

Overcoming the Chemistry Hurdle for First Year Bioscience Students

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Outline of Talk

- Introduction.
- Literature Review.
- Methodology.
- Results and Discussion.
- Limitations.
- Conclusions.





Introduction

- This study is a follow up of work done by Childs and Hayes (2009) on the development of an Intervention Programme for 'low achieving' chemistry students in The University of Limerick (Phase 1).
- Based on the success of Phase 1, an Expanded Intervention Programme Phase 2 was developed for three groups of students identified as low achievers.
- Phase 2 ran over two semesters, starting in first year (Part 1) and continuing into second year (Part 2).



Setting the Scene (1)

- Chemistry is an important foundation subject for Bioscience students.
- However many of the students do not have an adequate grounding in the basics of Chemistry for studying it in higher education.
- There is a similar problem in Ireland, students without an adequate background in Chemistry are often left behind.

Setting the Scene (2)

- The last ten years has seen a huge expansion in the numbers entering higher education in Ireland, with over 60% entering third level education in 2009 (Forfás, 2009).
- This expansion leads to the problem of a very diverse group of students in higher education. (Childs & Sheehan 2009).
- Also, science courses at third level have significantly high rates of non-completion (22.2%). (Flanagan & Morgan 2004).
- Unless these weaker students are supported and given the time and help they need, they are at risk of non-completion of their third level studies.



The Irish Context (1)

- Irish Second Level Education consists of two cycles: The Junior Cycle (3 years) and The Senior Cycle (2 years).
- The Leaving Certificate Examination is the final examination in the Irish Second Level School System.
- A minimum of six subjects are studied and examined, and can be studied at higher and ordinary level.
- Five science subjects are offered: Agricultural Science, Biology, Chemistry, Physics and Physics & Chemistry.

The Irish Context (2)

- Low uptake of the physical sciences at Senior Cycle (12-14 % for Physics and Chemistry).
- Over 50% of the cohort opt to take Biology at Leaving Certificate level (Childs, 2010).
- Each pupil receives points depending on their grade in each subject.
- The score from pupil's six best examination subjects are used for entry into higher education courses.



A Course of Treatment

- An Intervention Programme was designed to meet the needs of the students.
- The design of this programme is based on the use of a diagnostic tool to identify students' chemical misconceptions and to then use this to combat these misconceptions (Berg 2005).
- The programme involved a blended learning approach; a combination of face-to-face teaching and learning, as well as online resources and also elements of formative assessment.

Research Questions

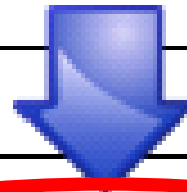
- The Intervention Programme was guided by the following research questions:
 1. Can diagnostic tests that identify students' prior chemical knowledge and misconceptions be used to design an effective Intervention Programme?
 2. Does this targeted Intervention Programme improve students' performance in the post-test?
 3. Does this Intervention Programme improve students' performance in their concurrent Chemistry module?

Methodology (1)

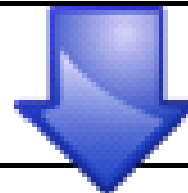
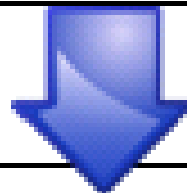
Phase 2

- Designed for **three groups** of students (Group A, Group B & Group C), identified as 'low achieving' students.
- Began in the **second semester** of their **first year of study** (2009-10), **running over two semesters** (Part 1 and Part 2).
- **Ten week programme** of tutorials covering basic chemistry concepts, in each semester.
- **ICT resources** were made available to students.
- Student **worksheets** were given to participating students which they completed during weekly tutorials.

Phase 1
(Regan *et al.*
2011)

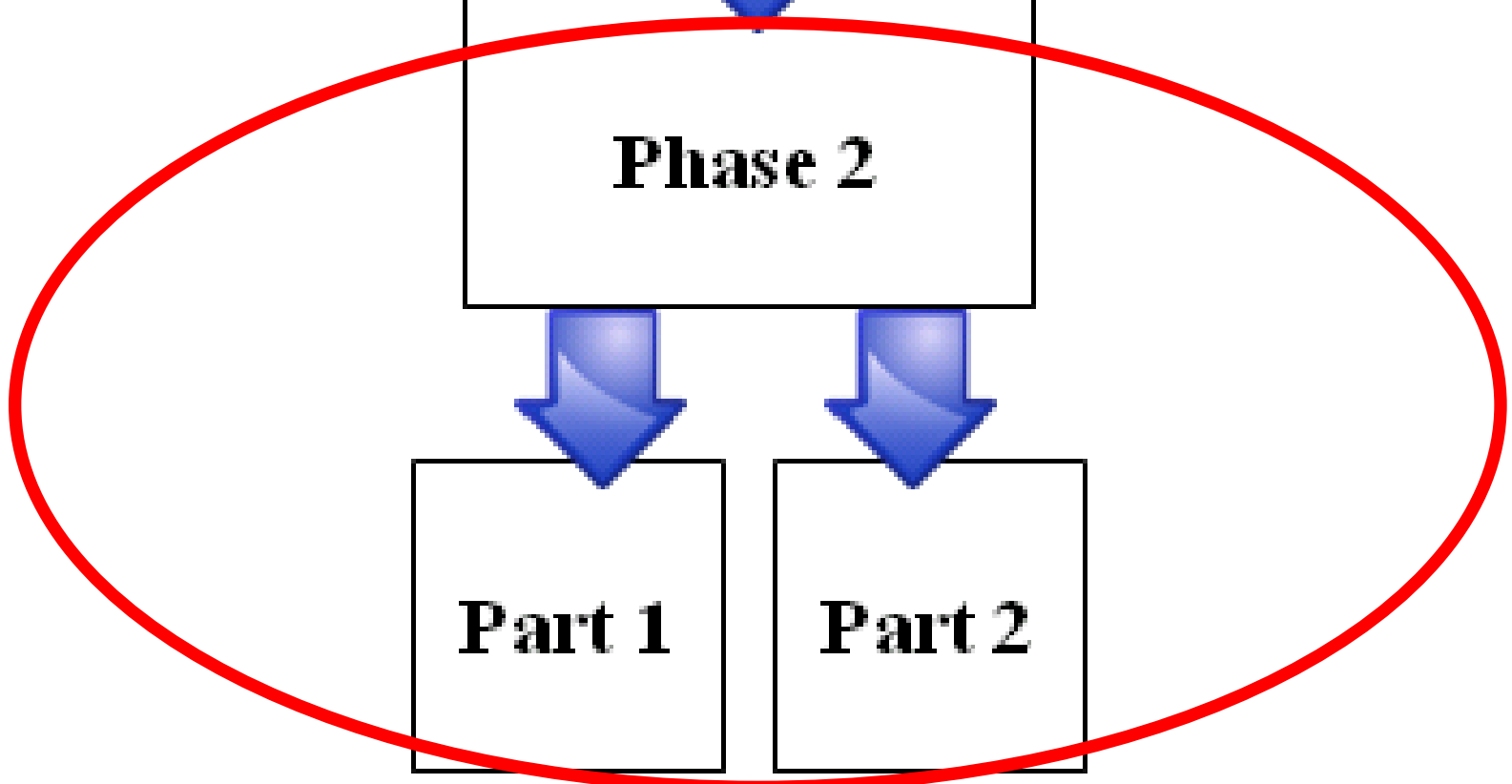


Phase 2



Part 1

Part 2



Methodology (2)

The three groups of students who were chosen to participate in the Intervention Programme had been identified as low achievers due to the following reasons:

- Little or no chemistry studied at second level.
- Academic background is weak (measured by CAO Points).
- An increase in the number of non-standard students.
- Poor performance of these groups in past third level chemistry exams.
- High level of attrition.

Methodology (3)

- A pre-diagnostic test of chemical concepts and misconceptions was designed and administered in the first tutorial session.
- Results from the pre-diagnostic test were used to design the tutorials to suit the needs of all students.
- A post-diagnostic test was administered in the final tutorial session.
- Questions for these tests were taken from chemical concept inventories. (National Institute for Science Education 2008; *Journal of Chemical Education* 2008).
- For Part 2 a different diagnostic test was used, which focused on chemical calculations using the mole concept. Similarly, the results of the pre-test were used to design the science content of the programme.

Methodology (4)

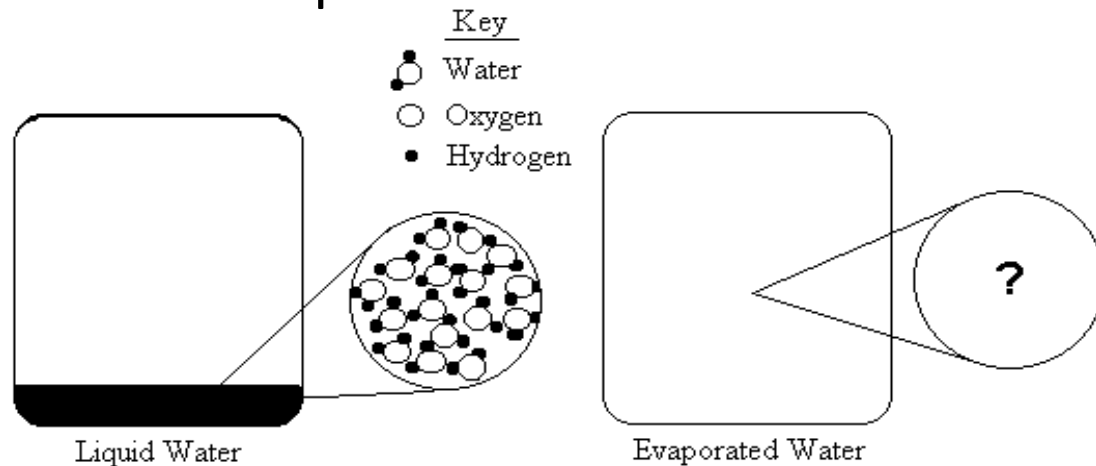
The Diagnostic Test – Part 1

- The diagnostic test contained a total of 15 questions, including multiple choice and free response questions.
- The test also collected information on the student's prior experience in chemistry and mathematics.

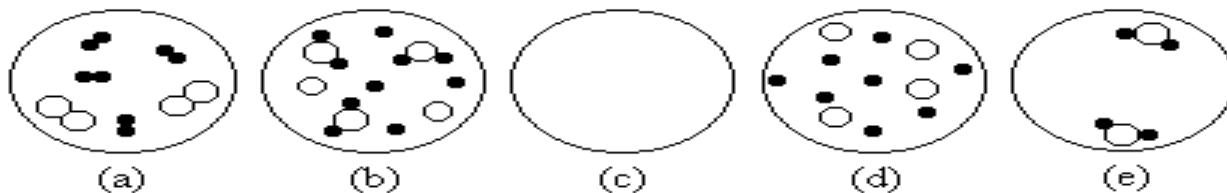
Concept	Questions	Source
Particulate Nature of Matter	4,5,7,8,10,15	Mulford and Robinson (2002); Sheehan (2010)
Atomic Structure	1,2,3,6,9	Mulford and Robinson (2002)
Chemical Reactions	11,13,14	Mulford and Robinson (2002); Sheehan (2010); Developed by the author
Reacting Masses and Stoichiometry	12	Developed by the author

Sample Diagnostic Test Question 15

The circle on the left shows a magnified view of a very small portion of liquid water in a closed container.



What would the magnified view show after the water evaporates?



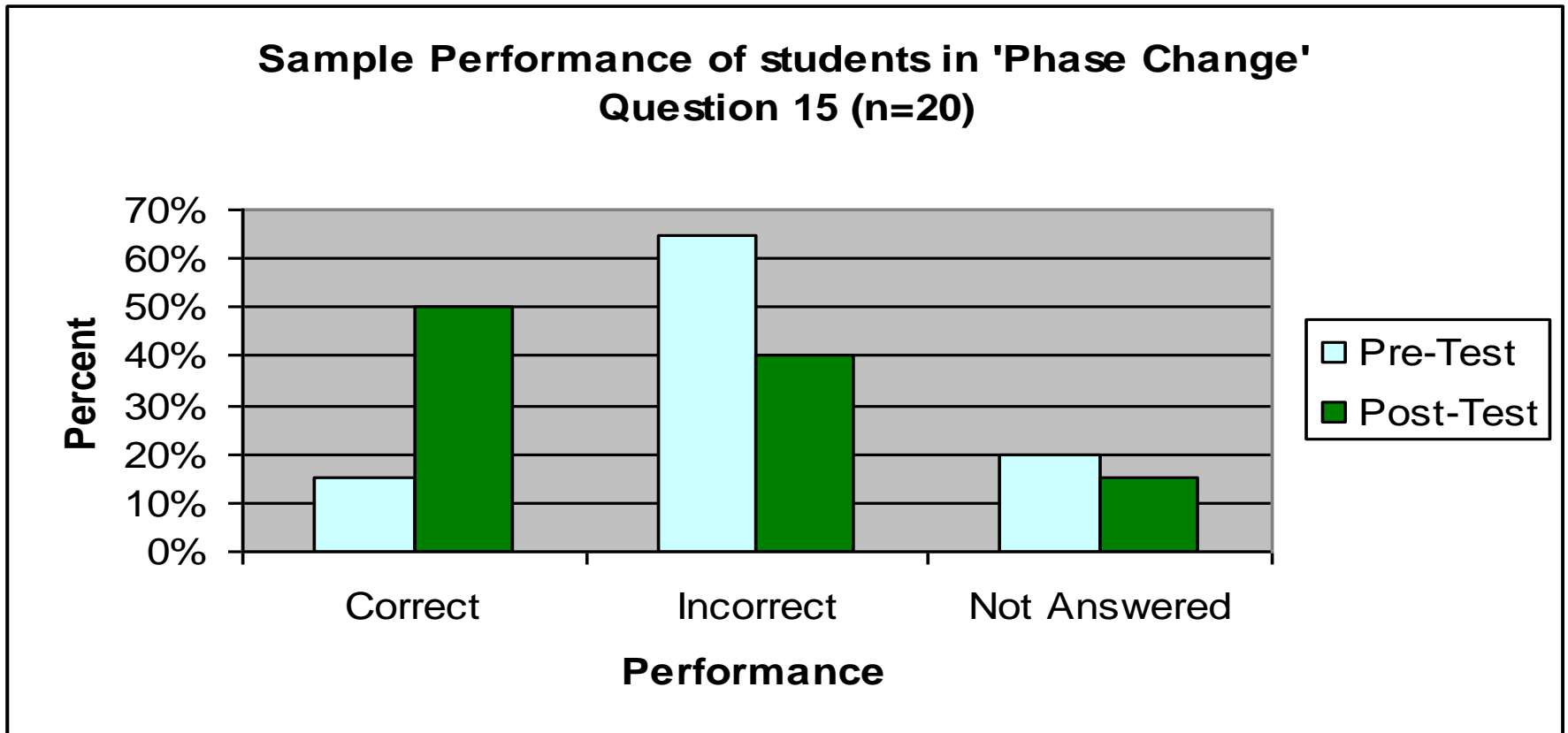


Results

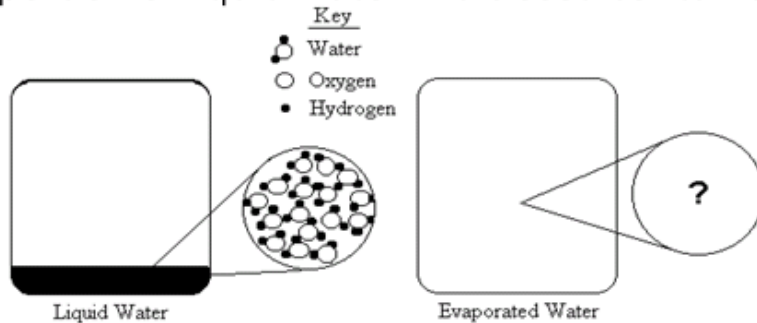
The results will be divided into two sections:

- a) Pre- and post-Diagnostic Results.
- b) Performance of students in the concurrent Chemistry module.

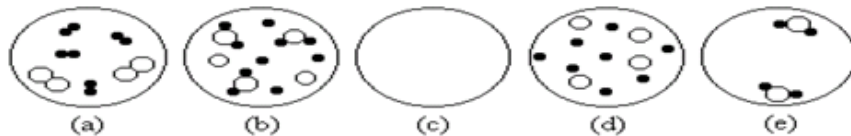
a) Sample Performance of Students in Test Question 15



The circle on the left shows a magnified view of a very small portion of liquid water in a closed container.



What would the magnified view show after the water evaporates?

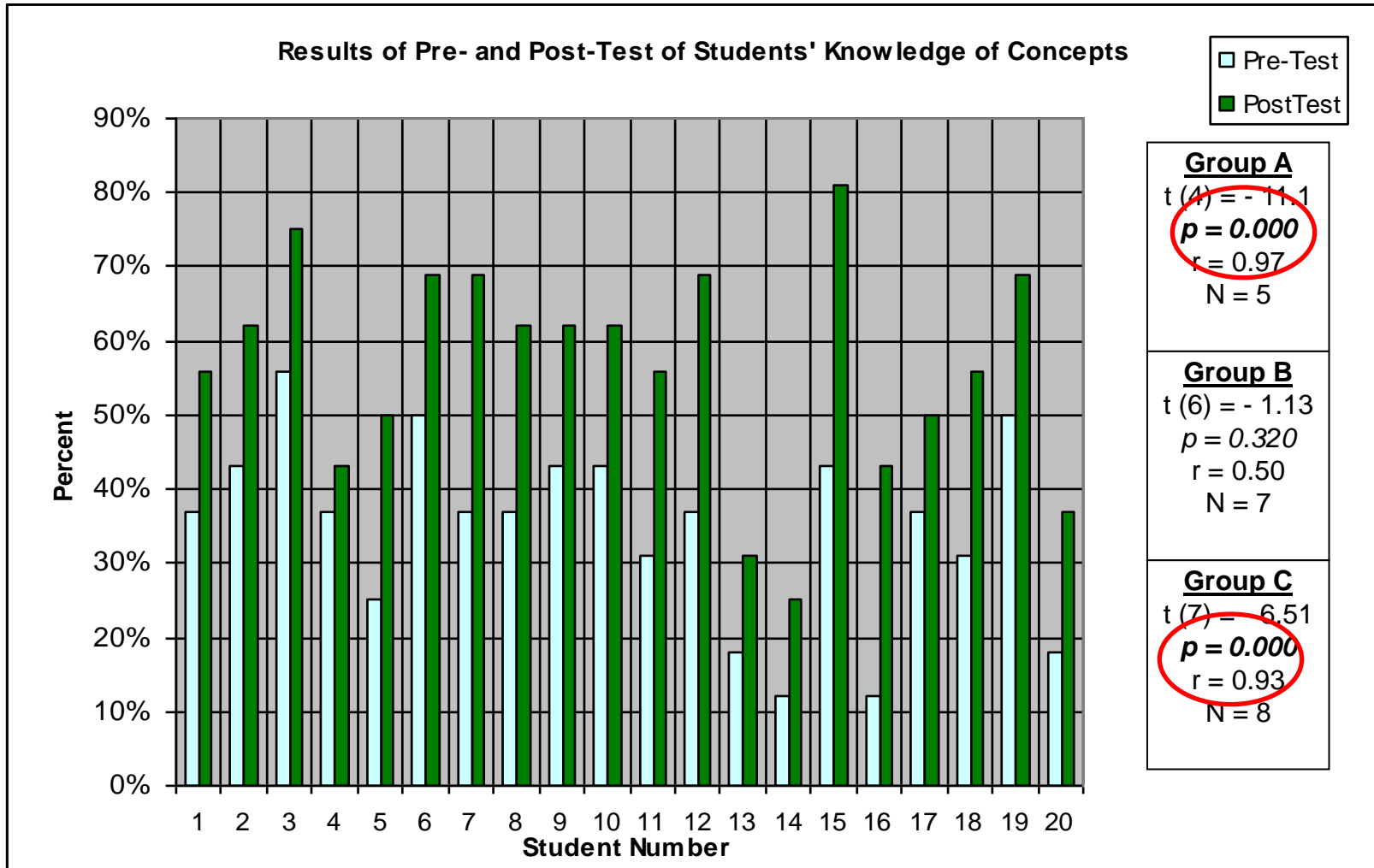


- Option D was the most popular choice.
- This indicates that students believe when water evaporates, the water molecules separate into hydrogen and oxygen atoms.

•15% of students got 'Phase Change' Question correct in the pre-test, this increased to 50% getting it correct in post-test.

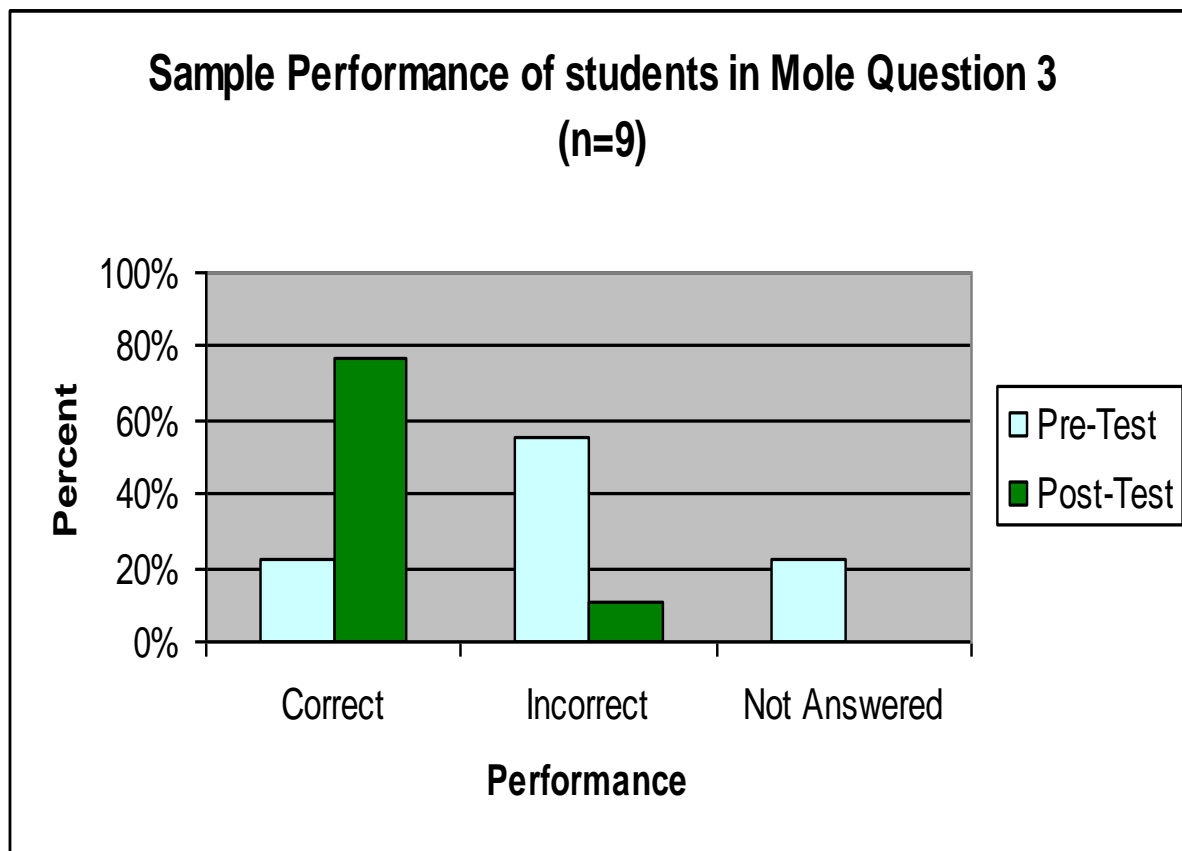
•However, 40% of students still got this question incorrect in the post-test showing that some students still held misconceptions. (10% did not answer)

Pre- and Post-Diagnostic Test



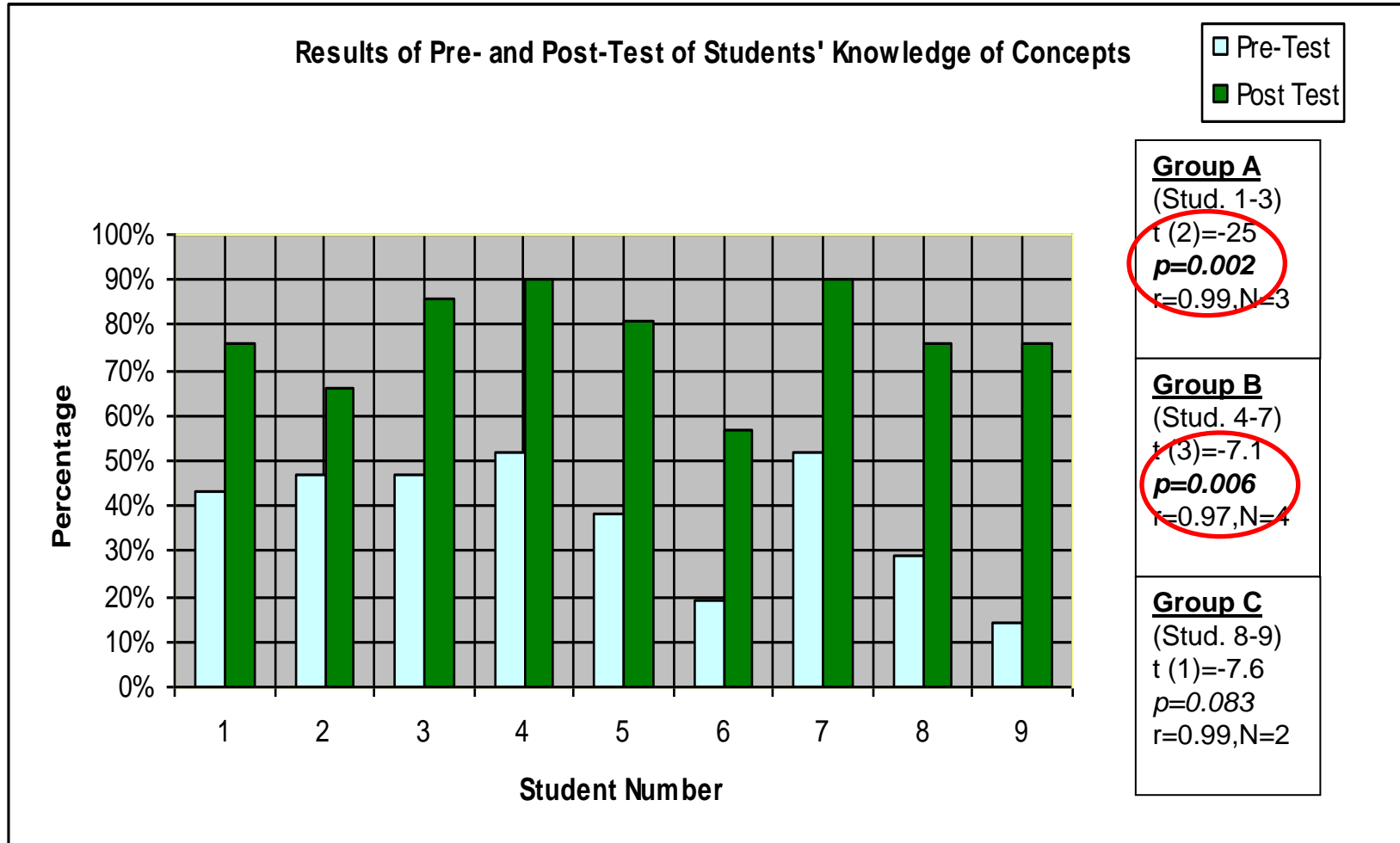
Sample Performance of Students in Test Question 3

How many moles of sulfuric acid,
 H_2SO_4 are there in a 10.0g sample?

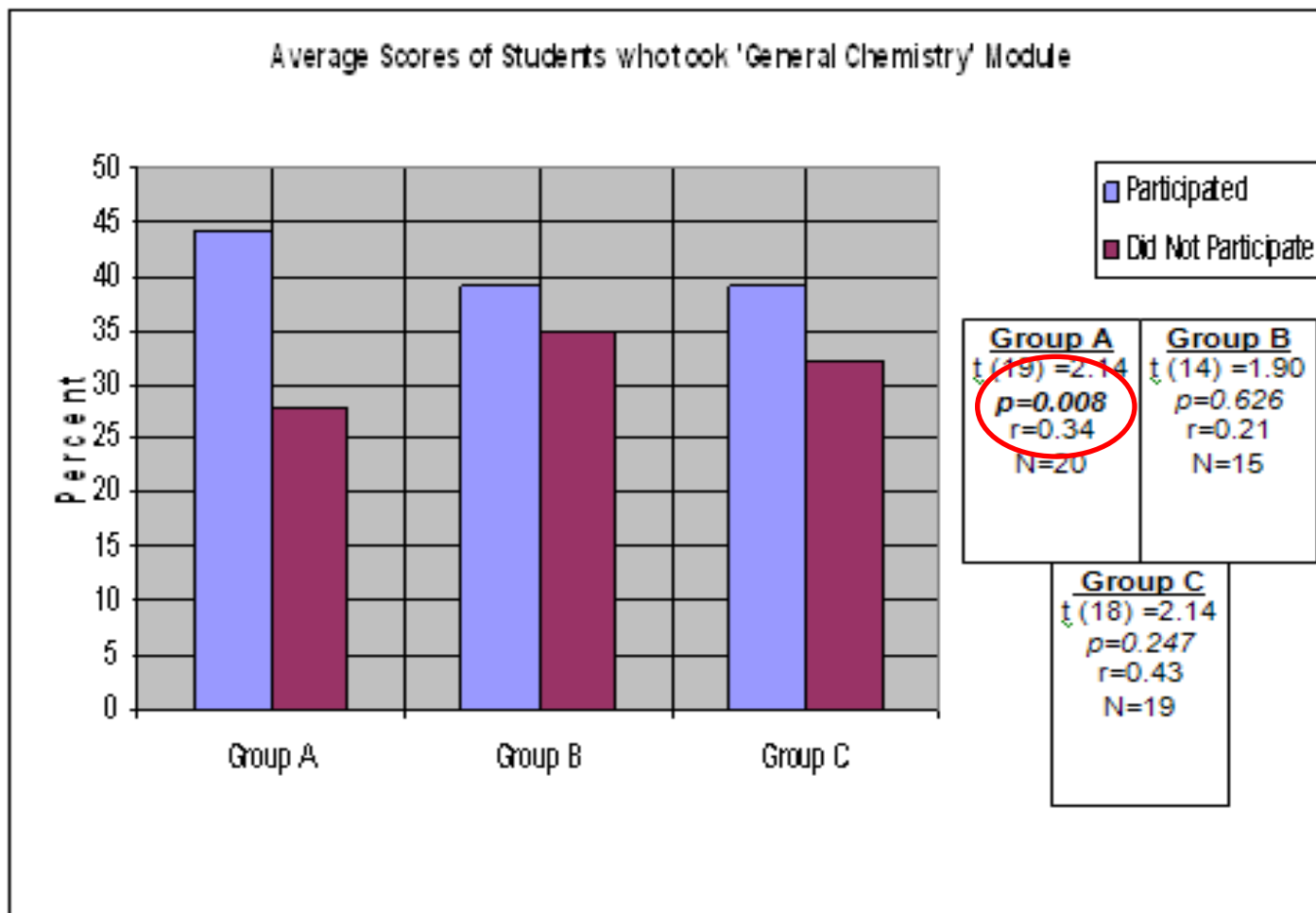


- 22% of students got question correct in the pre-test.
- This increased to 77% getting it correct in post-test.
- 11% of students still got this question incorrect in the post-test.
- All students attempted this question in the post-test.

Pre- and Post-Diagnostic Test



Performance of Students in Concurrent Module





Other Aspects of the study

- Student Interviews were carried out with 6 students at the end of the Intervention Programme.
- Students' attitudes and confidence levels in Chemistry were examined.
- Students' backgrounds in Mathematics were looked at.
- ICT based resources were made available to students.



Results from Student Interviews

The main themes that emerged from an analysis of the student interviews were:

- **Language of Chemistry**: Students found the language of chemistry difficult to understand.
- **Chemical Calculations**: The mathematical element to chemistry was difficult for students.
- **Use of algorithms**: The students mentioned their reliance on formulas when carrying out calculations.
- **Pace of the lectures**: Students found the pace of lectures too fast and were overloaded by the amount of material covered.
- **Formative assessment**: Students found the formative assessment used during tutorials to be worthwhile as it gave them immediate feedback and increased their confidence.



Limitations

- This was an optional programme, which means that not all students who are at risk attended.
- Poor and inconsistent attendance at the tutorials affected the results.
- Many students who attended some of the ten week programme could not be assessed as they did not attend both pre- and post-test sessions.
- Improvements noticed may be due to the self-selected nature of the sample.

Conclusions

- The results of this intervention programme are positive.
- All students improved between the pre- and post-test in both Part 1 and Part 2 of the Intervention Programme.
- The examination results of students who participated in the Intervention Programme are slightly better than those who did not participate in the programme.
- The Intervention Programme has demonstrated the value of using diagnostic testing and tailoring tutorials to help 'at risk' students.
- More details on Phase 1 can be found at:
Regan, A., Childs, P. E. and Hayes, S. (2011) 'The use of an Intervention Programme to improve undergraduate students' chemical knowledge and misconceptions', *Chemical Education Research and Practice*, 12, 219-227.



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