USING COGENERATIVE DIALOGUE WITH UNDERGRADUATE BIOCHEMISTRY STUDENTS TO IMPROVE LEARNING ENVIRONMENT

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This is a study of utilizing cogenerative (cogen) dialogue in an undergraduate biochemistry class. By cogenerative dialogue, it means that the teacher meets with four or five target students once a week and encourages students to discuss ideas for improvements in the learning environment in the classroom. With this formative feedback, the teacher can implement and test the ideas for improvement during the same semester as she teaches the class. Other students not in the cogen group have an opportunity for providing feedback indirectly through the target students or more directly through the class Web site on a bulletin board where comments can be posted anonymously. The teacher and student researchers work together to analyze the transcripts of the cogen meetings, sorting the data, looking for themes, but focusing on the contradictions, so that the teacher can understand better how to improve the learning environment in her classrooms.

Introduction

Many science education researchers focus their research on science teaching and learning at the K-12 level. However, increasingly we realize that if the college science teaching were better at helping students (and future science teachers) construct knowledge through their prior experiences and culture that K-12 education would improve.

Recently, some recent reports (NRC, 1997, 2002, 2003) and edited books (Taylor, Gilmer & Tobin, 2002; Sunal, Wright & Day, 2004) report not only on the problems in college science teaching but also on some possible solutions. For instance, Bowen (2002) and White (2002) point to problems in college science teaching, while Abbas, Goldsby and Gilmer (2002), Humerick (2002), and Gilmer (2002) point to ways to improve the teaching and learning of chemistry and biochemistry. Better communication and listening to one’s students and reflecting on what they say can help the teacher modify the teaching.

A way of learning from one’s own students is the use of cogenerative dialogue on how to improve the learning environment in the classroom. Tobin, Elmesky and Seiler (2005) utilize cogenerative dialogue, especially in urban science classrooms. In this edited book, Seiler and Butler say that cogenerative dialogues are “useful activities for teachers and administrators to identify and resolve contradictions that pertain to science education, either by strengthening or extinguishing them” (p. 64). Also Seiler and Elmesky (2005) indicate cogenerative dialogue:

1) “allows classroom events to be a source for theory-building as well as for inviting changes in classroom practice” (p. 13), and

2) provides “a structure for maintaining mutual focus or entrainment and fostering solidarity and positive emotion energy (Collins, 1993) as we form collective understandings among researchers” (p. 13).
These ideas led to our study of a biochemistry classroom in which one of the authors was the undergraduate biochemistry teacher, and the other, an undergraduate student in another biochemistry class, was a researcher in the cogen group for this study.

**Theoretical Frameworks**

There are three theoretical referents utilized for this study: social constructivism (Tobin & Tippins, 1993), cultural-historical activity theory (CHAT) (Engeström, Miettinen, & Punamäki, 1999), and theory of structure (Sewell, 1992, 1999).

Utilizing social constructivism as a theoretical perspective, people learn based on prior constructs and experiences. By providing some experiences that involve collaborative learning, students have opportunities to construct meaning by interacting together, either on-line or in person. Each student can tap into his/her prior knowledge and bring that to the fore when working on collaborative projects that are due for class or in the cogen group interactions.

Through CHAT individuals (and societies) live within constraints and opportunities that modulate the contradictions and coherences that influence what activities happen and why they happen as they do. According to CHAT, in human interactions, there are several interacting factors that can influence the flow of Subjects attaining their Objects and moving towards their Outcomes: Tools, Communities, Division of Labor, and Rules or Schemas (Figure 1).

![Figure 1: CHAT diagram of how various factors influence how and if the Subjects move (or flow) towards their Objects in quest of Outcomes in human activity.](image-url)
For this paper the faculty member with the help of the student researcher examines the contractions and coherences in the flow of the students (the Subjects in CHAT) toward their Objects to come to understand biochemistry and its connections to other fields of science towards their Outcomes (i.e., their chosen professions and way of life).

Influential factors in this flow include Tools or resources available to the students (the Internet, the textbook, the library), Communities (collaborative student groups, cogen group, and a second biochemist who tag-team taught the same class), Division of Labor (among students in collaborative groups, and between both biochemists and their students), and Rules/Schemas (constraints in undergraduate programs, culture of authoritarian science teaching, MCAT testing). By focusing on progression of undergraduates toward becoming professionals and on how the various elements influence this flow, it is possible to learn how to improve the system.

Sewell’s ideas on the dialectic tension between structure and agency help one uncover the contradictions within the CHAT framework. The structure one provides in a classroom influences the agency of both the students and the faculty members, while the agency of the individuals involved also influences the structure.

**Design of the Study**

Two biochemistry faculty members tag-team taught two large sections of an advanced level biochemistry course. The goal of tag-team teaching (Brush, 2002) was to see if it were possible to reduce the time load of the faculty so that there would be more time for research. The course was General Biochemistry II, which is the final biochemistry course taken by biochemistry majors and students with other majors who plan to go to medical school. It is an intensive course with emphasis on biosynthesis, biodegradation, and regulation of advanced metabolism.

Teaching even one section of 70-90 students for an entire semester, three times per week, for such an advanced level classes is consuming, especially in light of the rigorous demands in the research, for the faculty who are directing graduate students in biochemistry research, coupled with the competitive atmosphere in obtaining and keeping research grants and in getting research publications accepted.

We use pseudonyms for the names of the students in the cogen group, the undergraduate researcher and the two biochemistry teachers. We use qualitative data from the discussions with the cogen students and written responses to the questionnaires given at two times during the semester from all the students. Using Guba & Lincoln (1989), we develop a fourth generation evaluation of the classroom and the cogen meetings.

Therefore, to learn from this tag-team teaching (Brush, 2002), one of the two faculty members, Kristin requested that students sign up if they were interested to be part of a cogenerative group that would meet once a week at lunchtime during the semester to talk about how to improve the learning environment in the classroom. About one half of the total of 160 students from both sections indicated a potential interest in being part of the dialogue, having seen the human consent letter on-file with the university.

After the first quiz in the second week of classes, Kristin selected two students from each section, selecting one student who did the best and one student who had more trouble with the first quiz, and then balanced for gender and ethnic background with the two remaining students.

The “cogen” group (Martin, 2006; Geelan, Gilmer & Martin, 2006) meet each week and discussed ideas for improving the classroom while the cogen students and Kristin shared “bread”
together—bagels, cream cheese or humus, fresh fruit, and sometimes cookies. The undergraduate involved in the analysis, Jennifer, videotaped and audiotaped each session and transcribed the words of Kristin, the four students in the cogen, and Jennifer’s own points that she interjected within the cogen meetings. The second faculty member, Thomas, did not participate in the cogen sessions, although Kristin updated him on what the students were saying each week. In addition, there was an electronic site on Blackboard where all students could provide ideas on how to improve the learning environment, in which a student could post either anonymously or using the student’s name. Also the cogen students acted as reporters for others in the class who might tell a cogen student their ideas, and the cogen students would synthesize these ideas and bring them to the cogen sessions. Kristin sometimes mentioned the results of the cogen sessions in class until some students in the class said that they did not want to “waste class time” on hearing about the results when they wanted to use the time for learning biochemistry.

Kristin taught most of the first half of the semester for both biochemistry sections, and Thomas taught most of the second half. Therefore, what the students liked about Thomas’ teaching did not help Kristin improve her teaching during the semester of study. However, what she learned from this study she could harness in the next semester.

**Findings of the Study**

The four cogen students remained in the cogen group for the entire semester, providing valuable feedback in a formative fashion. This allowed Kristin to modify her teaching in some respects during the semester of the study. The students in the class could see if (and how) Kristin responded to the students’ suggestions for change. For instance, the students requested that Kristin list the objectives for each lesson at the beginning of the class, and she did that, and the students said it helped them see the important points of each class.

Oliver: *Another thing to mention, if we could have like objectives at like the end of each PowerPoint or what to focus on inside the PowerPoint...*

Kristin responds: *I can do a summary, but I think I do summaries, like, maybe I don’t do them enough. So I [will] try and do them.*

Here are some comments from cogen students:

Oliver: *The only thing I wanted to mention real quick like, can we get the other screen fixed? It’s really distracting.*

Oliver: *I don’t know, maybe, uh, certain things, I guess, like pathways and stuff like that will be like good, I guess, if we could have one screen on the PowerPoint and the other screen actually write it out, the entire pathway.*

There were other things that were easy to do, like adding slide numbers to the PowerPoint slides, getting a laser pointer that was brighter and a different color (i.e., red rather than green), and fixing one of the two LCD projectors so that the image was brighter and sharper in one of the two classrooms.

The cogen students told Kristin that they liked having quizzes in the weeks between hour exams, but they wanted study guides of what to study. There were many complex topics, such as the *de novo* synthesis of purines (the bases in DNA and RNA), in which one or a few atoms at a time are added to build the complex fused purine ring system. Both teachers expected the students to learn and understand the biochemical steps.
However, it was not fully recognized or understood until after the semester ended the nature of the conflict between the two teachers in how detailed they wanted the students to know the material. Kristin was more interested in the students’ understanding (rather than memorizing) the material, so that the students could compare one metabolic scheme with another or see the connections between how the output of one cycle (like the Krebs cycle) fed into the electron transport chain. Therefore, Kristin’s questions on the quizzes and hour examinations were more conceptual.

Tammy: ...we don’t know what [Thomas] thinks is important [on Kristin’s exams]...

In contrast, Thomas wanted the students to know each individual step of the metabolic schemes with the name of each enzyme that catalyzed each step and how enzyme was regulated. He also asked thought-provoking application questions, which if the student did not know the biochemical details, then s/he would have a hard time applying the material and answering the questions correctly.

Alexis: ...how can I actually apply this concept to answer this question, maybe [give us] at least two in a lecture?

Alicia: ...how you like to create exams that give you, that allow you, to have time to think...

Therefore, it was hard to tell the students on a study sheet what exactly they should learn.

Kristin’s response: I told Thomas, sort of what you were saying, that, the test is an opportunity for people to learn. To give people an opportunity to learn, where they have enough tools that they can put things together, and then it gives you confidence that you can do it or it teaches you, [so you say to yourself,] ‘I need to learn it better, so I can do that.’ And he agreed that it’s good to do that, but he says that they can also learn after the test.

The two faculty members co-prepared and co-edited most tests and quizzes, so the tests reflected the values of both faculty members. However, Oliver had a hard time as it took him (and many of the other students as well) to think through the problems. He commented:

Oliver: The problem that I have is that there are so many questions that are critical thinking questions that you really have to go into them, and then you have the regular sort of questions that are more straightforward.

Kristin responded: So that one problem sort of like crossed into a number of different chapters, and you, sort of, had to synthesize to answer it. I try to generally have one synthesis sort of question like that on an hour exam and others more straight...what I consider more straightforward.

Kristin, when she taught a similar course by herself, provided opportunities for students to work together in collaborative groups, using technology to facilitate learning (Gilmer, 2004). This was important to Kristin, as she wanted students to construct meaning by using language in their spoken English and in their writing. In the tag-team teaching context, however, Thomas was uncomfortable including collaborative learning as direct part of the grade. Thomas made a compromise and allowed one opportunity for a student to change the grade of a low quiz to the grade obtained from doing a Chemistry Is In the News (CIITN) (Glaser & Carson, 2005) assignment. For this assignment each collaborative group of students identified a newspaper
article on an assigned topic (Asian bird flu for one section of class, and cyclooxygenase-2 inhibitors for the second section). One of the cogen students, Alicia, had been in another cogen student from the first semester of the two-semester sequence. In the earlier semester, I had given students a chance to pick their own topic for their collaborative group. Alicia commented on the prior course:

“I think being able to choose the topic was nice because if it’s interesting to you, you’re going to take more interest in it...”

And she continued on the current course,

“it was kind of weird to have an optional task on a specifically required topic...”

“it might be easier for you if it’s just required because then everyone has the same thing across the board...”

Each collaborative group had to peer review three other groups’ postings by responding (both quantitatively and qualitatively) to ten questions provided within the site. Once the reviews were complete, each group had an opportunity to improve their posting before Kristin gave the final grade, using the feedback that each group received from their peers and what they learned in peer reviewing the postings of other groups.

“Then I think two rounds [of peer review] are good.”

Kristin did all the grading for the students who signed up to participate in CIITN, which was about 2/3 of the students. Doing this project benefited most of the students who participated, and they appreciated the chance to improve their grade using alternative assessment strategies.

“It sort of gives people a chance to earn points in an alternate way, so you’re looking at alternative assessment.”

During the semester, the cogen group (and other students via the Blackboard Web site) provided valuable feedback on how to improve the learning environment, especially on the more structural features of the classroom. In addition, there were two other opportunities for all students to provide detailed feedback on the coherences and contradictions in the class—one was part way through Kristin’s teaching and the other at the end of the course.

Having the opportunity to meet with the four cogen students helped Kristin understand the demands and goals of her students. She facilitated their understanding of biochemistry and learning how to learn. The strongest of the cogen students taught the other cogen students how he learned, which facilitated their growth. He also learned to cross connect ideas that he had memorized, so he became a superb learner. This same student not only had the highest score on the first quiz but also was the one who did the best of all students in both sections at the end of the semester. The cogen student who was one of the weaker students at the beginning of the semester improved significantly, and he provided much helpful feedback within the cogen group.

The cogen students’ sense of agency became enhanced during the course of the semester, thereby influencing the structure of the classroom, especially when Kristin taught. There was less of an impact of the cogen group on the classroom structure when Thomas taught because he did not attend the cogen sessions. This points to Sewell’s theory of structure in which there is dialectic between structure and agency, where one can enhance the other.
However, the more deep-seated contradictions were harder to address formatively during the semester. For instance, there was a conflict in the values between those held by the two tag-team teachers and the societies in which they interact. Biochemists generally tend to value the rational value structure in their interactions with graduate and undergraduate students who are involved in research (Balinsky, 2006), yet when biochemists teach they value the authoritarian mode more, in which the faculty member has the knowledge and the students are to obey and learn the material exactly (generally by memorizing). Thomas focused more on the authoritarian value structure while teaching yet more the rational one when interacting individually or in small groups with students. Kristin, instead, used three value systems, the authoritarian, and rational and (sometimes) pluralistic (or postmodern) in her teaching, which went against the grain of the more authoritarian values enacted by Thomas in the second half of the semester. This resulted in conflicts in how Kristin and Thomas chose to assess their students, which was critical to the students as so many of them were pre-medical or pre-dental students. These students were in the midst of trying to get accepted into professional schools. The students would hear one value system when Kristin taught but see on the quizzes and hour examinations not only Kristin’s values but also Thomas’ values by the questions he asked of them to answer. It made it hard for the students to study, but it also may have expanded their view of biochemistry.

Another contradiction in the learning environment was how the students would play off the two faculty members in getting a higher grade on the quizzes and tests, originally graded by a group of teaching assistants. This did not come up at the cogen meetings. Kristin did not discover until near the end of the semester that the students saw her as a “strict mother” as she did not give nearly as many added points in any regrading of quizzes and hour examinations as Thomas did. This caused a conflict for the faculty members.

What Kristin learned on how to improve the learning environment in her teaching was that the students enjoyed when Thomas actually wrote the detailed chemical structures for each and every biochemical step while he spoke while teaching, while Kristin mainly used PowerPoint slides (taken from the textbook), pointing to the structures and explaining the connections. Kristin also used active learning opportunities within the PowerPoint slides. Kristin once tried writing structures while talking in her teaching, but found it very hard to talk and write complicated biochemical structures at the same time while teaching to her 70-90 students at a time. Kristin had learned from prior teaching that she needs to be close in space to her students, rather than stuck behind the overhead projector and behind the large desk, where she finds it difficult to interact with and see her students, while figuring from their expressions how well they understand the material. She would tend to walk up and down the central aisle or up the stairs in center of one of the classrooms.

In the future, Kristin had planned to use the two sets of screens differently. Instead of both screens showing the same slide as she had in this study, one slide could show the overview of the reactions within a particular biochemical pathway from PowerPoint, while the other screen could have a slide of pre-hand-drawn structures, showing what is most important to learn for each step. Meanwhile, she could still be with her students, standing on the middle aisle or out in front with them (depending upon the structure within the classroom). What happened, however, was that she taught in a split-classroom, in which the students were on each side of her. They could only see the one screen on their side of the room, so this did not work, but what Kristin did was switch back and forth from PowerPoints to hand-drawn sheets she had prepared in advance, with focus on the individual biochemical steps, including detailed structures. This worked better than just
using PowerPoint slides as she did in the study reported here. As evidenced below, however, one cogen student, Charles, liked the PowerPoint slides, just as they were, as he said that it helped him to focus on what I wanted them to learn:

Charles: *Because I know we talk about a lot of what needs to be changed and everything, but there are a lot of things right off the bat that were way better, like PowerPoint; all and all, I enjoyed the PowerPoint, so it kind of narrows things down compared to the book.*

In the future of tag-team teaching, there should be an understanding between the faculty members of a common value structure to use in regrading of tests and quizzes.

**Implications for Science Education**

Such a study as depicted here can be a model for how science faculty could come to learn on how to improve the learning environment in their science classroom. The cогenerative dialogue would be useful in any teaching situation, whether at the K-12 level or the higher education (in science education classes as well as science classes), whether in a tag-team teaching situation or a single faculty member teaching the class.

Tag-team teaching complicated this study, but there were valuable lessons to learn here as well. It is of great interest to science educators how university-level faculty members teach science for pre-service science teachers who are still preparing to be science teachers and for practicing science teachers through in-service workshops. This research examines how two biochemistry faculty members tag-team teach an advanced level biochemistry class, focusing on the contradictions and coherences in students’ learning between the two faculty members. The formative feedback through the semester from the cogen students was critical in Kristin’s growth. Through such research faculty members can learn to address these issues by utilizing theoretical perspectives that fit the situation, thereby improving students’ learning and interest in science.

**References**


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