Towards a Tetrahedral Orientation in the Teaching and Learning of Chemistry

Harvey Peltz
Mathematics-Science Curriculum Consultant
River East Transcona School Division

Brian Lewthwaite
University of Manitoba

NSERC CRSNG
CRYSTAL CREAS

Focus of the U of M CRYSTAL

- 17 research projects most of which are multi-year.
- Two focus on chemistry education development in Manitoba in line with current research in chemistry education.
- These initiated because of the introduction of the new Manitoba Grade 11 & 12 Curriculum.
- One with in-service teachers focusing on the intent of the new curriculum.
- One with pre-service chemistry teacher candidates.
- Similar to all our CRYSTAL projects focus is on ‘development’.

Improving Teaching & Learning Development Project

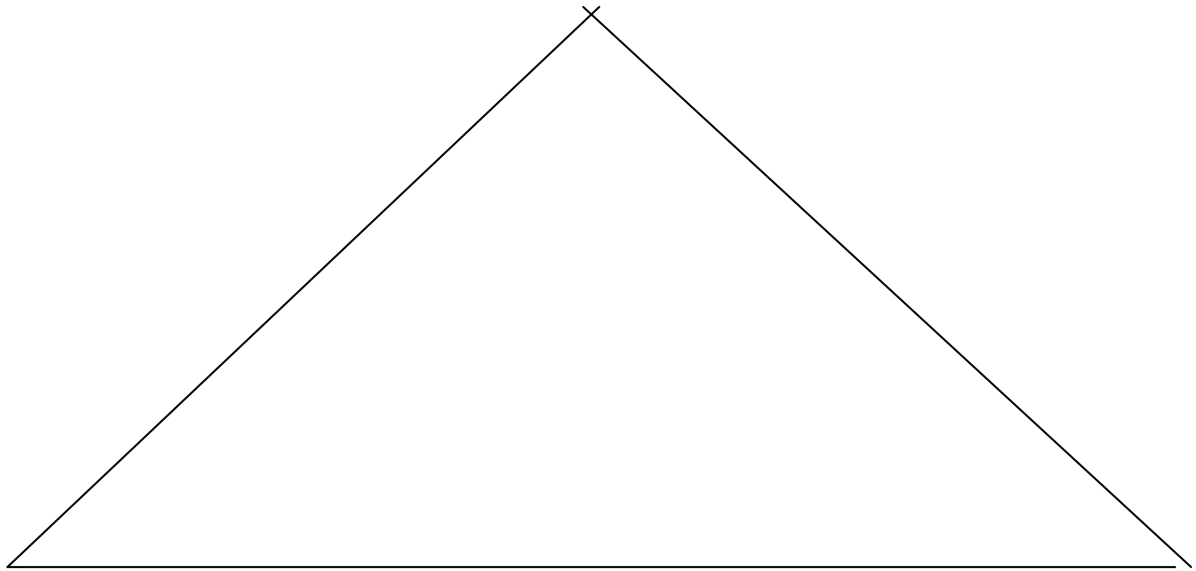
- 'Development' is about progressive change: next steps from where you are now (Bronfenbrenner).
- The chemistry education development project was a scholarly choice for impacting change because of the new curriculum.
- Based on a predictable reality: Teacher change is rarely in leaps.
- Development a 'joint function' of the characteristics of the individual (teacher in this case) and their environment: physical & psycho-social (school environment, changes in curriculum).
- Most significant part of the biological environment is the microsystem: those closest to the individual such as colleagues, students, development opportunities through professional learning communities.

Improving Chemistry Teaching & Learning Development Project

- Most curriculum changes make teachers aware of the change at a superficial level but are not accompanied by pedagogical change in themselves (Harlen)
- Unless accompanied by **quality professional development**
  - providing opportunity for ongoing 'community' building.
  - clinked to curriculum mandates & assessment practices
  - practical but accompanied by opportunity for consideration, reflection and expectation
  - resource materials developed have to be 'ready to go'; easily transferable and modifiable for each.
  - participatory rather than dominated
  - supported by management over time
  - time dependent so must be provision of time & resources
  - led by credible individuals – they have to work well with teachers

Chemistry’s Modes of Representation & the New Curriculum: Fostering Learning & Engagement

macroscopic or experimental (visual lab-based experiences)

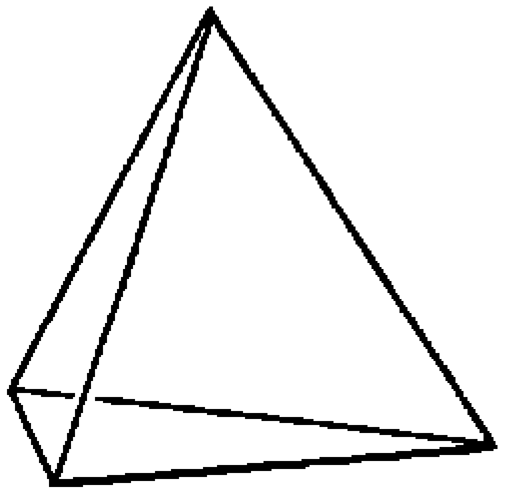


molecular (what we can’t see but if we could, we would ‘learn’)

symbolic (how we express what is happening in abstract symbols & formulae)

A Further Mode (Mahaffy, 2006) (The Tetrahedral)

- Arguably, the curriculum is not only at the molecular, macroscopic and symbolic but also the human element level.
- Chemistry as a human endeavor - associated with chemistry in an historical and contemporary context (e.g., industry, body, environment).
- Curriculum is progressive from a chemistry education perspective.
- Questionable influence?



Evidence of Four Modes in the Curriculum

C12-6-03: Outline the *historical development* of voltaic (galvanic) cells. Include: contributions of Alessandro Volta, Luigi Galvani.

C12-6-04: Explain the operation of the a voltaic (galvanic) cell at the *visual*, *particulate*, *and symbolic levels*.

C12-6-11: Describe *practical examples* of electrochemical cells. Example: electroplating, electrolysis of brine, batteries.

Progress thus Far

- Fourth year of the project; about to start fourth phase of five.
- Three cohorts (~15 each) of teachers (South Winnipeg, RETSD (North Winnipeg) & West-Manitoba)
- 3 professional days for each cohort/ second semester/year
- Has involved 72 teachers, 58 are repeat returnees (3 or more) and have ongoing participation. 21 have attended all 9 sessions.
- Focus at most on one curriculum cluster per session: practical, participatory, reflective.
- Over 200 online resources developed available through CRYSTAL website (3000 downloads not just from MB)
- 16 CRYSTAL Teacher Participants have also lead seven PD sessions for MB teachers attended by ~ 155 teachers

Researchable Influence? Teacher's Comments

1. Have teacher orientations to chemistry teaching changed:

- Manitoba curriculum identifies 5 goals for science education: academic, utilitarian, vocational, humanitarian, intrinsic interest.
- Orientations of our participants initially indicated a strong academic rationalist orientation for teachers but not necessarily their 'true' orientation.
- Often perceived to be an orientation of expectation influenced by environment – school, curricular, societal.
- Data indicates for many a re-establishment of orientations related to engagement, interest and the utilitarian.

Researchable Influence? Teacher’s Comments

“I always enjoyed chemistry and becoming a teacher of chemistry was a logical choice. I wanted to instill that same interest. Teaching the chemistry in an interesting manner is often compromised by completing the course…I think this [PD & Curriculum] has brought me back to some initial motivations.”

“I’ve made a school shift [change of schools for teaching] and the emphasis here is much more on the student and their learning. I focus more on their success and what we are doing [in the PD] is quite student centered and fits with that’.

Researchable Influence? Teacher's Comments

2. Investigating what pedagogical practices have changed as a result of the CRYSTAL efforts

- Initial student survey of teacher practices that (1) assist (impede) their learning, (2) influence the development of a positive (and negative) learning environment, and (3) influence their enjoyment (or lack of) of chemistry
- 32 low-inference chemistry teaching practices identified from 425 students.
- Most common practices accounted for 78% of student responses: performing demonstrations, assisting students when they need help, using a variety of strategies to get across ideas, using lots of examples, solving problems, explaining ideas as students copy notes, performing experiments
- In the 'top 10' only one was 'progressive' – molecular (visual) examples. Little mention of the 'human element'.

- Development of a “Chemistry Teacher Inventory” based on student responses.
- 34 behaviors that students and teachers and literature identified as influences on learning and engagement.
- Quantify teacher perceptions (1-5) of their degree of use.
- Most commonly used primarily at the symbolic: performing of calculations in class (4.52) and tests (4.56)
- Most limited (rarely) used primarily at the molecular, human element and macroscopic: visual images (2.24), computer-based simulations (2.01), use of manipulatives (1.24) demonstrations (2.87), history of chemistry applications (2.10), history of the development of chemistry ideas (2.17) and explaining at the molecular level (1.24).

- Statistically identify where change is occurring over time and also between teaching of Grade 11 & Grade 12.
- Significant increased changes occurring: (1) visual images are used to clarify chemistry ideas; (2) talking about the historical development of chemistry ideas; (3) asking to explain what has been demonstrated; (4) using manipulatives to help understand what is happening at the molecular level; (5) having to explain chemistry ideas at the molecular level; and (6) referring to the history of the development of chemistry ideas while teaching.
- Statistically significant decreased changes between 2006 and 2008 include (1) students making notes from textbooks; (2) students performing calculations in class, and (3) students are assigned problems from texts.
- Most common practices still primarily at the symbolic level – calculations, solving problems, copying notes with explanations

- Between Grade 11 & 12:

  Teachers are more frequently using prescribed labs, everyday examples, visual images, computer-based simulations, historical contexts, and group learning opportunities in Grade 12 than Grade 11.
- Teachers are performing calculations more frequently on tests and in class in Grade 12 than Grade 11.
- Data suggest that teachers of Grade 12 are showing a more substantial movement towards a tetrahedral orientation despite placing considerably more emphasis on quantitative chemistry, a characteristic of the Grade 12 curriculum.
- Evidence of change in teaching practices, not dramatic but significant.

Summary

- Evidence that this CRYSTAL effort is influencing teachers and their students.
- Currently focusing on students using a similar inventory to assist teachers in identifying what behaviors assist their students' learning. What should I as a teacher do more? Less?
- Two phases this year: Focus on assessment exemplars & classroom based research with teachers on their response to student perceptions of what influences their learning.
- **If students can identify what influences their learning, should we respond to their suggestions? If so, why is there little regard or response to these suggestions in science education reform? Why does reform not begin with what students say? How can we respond?**

Acknowledgments

- Natural Science and Engineering Research Council
- Curriculum Consultant: G. Bush
- Gayle Peters: Resource Development
- River East Transcona, Pembina Trails and Brandon School Divisions for their support and engagement in this project.