A Complex Instruction Rotation Applied to a High School Chemistry Classroom

Jennifer Kennison Science Department
Bellows Free Academy St. Albans, Vt.

with

Charles Rathbone, Ph. D. University of Vermont
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Abstract

Jennifer Kennison noticed something different about the way her high school chemistry students were working together during Complex Instruction rotation. Her attention to the change in her students' learning caused me to think about how Elizabeth Cohen's often referenced Kurt Lewin's comment "There is nothing so practical as a good theory." As a result, I decided to ask two students who were teaching CI rotations if they would be interested in working together on a conference presentation that looked at their work through the eyes of Lewin's dictum. They would take on responsibility for documenting and writing about their CI units and I, their advisor, would take on Lewin. Both Jennifer, an experienced teacher and MEd. candidate, and Bethany Brodeur, a senior elementary education major, agreed to this task. The resulting papers formed the core of our presentation at the 2004 conference of the New England Educational Research Organization. Together, they form a short volume that integrates learning about CI with the practical implications of implementation of CI at the elementary and secondary levels. This paper reports Jennifer's observations and reflection for the CI Rotation she taught on the periodic chart of the elements. CR

Introduction:

After 17 years of teaching high school science, I spent a year out of the classroom. During that year, I had the opportunity to reflect on my own practice as an educator. Immediately upon NOT going into the classroom in September, I had my first 'ahha' moment. As a science teacher, I had always been able to say that, yes, students in my class worked in small groups. We veteran science teachers pride ourselves on student lab partnering. But, I realized, I had never taught students to work in a group. How could I have overlooked such a basic idea for so long? I know many adults who can't work in groups; how could I expect teenagers to inherently possess these skills? I then learned of a professional development opportunity with Charlie Rathbone, Ph.D. His reputation for teaching Complex Instruction (CI) drew me to attend his workshop, to later enroll in an introductory course in CI and to followed up with a course in Differentiated Instruction that allowed me to revisit the principles of CI. This paper is simply an attempt to put into writing an experience in the
design and implementation of a CI rotation at the high school level. Although the experience described here is a defined point in time, my continuing experiences and reflections on CI are a moving target.

Description of school and classes:

Bellows Free Academy, (BFA), is located in the town of St. Albans, Vermont. BFA is a high school with roughly 1200 students in grades 9 through 12, drawing its student body from a 40 mile radius. Although the BFA community does not reflect a broad cultural diversity, it does reflect a broad socioeconomic diversity.

BFA uses ‘ability grouping’; it is a tracked system. I teach in the science department where the tracking is significant. Students at BFA are required to ‘get’ 3 years of science. At the freshman level, students are placed in 5 different levels. That pattern continues in the sophomore year but narrows a bit in the junior year when there are three levels in which students are placed. My teaching responsibilities at BFA include 4 sections of chemistry in a given trimester. These students are largely juniors in high school, but can include ‘accelerated’ sophomores or straggling seniors. Of the 4 sections, my responsibilities include the upper track and the mid level track. Still, the diversity within these tracks is quite large. In the upper track, it is usual for my classes to number 24 to 26 students. These students range from those who have clearly had many opportunities to learn science and math to students who have not experienced success in either math or science.

Another significant factor, in my view, is the fact that BFA is on a trimester system. This, in and of itself, is not significant, but the manner in which the trimester system is implemented is. At BFA, I am likely to see students for only 12 weeks. At the 12 week point, classes, the students in the classes and the teachers are shuffled. Students in my chemistry classes from August to November are likely to NOT be in my classes between November and March. For instance, last November, the change in trimester left one of my upper track chemistry sections with 8 of the original 25 students. The same is true for my mid level chemistry students; this spring, my mid track section of 18 students has become a section with 6 of the students from the winter section. This is a challenge in terms of expectations. I must view students’ learning opportunities as a finite, 12 week, period of time.
The Rotation: What it was about.

Eighteen months after my initial introduction to Complex Instruction (and 19 years into my teaching career), I designed a Rotation to address the National Science Education Standard that states:

*When elements are listed in order of atomic number, repeating patterns of physical and chemical properties identify families of elements with similar properties. This “Periodic Table” is a consequence of the repeating pattern of outermost electrons.*

This piece of chemistry content is central to the facility with which students attain much of their understanding of chemical reactions in general. As a teacher, I had repeatedly made the error of perceiving this standard as ‘easy’. To me, the ‘expert’, the periodic table is a series of patterns that unburdens the task of memorization. There should be no need to memorize the specific details of each element because the patterns are visible on the table itself (which, by the way, hangs prominently on the wall of every chemistry classroom). Students had only to ‘see’ the patterns. This is easier said than done for students, the ‘novices’.

In recognizing the discrepancy between the way that I perceive the periodic patterns and the way that students struggle with them, I knew that students needed to interact with this content more intimately and from their own perspectives in order to construct understanding. Previous teaching experience had given me a small arsenal of activities that could lead to student understanding. It was my intention to retool these activities to create redundant learning opportunities that were rich enough to engage students in dialogue and rich enough to cause students to confront their own misperceptions.

The rotation itself was composed of 3 different learning opportunities intended to be approached by student groups (of 4) one at a time over a period of 3 days. Each learning opportunity, or activity addressed student groups with this as the ‘big idea’:

**Big Idea:** The periodic table could be considered the chemist’s most valuable tool. It is organized, not random. If you understand the organization, you can use it to predict properties of the elements. Memorization becomes unimportant, the table itself will tell you whatever you need to know.
Activity #1, entitled "What Was He Thinking?", was designed so that students were required to create an organizational pattern of their own in an attempt to recreate the thought process of Dmitri Mendeleev; the scientist credited with the design of the first useful and widely accepted periodic table of the elements. In this activity, students were given cards to represent 20 elements. The elements were not identified by name, but each card contained information about the element. The information included properties like, mass and combining ratios of the given element when bonded to oxygen.

Activity #2, entitled "Very Trendy", was designed to create a reason for students to look at the pattern that would be created on a line graph if properties of the first 20 elements were plotted against atomic number. Each student chooses a property, creates a graph finds the pattern, interprets the graph, compares to the arrangement on the modern periodic table and finally compares to the other graphs created within the group. In this way, students are faced with the repeating nature of the properties of elements with a 'graphic' repetition; a picture, if you will.

Activity #3, entitled "Test Your Metal", was designed as a partial inquiry into the chemical reactions of alkali metals with water. Given unidentified samples of 3 metals that are in the same chemical family, students were required to identify each metal by using the evidence gathered as they reacted each metal with water and by using prior knowledge of the relationship between atomic structure and chemical reactivity.

Each of the three activities required a 'group product' that included a large, display-quality chart of their conclusions and their logic. Further, each activity required an individual product of each group member in the form of a related homework job.

The Rotation: How the days went.
Each day was structured in the same way. Ten minutes were allotted for an 'orientation'. Fifty minutes were allotted for completing the activity and 10 more minutes were set aside for the 'report-out' phase of the class.

When students entered class, they were met with several charts hanging on the walls. Four roles were laid out on 4 different charts: Facilitator, Materials Manager, Director of Display and Director of Logic. These charts contained the responsibilities for each role and some scripted dialogue for each role. Another chart was designed to communicate the composition of the student groups and the roles that were to be played by each member in the group. Finally, a chart that specified the abilities needed to complete each task was prominently displayed. When all students were settled into their assigned seat, I led students through each of the charts: group composition, roles and abilities.

Students then met at predetermined places in the room and sent their materials manager to retrieve the 'activity cards that would tell them what was required of each group and what further materials would be needed. This phase of each day was characterized by intense, focused student-student interaction. Students were allowed to involve me, the instructor, only by putting their questions first through the group and then by sending the materials manager to ask the question if no one in the group could answer the question. As the instructor then, I was free to watch the progress of the various groups and listen in on their thought processes. I took notes on their remarks, questions and strategies until the report out phase of the period drew near. At that point, I began to call short meetings of each role being used within the student groups. For instance, I called a two-minute meeting of all the facilitators to remind them that it was they who would be in charge of organizing the report out. Similarly, I called a meeting of the material managers to remind them that they must organize the clean-up and retrieve the 'individual report' work that was to be each student's homework. This was intended to refocus students on the need to attend to each aspect of the activity.

The last phase of each day, the report-out phase, was structured so that the classroom chairs were arranged in a large circle with each group sitting together. Student groups had been given specific prompts to respond to during the report-out. Groups reporting out were not to give 'answers'. For instance, on day #1, student prompts were "What difficulties did your group face?" and "What advice do you have for the group that will work on your activity tomorrow?" I, as the instructor, scribed the remarks
of each group so that the following day would open with the previous day's closing remarks.

Finally, it is important to note that day #1 found the students scrambling to finish within the allotted time. I expected that this would be the case as each job was huge. Students learned in the first day that the next 2 days would need see increasingly efficient time-management if the group was to 'finish'. Also significant to note is that on day #3, all groups finished comfortably. This was a function of increased student focus and the fact that students were making gains on understanding content each day. The concepts needed to complete the tasks were more readily retrievable.

The Rotation: Assessment of Learning Differences.

As the school year has progressed, I can point to anecdotal evidence of increased student learning. Some examples include: continuing use of scientific vocabulary by students as it relates to the content addressed in this rotation, ease of recall of the patterns exhibited on the periodic table by students who experienced this rotation, student application of the ideas addressed in this rotation. Furthermore, students in both ability tracks experienced this rotation. The evidence as stated above is yet more visible to me in the mid level track. This is, by far, the most understanding exhibited by the mid level students that I have witnessed in my career.

That said, the most direct evidence of student learning is represented in journal entries written by the students themselves in the days following the rotation. These entries were written in response to 2 prompts. "How has your understanding of the periodic table grown in the past week?" and "How well did your group work, work?" Below are unedited responses scribed directly from student journals with the permission of the students who wrote the entries.

Student Journal Entries; October 2003

"I really like the way you "teach" this class. I'm used to a teacher just standing in the front and teaching everything. Your method of letting us teach ourselves and then ask questions works great. It also tells me now that I can figure out a lot of this chemistry just by using my own logic and not being fed the information. In turn I think everyone in the class has increased understanding in this way since we all worked to teach ourselves. We will remember it easier on a test, or whenever we need to know these things since we played an active role in
finding out the information. Because of this teaching method I have taught myself a lot about the periodic table.” – Vinny L.

“I know a lot more about the periodic table now that I have done activities with it. I understand how they are grouped together as I did not before. It helped a lot working in groups because getting another persons idea or opinion on what we were doing was very helpful. It helped me to understand more clearly when someone explained what to do on the activity in a way that I could understand.”
- Kristi R.

“My increased understanding of the periodic table would be that the P.T. is based on patterns. I find it hard to believe that all of it fits so well together, not hard to believe but kind of amazing.
My group worked well together. The reason we worked well was that we all listened to each other and no one person tried to take control of the group.”
- Corey H.

“Before the activities, I only understood simple patterns in the Periodic table. Most importantly, I can see the difference in ionization energy and electronegativity, because of the violence of the reaction with water. Group I has 1 valence electron so therefore has the opposite reaction of group 17 which has 7. Also in regards to these properties, I saw the patterns which they make on paper. The varying graphs represented the properties well.
The group worked very well. It was helpful to be able to bounce ideas off other members rather than to take notes. Also it was organized well so that each person knew their job and did it well.” – Doug W.

“Over the 3 days we just had, I do have a better understanding of the Periodic Table. Because of the activities and making patterns and connections, I was able to make myself search for answers like “why does this work?”
I believe our group did work because we all pitched in and tried helping one another understand what was going on if they were having trouble.”
- Corey K.

“The opportunity to learn more has been a lot better since Monday. Monday I didn’t know why the elements are set up like they are. The group work worked really well I thought! I got a chance to work with the elements and had time to discuss it with my classmates. What also worked well was the fact that everyone had a job and it made the ‘work time’ go smoother” – Tiffany S.

“After the group work that we have been doing I can now understand more about the alkali and the halogen families. I know that the alkali want to give
electrons and the halogens want to gain an electron. ...I learned that the ionization is connected to the atomic radius. I know that an element with a smaller radius is more likely to gain an electron over an element with a large radius.

Working with a group worked for me. We all pushed each other to get the work done, even though we were missing a person each day. Having a time limit made us work faster.” – Kristen P.

“I feel that my understanding of the periodic table has greatly increased. When we started the week my understanding was very limited. Now I know that there is reasoning for the groups and families and when I look at the periodic table I can pinpoint things and say “this is why that is there and this will make that happen” etc...

Working in groups was an excellent idea. I feel that it worked well because we had a goal each day that we needed to meet. And I think that having a specific goal forced us to work together and get the job done.” – Lindsey C.

**What Made A Difference?** What an instructor can do to make it work.

First, crucial to my process and the success of this rotation was the identification of the big idea. I needed to clarify the specific, targeted understanding that students should walk away with. From this, I could draw on my past experience to identify activities that could be used to design rich and redundant learning opportunities that would lead students into understanding of the big idea. This concept of redundancy is a huge shift in perspective for me. Curricula are generally viewed as a sequence; I now view every unit through a filter of possible redundancy. Not every instructional unit provides appropriate redundancy in my experience, but some do. Further, some content should be visited in a redundant way as it is difficult for students to grasp the first time through or from only one perspective. Creating this sort of rotation gives students an opportunity to interact socially over teacher-identified content objectives.

Once the target and redundant learning opportunities were identified, I focused the weeks before the rotation on the prerequisite skills, content and attitudes needed for student success. This required the continuous assessment of all these skills, the content and the attitudes. I recognize now how important both the collaborative (classroom) norms and collaborative skills were to the success of this unit of instruction. Preparing students for this rotation by assessing only content readiness would not have resulted in the success that I was looking for. Students needed to have some experience with group work roles and with group work skills. This
training was subtle for some weeks and then became more direct when I used specific skill builders suggested in Elizabeth Cohen’s *Designing Groupwork*. These norms and skills could not have been well-established in a short period of time. My students were ready for this rotation in October, but early in September they would not have been ready.

Finally, the journal entries were, and are, a revelation to me. At the close of day #4, a wrap up day, I asked students to make a self-reflective journal entry to address both the attainment of content in their view and to address the group work process. When I read the entries last fall, I was pleased at the correct use of scientific vocabulary in the appropriate context; it seemed a reflection of student understanding. Further, I was pleased at the positive tone of student entries regarding group work. Better still, was the evidence that students recognized both the benefits of the use of roles and the need to work cooperatively.

Now, months later, when I read the entries copied in this paper and others like them, I am stunned by the evidence of content attainment. I believe that these students understand more about the ‘big idea’ than I realized in October.

**Implications / Conclusions:**

It is impossible for me to ignore the importance of social interaction as it relates to student learning. However, of equal importance are both the establishment of classroom norms that allow for student-student interactions of a respectful nature and the cooperative skills that are necessary for successful group process. The clientele that I deal with as a high school science teacher has had 11 years of training in a system that creates competition in the classroom. These students do not know, instinctively, how to learn cooperatively. These skills must be taught so that social interaction over important content can occur, thereby facilitating the goal of education – student learning. More powerfully, after students have learned the prerequisite skills and attitudes needed for effective group work, they too, will tell you that their learning increases when they are engaged, with their peers, in conversation over a big idea.