The Quality of an Educational System cannot Exceed the Quality of its Teachers

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Overview of Presentation

- Background
- Focus of Study
- Research Questions
- Methodology
- Results
- Key Findings
- Conclusions
- Implications and Future Work

Background

Irish Education System

- Producing students with average reading and scientific literacy (Perkins *et al*., 2011).
- Producing students with below average mathematical skills (Perkins *et al*., 2011).
- Those entering third-level education often lack critical thinking and independent learning skills (Department of Education & Skills, 2010).
- Misconceptions about basic chemistry concepts are widespread among Junior & Leaving Certificate students (Sheehan, 2010).

School Systems

- The quality of an educational system cannot exceed the quality of its teachers (Barber & Mourshed, 2007).
- Raising the calibre of pre-service and in-service teachers is a successful strategy for improving educational systems like Ireland's (Mourshed *et al.*, 2010).

Subject Matter Knowledge

- The presence of misconceptions in the subject matter knowledge of teachers has been found to affect their
  - lesson plans, and
  - ability to detect and correct misconceptions amongst students.

- They can also lead to teachers
  - reinforcing misconceptions,
  - incorrectly criticising student answers, and
  - accepting faulty lab results.

(Abell, 2007; Hashweh, 1987)

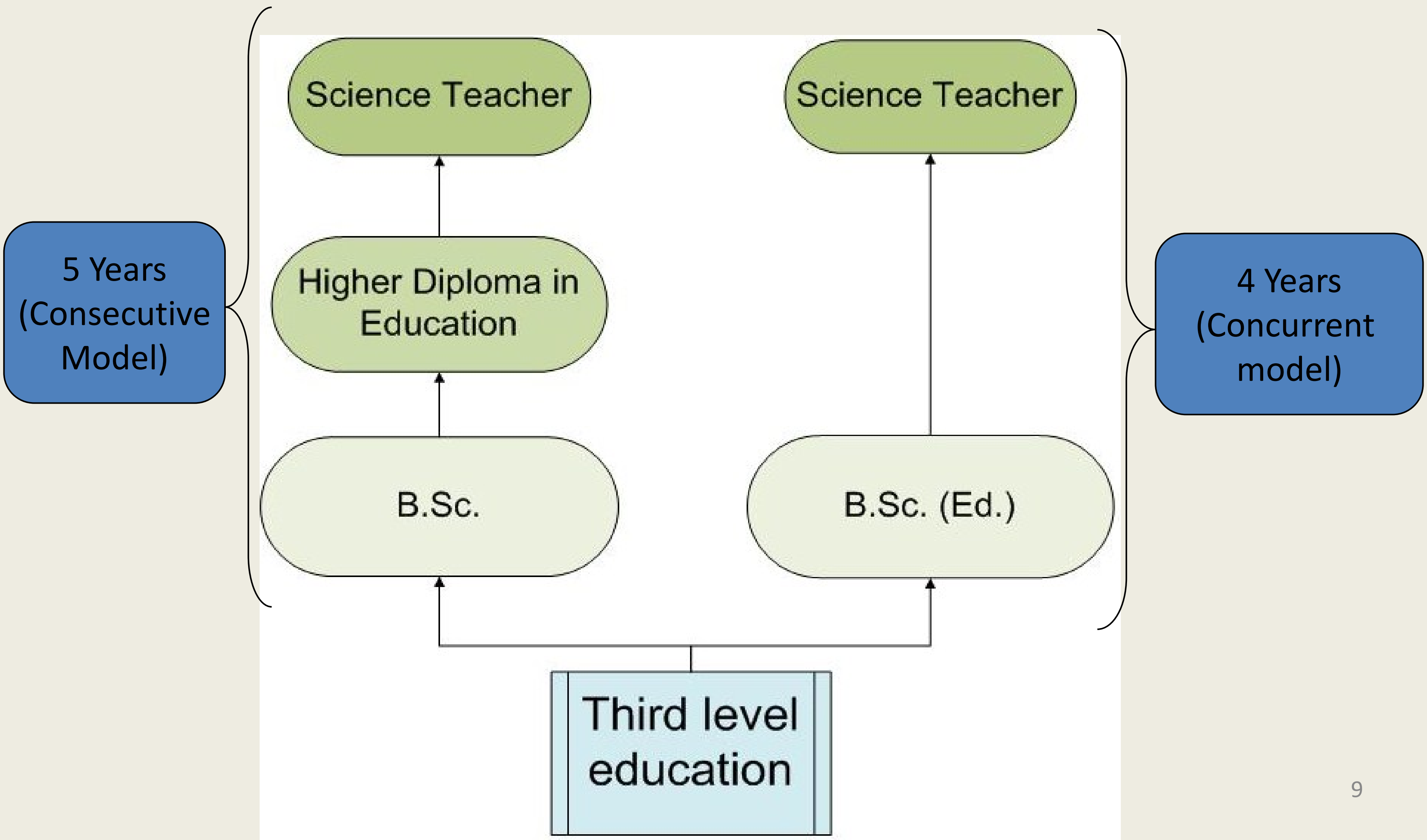
Focus of Study

- To gain insight into the chemistry subject matter knowledge of pre-service science teachers in Ireland by investigating the prevalence of misconceptions among this group.

Research Questions

- What **number and type of misconceptions in chemistry** are held by Irish pre-service teachers?
- Does the **number of years of science and science pedagogy study** have an effect on the number or type of misconceptions?
- Is there a link between the number of misconceptions and **gender, age or previous school experience**?
- Does **mode of entry to teaching** (concurrent or consecutive) have an effect on the number or type of misconceptions?

Modes of Entry to The Teaching Profession in Ireland



Methodology

Overview of Study

Phase 1

- Development of Instrument
- **<u>Pilot Study</u>**
- Revision of Diagnostic Instrument
- Administration of Instrument in Institution across Ireland
- Analysis of Results

Phase 2

- Design of Intervention Programme for Pre-service Science Teachers
- Design of Programme for In-service Teachers

Phase 3

- Implementation & Evaluation of Intervention Programme
- Revision of Related Materials

Phase 1

Misconceptions categorised	• Leaving Certificate chemistry syllabus was used as a framework.
Questions selected	• Suitable questions identified from the literature or developed by the authors.
Piloting of Instrument	• 212 pre-service science teachers across 4 years of a concurrent course. (Response Rate 77%)
Revision of the instrument	• Based on the results of the pilot study and interviews with participants.
Institutions recruited	• Course directors and science pedagogy lecturers contacted
Administration of instrument	• 467 pre-service science teachers in concurrent and consecutive courses across Ireland
Analysis of results	• Statistical Package for Social Sciences (SPSS v19)

Sample Group

- 467 pre-service science teachers (PSSTs) were involved in the study.
- They were spread across consecutive (144 PSSTs) and concurrent models of teacher training (323 PSSTs).
- There were 10 institutions involved, 2 of which were in Northern Ireland.
- 31% had a chemistry specialism, 66% had a biology specialism and 17% had a specialism in physics.

Diagnostic Instrument (20 Questions)

Concept Area	No. Qns	Concept(s) being tested	Source of Question
Particulate Nature of Matter	4	Microscopic nature of atoms, elements, compounds and mixtures	Mulford & Robinson (2002); Adapted from Sanger (2000)
	1	Conservation of Matter	Adapted from Mulford & Robinson (2002)
	1	Understanding of phase change	Yezierski & Birk (2006)
	2	Meaningful conversions from symbolic to microscopic	Author developed; Nurrenbern & Pickering (1987)
Stoichiometry & the Mole Concept	4	The mole as a counting unit, using the mole concept in stoichiometry and understanding of molar volumes	Gower *et al.* (1977); Developed by author
Chemical Bonding	5	Process and energetics of bonding, effect of bond type and structure of Ionic Compounds	Peterson & Treagust (1989); adapted from Mulford & Robinson (2002); Author developed; Adapted from Jensen (unpublished)

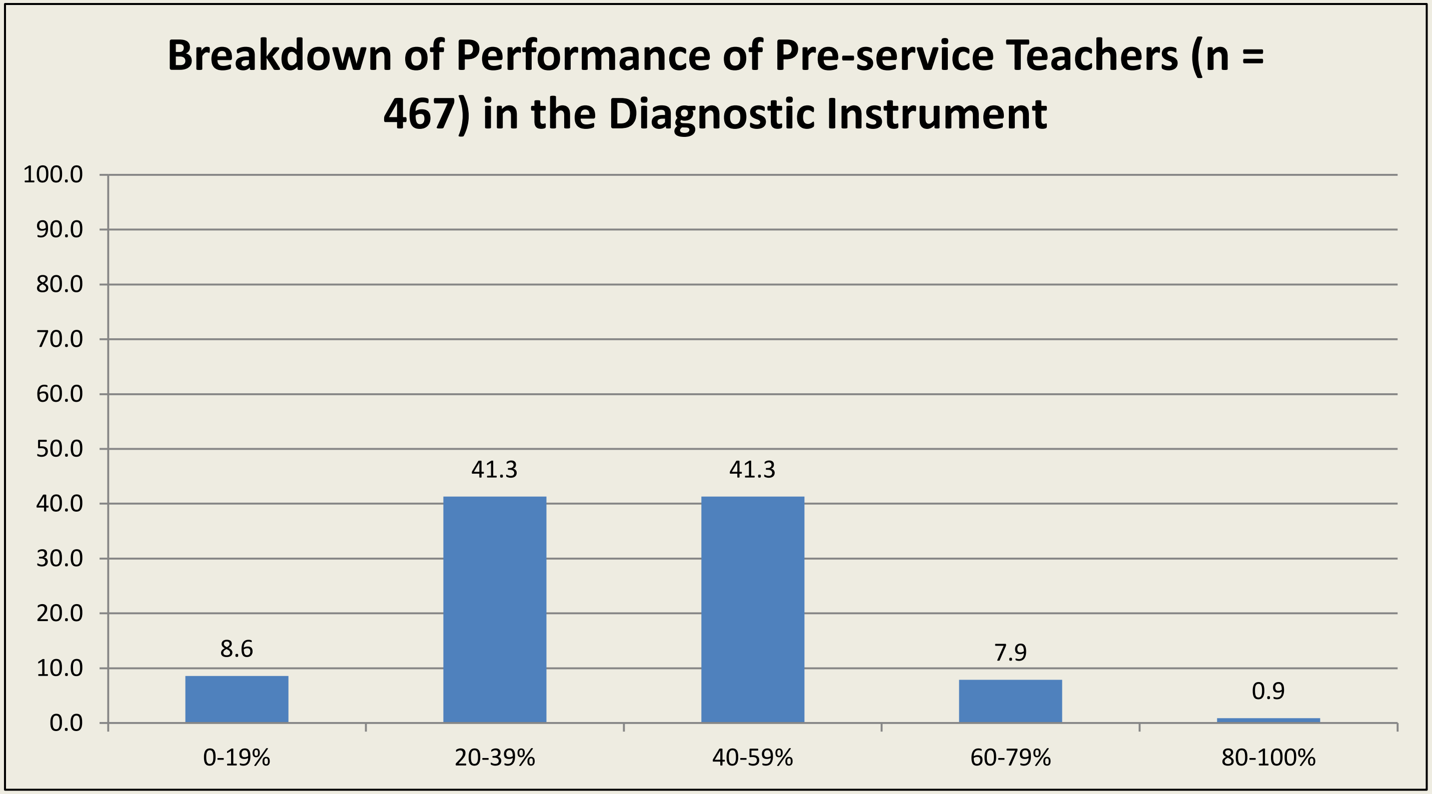
Results

Pilot Study

- Over 80% of the 212 PSSTs involved in the pilot study achieved less than 40% in the instrument (M=30.8%).
- All areas of the diagnostic instrument were poorly understood.
- Particulate Nature of Matter was the most poorly understood area (M=28.2%).
- Those with Higher Level Leaving Certificate chemistry achieved significantly higher scores in the instrument.
- A number of factors had a significant impact on performance:
  - gender,
  - age, and
  - specialism.
- There was no significant difference associated with year of study.

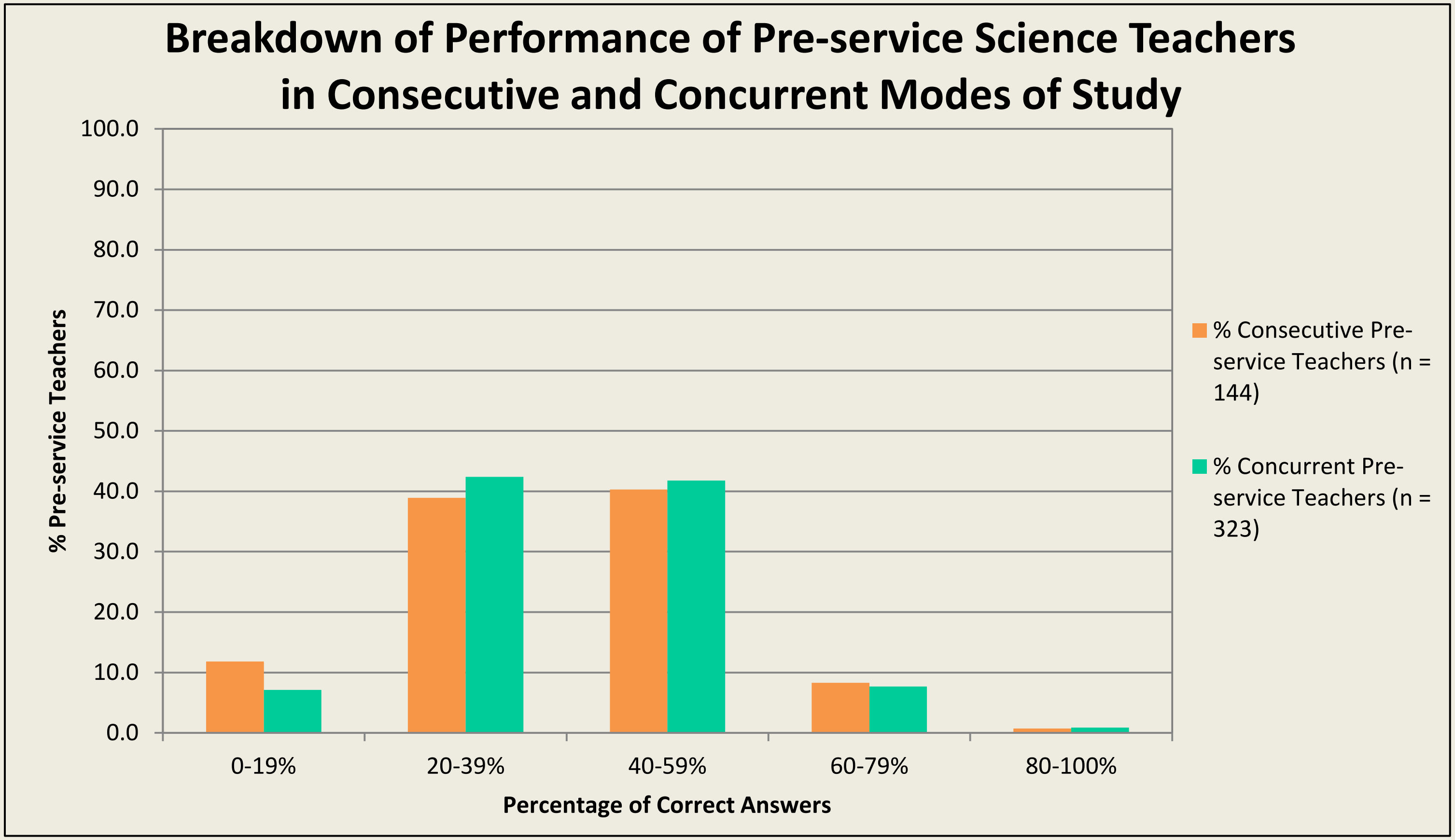
Results of Wide-scale Study

Overall Performance in Diagnostic Instrument



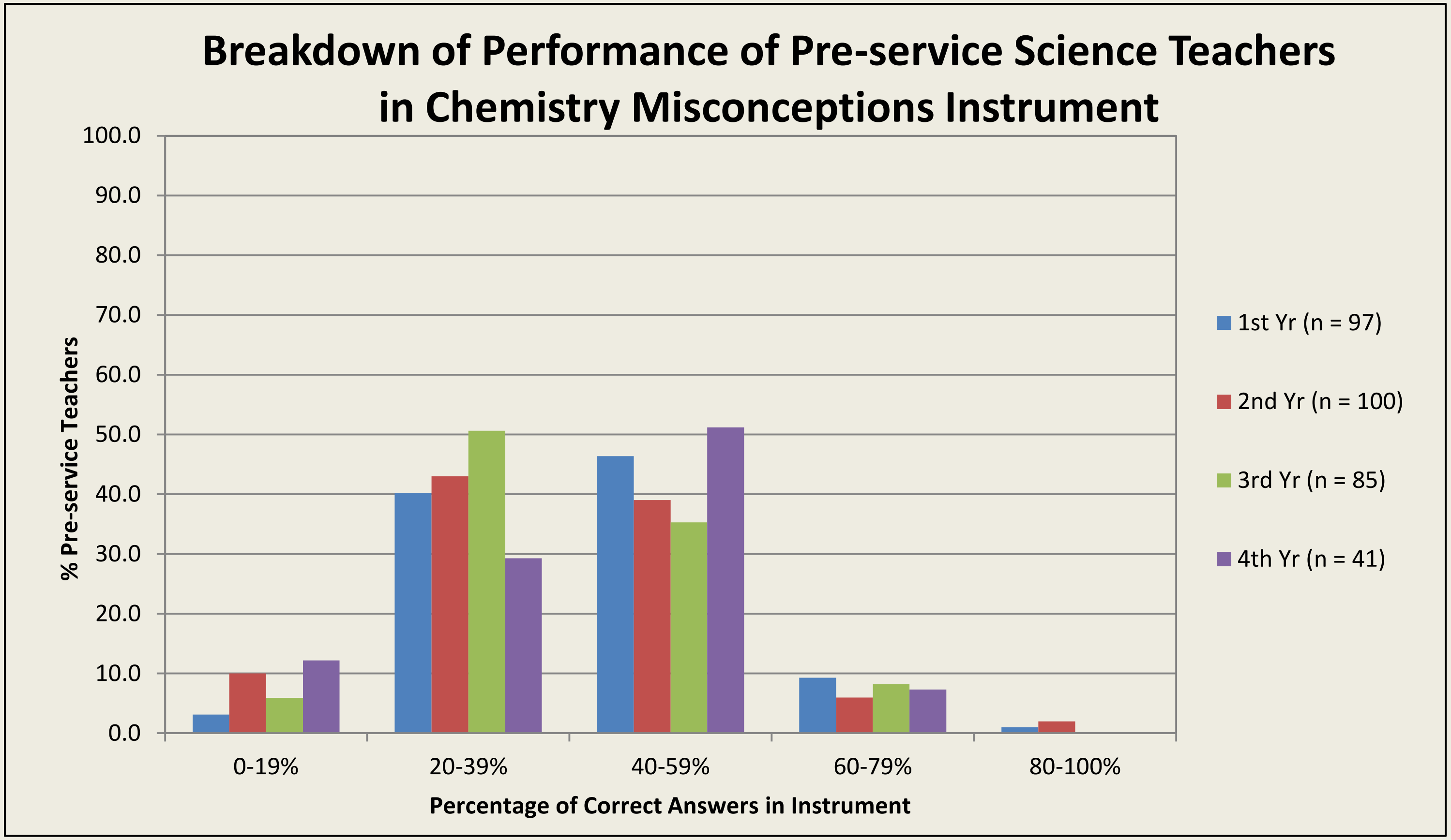
- 50% of those involved in the study achieved less than 40% in the instrument.
- A further 14% achieved exactly 40%.

Performance in Instrument: Mode of Entry



- No significant difference between modes of entry to the teaching profession and pre-service teachers overall performance on the instrument.

Performance in Instrument: Year of Study (n = 323)



- No significant difference between concurrent pre-service teachers in each year of study

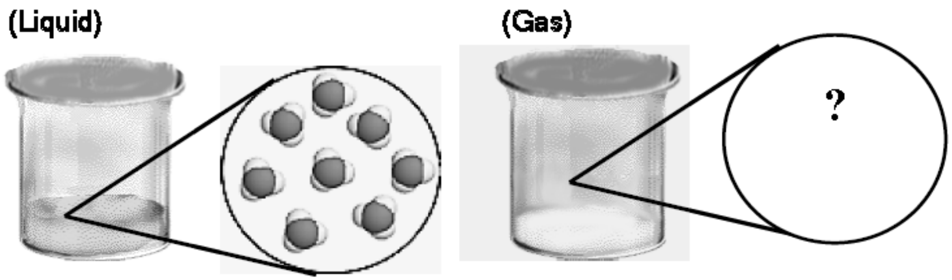
Breakdown of Scores in each Conceptual Area for all PSSTs (n = 467)

Concept Area	Mean Percentage	% Not Attempting Section
Particulate Nature of Matter	44.4%	0
Stoichiometry & Mole	40.4%	0.9
Chemical Bonding	36.4%	0.4
Equilibrium	17.6%	3.2
Overall Score	**37.4%**	**0**

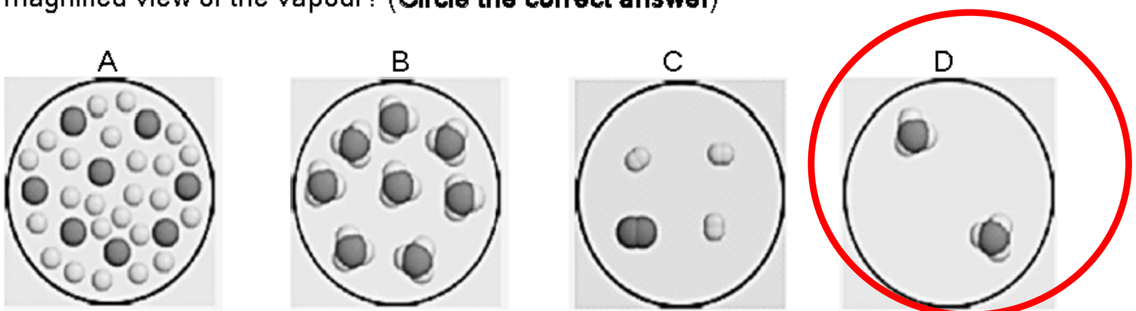
- All areas were poorly understood.
- Equilibrium was the most poorly understood conceptual area.

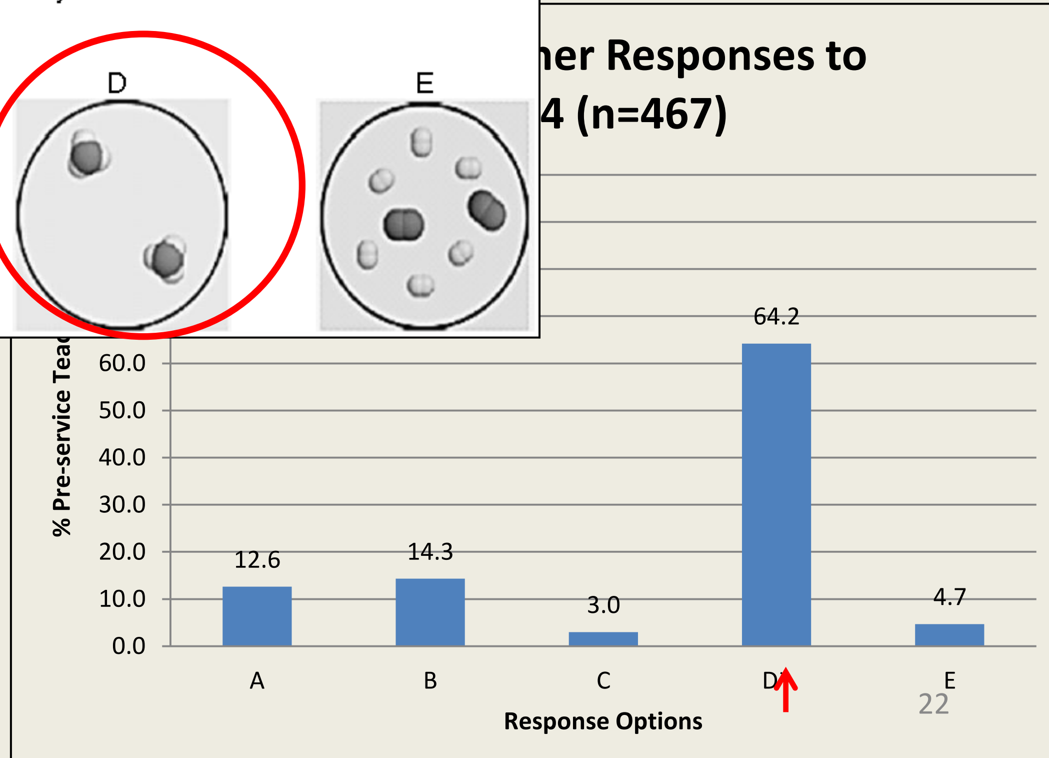
Phase Change

4. A sample of liquid ammonia (NH_3) is **completely evaporated** (changed to a gas) in a closed container as shown:



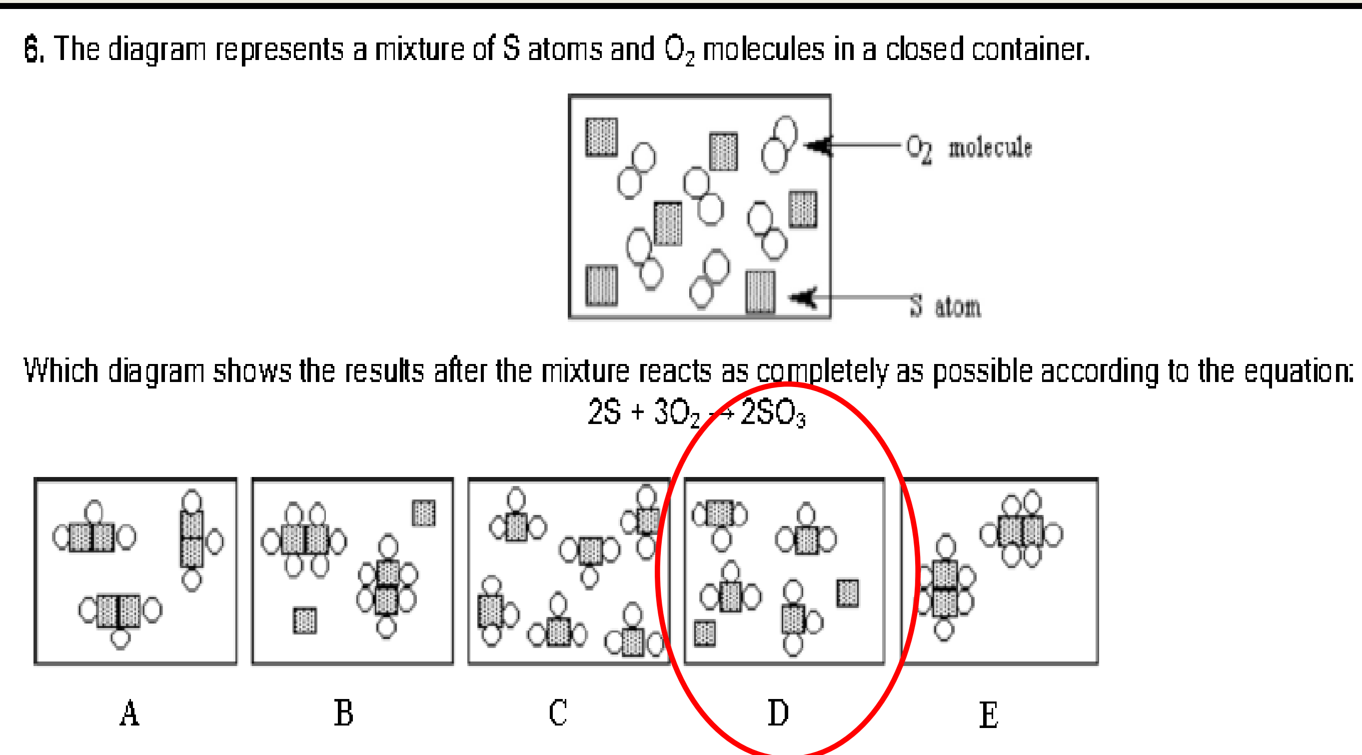
Which of the following diagrams A, B, C, D, or E best represents what you would 'see' in the same area of the magnified view of the vapour? (**Circle the correct answer**)





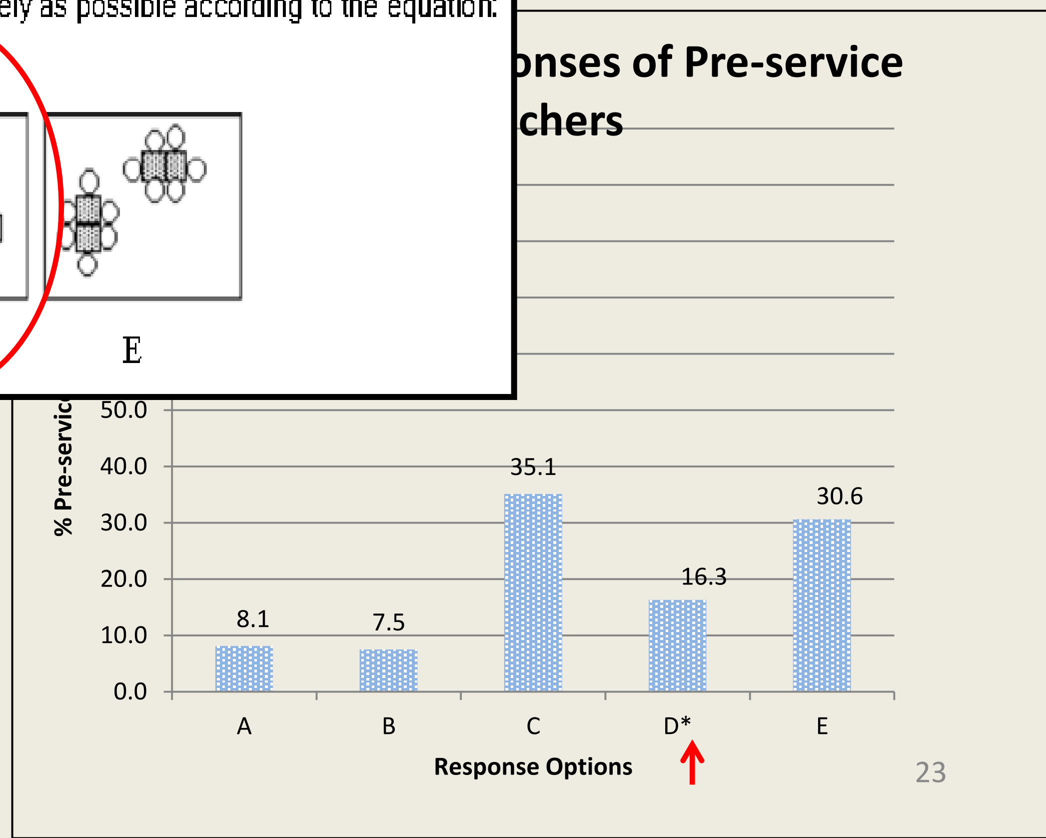
- 20.3% selected responses which indicate that bonds break on boiling.

Chemical Formulae


6. The diagram represents a mixture of S atoms and O_2 molecules in a closed container.

Which diagram shows the results after the mixture reacts as completely as possible according to the equation:

$$2S + 3O_2 \rightarrow 2SO_3$$



- 46.2% are confusing subscripts and coefficients.
- 73.8% are failing to conserve atoms.

Energetics of Bonding

13. Hydrogen burns in air according to the equation:

$$2H_2 + O_2 \rightarrow 2H_2O$$

Which of the following is mainly responsible for releasing energy? (**Circle the correct answer**)

A) Breaking hydrogen-hydrogen bonds.

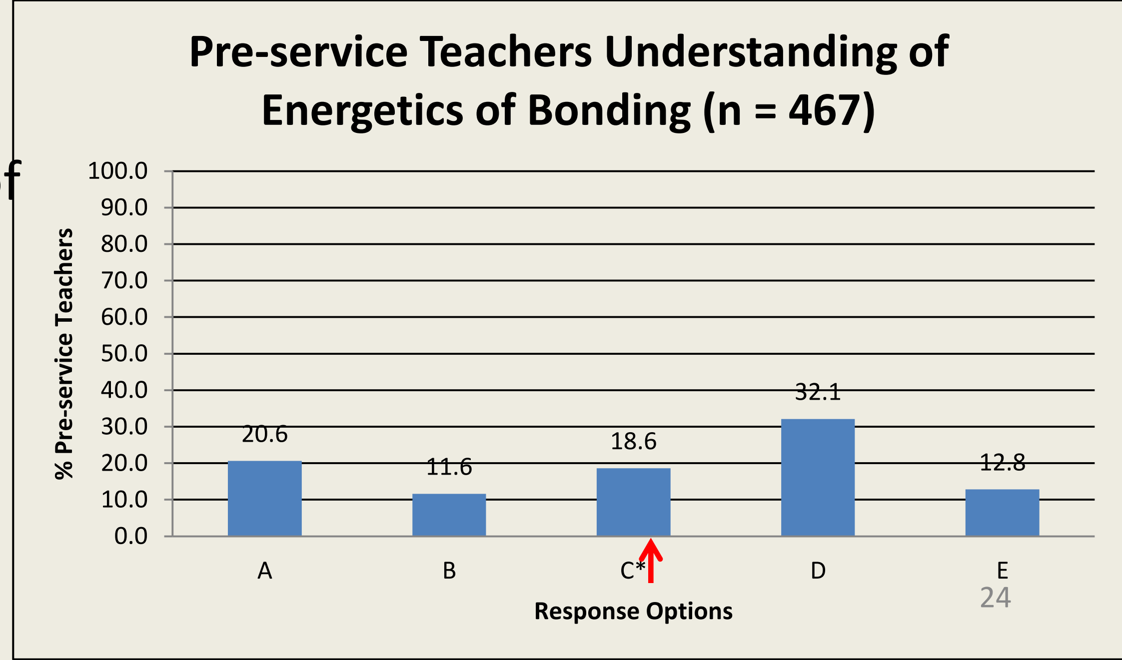
B) Breaking oxygen-oxygen bonds.

C) Forming hydrogen-oxygen bonds.

D) Both (A) and (B) are responsible

E) (A), (B) and (C) are responsible.

- 64.3% selected answers indicating that the breaking of bonds releases energy.



Relationships of Significance

Relationship being Tested	Significance (✓ means $p<0.05$)	Meaning
Specialism & Overall Score	✓	Those with a chemistry specialism (M=40.9%) did significantly better overall, while those with a biology specialism achieved significantly lower scores (M=35.5%).
Leaving Certificate Chemistry Level or A level Chemistry & Overall Score	✓	Those with higher level chemistry for the Leaving Certificate (M=41.2%) or A level chemistry (M=46.2%) achieved higher scores than those that did not study chemistry.
Mode of Entry to Teaching Profession	✗	No significant difference in overall score was associated with entry through either the consecutive or concurrent models of teacher education.
Year of Study & Overall Score	✗	Those in their fourth year of study achieved the same scores as those in their first, second and third years of study

Conclusion

Key Findings

- Chemistry misconceptions are widespread among Irish pre-service science teachers.
- Mode of entry to the teaching profession has no significant impact on the number of misconceptions.
- These misconceptions are not reduced or altered significantly over the course of a four-year concurrent programme.
- PSSTs chosen specialism and their previous second-level chemistry experience were found to have significant impact on the number of misconceptions.
- Limitations include:
  - semi-longitudinal nature of study, and
  - the lack of homogeneity e.g. entry standards.

Conclusions

- Science teacher education programmes appear to have little effect on the chemistry misconceptions of pre-service science teachers.

- The programmes do not appear to produce pre-service teachers with sufficient subject matter knowledge to effectively address the misconceptions of their future students.

- Possible reasons for this include:
  - the manner in which university chemistry modules are taught,
  - how these chemistry modules are assessed,
  - lack of time to address these issues in science pedagogy modules, and
  - lack of integration between science courses and science pedagogy.

- This study highlights the need to address the chemistry misconceptions of pre-service science teachers early and often.

Implications & Future Work

- Why do the pre-service science teachers' chemistry misconceptions remain unchanged over the course of their studies?
  - textbooks, lecture style, cognitive level, science pedagogy
- What are **appropriate strategies & teaching materials** for reducing these misconceptions
  - for pre-service science teachers and
  - for in-service science teachers?

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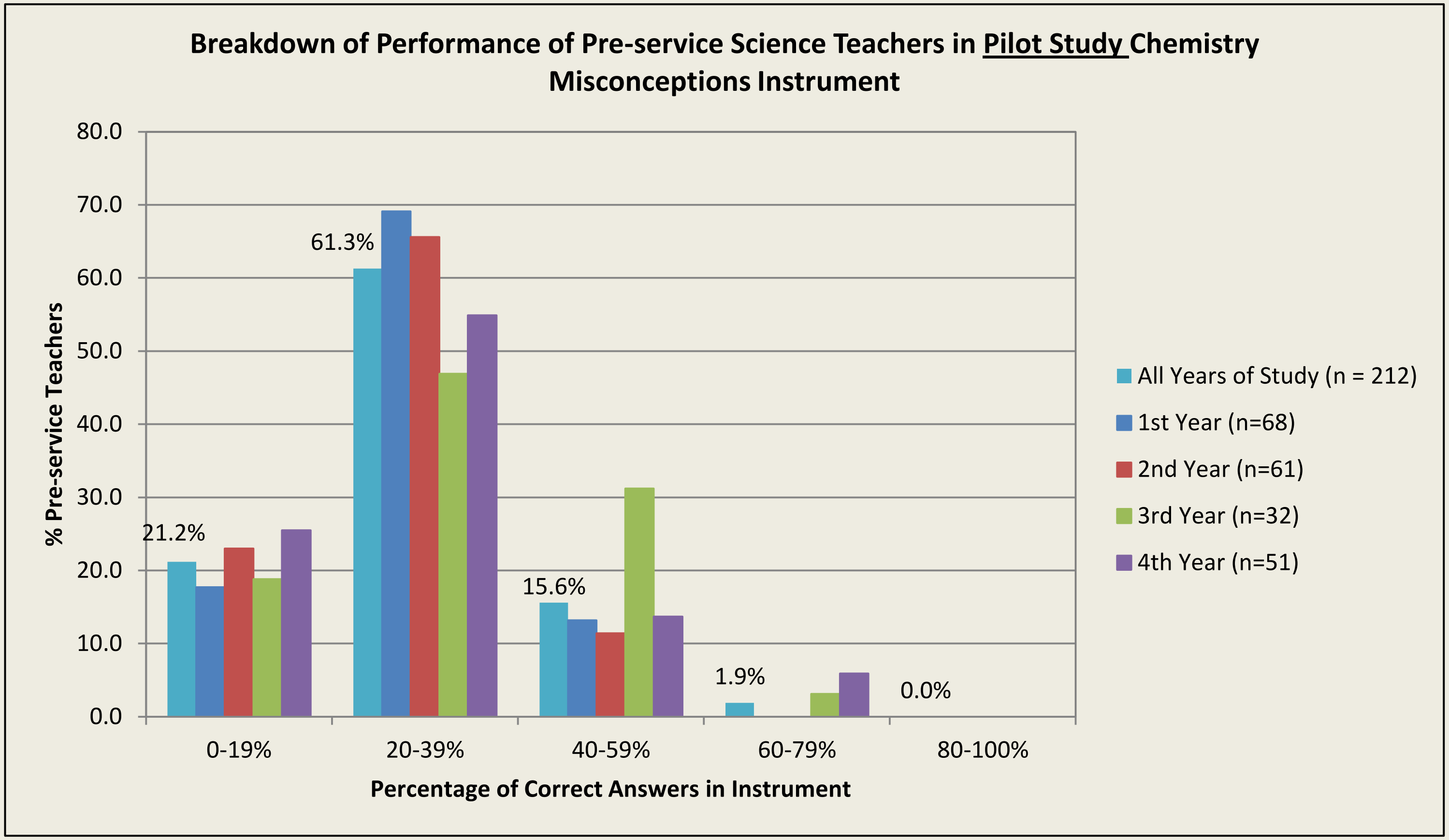
Appendix

Results



- Over 80% of those involved in the study achieved less than 40% on the instrument
- No significant difference between the pre-service teachers in each year of study

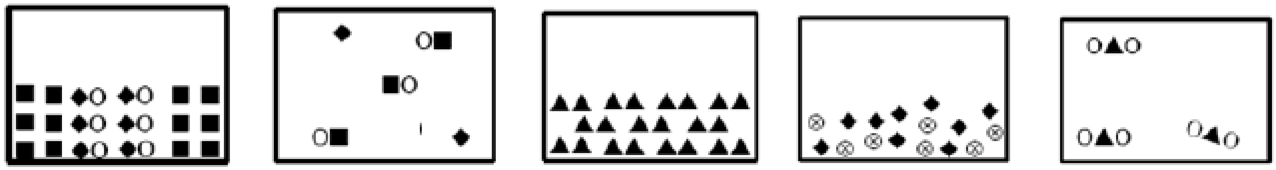
Results: Pilot Study

Concept Area	Mean Percentage	% Not Attempting Section
Particulate Nature of Matter	28.2%	0
Stoichiometry & Mole	43.0%	0.5
Chemical Bonding	32.7%	1.4
Equilibrium	31.1%	0.9
Total	30.8%	0

- All areas poorly understood
- PNM most poorly understood conceptual area

Wide-scale Study PNM Question

2. The following drawings contain representations of atoms and molecules. Classify each of these drawings (labelled A, B, C, D and E) according to the three characteristics listed below. You should classify all five drawings for each category.



A B C D E

Characteristic A: State of Matter

________________ solid

________________ liquid

________________ gas

Characteristic B: Physical composition of matter

________________ pure substance

________________ heterogeneous mixture

________________ homogeneous mixture

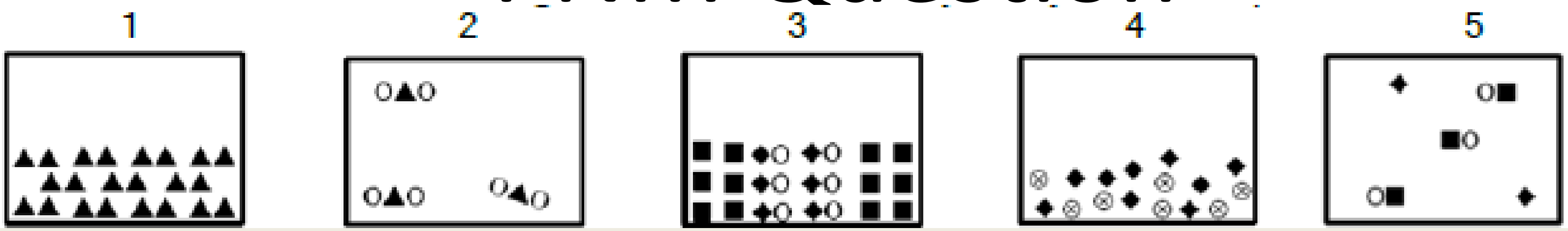
Characteristic C: Chemical composition of matter

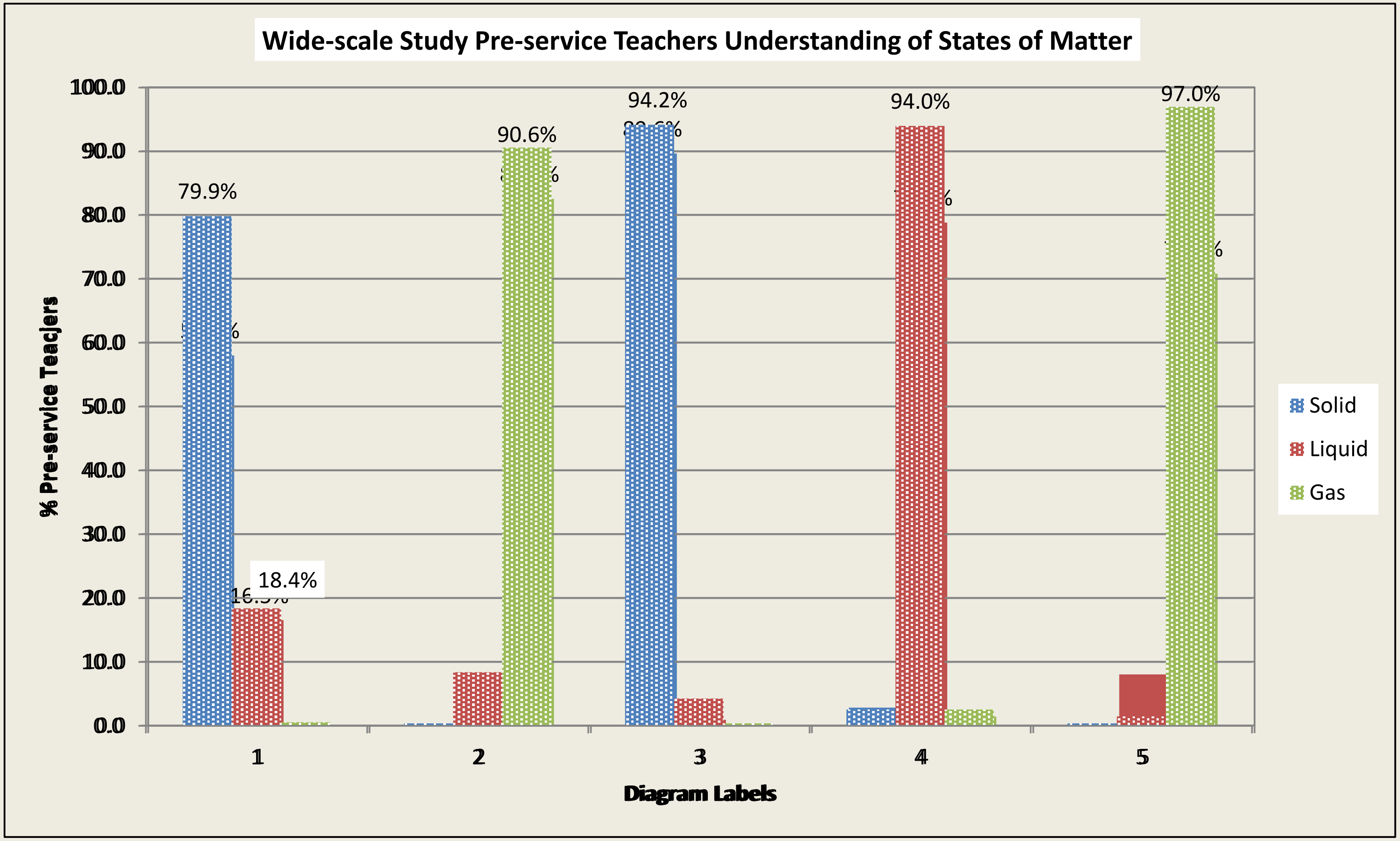
________________ elements

________________ compounds

________________ element and compound

PNM Question





PNM Question