

Using Student-centred Learning Strategies in the Physical Chemistry Classroom

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Physical chemistry is an empirical science. A science is a set of constructs, called theories that link fragments of experience into a consistent description of natural phenomena. There are three major areas of physical chemistry: molecular structure, the equilibrium properties of systems, and the kinetics of transformations of systems. The theoretical foundations of these subjects are, respectively, quantum mechanics, thermodynamics and equilibrium statistical mechanics, and chemical kinetics and kinetic theory. These theories, firmly based on experimental findings, constitute the structure required for the understanding of past accomplishments and a basis for recognition and development of significant new areas in physical chemistry.

Physical chemistry course is for the second year student in China as well as in The University of Sydney. In China, students usually have learnt Inorganic chemistry and Organic chemistry before. This course contains 96 hours for the lectures and 40 hours for lab works a year in China.

Background

Most of us who teach chemistry grew up learning chemistry from the lecture method. Over the past decade, I never doubted that it was the way to teach chemistry. Today the lecture system is still the preferred teaching style in China. Indeed, lecture is a comfortable format for many instructors and a non-threatening one for students. It is low cost, easy to control, and an excellent method for organizing course content. However, many of us are becoming more aware that during lectures students are not actively engaged with the topic, they usually listen for very long, and their retention of concepts is minimal. Studies show that students are not attentive 40% of the time they are in class and that although attention is high for the first 15 minutes, it declines rapidly until the final 10 minutes of class. After I came to The University of Sydney, I began to learn more about student-centred teaching strategies, but I haven't tried them in my teaching processes. Now I will present a plan as to how I might make several changes to my teaching strategies which would result in a more student-centred teaching approach.

Student-centred strategies

In a student-centred classroom, students are encouraged to participate actively in learning the material as it is presented rather than being passive and perhaps taking notes quietly. Students are involved throughout the class time in activities that help them construct their understanding of the material that is presented. The instructor no longer delivers a vast amount of information, but uses a variety of hands-on activities to promote learning. As I learned more about student-centred learning environments, I am going to use a group of learning strategies in the future. They will include mini-lectures using *PowerPoint* presentations, in-class collaborative learning, peer presentations, and ongoing assessment techniques.

Mini-lectures

Because I have learned that students concentrate on the lecture in a class just about 15 minutes, so I should modify my lecture material. I'd like to have a series of *PowerPoint* slides or ChemModules as mini-lectures. In class, I will ask the students to work out of a syllabus in which I included the *PowerPoint* notes. I will include the solution slides in the notes, but show them after students have given their answers. The same modules will be available on my web site for review and include the solutions. In mini-lectures, I will continually give students short learning checks to survey the understanding and progress of students.

Small group inquiry/investigation tasks in class

Within each set of *PowerPoint* notes in the syllabus, I will integrate inquiry tasks for collaborative learning during class. Students work in study teams applying the

concepts immediately and problem solving together. Learning is enhanced when students become engaged in the processing of information. Here is an example of one page of a team worksheet done by groups of students in class.

System	S	R	R'	C	P
H ₂ (g), N ₂ (g), O ₂ (g)					
NH ₄ Cl(s)=NH ₃ (g)+HCl(g)					
CaCO ₃ (s)=CaO(s)+CO ₂ (g)					
NaCl, H ₂ O					

- Why is the S different, while C is the same for the same system?
- How to determine the concentration restriction (R') of the system?
- How to determine the number of phase of the system?

As students work together in the classroom, they think and use the language of physical chemistry. They use peer instruction to fill in gaps in mathematics and physical chemistry for each other by providing immediate feedback and correction to each other's ideas. I suppose that peer instruction can help students begin to form questions about what they don't understand and begin to model successful problem solving for their peers. The very important advantage for working in groups is that students who are too shy to ask the professor for help can ask a member in the group. However, the importance of establishing a learning community that supports all the students in the class cannot be overrated. Because some students may argue that working in groups helps them to understand the material for the first time and learning physical chemistry may not always be so enjoyable. If too much of it is used, the student will also leave the class.

Programmed presentations

At the mid-semester, I will hand out a review worksheet or assign different questions from the text to each study team in the classroom. Students will manage to find a way to work together, discuss the problem and write up a solution on a transparency. After 15 minutes, let one or two students describe their solution to the class using an overhead projector. I believe that the students will be active and try their best to show their work and to teach a class just like asking a question or making a suggestion. If there are any misconceptions in their presentation, I will interject a thought or clarification as needed. As long as students are given the time to prepare their solution, the programmed presentation is a positive experience that strengthens the self-confidence of many students.

Assessment of student learning

In many of our classrooms, we often have a large gap before we test students on the material we discuss in our classes. After the first examination, we are surprised and disappointed by what the students did not learn by this time. It is often too late to make up for the material that was missed. So in order to know what students were thinking and learning each day while we were in class, I am going to plan to integrate learning checks within the PowerPoint slides of my ChemModules. These learning checks are a type of formative assessment technique, which is a non-graded assessment that occurs throughout the class time.

- Determine the species of material (S), the number of independent reaction (R), and concentration restriction (R'), component (C) and phase (P) of the following system:

When a learning check appears in a module, I will give students time to work out the answers, individually at first, and then in groups. Many of the learning checks involve short multiple-choice or fill in questions. The results in class serve as a discussion of the concepts. Students get a quick assessment of their own learning and what they need to work on. The learning checks are a way for students to continually adjust their understanding. At the same time, I can determine what is working in my mini-lectures and what needs more attention. The ability to adapt to particular needs has results in some of the most productive teaching I have ever done. There are a variety of other types of formative assessments that can be used in my physical chemistry class to assess what students are thinking and learning each day.

For example:

- Discussion-questioning* A quick way to add some active learning to a classroom is to take a lecture break every 15-20 minutes. This means that I stop talking for about 2 minutes while students discuss the ideas with each other, check and clarify their notes, and ask questions. I circulate about the room and help them review the ideas. This is a quick way to add student-centred learning that does not require prepared worksheets or other materials.
- Interactive teaching/learning* During class or at the end of class, students are given a few minutes to write a short paragraph in their own words that explains the major ideas discussed that day. They share their paragraphs with other students, and give feedback to each other. They may turn the paragraphs in as they leave class. I will return them the next day and discuss any topics that were not clear. In this way, I believe that I can obtain instant feedback in their thinking and students learn to summarise information. On the other hand, at the beginning of class, each student writes a question about the class content on a card and places it in a container. I draw out some cards and read the questions to the class. Students are expected to provide answers. The discussion reviews topics that are unclear and gives students who would not ask a question in front of their peers a chance to present a question to the instructor. Students learn to assess and make clear what they don't know. And I obtain feedback on the level of difficulty of various topics I present.

It is obvious that the benefit of using formative assessments is that instructors and students have an ongoing evaluation of what students understand and what needs more attention. The instructor adapts to the needs of the class by adding another example, challenging thinking, or moving on to the next topic.

Conclusions

Student collaboration and programmed instruction using non-graded classroom assessments and team worksheets in a student-centred classroom provides continuous feedback to both students and instructor throughout the class time. Students interact with each other as well as the instructor, which means they are processing ideas and learning. They are using new vocabulary in a non-threatening setting and participating in problem solving as they work and explain concepts to other students. The introduction of a student-centred classroom is an exciting way to put learning back in teaching while providing students with the tools for lifelong learning and success.

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