



# Introducing **Problem Based Learning** as Final Year Projects

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# Adoption of PBL in Chemistry's Laboratory Classes

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## **First Introduction to Chemistry's Lab Courses**

2002 – 2003 (2<sup>nd</sup> Term) – as a trial run  
Half of a regular 2<sup>nd</sup> year lab course (equivalent to 1-unit)

## **Full Implementation into the Undergraduate Curriculum**

Since 2008 – 2009 (2 Terms, 4-units)  
As final year compulsory projects

## **Final year Laboratory classes before 2008**

Students were required to take 3 lab sessions  
Lab classes: experiments with lab manuals

# What is Problem-based Learning:



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## Problem-based Learning (PBL)

A student-centered instructional strategy in which students collaboratively solve problems and reflect on their experiences.

### Characteristics of PBL:

- Learning is driven by challenging, open-ended, research problems.
- Students generally work in collaborative groups.
- Teachers take on the role as “facilitators” of learning.



# The Basics of the Arrangements of PBL in Dept of Chemistry

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## Each group is composed of:

- 1 Project proposer/consultant (professor / instructor)
- 1 Laboratory supervisor (instructor)
- 1 Group leader (teaching assistant)
- 4 Students

**In PBL, students are encouraged to take responsibility for their group and organize and direct the learning process, with the support from the group leaders and instructors.**

# Objectives / Learning Outcomes



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## Professional Learning Outcomes

- Acquire scientific research skills.
- Enhance students' ability in conducting scientific investigations independently.
- Acquire advanced chemistry knowledge and skills on specific areas.
- Familiar with the use of chemical literature and databases.
- Learning how to apply their chemistry knowledge in actual investigative works.

## Generic Learning Outcomes

- Enhance problem-solving skills.
- Professional presentation skills – professional scientific oral presentations and written reports.
- Communication and team-work skills.
- Acquire skills on project management and team management.



# Outline of the Major Teaching & Learning Activities/Requirements

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**Objective of the course design – a close replication of the actual scientific research environment**

Lab-based research work: 6 – 8 hrs / week

Oral project presentation: 1st semester: 2 oral progress reports  
2nd semester: 1 oral progress report  
1 final oral presentation

Written project reports: 1st semester: 1 written progress report  
2nd semester: 1 final project report

Brief meeting (students and group leader): Once every week

Brief meeting (students, TA and instructor): Once every month

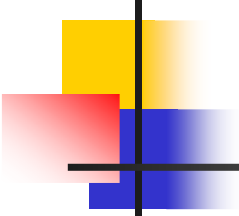
# Assessment Scheme



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- (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))

# Topics in 2010 - 2011

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- (1) Light Controlled Surface Hydrophobicity
  - (2) Nanomaterials for Near-Infrared-Induced Photocatalysis
  - (3) Synthesis, Characterization and Reactivity of  $\text{Cp}_2\text{ZrCl}_2$
  - (4) Asymmetric Epoxidation of Alkenes with Chiral Ketones Derived from Arabinose
  - (5) Synthesis of Biological Study of Platinum Compounds as Anti-Tumor Agent
  - (6) Asymmetric Michael Addition Catalyzed by Amino Acids
  - (7) HMF (5-hydroxymethylfurfural) in Foods
  - (8) Synthesis of Metallocorroles
  - (9) Synthesis and Biological Activity of Antifungal Peptides
  - (10) Extraction Conditions for *Artemisia Annua*
  - (11) Organogelators – Synthesis and Property Studies
  - (12) Preparation and Spectroscopic Study of CdTe Quantum Dots
  - (13) Amine-borane for Hydrogen Storage
  - (14) Obtaining Fuels from Sustainable Resources
  - (15) Preparation and Characterization of Biodegradable Polymers



# Evaluation Results of 2009 - 2010

## Comparison of PBL and Regular Lab Classes (Students' View)

	PBL better	About the same	Regular lab better
Appreciating the complexity of actual chemistry problems	81%	8%	12%
Acquiring skills for searching the chemical literature	88%	8%	4%
Planning experimental work	69%	19%	12%
Learning practical lab techniques	38%	35%	27%
Understand the relations between different areas of chemistry	58%	15%	15%
Learning the basic principles of different areas of chemistry	19%	15%	50%
Developing skills for effective and efficient team work	85%	4%	4%
Developing presentation skills	92%	8%	0%
Developing project planning and management skills	88%	8%	4%
Developing greater interest in learning chemistry	35%	27%	8%

# Evaluation Results of 2009 - 2010

## Course Effectiveness (Students' View)

	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
I become more motivated to engage in self-learning for chemistry	20%	32%	36%	8%	0%
I become more skillful / efficient in self-learning for chemistry	12%	40%	28%	16%	0%
I feel more confident about carrying out chemistry-related research independently	4%	56%	32%	8%	0%
My interest in working on chemistry-related projects were increased	8%	40%	28%	20%	4%
My PBL group leader was very helpful throughout the project	36%	48%	12%	0%	4%
The supports provided were sufficient	24%	36%	20%	16%	4%
I think the PBL course has been well designed and organized	8%	52%	28%	12%	0%
PBL is an effective way for learning chemistry	8%	56%	28%	4%	0%
Overall, I enjoy the PBL experience	12%	52%	28%	0%	8%

# Evaluation Results of 2009 - 2010

## Some Remarkable Free Comments from Students

### Things that Students **LIKE MOST** about PBL:

Better than teaching lab that PBL can be more flexible  
Just like the real research, but PBL is much easier of course  
Better preparation if working in lab in the future.

Challenging and fun

I really gain experience in this PBL by actual practice.  
This gives chances for us to know there are plenty of minor things that we have to pay attention to; and also a place for us to tackle our problems encountered.  
These are important knowledge that cannot be taught in lectures, while they are often encountered once we have to work.

The process of collaborating with team members and exploring the world of science

# Evaluation Results of 2009 - 2010

## Some Remarkable Free Comments from Students

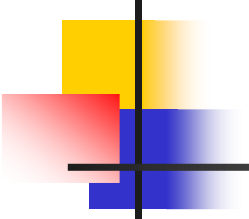
### Things that Students **DISLIKE MOST** about PBL:

Perhaps the grouping would be a difficult job.  
In case of having unfriendly partners, if the other 3 are already closely related, they may probably bully another one, either giving high work-load, or ignorance, or giving an extreme low participation in peer assessment.  
This would create extreme unfairness.

Some groups are treated too harsh

Some of the topics are exceptionally time-consuming, even during the very step of the synthetic route

There were too many oral progress reports, better to cut half of them.



# Supported by Teaching Development Grant (2009 – 2012)

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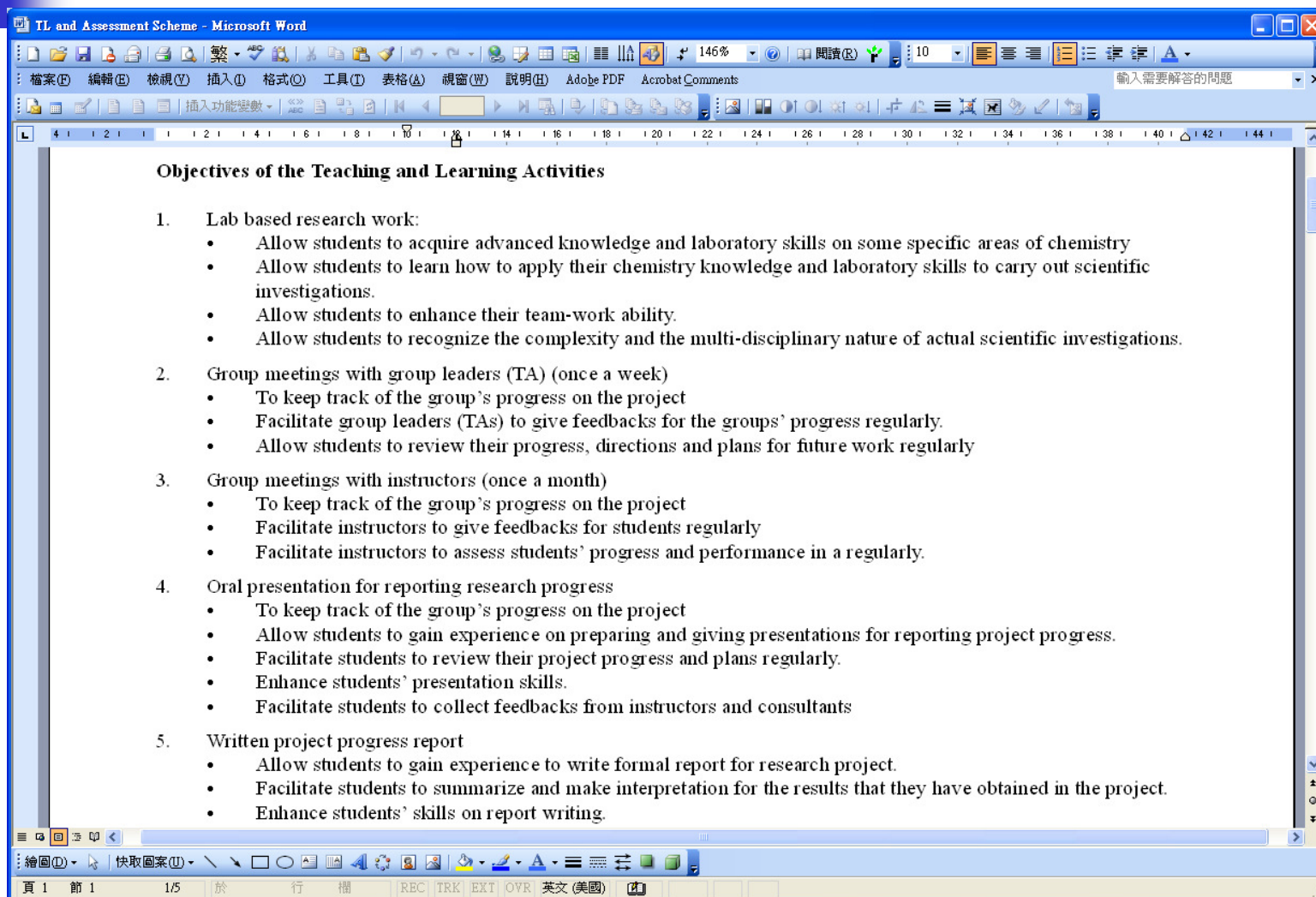
## Development of the Problem-based Learning Model for Transitioning Undergraduate Students from Classroom to Research

### Key areas of development:

- Define the key professional and generic learning outcomes that are crucial to undergraduate graduates, with inputs from teachers and students.
- Design relevant teaching and learning activities and teaching materials to students to attain these learning outcomes
- Devise assessment scheme in response to the defined learning outcomes
- Develop protocols for guiding teachers, teaching assistants and students to design, plan and work through the projects.
- Develop a web-based platform to support the implementation of T&L activities and course logistics.
- Conduct surveys to evaluate the T&L effectiveness
- Arrange workshops to introduce the PBL model to other departments/faculties

# Protocol for Facilitating the Course Management (Example)

## Objectives of Each T&L Activity



The screenshot shows a Microsoft Word window with the title 'TL and Assessment Scheme'. The document content is as follows:

### Objectives of the Teaching and Learning Activities

1. Lab based research work:
  - Allow students to acquire advanced knowledge and laboratory skills on some specific areas of chemistry
  - Allow students to learn how to apply their chemistry knowledge and laboratory skills to carry out scientific investigations.
  - Allow students to enhance their team-work ability.
  - Allow students to recognize the complexity and the multi-disciplinary nature of actual scientific investigations.
2. Group meetings with group leaders (TA) (once a week)
  - To keep track of the group's progress on the project
  - Facilitate group leaders (TAs) to give feedbacks for the groups' progress regularly.
  - Allow students to review their progress, directions and plans for future work regularly
3. Group meetings with instructors (once a month)
  - To keep track of the group's progress on the project
  - Facilitate instructors to give feedbacks for students regularly
  - Facilitate instructors to assess students' progress and performance in a regularly.
4. Oral presentation for reporting research progress
  - To keep track of the group's progress on the project
  - Allow students to gain experience on preparing and giving presentations for reporting project progress.
  - Facilitate students to review their project progress and plans regularly.
  - Enhance students' presentation skills.
  - Facilitate students to collect feedbacks from instructors and consultants
5. Written project progress report
  - Allow students to gain experience to write formal report for research project.
  - Facilitate students to summarize and make interpretation for the results that they have obtained in the project.
  - Enhance students' skills on report writing.

# Protocol for Facilitating the Course Management (Example)

## Detailed Assessment Scheme

TL and Assessment Scheme - Microsoft Word

Overall Marking Scheme:

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

(a) Lab Performance

Weighting: 30%

Assess mode: Individual student

Assessed by: The corresponding instructor (10%)  
The corresponding group leader / TA (20%)

Frequency: Twice in a semester: 1<sup>st</sup> time: The 8<sup>th</sup> week of a semester  
2<sup>nd</sup> time: One week after term break

Areas assessed: Lab technique, scientific knowledge, preparation and seriousness (20%)  
Communication and coordination skills (5%)  
Proficiency in recording data in the lab notebook (5%)

(b) Monthly group meeting with instructors

Weighting: 10%

Assess mode: Individual student

Assessed by: The corresponding instructor (10%)

Frequency: Once a month in the semester:

Areas assessed: Participation in the discussion  
Participation in conducting the project

(c) Oral progress presentation

頁 4 節 1 於 5.7cm 行 9 欄 24 REC TRK EXT OVR 英文(美國)

# Protocol for Facilitating the Course Management (Example)

## Guidelines for Preparing the Presentations

**Details and Suggested focus for oral presentations for reporting research progress**

- Time allowed for each group: 15 minutes (including Q & A).

**1<sup>st</sup> Presentation (1<sup>st</sup> Semester, 6 Oct 2010)**

- (a) Brief introduction about the topic / problems to be solved.
- (b) The goal(s) to be achieved in the project.
- (c) Literature survey / brief descriptions of some recently published previous works.
- (d) Proposed approach for solving the problem
- (e) Outline of the project plans (in stages)
- (f) Preliminary results (if any)

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**2<sup>nd</sup> Presentation (1<sup>st</sup> Semester, 17 Nov 2010)**

- Brief descriptions on:
  - (a) The objective(s) of the project.
  - (b) Proposed approach for solving the problem / brief project plan
  - (c) The current stage of the investigation
- The experimental results obtained during the previous month
- Interpretation of the experimental results. Is the progress on track?
- Any deviation from the original plan?
- Any difficulties encountered / newly surfaced problems that needed to be tackled?
- Working plan for the next few months.

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**3<sup>rd</sup> Presentation (2<sup>nd</sup> Semester, 2 March 2011)**

- Brief descriptions on topic / problem that have to be solved.
- Summarize the works that have been done. Highlight the deviation from the original plan.
- Highlight the new scientific findings (if any) with adequate supporting evidence.

頁 2 節 1 2/5 於 4.5cm 行 6 欄 25 REC TRK EXT OVR 英文(美國)



# Web-based Platform Developed with Moodle

<http://pbl.chem.cuhk.edu.hk/moodle>

## Why moodle?

- Open source  
*(free to use)*
- Flexible and expandable  
*(lots of add-on modules available)*

The screenshot shows a web browser window titled "Moodle Site for Problem-Based Learning - Windows Internet Explorer". The address bar shows the URL "http://137.189.38.46/moodle/". The page content includes a navigation menu on the left under "Site Administration" with items like Notifications, Users, Courses, Grades, Location, Language, Modules, Security, Appearance, Front Page, Server, Networking, Reports, and Miscellaneous. The main content area is titled "Available Courses" and lists two courses: "Problem Based Learning 2009 - 2010" and "Problem Based Learning 2010 - 2011". The second course lists teachers: Admin User, YS Cheung, Kevin Leung, Lea Yang, and WF Chan. A "Turn editing on" button is visible. On the right, there is a "Calendar" widget showing "September 2010" with a grid of dates. At the bottom, it says "You are logged in as Admin User (Logout)" and features the Moodle logo.

# What are now Implemented on the Moodle site?



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- General information/instruction about the course
- Previous presentations' powerpoints and reports
- Supporting resources for self-learning
- Platform for collecting the assessment data
- Platform for conducting course survey



# Using the Moodle Site to Collect Assessment Data

The screenshot shows a web browser window titled "Course: Problem Based Learning 2010 - 2011 - Windows Internet Explorer". The address bar contains the URL: <http://137.189.38.46/moodle/course/view.php?id=3&edit=0&sesskey=QLxXI7at1u>. The browser's menu bar includes "檔案(F)", "編輯(E)", "檢視(V)", "我的最愛(A)", "工具(T)", and "說明(H)". The address bar also shows "Google" and a search icon. The browser's toolbar includes icons for home, back, forward, print, and search, along with the text "Course: Problem Based Learning 2010 - 2011" and "網頁(O)", "工具(O)".

The main content area displays a list of assessment items:

- Performance Assessment by Instructor (Analytical) (2nd Term - 1st Round)
- Performance Assessment by Instructor (Inorganic) (2nd Term - 1st Round)
- Performance Assessment by Instructor (Organic) (2nd Term - 1st Round)
- Performance Assessment by Instructor (Physical) (2nd Term - 1st Round)
- Performance Assessment by Instructors (2nd Term, 2nd Round)**
- Performance Assessment by Instructor (Analytical) (2nd Term - 2nd Round)
- Performance Assessment by Instructor (Inorganic) (2nd Term - 2nd Round)
- Performance Assessment by Instructor (Organic) (2nd Term - 2nd Round)
- Performance Assessment by Instructor (Physical) (2nd Term - 2nd Round)

5 Performance Assessment (by TA / Group Leaders):

- Performance Assessment by TA / Group Leader (1st Term - 1st Round)
- Performance Assessment by TA / Group Leader (1st Term - 2nd Round)
- Performance Assessment by TA / Group Leader (2nd Term - 1st Round)
- Performance Assessment by TA / Group Leader (2nd Term - 2nd Round)

6 Peer's Assessment

**Peers' Assessment (1st Term)**

- Peers' Assessment for Group 1 (1st Term)
- Peers' Assessment for Group 2 (1st Term)
- Peers' Assessment for Group 3 (1st Term)
- Peers' Assessment for Group 4 (1st Term)
- Peers' Assessment for Group 5 (1st Term)
- Peers' Assessment for Group 6 (1st Term)
- Peers' Assessment for Group 7 (1st Term)
- Peers' Assessment for Group 8 (1st Term)

The browser's status bar at the bottom shows "網際網路" and "100%".

# Using the Moodle Site to Collect Assessment Data

PBL1011: Performance Assessment by TA / Group Leader (1st Term - 1st Round) - Windows Internet Explorer

http://137.189.38.46/moodle/mod/questionnaire/view.php?id=35

檔案(F) 編輯(E) 檢視(V) 我的最愛(A) 工具(T) 說明(H)

PBL1011: Performance Assessment by TA / Group Lea...

- Tang Qianing (Group 12)
- Chan Yuk Chi (Group 13)
- Yeung Hoi Sze (Group 14)
- Au Chi Wai (Group 15)

**\*3** Name of Student 1: **(Students' names listed at the end of this page)**

**\*4** Performance of Student 1:

	A	A-	B+	B	B-	C+	C	C-	D+	D	F
Technique, scientific knowledge, preparation and seriousness	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Group communication and coordination	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Recording of experimental details (Lab notebook)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

**\*5** Name of Student 2:

**\*6** Performance of Student 2:

	A	A-	B+	B	B-	C+	C	C-	D+	D	F
Technique, scientific knowledge, preparation and seriousness	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Group communication and coordination	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Recording of experimental details (Lab notebook)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

完成

網際網路 100%

# Using the Moodle Site to Collect Assessment Data

The screenshot shows a web browser window titled "Course: Problem Based Learning 2009 - 2010 - Windows Internet Explorer". The address bar shows the URL "http://137.189.38.46/moodle/course/view.php?id=2". The page content is organized into several sections:

- People:** Includes a link for "Participants".
- Activities:** Includes links for "Forums", "Questionnaires", and "Resources".
- Search Forums:** A search box with a "Go" button and a link to "Advanced search".
- Administration:** A list of administrative tools including "Turn editing on", "Settings", "Assign roles", "Grades", "Groups", "Backup", "Restore", "Import", "Reset", "Reports", "Questions", "Files", "Unenrol me from PBL0910", and "Profile".
- Course categories:** Includes a link for "Miscellaneous".
- Topic outline:** A central section with a "News forum" link and four numbered items:
  - 1 TA's Evaluation on PBL:** Group leaders (TAs) please provide your views about this year's PBL by completing the following questionnaire. Thank you. Includes links for "Instructions" and "Feedbacks from TAs (Group Leaders) on PBL (2009 - 2010)".
  - 2 Students' Evaluation on PBL:** Students please provide your views about this year's PBL by completing the following questionnaire. Thank you. Includes links for "Instructions", "Feedback from students on PBL (Part 1)", and "Feedback from students on PBL (Part 2)".
  - 3 Students' and TA's Survey on PBL's Learning Outcomes:** Purpose: To collect TA / students' feedbacks about how the learning outcomes of PBL have been achieved in this year. Includes a link for "PBL Learning Outcomes (TA / Students' Feedbacks)".
  - 4 Students' Peer Assessment (Round 4):** Evaluation Period: 5 March 2010 - 24 April 2010. Includes a link for "Students' Peer Assessment (Round 4)".
- Latest News:** Includes a link for "Add a new topic..." and a message: "(No news has been posted yet)".
- Upcoming Events:** Includes a message: "There are no upcoming events" and links for "Go to calendar..." and "New Event...".
- Recent Activity:** Includes a message: "Activity since Thursday, 9 September 2010, 03:53 AM" and a link for "Full report of recent activity...". Below this, it says "Nothing new since your last login".

The browser's status bar at the bottom shows "100%" zoom and "網際網路" (Internet).

# Using the Moodle Site to Collect Assessment Data

The screenshot shows a web browser window titled "PBL0910: Feedback from students on PBL (Part 1) - Windows Internet Explorer". The address bar shows the URL: <http://137.189.38.46/moodle/mod/questionnaire/view.php?id=5>. The page content includes:

- Page title: **Problem Based Learning 2009 - 2010**
- Breadcrumbs: [pblmoodle](#) > [PBL0910](#) > [Questionnaires](#) > **Feedback from students on PBL (Part 1)**
- Buttons: [View](#), [All responses \(26\)](#), [Advanced settings](#), [Questions](#), [Preview](#), and [Update this Questionnaire](#)
- Section: **Feedback from students (Part 1)**
- Text: "As you have participated in the Problem-based Learning III (PBL) this academic year, we would like to receive your opinions on comparing the effectiveness of PBL with the regular laboratory courses."
- Text: "Part 1: To compare the learning effectiveness of PBL with the regular lab courses."
- Text: "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."
- Item 1: **\*1** 1. Appreciating the complexity of actual chemistry problems
  - PBL is better
  - They are about the same
  - Regular lab course are better
  - No comment / Not applicable
- Item 2: **\*2** 2. Acquiring skills for searching the chemical literature

The browser's taskbar at the bottom shows the system tray with icons for network, volume, and power, and the taskbar text "完成" (Completed).

# Using the Moodle Site to Collect Assessment Data

PBL0910: Questionnaire Report - Windows Internet Explorer

http://137.189.38.46/moodle/mod/questionnaire/report.php?instance=2&sid=2&action=vall

View All Responses. All participants. View Default order Responses: 26





## Feedback from students (Part 1)

As you have participated in the Problem-based Learning III (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. 1. Appreciating the complexity of actual chemistry problems

Response	Average	Total
PBL is better	 81%	21
They are about the same	 8%	2
Regular lab course are better	 12%	3
Total	 100%	26/26

### 2. 2. Acquiring skills for searching the chemical literature

Response	Average	Total
PBL is better	 88%	23
They are about the same	 8%	2
Regular lab course are better	 4%	1
Total	 100%	26/26

完成

網際網路 100%





# Acknowledgements

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We thank The Chinese University  
of Hong Kong for the Teaching  
Development Grant