

# Curriculum development: Reflecting upon PBL and CBL activity in chemistry at NTU in 2008-09

Dr Paul Martin

Chemistry For Our Future Lecturer,  
NTU

# Contents

- Chemistry for Our Future (CFOF)
- Context- and Problem- Based learning (C/PBL)
- Brief description of case-studies at NTU
- Student feedback
- More detail about a Masters level case study and feedback
- Reflections

# CFOF Mission Statement:

**Help ensure that there is a sustainable chemical science base within higher education which will attract able students from all backgrounds and provide chemical science courses appropriate for students and employers in the 21st Century.**



# And the problem with chemistry is...?

## **Decline in students studying chemistry**

- 36,000+ take 'A'-level chemistry in UK
- 3000 enter chemistry degrees
- % choosing chemistry has fallen

## **Why?**

- Hard subject
- Boring courses
- Poor image of Chemical industry
- Unattractive syllabi
- Poor career prospects
- Not a "vocation"

# CFOF – Leicester (lead) + Hull, NTU & Plymouth

## Some definitions:

- PBL – Problem-based Learning
- CBL – Context-based Learning
- EBL – Enquiry-based Learning
- NEW: Research-linked Learning (RLL)

## Strand 3.2 CFOF

- 1.explore blended delivery that may help attract students
- 2.link courses to career, interdisciplinary and generic skills
- 3.Effect sea-change in teaching methods
- 4.Use problem-solving at all levels.
- 5.transferability

## How do these approaches help ?

- Develop understanding of theory by investigating & solving real life problems.
- Students are encouraged to apply previously acquired knowledge, from all areas of the lecture course, & develop new knowledge and skills in order to derive a solution to a scenario.
- Enhancing & learning theoretical chemistry.
- Encourages development of softer skills, team work presentation, communication. Skills which are widely sort by employers and often overlooked by traditional lecture courses.

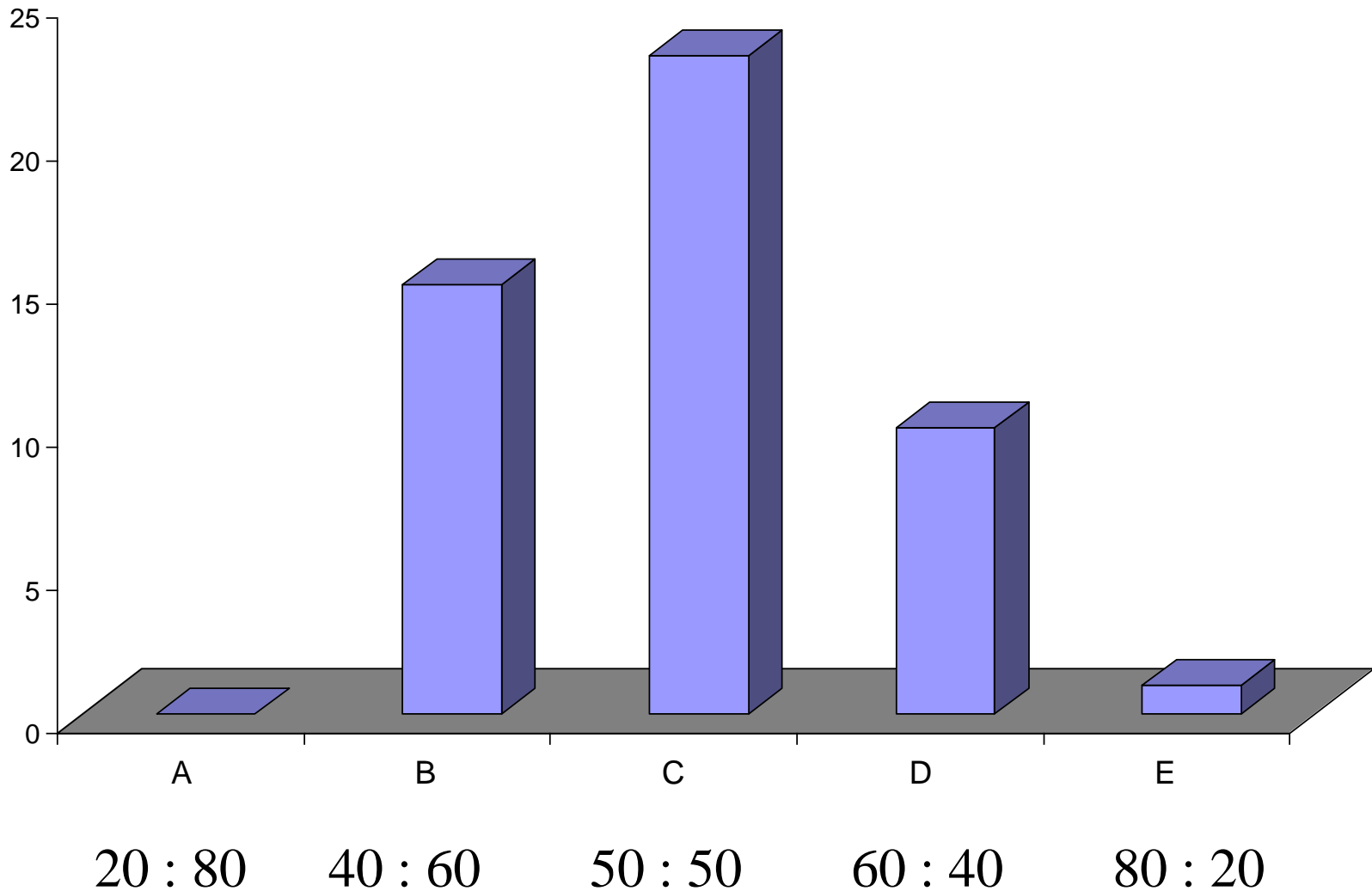
# 5 main Case Studies

<b>Sending the Right Signals</b>	<b>Biological Chemistry</b>	<b>Scientific writing problem</b>
<b>Tale of 2 Deaths</b>	<b>Biological Chemistry and/or Forensic Science context</b>	<b>Forensic case study</b>
<b>The Moly-go-round</b>	<b>Organometallic chemistry</b>	<b>PBL practical activity</b>
<b>The Brixham Labs</b>	<b>Environmental Chemistry and Testing in the Tamar Estuary in collaboration with Astra Zeneca</b>	<b>PBL exercises</b>
<b>Unlocking the Oxygen Storage Capacity of Ceria</b>	<b>Surface chemistry</b>	<b>RLT exercise</b>

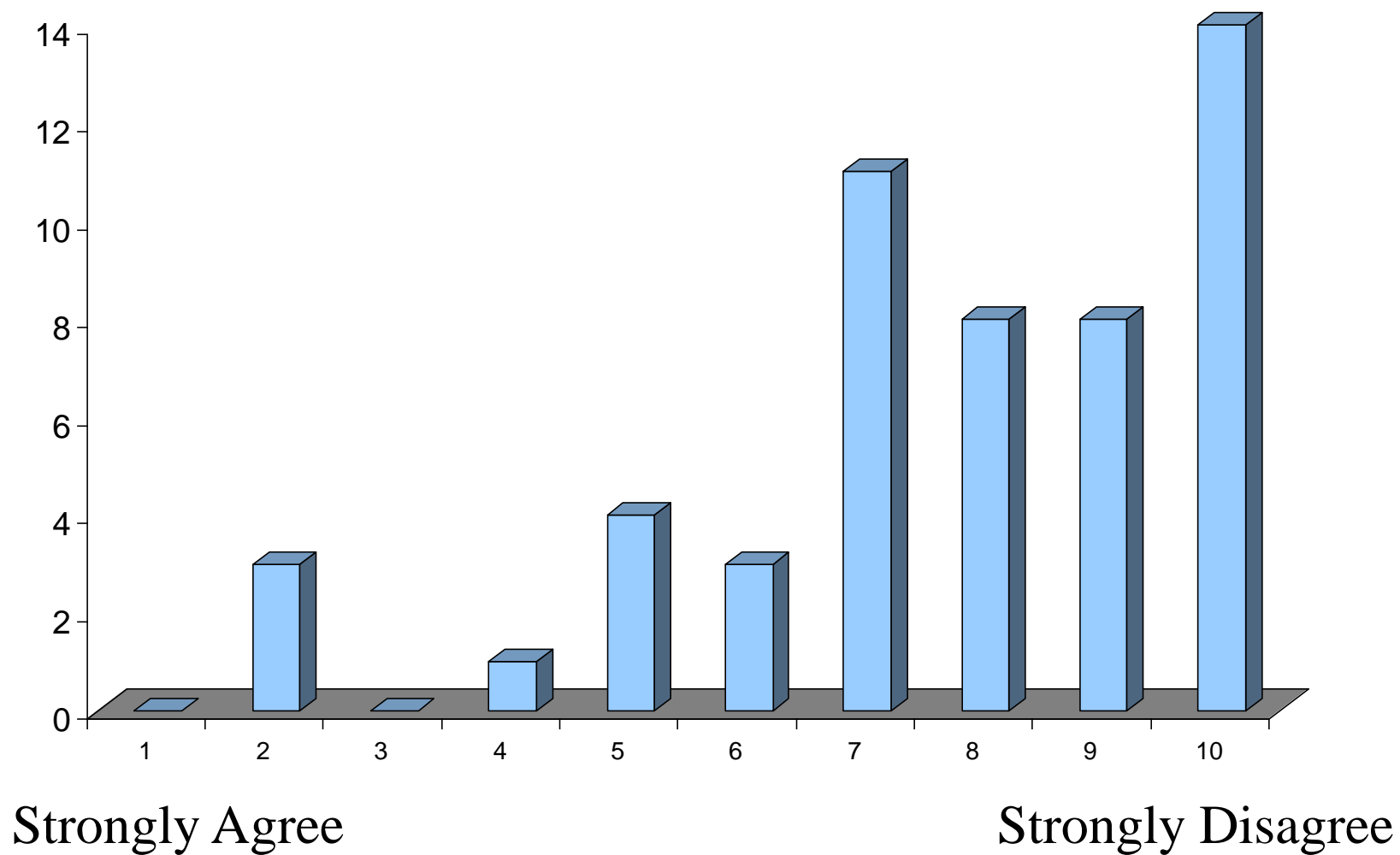
# Student feedback

- Firstly generic feedback from all students concerning their c/pbl experience
  
- Some student feedback for specific resource/activity relating to specialist content/activity/skill for particular resource

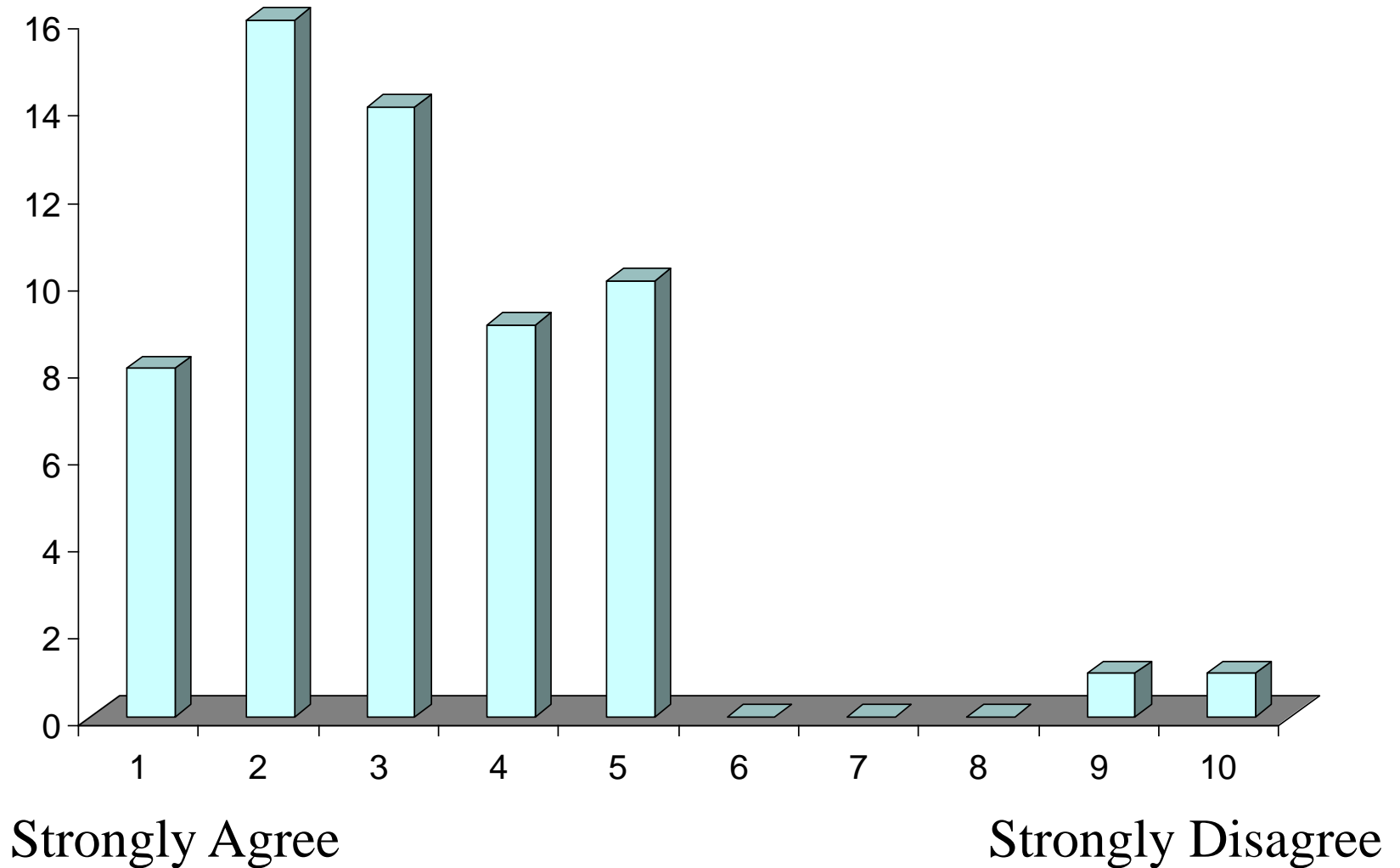
## Ideal proportion of C/PBL : Traditional Lectures/Labs



# I did NOT learn any new Chemistry



# The work helped me make more sense of theory



# Student Feedback: Sending the Right Signals – Biological Chemistry – Scientific writing problem

	Strongly agree <span style="float: right;">Strongly disagree</span>									
	<b>1</b>	<b>2</b>	<b>3</b>	<b>4</b>	<b>5</b>	<b>6</b>	<b>7</b>	<b>8</b>	<b>9</b>	<b>10</b>
Makes sense of cell signalling theory	2	8	10	3	4					1
Danger of prescription drugs	7	8	7	2	2				1	1
Biomolecule recognition by cell receptors	3	4	5	5	6	3		1		1
Cell signalling pathways	5	8	6	4	3		1		1	
Antidepressant action	12	4	7	4		1				
Improve understanding of antidepressant side effects	13	4	5	2	2		1		1	
Differences between tricyclic and tetracyclic structure	12	8	5	1	2					
Antidepressant side effects	13	4	5	2	2		1		1	

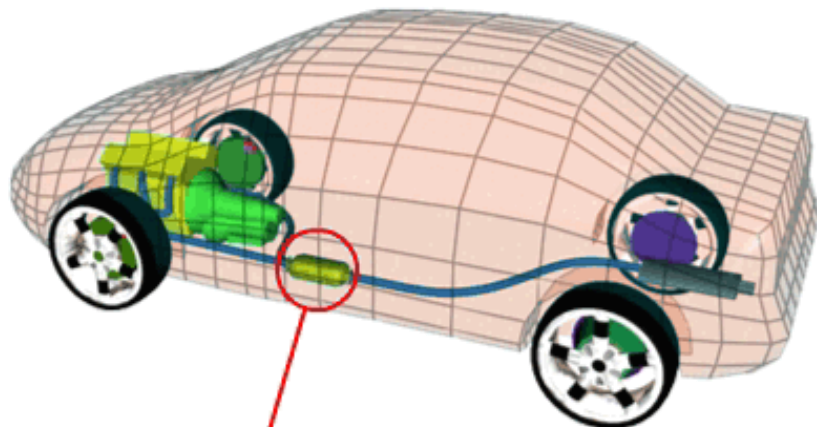
# Student Feedback: Sending the Right Signals – Biological Chemistry – Scientific writing problem

	Strongly agree <span style="float: right;">Strongly disagree</span>									
	<b>1</b>	<b>2</b>	<b>3</b>	<b>4</b>	<b>5</b>	<b>6</b>	<b>7</b>	<b>8</b>	<b>9</b>	<b>10</b>
Practise and improve literature searching	12	4	3	5	2			1		1
Scientific writing appropriate to audience	13	5	5	2	1		1	1		
Understand what make a good scientific article/writer	3	8	6	3	4	1		1		2
Interesting	2	5	8	3	4	1	2	1		2
Improve scientific writing and communication skills	9	4	8		5			2		1

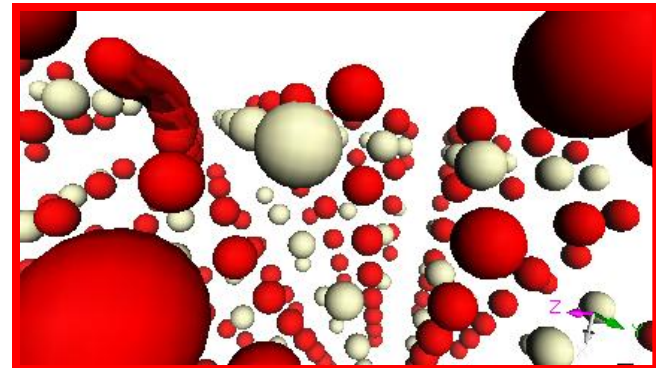
# Unlocking the Oxygen Storage Capacity of Ceria

- M level PBL/RLT resource

## Studying Ceria Surfaces



Typical Catalytic Converter Location

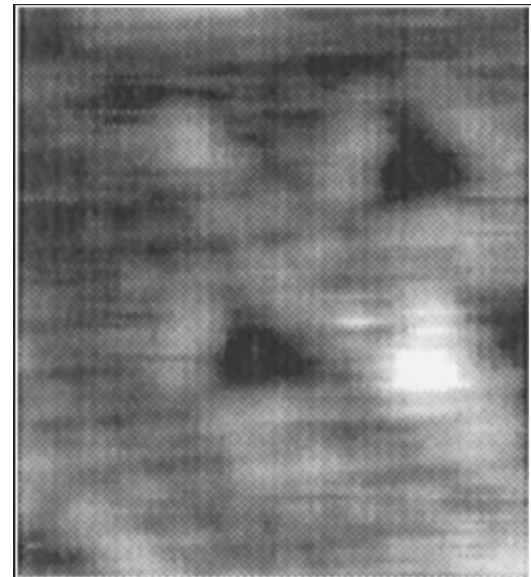


# A Multidisciplinary Surface Science Project

You have been assigned to help investigate the possibility of the formation of potentially important catalytic sites on the surface of ceria

Experimentalists have taken images of what they suspect are triangular vacancy clusters

As a respected chemist and materials modeller you are being contracted to collaborate with a multi-disciplinary surface science research group to investigate further these potentially important catalytic sites.



# What is the scope for possible learning outcomes here ? :

- Good example of understanding how modern research uses the synergy between advanced experimental and theoretical techniques.
- Migration profiles, thermodynamics, free energy – activation energy.
- Scope for solid state chemistry, crystal structures, surface science, catalysis
- Experimental methods – STM , could be extended to other techniques
- Multi-scale modelling

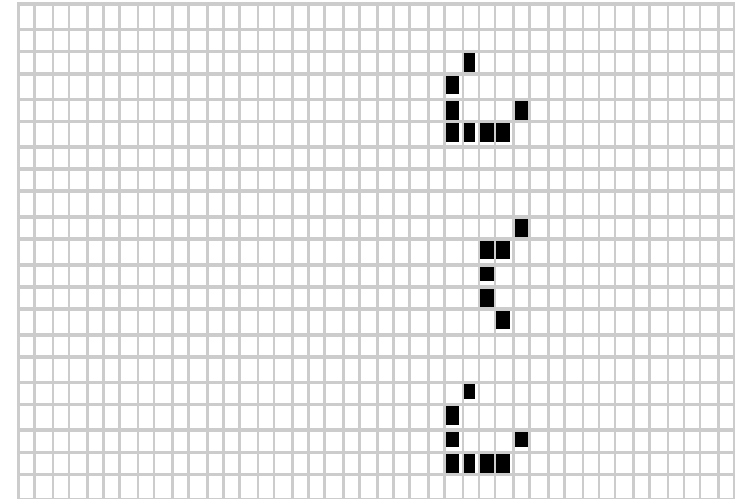
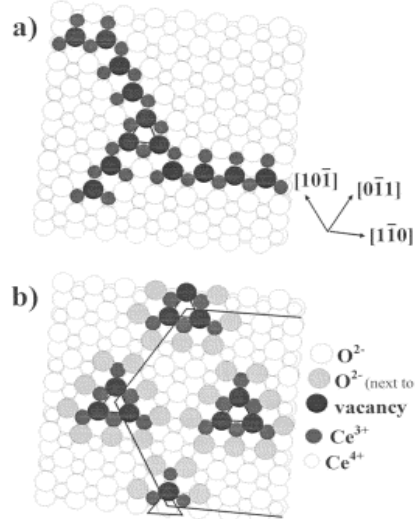
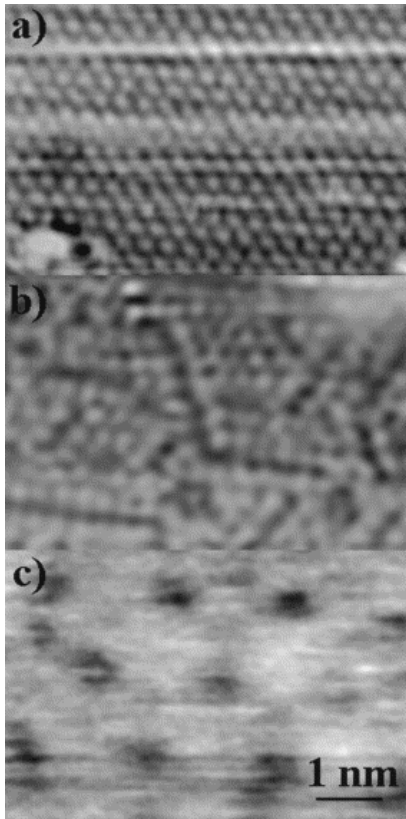
# The Task

- You are being contracted to provide advice in computational solid state chemistry.
- 2 general areas of concern
- 1... Representing solid-state surface ion positions in computer memory.
- 2... Describing the anisotropic oxygen migration at the surface of ceria in terms of a logic table.
- The scientific programmers need this information to then write object-orientated code to simulate ceria surfaces at the mesotopic level

# Experimentally Observed Triangular Vacancy Clusters

Higher level research challenge would eventually be:

Build an uncoupled/indirect mesoscale simulation model to investigate vacancy clustering and further isotopic effects

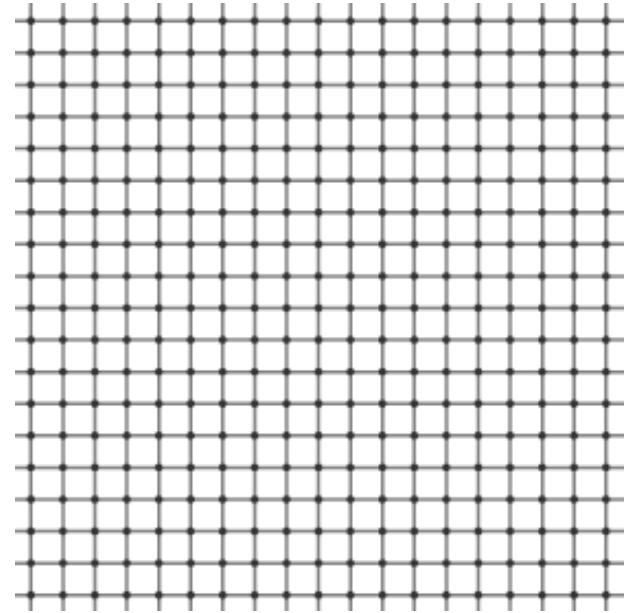
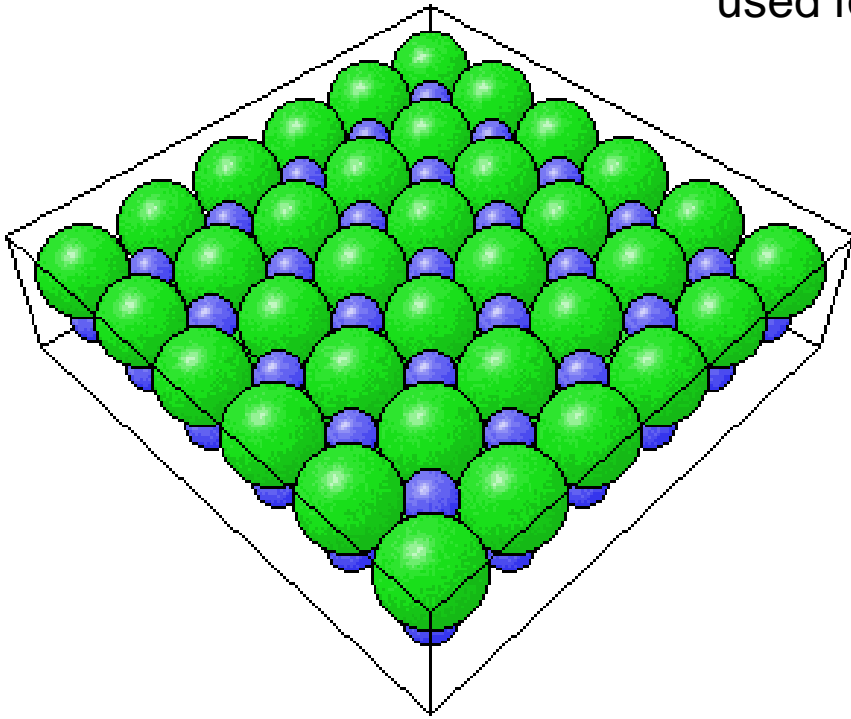


At present our the student challenge:

1. Represent ceria surface atoms and positions in computer memory
2. Generate rules for oxygen migration for ceria surfaces

# Co-ordinate systems.....

Project partners realise that we need to be able to describe the structure of a given surface in computer memory, that can be subsequently used for simulation experiments

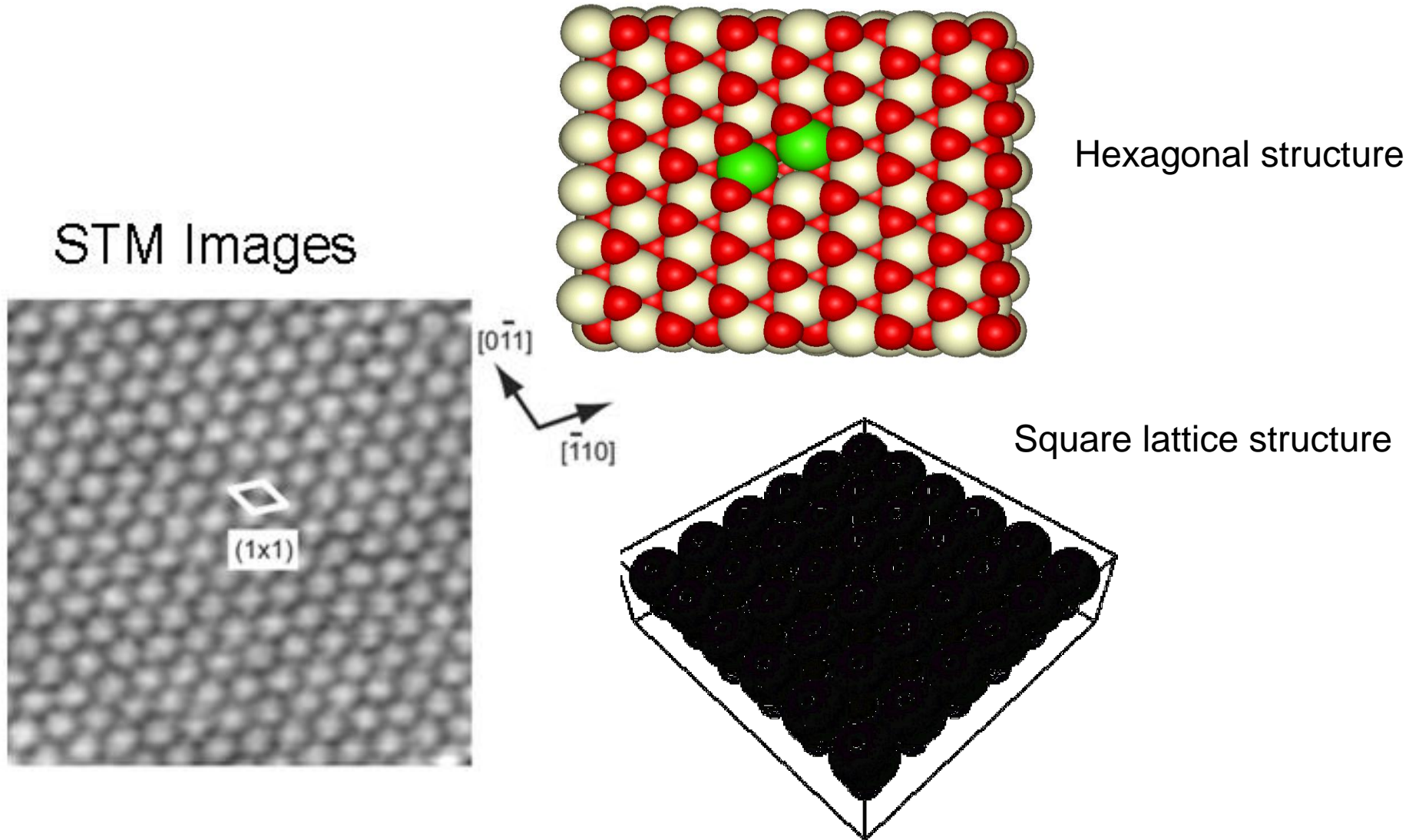


$$2D\_Array = [x_0 \dots x_n] \cdot [y_0 \dots y_n]$$

And then each coordinate position is given a file with data about an ion in that position

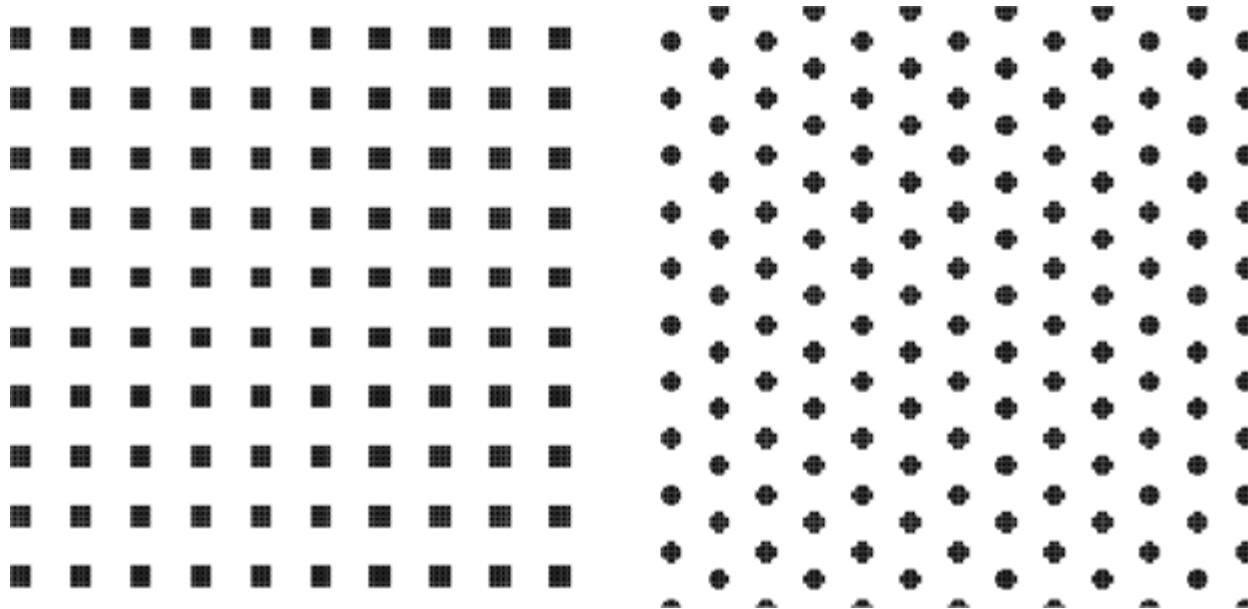
- What data/information about each respective ion would be needed ?


# The Stable Surface of Ceria



- What are the differences in surface structure (square v hexagonal), describe them ?

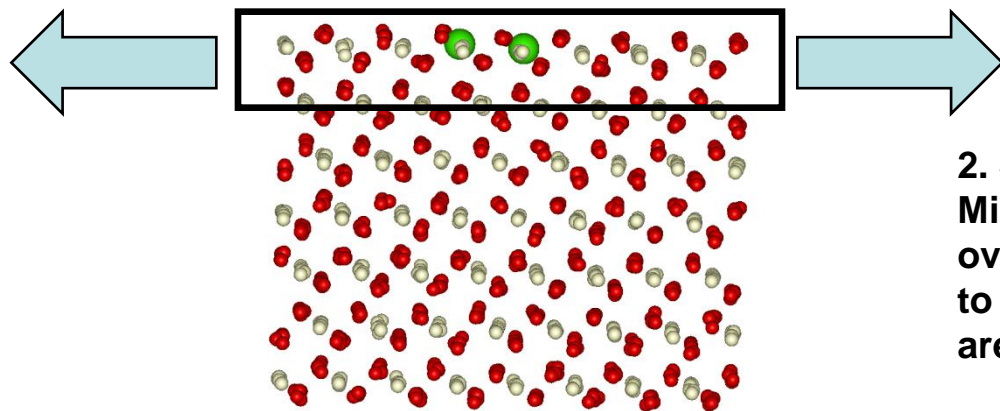
# Lattice co-ordinate conversion



Square\_2D\_Array =  $[x_0 \dots x_n] \cdot [y_0 \dots y_n]$   Hexagonal\_2D\_Array =  $[x_0 \dots x_n] \cdot [y_0 \dots y_n]$

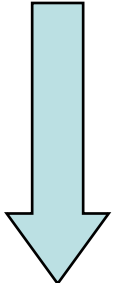
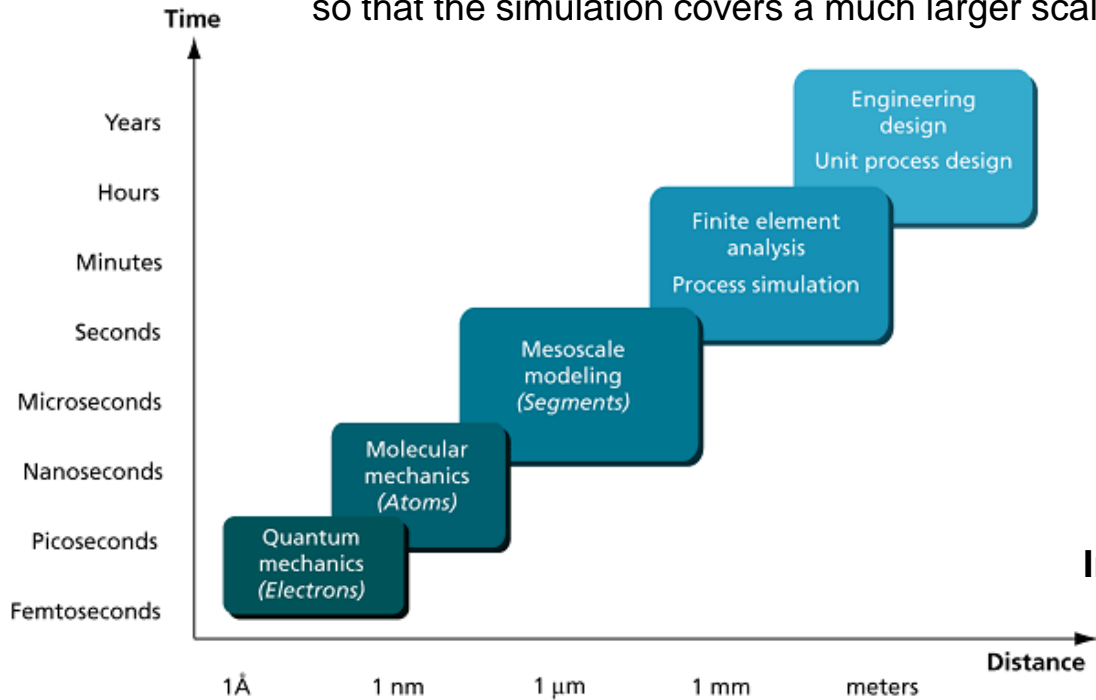
- 1...What are the operations and steps to go from one to the other
- 2...How would you do the same for a 3-D lattice coordinate system

1. Students are given research paper on calculation of Energies of Migration. How could they be used to Investigate Vacancy Clustering ?



2. Students realise that oxygen Migration needs to be simulated over a much larger surface area, to test whether triangular clusters are an emergent property

Investigate Vacancy Clustering using an **Un-coupled** Surface simulation so that the simulation covers a much larger scale of surface area



3. We therefore Introduce concept of **Multi-scale Modelling.**

**[ie] Activation Free energy of Migration calculations at atomistic scale feed into larger scale simulation of surface to Investigate emergence of vacancy clusters**

# Student Feedback: **Unlocking the Oxygen Storage Capacity of Ceria**

	Strongly Agree					Strongly Disagree				
	1	2	3	4	5	6	7	8	9	10
The activity was a good example of the synergy between experimental and theoretical / computational research.	3	4	4	2			2	2		
The work improved my understanding of how defects might form in surfaces	4	5	5			1				
I understand better energy profiles and how they might be used to investigate oxygen migration in surfaces	6	7	2							
The activity allowed me to understand how atomistic simulation results can be used in a different mesoscale simulation on a larger scale to form a multiscale surface simulation.	3	5	3	2		1		1		
The work gave a good example of both experimental and theoretical techniques available for surface investigations.	5	7	1	2						
The work improved my understanding of the importance of defects in catalysis and surface chemistry	4	6	1	2	1				1	

## Lessons learnt:

- Needs to be novel science and educationally sound/appropriate for module composition
- If activity involves a large amount of course-work – assessment scheduling is important
- Previous knowledge/experience: lots of new terminology – some students have better starting position than others, (ie) knowledge, skills, experience (inc. E/PBL)
- Need clear explanations of tasks/new info.  
throughout activity
- Computing labs :
  - **Potential for software licensing issues**
  - **Practical issues: room booking / type of room**

# Conclusions:

- Problem Based Learning can (and needs) to involve a range of scientific and generic skills from scientific writing through IT and programming, presentation skills, research methods, mathematical problems, modelling, team working, etc.
- Students prefer a blended approach to learning involving a variety of activity, including traditional lectures and labs, also PBL, RLT, CBL projects, individual/group work.
- E/PBL is useful and appropriate across all curriculum areas and at all levels.
- Various rigorous assessment models are possible.
- At higher levels we have successfully trialled a blended PBL/Research-linked teaching/resource. Exciting = Scope for all undergraduate levels, and other curriculum areas ?
- Available soon via : [www.heacademy.ac.uk/](http://www.heacademy.ac.uk/)