if the instructor in the next lab is a member of your entering graduate class? What if the instructor in the next laboratory is your office-mate? What if the instructor in the next laboratory is one of the five senior undergraduates who also teach in the laboratory program?

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Case 6: The Morning After (with Joseph Gardner)

As a GSI, you are responsible for grading examinations. The morning after the exams were graded, but before they are returned, a terribly upset student is brought to you by one of her friends. The friend, a former student of yours, asks her to tell you what has upset her.

> "I don't know what to do," she says with a shaking voice and teary eyes. "My TA saw me in the hallway this morning and asked how I did on problem 4. I told him I messed it up. I was kind of embarrassed because he had been giving me all this extra tutoring, and ... but... but then he said that he graded that question and I shouldn't worry because he 'helped me out!' I just kind of said 'thanks' and then left. What am I going to do? How can I... He gives me my grade and everything—right?"

How do you respond? Would your response be changed if the student was male and the GSI was female? Both male or both female? What if you had overheard this conversation by accident instead of having had it brought to your attention?

Conclusion

Lessons that relate to changes in behavior, especially where skills are needed in order to anticipate or avoid potential problems, are not transmitted by teaching them like factual subject matter. Examining case studies in a focus-group format is a powerful way to engage discussions about topics that benefit from deep personal input.

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