Development of a Problem-based Learning Model for Transitioning Undergraduate Students from Classroom to Research

Dr. Kendrew K. W. Mak*  Prof. Kevin W. P. Leung
Dr. Wing-Fat Chan  Dr. Yu-San Cheung

Department of Chemistry
Why and how did we introduce problem-based learning into undergraduate curriculum (as final-year projects)?

How did we make use of the e-learning tools to enrich students’ learning experience and support course administrations.
Traditional Undergraduate Lab Courses vs. Postgraduate Research

Regular Undergraduate Lab Courses:

- Each experiment is mainly focus on a few major lab skills or important chemical principles.
- The experiments are mostly close-ended, in cook-book style.
- Students’ involvement in the design of the experiment is very minimum (in most case, it is actually none at all).
- They are quite effective and efficient for:
  - basic training on lab skills, and
  - illustrating the chemical principles covered in lectures
TRADITIONAL UNDERGRADUATE LAB COURSES VS. POSTGRADUATE RESEARCH

• They are not quite adequate for preparing students to work on independent scientific research.....

In (Postgraduate) Chemical Research:

• Problems are all open-ended, and always ill-defined.
• Students have to plan and design their experiments.
• A real (authentic) problem is always *multi-disciplinary* / *multi-dimensional* (involves several areas of chemistry).
• Students have to maintain good project management (e.g. progress management, resource management, etc.)
INTRODUCTION OF PROBLEM-BASED LEARNING AS FINAL YEAR PROJECTS

Students work like real research teams.

- Students work in teams, and they take the leading role in working on the research project.
- Students have to solve the encountered problems by and large on their own.
- Instructors / teachers take a step back, and allow students to take an active role in designing strategies for completing the project.
# Course Design: A Close Replication of Postgraduate Study

<table>
<thead>
<tr>
<th>PBL in Chemistry</th>
<th>Research / Postgraduate training</th>
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<tbody>
<tr>
<td>3 Oral progress presentations in the two semesters</td>
<td>Research group seminar</td>
</tr>
<tr>
<td>Written progress report <em>(end of 1st semester)</em></td>
<td>Annual progress report</td>
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<tr>
<td>Final oral presentation</td>
<td>Oral examination for postgraduate degree</td>
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<tr>
<td>Written final project report</td>
<td>Thesis</td>
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<tr>
<td>Final oral presentation: Abstract for the presentation</td>
<td>Symposium / conference</td>
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<tr>
<td>Poster presentation</td>
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DIFFICULTIES THAT WE ENCOUNTERED

Students lack of proficient skills and experience in:

- advanced laboratory techniques
- operating advanced scientific instruments
- literature search / using professional literature database
- preparing formal presentations and reports for research projects
- project management
- problem solving on research projects
DIFFICULTIES THAT WE ENCOUNTERED

Complicated assessment scheme, tedious in collecting the marks

(a) Lab performance (30%) - individual
(b) Monthly meeting with instructors (10%) - individual
(c) Oral progress presentations (10%) - group
(d) Written progress report (10%) - group
(e) Final oral presentation (15%) - group
(f) Written project report (25%) - group
(g) Peer’s assessment (+/- 10% of the total sum of items (c) – (f))
MOODLE PLATFORM

• Enriching the learning experience
• Facilitate the course administrations

Why Moodle?

• Open source application (free to use)
• Lots of free downloadable add-ons (flexible and easy to customize)
INSTRUCTIONAL VIDEOS

• Techniques for using the library resources
• Use of some specific/essential software
• Advanced laboratory skills

3. [Instructional Videos]
   - [Video] How to use SciFinder
   - [Video] How to use Web of Science
   - [Video] How to use ChemDraw
   - [Video] How to access E-Journal
   - [Video] About Gas Chromatography
   - [Video] About High Performance Liquid Chromatography
- Walkthroughs of the essential techniques of searching SciFinder (database for chemical literatures)

Example: [http://youtu.be/P-UGnbGXD40](http://youtu.be/P-UGnbGXD40)

<table>
<thead>
<tr>
<th>Problem Based Learning (2012 - 2013)</th>
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<tbody>
<tr>
<td>Login SciFinder (Web Version)</td>
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<tr>
<td>Search Articles for a Topic</td>
</tr>
<tr>
<td>Refine and Save a Search</td>
</tr>
<tr>
<td>Further Information Available for an Article</td>
</tr>
<tr>
<td>Search for Substances that Match an Exact Structure</td>
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<tr>
<td>Search for Derivatives of a Compound (Part 1)</td>
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<tr>
<td>Search for Derivatives of a Compound (Part 2)</td>
</tr>
<tr>
<td>Search for Reactions of a Chemical Substance</td>
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</table>
Videos uploaded to Youtube

• Free to use
• Fast and stable streaming
• Minimum (zero) maintenance
• Support all (most) devices and platforms

HPLC01 – Turn Instrument On and Setting Up Methods
HPLC02 – Setup DAD Signal
HPLC03 – isocratic Elution
HPLC04 – Gradient Elution
HPLC05 – Set Sequence for Auto Injection
HPLC06 – Solvent Filtration and Change of Mobile Phase
HPLC07 – Sample Filtration and Sample Cleanup Using SPE
HPLC08 – Analysis of Chromatogram
HPLC09 – Change of Column
THE ESSENTIAL SOFT-SKILLS

Ex-students share their PBL experience about:

• approaches for tackling the difficulties that they have encountered in PBL
• how to make professional presentations for scientific research projects
• how their PBL experience helped developing the essential skills for problem solving and career development.

Ex-group leaders (TAs) share their experience about:

• what makes a successful scientific investigation and good teamwork
Undergraduate students lack of experience in preparing technical presentations and project reports.
Complicated Assessment Schemes with Lots of Assessment Data

Collect assessment data from:

- Professors (*presentations, reports*)
- Lab instructors (*presentations, reports, lab performance*)
- Teaching assistants (*lab performance*)
- Students (*peer assessment*)
Feedback from students on PBL (Part 1)

As you have participated in the Problem-based Learning (PBL) this academic year, we would like to receive your opinions on comparing the effectiveness of PBL with the regular laboratory courses.

Part 1: To compare the learning effectiveness of PBL with the regular lab courses.

Please choose one of the three options against each item to indicate your views. Choose the option that you think is more effective for achieving each of the learning goals.

1. Appreciating the complexity of actual chemistry problems
   - PBL is better
   - They are about the same
   - Regular lab course is better
   - No comment / Not applicable

2. Acquiring skills for searching the chemical literature
   - PBL is better
   - They are about the same
   - Regular lab course is better
   - No comment / Not applicable

3. Planning experimental work
   - PBL is better
   - They are about the same
   - Regular lab course is better
   - No comment / Not applicable

4. Learning practical lab techniques
   - PBL is better
   - They are about the same
   - Regular lab course is better
EXCELLENT RESEARCH RESULTS OBTAINED FROM PBL PROJECTS

Ms. LEUNG Chui-Fan
Supervisor: Prof. XIA Jiang
Department of Chemistry
The Chinese University of Hong Kong

Ms. LEUNG Chui-Fan is currently a final-year chemistry undergraduate student who, together with three other students, worked on a final-year group research project for the exploration and construction of efficient protocols for utilizing inexpensive domestic microwave oven for solid peptide synthesis, under the supervision of Prof. XIA Jiang.

Microwave-assisted Solid-phase Peptide Synthesis of Antimicrobial Defensins

Leung Chui Fan*, Kwok Ka Ngai, Lui Yin Lam, Cheng Fung Yoo, Zhang Han, and Xia Jiang

Antimicrobial defensin, which has a 20 amino acid sequence KNKELILGEGRCDRPFCWCT, was successfully synthesized by Fmoc-based solid-phase peptide synthesis (SPPS), with reaction conditions optimized and generalized in a domestic microwave oven at constant power level. The entire synthesis was completed in one day. SPPS was also performed with the laboratory batch microwave reactor and the standard conventional method at room temperature respectively to justify the microwave-assisted efficiency. The power level used in the domestic microwave oven was constant with the laboratory batch microwave reactor. The identity and purity of the peptide chains synthesized from different methods were characterized by mass spectra and HPLC, and their percentage yields were measured. Flexibility of scaling up of microwave-assisted SPPS was also tested and surprisingly unfolded the reaction time was reduced with increased amount of room, overreaching the common belief that the reaction time is proportional to the heated volume. Syntheses at lower power level and at selected temperature in water bath were also conducted, but they failed to show substantial efficiency, revealing the existence of the non-thermal effect of microwave.

The coupling-deprotection-wash procedure under microwave radiation...
COMPARING PBL WITH REGULAR LAB CLASSES (STUDENT EVALUATION 2010-2011)

- Appreciating the complexity of actual chemical problems
- Acquire skills for searching the chemical literature
- Planning experimental work
- Learning practical lab techniques
- Understand the relations between different areas of chemistry
- Learning the basic principles of different areas of chemistry
- Developing skills for effective and efficient team work
- Developing presentation skills
- Developing project planning and management skills
- Developing greater interest in learning chemistry
"Problem-based learning is different from lecturing education confined in a classroom, in the sense of being highly problem-oriented. It is not like writing for an exam paper, but it is bringing paper knowledge to practical research situation. Through academic discussion and scientific analysis, research issues can be identified, and then solved systematically. Working in a team can also allow us to learn from each other."

PBL gave me an irreplaceable opportunity to work on “authentic” chemical research in an “authentic” research environment. Before working on this PBL course I didn’t have a tiny bit of idea about the complexity of real research problems, was totally clueless about how to run a scientific research project.

But now, after finishing the PBL project, I am very confident of my skills for serious R&D works. Although it (PBL) is definitely a hard work, much harder than an ordinary lab course, but I enjoyed it very much, and definitely I could not acquire that useful experience from elsewhere.
Thank You!