Cogenerative Dialogue: Improving Undergraduate Biochemistry Teaching and Learning

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Introduction and Background

Recently published reports (NRC, 2002, 2003) and books (Author 1, 2002a; Sunal, Wright & Day, 2004) report not only on problems in college science teaching but also some possible solutions. For instance, Bowen (2002) and White (2002) point to problems while Author 1 (2002b), Humerick (2002), and Author 1 (2002c) suggest ways to improve the teaching and learning of chemistry and biochemistry. Krockover, Adams, Eichinger, Nakhleh and Shepardson (2001) report using collaborative research teams to improve science education in general chemistry undergraduate courses and in science courses for pre-service elementary teachers. Better communication and listening to one’s students and reflecting on their feedback can help the teacher modify the teaching.

Students entering undergraduate biochemistry courses are usually already committed to studies in biochemistry or a related field. These students have excelled, in general, in biology, organic chemistry, and physics before starting the biochemistry two-semester sequence. Most of the publications on college science teaching focus on the introductory science courses, and few and far between are the publications on upper-level science courses.

We undertook this study as a collaborative learning venture whereby a small group of students, in partnership with their instructor, sought to discuss and improve upon a second-semester biochemistry course at a major American university. We present student opinions and suggestions regarding all aspects of the course from physical facilities to teaching and assessment techniques. As a part of the dialogue, we also evaluated two recently developed instructional methods— the personal response system (PRS), and a teaching tool called Chemistry Is In The News (CIITN) (Glaser & Carson, 2005).

Theoretical Frameworks

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

Social constructivism theorizes that people learn based on prior constructs coupled with new experiences. Providing experiences involving collaborative learning, students 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 cogenerative group interactions.

Through CHAT, individuals (and societies) live within constraints and opportunities that modulate the contradictions and coherences that influence the activities that happen in life. According to CHAT, in human interactions, several interacting factors that influence the flow of Subjects attaining their Objects and moving towards their Outcomes include Tools, Communities, Division of Labor, and Rules or Schemas (Figure 1).
Experimental Methods

The program was undertaken as a cogenerative dialogue (Tobin, Elmesky & Seiler (2005); Martin (2006); Author 1 (2006)) between the instructor and five undergraduate students from the biochemistry class, code-named Mike, Alizee, Alice, Jane, and Moh. The professor selected the students based upon their background, interests, and quiz grades, with a mixture of different cultures and both sexes. These students contributed their own ideas as well as those of other students in the class. The cogenerative dialogue group met weekly over a light lunch for approximately a one-hour period for the 12 weeks of the course instruction to discuss relevant issues within the learning environment. We audio and video recorded each cogen session for later transcription and presentation. In addition, we had written feedback from all students in an anonymous survey at the end of the semester.

An undergraduate researcher transcribed the cogen sessions in the next semester as part of a directed independent study course. The researcher was one of the former cogen participants of this study. We sorted and coded the text of the transcripts using the NVivo program (version 1.0.118) for analysis. We identified five major areas of effect upon the students’ learning ability: Class Environment, Biochemistry Content, Teaching Methods, Teacher Learning, and Other Effects. Figure 2 shows an organizational chart of areas the students identified in their dialogue with the instructor. Each identified area (“node,” in NVivo) contained several subjects, which we explored in detail in the analysis.
Results and Discussion

In this proposal, we provide at least one quote from each of the five major nodes (Figure 2), but in the presented paper we would provide more data.

Class Structure

One of the main issues and the most difficult for the students, which detracted from the students’ ability to learn biochemistry, was the physical facility. The design of the classroom for lectures during the study was poor and presented many physical impediments to effective learning. In early cogen meetings, the students often raised this issue about the structure of the classroom; however, since we could do nothing about the classroom during the semester and the course could not be moved to another location, we did not discuss it further.

Dr. J: Apparently, the classroom is horrible to teach in.

Mike: It is like a hallway. There is like one side of the room…. like one third of the room has students and has a projector, and there is a third room where there is nothing, and she (Dr. J) is in the middle, but there are columns in the sides, and there was...

Alice: I think it was design of two little classrooms and a hallway right down the columns.

Dr. J: I can’t see all the students in the same time. I have to move [from one side to another.]
(Cogen meeting transcript, 2006)

Early on, the students also discussed some technical malfunctions involved in some of the recent teaching methods – especially the LCD projectors used to show PowerPoint presentations. We conclude that while the students were interested, an instance which causes a distraction or draws attention away from the biochemistry content caused a break in the students’ concentration, and thus, their learning process.

Biochemistry content

The students found the emphasis on “big picture” ideas over details very useful in understanding and recalling the information contained in the course, not only for the information but also for the context of the information with regard to the larger concepts in biochemistry.

Biochemistry instructor who teaches General Biochemistry II should always know that this class is all about conceptual ideas where things are linked. Dr. J always focused on “big picture” kind of questions which things are liked between chapters. The cogen group knew that this class is not based on memorization only (unlike General Biochemistry I); it also deals with understanding the concepts and linking things together. This is a key element on the learning environment of the classroom because using this method (linking concepts), things will make sense and it will encourage students to make an educated guess about things that are related to biochemistry.
(Moh, directed individual student report, 2007)

Teaching Methods

In terms of the teaching methods of the course, the students emphasized to the instructor to slow down the speed of instruction to match the detail and difficulty of course material, i.e., to speak more slowly on complicated pathways, but continue at a faster pace through less challenging concepts. A guest lecturer in the class had spoken much faster, so the students received well Dr. J’s discussion of the application of the “big picture” in biochemistry.
Dr. J was very interested in teaching and had studied her own classroom in the past with action research (Author 1, 2002c). Therefore, she had explored various avenues previously to improve her teaching. Students in this class were competitive as most were premedical students, so they were very concerned with the grade. Dr. J tended to focus on teaching the “big picture” and tried to develop questions on the tests that asked students to synthesize the larger picture and ask less memorization questions.

Dr. J: I am looking for patterns myself and what to ask you…and that might help you to think about it. The final will not be as detailed as the quizzes, but will be a big picture. I am a big picture person. Try to connect things together and that is why I do that. I am looking for patterns myself, and what to ask you: i.e., where is NADPH made and how is it used? And that might help you to think about it. (Cogen meeting transcript, 2006)

The students found the uploading of former quizzes and tests from earlier semesters to the class Web site useful, not for so much for their biochemistry content but for the format of the tests, to determine the instructor’s style for asking questions. Dr. J required the students to show an attempt at answering the question before the student could see the answers.

The students took well to the use of technology in teaching methods – especially the use of E-mail, electronically submitted work, electronic distribution of PowerPoint presentations, and Blackboard software for classroom integration. Students’ positive response to the use of Blackboard software and Web interactions stands as proof of the utility of the university-wide adoption of the software and ease-of-use of the university’s single-login system, in which students use one username and password to log onto all University Web-based services.

Response was generally favorable for the use of the Chemistry Is In The News (CIITN) Web site (Glaser & Carson, 2005) in which students read an article on biochemistry from a newspaper and reported on it, in groups, to their classmates – involving outside research and writing. Issues with CIITN included miscommunication on the part of the students, issues with the Web site, and the potential issues inherent in a peer-review system. Student reaction was mixed but generally favorable for the use of the Personal Response System (PRS), which uses radio frequency response units (“clickers”) with multiple buttons to communicate with a central receiver in a multiple-choice, quiz-type review. Student issues with the PRS system centered on problems with the program used and some minor hardware issues. In general, students enjoyed and learned from the use of technology, however, poorly functioning technology seemed to generate frustration and enmity toward the format, but not the idea.

Teacher Learning

Dr. J learned considerably from the cogen students during cogen, for instance, Mike gave her feedback immediately after a class in a cogen, when he said, “The one slide you put up about nitrogen metabolism—that was great,” to which Moh responded, “Yeah.” (Cogen meeting transcript, 2006)

Other Effects

Even after the end of the course, two of the cogen students gave Dr. J additional feedback. One cogen student, Moh, said Dr. J could have made better use of class time by arriving more than five minutes early as she usually did, to get the technology ready in the midst of questions from arriving students, as preparations always took longer than she expected.

One problem for instructors who use PowerPoint for lecture faces is time management. It takes some time to load [the programs] and get ready for lecture. The problem is that if this time were
deducted out of class time, less time would be left for lecture. For example, if the instructor used ten minutes for preparing and loading PowerPoint, and the class is only 50 minutes long, then only 40 minutes is left for lecture. This is not including other time consuming things such as opening websites, loading the PRS system, using the handwritten projector, and fixing the microphone. For better time management, as soon as the class starts, the instructor should be ready to lecture. (Moh, directed individual student report, 2007)

The second cogen student, Alizee, reminded the instructor that since she promised to have material posted for review by a certain time, she should try keep to that timetable.

Some of the people told me that they were waiting for you to post the final review, because you had said in class that you were probably going to cut some of the review material down and then finish Chap 28, having it posted at least by Sunday. (Alizee, e-mail after grades were due at end of the semester, December 2006)

Both of these students’ comments shared accurate perceptions of occurrences, and Dr. J appreciated their advice. Students are still cautious saying certain factors that affect the learning environment during the semester, as they may be afraid that their mentioning such items could lower their grade. Dr. J tried to defuse such concerns, but they were obviously still there, to a certain degree.

Interest to the NARST Community

The results presented within, and conclusions drawn from the study, present vital feedback from students on the effectiveness of instruction using new methods, as well as distracting influences in the classroom. The feedback is concurrent with the semester, so students and the instructor can determine any improvements. The lessons learned from this project can be applied to science education in other science courses, not just undergraduate biochemistry courses, and therefore would be of great interest to the NARST membership at large. Our presentation also includes excerpts of transcripts and video clips of the cogenerative dialogue group, which further emphasize, in the students’ own words, the critical points of this study.

This study also builds on concepts and ideas presented at the 2007 NARST Annual International Conference (Author 1, 2007), in which one of us presented a paper describing the use of cogenerative dialogue in a team-taught, biochemistry course. The ideas explored in the previous paper are further investigated and refined, leading to a greater understanding of factors affecting the learning environment of students in a collegiate environment.

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