Enabling scientific investigation using Integrative Thinking strategies as a framework by which scientific thought can be achieved

During the COVID-19 pandemic, it has been exceedingly difficult to meet curriculum expectations particularly as they relate to developing skills of Investigation and relating science to technology, society and the Environment. The use of tools like the Ladder of Inference are a cornerstone to meeting these objectives.

At the beginning of my career in 1998, I found myself at the Ontario Institute for Studies in Education (OISE) at the University of Toronto where I was working on my honours specialist in biology. As a part of that process, I wrote a paper on the use of Problem Based Learning (PBL) in secondary school science classrooms. Having grown up in Burlington, ON, I was aware of the PBL model that McMaster University was well known for having pioneered for the study of medicine in Canada. As a former research scientist, this approach appealed to me as a way to help students learn to make conclusions, work through complex scenarios and come to solutions for difficult problems. My feeling was that students would need these skills throughout their life journey, and as a teacher in the Hamilton-Wentworth District School Board, it would make sense that many would one day end up at McMaster. Starting the process of understanding how to do PBL in high school would be of benefit to them. The problem is that PBL is extremely time consuming and difficult to incorporate into a secondary school classroom, particularly when students do not have a broad knowledge foundation for their PBL inquiries.

Old models of PBL

For the next sixteen years the mechanism by which PBL could be done in a secondary school classroom eluded me. From my experience in science classrooms, when students do any kind of practical hands on laboratory work, they are really good at asking questions and reframing those questions as a purpose for doing an experiment. They are good at making predictions about the outcome of their experiments and they are good at collecting materials and devising a method to test their hypotheses. In addition, students have the tools for making observations and collecting data. The place they really bog down and find challenging is their analysis. I often observe high school science students struggle to do the analysis required to make valid conclusions from the observations they have made.

In the more traditional approach educators, including myself, will give their students some sort of handout/resource that acts as the “LAB” activity. In this format, the students are given the “ingredients” and the “steps” to follow a particular “recipe.” As students work through the steps they observe and collect the data that their instructor WANTS them to. THEN, by way of answering questions, the instructor leads students to make the conclusions that are expected. While this approach is great for reinforcing concepts taught in class, it loses the true essence of scientific discovery.

Many remarkable possibilities

In the spring of 2014, at the suggestion of my principal I enrolled in a three day workshop called Integrative Thinking for Educators offered by I-Think at The University of Toronto's Rotman School of Management. (Today, I-Think is an education non-profit organization independent of the university). At those first sessions in 2014, we were introduced to three Integrative Thinking tools: the Ladder of Inference, Causal Model and Pro-Pro Chart, that can be used across subject areas and grade levels for complex real-world problem solving. Though, at the time while I could see applications for Integrative Thinking in the languages and humanities, its application in a science classroom was unclear to me. My concern was that as a scientist, I was (and still am) devoted to the process of the scientific method and I was unwilling to give up scientific thought for Integrative Thinking. Throughout the summer break I thought about this problem frequently with no resolution. THEN… quite literally in a dream I had an ah-ha moment: Integrative Thinking wasn't meant to replace the process of scientific thought, rather it could work as a framework by which scientific thought could be achieved. Now, I use the Ladder of Inference to let go of the reins and allow students to make their own conclusions about the observations they have made and the data they have discovered. In this way the class becomes far more student centred and collaborative.

After that first realization five years ago, it has become increasingly easier to see opportunities to incorporate Integrative Thinking tools into the classroom. Most recently, during the COVID-19 pandemic, it has been exceedingly difficult to meet curriculum expectations particularly as they relate to Developing Skills of Investigation and Communication **AND** Relating Science to Technology, Society and the Environment. For me, the use of tools like the Ladder of Inference has been a cornerstone to meeting these objectives. Indeed, this past semester my SNC2D students have been able to use the Ladder of Inference to do analysis of data to determine the Laws of Reflection and Refraction as well as the Law of Conservation of Matter and they have used Pro-Pro analysis to investigate different approaches to carbon sequestration as it pertains to the fight against global warming and climate change. In my SBI3U classes, students have used the Ladder of Inference to determine whether or not biological organisms are alive AND to come to a conclusion(s) about whether or not viruses like the Coronavirus are alive. My students have also used Causal Modelling techniques to analyze the events that took place which resulted in the publication of Darwin's ***On the Origin of Species.*** I include these examples as an illustration of the many possibilities of where these tools can be used. Indeed, there are many instances where my colleagues and fellow I-Thinkers (or notebook people as we call ourselves) have created their own unique approach to using Integrative Thinking tools and approaches in their classrooms. The many remarkable possibilities are truly endless.

The thing that I like and admire the most about the I-Think community is the collaborative approach that its members take toward making the educational experience for students better. While the process of learning how to do use Integrative Thinking strategies in the classroom has sometimes been challenging, assistance and input has always been only a text message or email away. That is the message that I would leave for individuals who are considering Integrative Thinking as a possible solution of how to approach the daunting task of embracing scientific investigation in the classroom. For me, this process has been a journey of many years, yet it feels like its only beginning.

Craig on Integrative Thinking in his classroom: https: //thelearningexchange.ca/itl-project-home/itl-project-reflections/itl-project-secondary/itl-project-craig-julseth/

About the Ladder of Inference: We use the Ladder of Inference to make our and others thinking explicit and question that thinking. Developed by Chris Argyris, this tool breaks down how we build our models into data, interpretation and conclusion.