

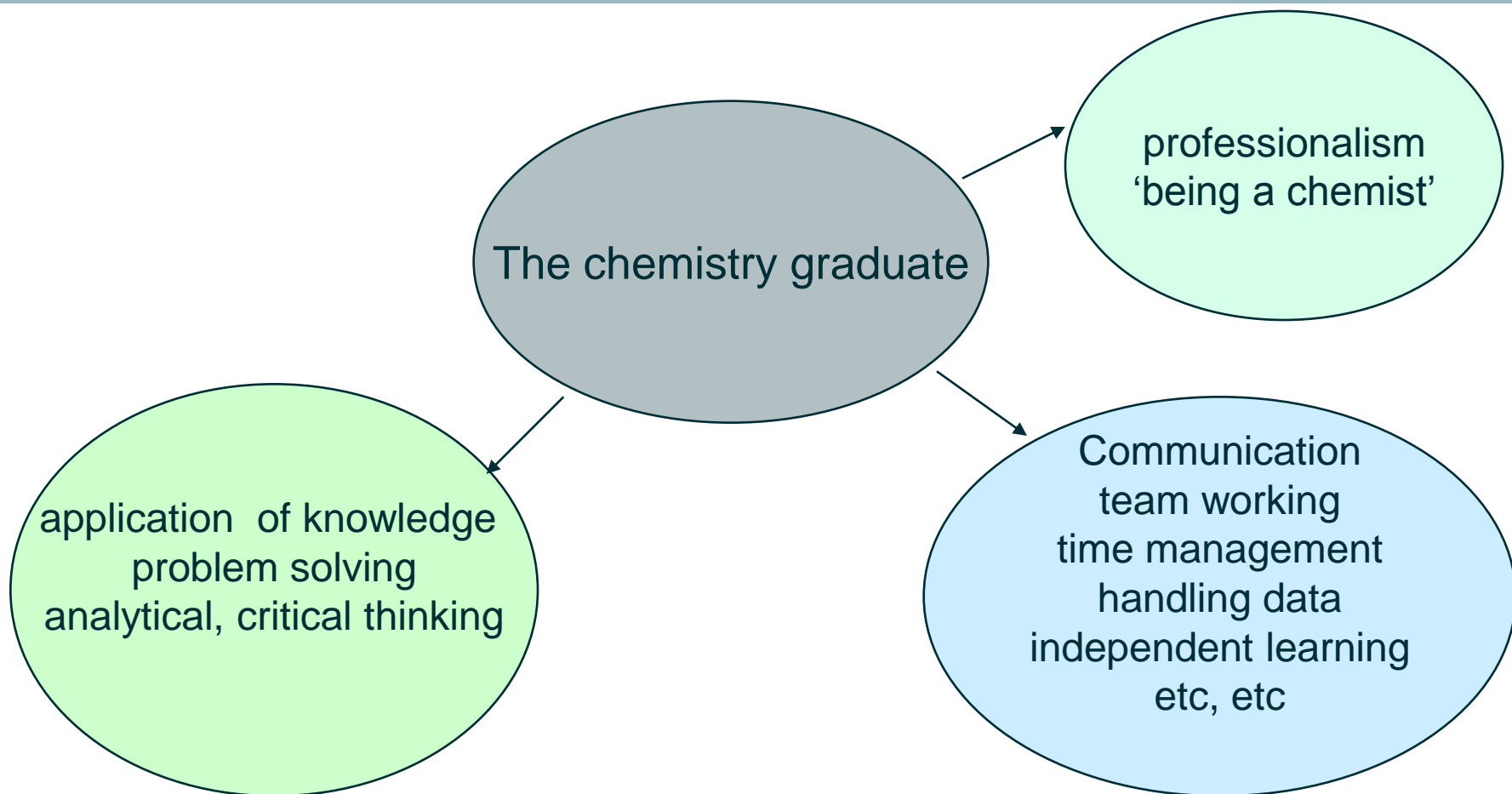
# Phenomenographic Study of Problem Solving with Chemistry Undergraduates

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# The challenge



# What is problem solving?

*“Problem solving is what you do when you don’t know what to do.”*

(Wheatley, 1984)



# Types of problems

(Johnstone, 1993)

| Type | Data       | Methods    | Outcomes |
|------|------------|------------|----------|
| 1    | Given      | Familiar   | Given    |
| 2    | Given      | Unfamiliar | Given    |
| 3    | Incomplete | Familiar   | Given    |
| 4    | Incomplete | Unfamiliar | Given    |
| 5    | Given      | Familiar   | Open     |
| 6    | Given      | Unfamiliar | Open     |
| 7    | Incomplete | Familiar   | Open     |
| 8    | incomplete | Unfamiliar | Open     |



# Traditional vs open-ended problems

- Predictive studies have focussed on algorithmic/logical structured problems
- What about open-ended problems?
- Is there a continuum from algorithmic → conceptual → open-ended?
- Does being proficient at algorithmic or conceptual problems lead to success in open-ended problems?



# Open-ended problems

From this....

Potassium dioxide reacts with carbon dioxide according to the following equations:



What mass of potassium dioxide would be required to convert 50 g of carbon dioxide to oxygen?



# Open-ended problems

To this....

You've been on Who Wants To Be a Millionaire and won £64,000. You decide to treat yourself and some mates to a holiday in America. The flight from Heathrow to New York is 7 hours.

To provide breathable air on an aircraft recirculation cells containing potassium dioxide are used.

What mass of potassium dioxide would be needed on a Boeing 747 for this flight?



# From algorithmic exercises to open-ended problems

Algorithmic

Familiar

Known method

Abstract

Equations

Routines

Based on taught content

Maths - formal

Accuracy important

Open-ended

Unfamiliar

Unknown method

Context

Develop equations

Develop routines

Less reliant on content

Maths - estimations

Accuracy less important



# Our study

- >200 undergraduates
- >6 open-ended problems
- Pre and post attitudes questionnaires
- Increased positive attitude towards problems with real life or work related context
- Open-ended problems more enjoyable than conventional ones
- Open-ended problems more challenging than conventional ones



# Phenomenography

- **Phenomenography** is a qualitative methodology that investigates the qualitatively different ways in which people experience something or think about something.

(Marton, 1986).



# Phenomenographic study

- Students solve open-ended problems
- Write down their thoughts, strategy, solution
- Sessions and interviews recorded
- Analysis of thought processes, reflections on experience



# Outcomes

- Analysis revealed several approaches, strategies over a number of different problems.
  - >Logical, structured, reasoning
  - >Ability to make approximations/estimates
  - >Inability to identify problem
  - >Focus on context of problem
  - >Focus on prior knowledge
  - >Affected by too much or insufficient data



# Analysis

|   | Logical | Makes estimates | Can't identify problem | Context | Prior knowledge | Data |
|---|---------|-----------------|------------------------|---------|-----------------|------|
| A | 9       | 1               |                        |         |                 |      |
| B | 6       | 2               |                        |         |                 |      |
| C | 6       | 1               |                        |         |                 |      |
| D |         |                 | 4                      | 5       | 3               | 4    |
| E |         |                 | 5                      | 3       |                 | 4    |
| F |         |                 | 4                      | 1       | 1               | 3    |



# Two approaches

- Students who are able to identify problems, make estimations and not distracted/confused by the context
- Students who are unable to clarify problem, are distracted by the context and are uncomfortable with a lack of data.



# Consequences

- Increasing use of problem-based learning to motivate students and enhance skills
- Need to be aware on distracting influence of context
- Need to support students in identifying aims of a problem and in handling lack of data



*“fun, got to decide which route to take to solve problem”*

*“explore range of answers and knowledge of chemistry”*

*“better to have questions in context!”*

*“had to use brain in a better way”*

*“enjoyed whole experience, exercised mind”*





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