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SoTL in Chemistry: How to Make the Learning Meaningful

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"We have a new opportunity to shape a new generation of faculty or, as is being widely proposed, choose a new configuration of academic staff that might include faculty but have the potential for greatly enhancing the substances and effectiveness of the scholarship that a changing society requires." (Rice, 2005)

Why SoTL?

One of the amazing and sad facts about education is the distance between the proclaimed importance for the society and the reality in the classroom. It is possible to teach without formal training in how to teach and it is possible to teach the same content for one's whole career even if the nature and goals of students change regularly. An indirect proof of it is the little interest by many instructors in pedagogical journals, as documented by Weimer (2008). This is unfortunately true in chemistry too.

The chemists' community is sensible and perceives the relevance of the scholarship of teaching and learning (SoTL) for many reasons, including the complexity of our discipline. In 1994 a task force composed by recognized leaders in chemical education was appointed by the Executive Committee of the American Chemical Society's (ACS) Division of Chemical Education for the evaluation of scholarship in chemistry (The Task Force, 1994). Recently, the American Chemical Society approved a new statement on scholarship (online at <http://www.divched.org/DivCHED/statement.pdf>) that outlines what scholarship should be. It differentiates between research and scholarship which are often seen as being synonymous: "...research is a process for obtaining information, and scholarship is a process for converting information into knowledge." And it makes it clear that scholarship in chemistry education can take a range of forms.

In a paragraph entitled "Enhancing the Quality of Chemistry Education," it says:

Preparing a scientifically literate public and a well-trained workforce that will advance scientific and technical innovations in the new millennium was the focus of the ACS 2003 invitational conference "Exploring the Molecular Vision." The report states that "Chemistry education can only reflect the current practice of chemistry if it also includes: 1) the convergence of chemistry with other disciplines, particularly with biology and physics, 2) the impacts of improved mathematical and computational tools and of interactions through cyberspace, and 3) the relevance of the discipline through engagement with broader society and the promotion of high ethical standards and environmental performance. Implementing these changes requires that educators not only update and reinvigorate the content of courses, but also determine and exploit pedagogical innovations and best practices. The scholarship of teaching and learning is still perhaps the least understood and recognized of all the forms of scholarship, but has the potential to transform chemical education. It must be encouraged and its role in preparing scientists for the new millennium must be recognized."

This document is particularly relevant because it comes from the world's largest scientific society. The American Chemical Society is a nonprofit scientific and educational organization with more than 160,000 chemical scientists and engineers as members. Significantly, in 2007

a task force from the ACS division of Chemical education produced a report on hiring and promotion in Chemical education.

In an international conference on chemical education a colleague asked in public: "Do you think that the teaching of chemistry in our universities has improved over the past twenty years?" About 60% of those present raised their hands. The second question was: "Do you think that our students are learning chemistry better than they were twenty years ago?" Very few hands were raised.

With this perspective in mind, I will try to explain how the tension required by the scholarship gives me the desire to improve my teaching. There are many definitions of SoTL; the one that appeal to me is: "systematic reflection on teaching and learning made public", as conceptualized at Illinois State University. Indeed, "the common process of paying careful attention to learning, studying what works in teaching, and altering practice and theory as a result of the scholarly work is apparent before or within any definition of the scholarship of teaching and learning." (Cambridge, 2006)

Raymond Francis (2007) expands this definition in seven steps for translating it in good practice:

1. identify the question, or describe what it is to be learned,
2. develop a plan to gather data,
3. gather and analyze data,
4. describe your results and generate a context for your results,
5. state your conclusions,
6. share your results with peers (make your results public with an audience),
7. make decisions about future actions related to your question.

Even if the scholarship is about the theoretic elaboration of the processes of teaching and learning, the logical implication of our elaboration is that it must generate better learning in our students. It is the continuous reflection on the practice and the guided search to improve it that generate the wisdom in the discipline. "When defined as *scholarship*, however, teaching both educates and entices future scholars. Indeed, as Aristotle said, "Teaching is the highest form of understanding" (Boyer, 1990). If we wish to be positively considered by our colleagues and to involve them into SoTL, we need to show that our students are better prepared and more able to develop and use their intellectual skills.

In spite of the high principles proclaimed, SoTL practice is still not familiar in chemistry. The shared feeling about the didactic of the discipline is that ability in teaching comes from the knowledge that the researchers acquire studying some aspect of the discipline in the laboratory. With this state of affairs, it is not a surprise that increasingly fewer students get interested in chemistry. So it is not only rhetorical to state the necessity of SoTL in chemistry and this is also a reason for positioning the scholarship on teaching and learning within the discipline (Weimer, 2008). We need to consider that one reason SoTL is not common in chemistry is because of the language used by the practitioner that can be quite distant from that used by colleagues in the field. So my desire is that this essay serves as a bridge by raising some key questions.

I was impressed by the deep insight of von Humboldt as reported by Lewis Elton (2008): "The fundamental dichotomy is not between either research and teaching, or between teachers and

students, but between university and school, according to which the university – in contrast to school – treats scholarship always ‘in terms of not yet completely solved problems, whether in research or teaching, while school is concerned essentially with agreed and accepted knowledge.’”

The Long Journey Towards SoTL

The realization that I had to reconsider my teaching came with the dissatisfaction of the evaluation that my students gave to my teaching. Notwithstanding my efforts in teaching and the huge amount of time that I gave to it, the benefits that students received, according to their opinions, was disappointingly low. This for me was particularly distressing because didactics was my field of research and problem solving is so important in an engineering university. The accepted standard in university, teaching as telling and learning as recall that I was using, brings tension between teachers and students, as reported by Entwistle (1984). The lecturer complained about the apparent lack of motivation of students:

"The main trouble is unwillingness to get down to work, but having said this, there is no doubt a paradox ... in that at some time in the past, in order for a person to have got here, presumably he had been willing, and something is going on which diminishes this willingness."

While students complained about the way teachers teach:

"So often are students bored by uninspired teaching or disenchanted by badly taught material. While university lecturers are undoubtedly knowledgeable, they are totally untrained and unexamined in the art of communication . . . The completely incorrect assumption is that anyone with a good degree will automatically be able to impart this knowledge to others."

So the answer cannot be in the complaining, but in the very meaning of the academic work, and scholarship is at the heart of that work. But how do we reach a goal that is not acknowledged, even if some have a personal sense something needs to be done?

Fortunately, I was able spend some time at the University of Glasgow in the Alex Johnstone Centre for Science Education, a recognized place of excellence in chemical education. While walking and talking with Alex in the Scottish highlands, I realized I had to change the curriculum. As required by the university curriculum, I was covering too much material in the time available, and the way I taught problem solving was completely wrong. As many teachers do, I taught the solutions to the problems one step at the time, explaining the various steps. Maybe it was even an elegant explanation of the solution, the way my instructors taught me, and the way one can find in the textbooks, but it was a procedure that did not help students understand how to approach problems in a fruitful way. Why? Because "Textbook solutions to problems and solutions presented by teachers in class are almost always efficient, well-organized paths to correct answers. They represent algorithms developed after repeated solutions of similar problems" (Herron, 1986).

As too frequently happens, I had only my own experience to guide me and I did not know adequately about pedagogy and the learning process. I was not aware that I was using logical processes that I had developed after solving many similar problems. The technique I was using was difficult to understand by students who do not have familiarity with those strategies (Bodner, 1987). In a study it was found that experts, too, have difficulties with more complex stoichiometric problems and "there was a substantial difference between the way 'experts' in the study solved problems and the solutions outlined in texts. ... This difference between the problem-solving performance of experts and textbook solutions is significant because the examples must convey to students an unrealistic idea about how problems are actually attacked. The examples provide no indication of the false starts, dead ends, and illogical

attempts that characterize problem solving in its early stages, nor do they reveal the substantial time and effort expended to construct a useful representation of a problem before the systematic solution shown in examples is possible" (Herron, 1990).

Taking all these things into consideration, I now have my students approach problem solving in cooperative groups and many of them become quite successful, not only in chemistry, but in the other subjects as well. In trying to understand the difficulties of students, it seems to me that they are short in self-esteem, probably because they have not often faced real academic challenges that they learned to overcome. If we understand the difficulties of our students with the concepts of our disciplines, we will develop "the most useful forms of representation of those ideas, the most powerful analogies, illustrations, examples, explanations, and demonstrations – in a word, the way of representing and formulating the subject that make it comprehensible to others." (Shulman, 1986) In problem solving, we will develop useful strategies that can be very useful to make our students more clever in solving problems.

The First Day of Class

Authentic learning, and problem solving in particular, requires the interest, motivation and engagement of students. In Shulman's *Table of Learning* (Shulman, 2002) the first step is **Engagement and Motivation**. Learning begins with student engagement in the subject, which in turn leads to knowledge and understanding. Learning cannot be only an intellectual endeavor; if our goal is to make our students successful learners we have to require them not only to think in a particular way, but also to perform particular skills.

The first day of class can be very important in creating the learning environment we want to have where students are deeply involved in the learning process. So I greet some of the students with a handshake: in this way I say to the class that they are important and we will accomplish the task together.

The first lessons are crucial for establishing a supportive and positive learning environment in the class. A study of the first days of school identified different classroom environments. In supportive environments teachers expressed enthusiasm for learning, were respectful, used humor, and voiced expectations that all students would learn (Patric, et al., 2003). In this way we make clear to our students that we are seriously engaged with the subject and with them. This means to take learning seriously because, as Shulman (1999) noted, we take something seriously when we profess it. And we profess something when we make it public. And we take learning seriously if we take the learning of our students seriously.

The consequence of this way of teaching is that our colleagues can become aware of it and this is very important because improving the quality of learning is part of being members of a community of scholars. We must change and end the experience of pedagogical solitude. We need to communicate our ideas and solutions to certain pedagogical problems with our colleagues. Even if our colleagues are not interested in SoTL, we can give them the chance to reflect about their teaching too. And this makes sense, because in improving the quality of learning, we are not alone, but members of a community of teachers. Such a community can provide its members many perspectives, answers, questions, and experiences about teaching.

Another advantage of a community of teachers is that it can offer opportunities for enrichment for the community, with a great advantage for all students. A joke says that one day God Almighty wished to invent the most beautiful professional figure on the earth and make the teacher. Why? Because we are intellectually free, we enjoy expanding knowledge, we have prestigious colleagues, and, more important, in course after course we have new students who bring us enthusiasm. Another day, God Almighty was depressed and decided to create the worst professional figure: the colleagues of the teacher. And we know why. It can be difficult,

but not impossible, to engage our colleagues in discourse about problems related to teaching and students' learning; but if we are successful, the benefits are relevant and significant.

Epilogue

I did not discover a recipe for good practice and maybe it is not possible, nor desirable, to find one because students are human being, each one different in what moves and motivates s/he in learning. From experience I know that when I believe in the possibility that my students will learn, and show them by example it is worthwhile to be involved, I can motivate them and even, in some cases, change their lives. There is no single best method or approach to teaching: what it is necessary is to have motivated teachers, linked to the scholarship of teaching and learning, who can adapt their style, approaches and knowledge for the benefit of students. Engaged teachers have the potential for greatly enhancing the effectiveness of the scholarship that a changing society requires, as Eugene Rice (2005) professed and von Humboldt sensed.

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