



A Study of Students' Abilities in Transferring Mathematical Knowledge to Chemistry

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Summary

- Background
- Research questions
- Methods: diagnostic tools
- Results and data analysis
- Conclusions and further work



Background

- PhD project on teaching and learning of mathematics for/by chemistry students.
- What kind of mathematical knowledge, skills, ways of thinking do chemistry students need?
- Is there evidence that a particular style of curriculum (e.g. teaching in context, RME, traditional,...) better facilitates student learning?

Research Questions

- Investigate whether or not students can transfer their mathematical knowledge from mathematics to chemistry. (Students = 2nd year chemistry students who have completed 'Calculus 101' in 1st year.)
- Does **proficiency** in mathematics in the mathematics context correlate with proficiency in mathematics in a chemical context?
- Does **confidence** with mathematics in the mathematics context correlate with proficiency with mathematics in a chemical context?
- [Does proficiency with mathematics at qualitatively different cognitive levels correlate with proficiency with mathematics in a chemical context?]

Diagnostic Tools

Kinetics Diagnostic Tool	
Mathematics Context	Chemistry Context
Calculating slopes of line	
Interpreting graphs: comparing slopes	
Differentiating simple functions	
Representing derivatives as slopes of tangents	
Multiplication of fractions	
Manipulation of indices	

Thermodynamics Diagnostic Tool

Mathematics Context

Chemistry Context

Evaluating a simple integral

Graphical representation of a simple definite integral

Sketching the graph of $1/x$

Evaluating the integral of $1/x$

Graphical representation of definite integral of $1/x$

Design of Diagnostic Tools

- Included a ***Certainty of Response Index (CRI)*** for each question (Bagayoko, Hasan and Kelly 1999)
- Function of the CRI:
 - Based on a six-point scale (0-5)
 - 0 implies lack of confidence (Total guess) with respect to answering a question
 - 5 implies complete confidence with respect to answering a question.
 - When used in conjunction with the answer to the question, it can enable one to differentiate between a lack of knowledge & a misconception.
- [Incorporated a Part (B) for each question, asking students to explain their reasoning to Part (A)]



[Design of Diagnostic Tools]

- [Where possible and relevant, for each particular mathematical concept, it was decided to have a **procedural question (rules for completing mathematical tasks)** & a **conceptual question (extension of mathematical tenets)** and likewise in the chemistry context (Engelbrecht, Harding and Potgieter 2005).]
- [Incorporated '**graphicacy**'-type & **visualisation** -type questions where possible as literature indicated that these can oftentimes be considered akin to higher order mathematical concepts (Briton et al. 2005) & (Gibson, 1998).]

Analysis of results:

transferring from mathematics to chemistry context

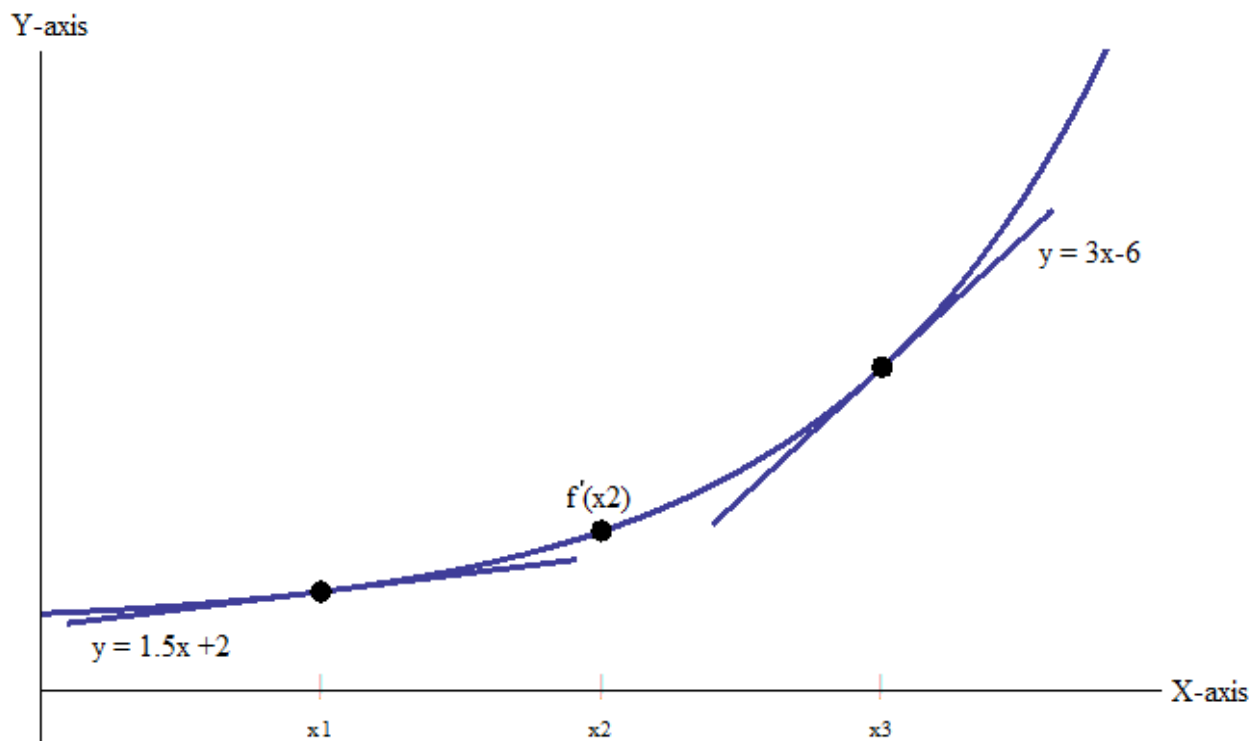
- Is there an association between correct/incorrect responses for linked mathematics/chemistry context questions?
- Is there an association between CRI values for linked questions?

Preliminary Results:

Kinetics Questionnaire:

Mathematics Context:

Q. Choose a value from the list of values given (A, B or C) for the derivative of the graph at the point x_2 .

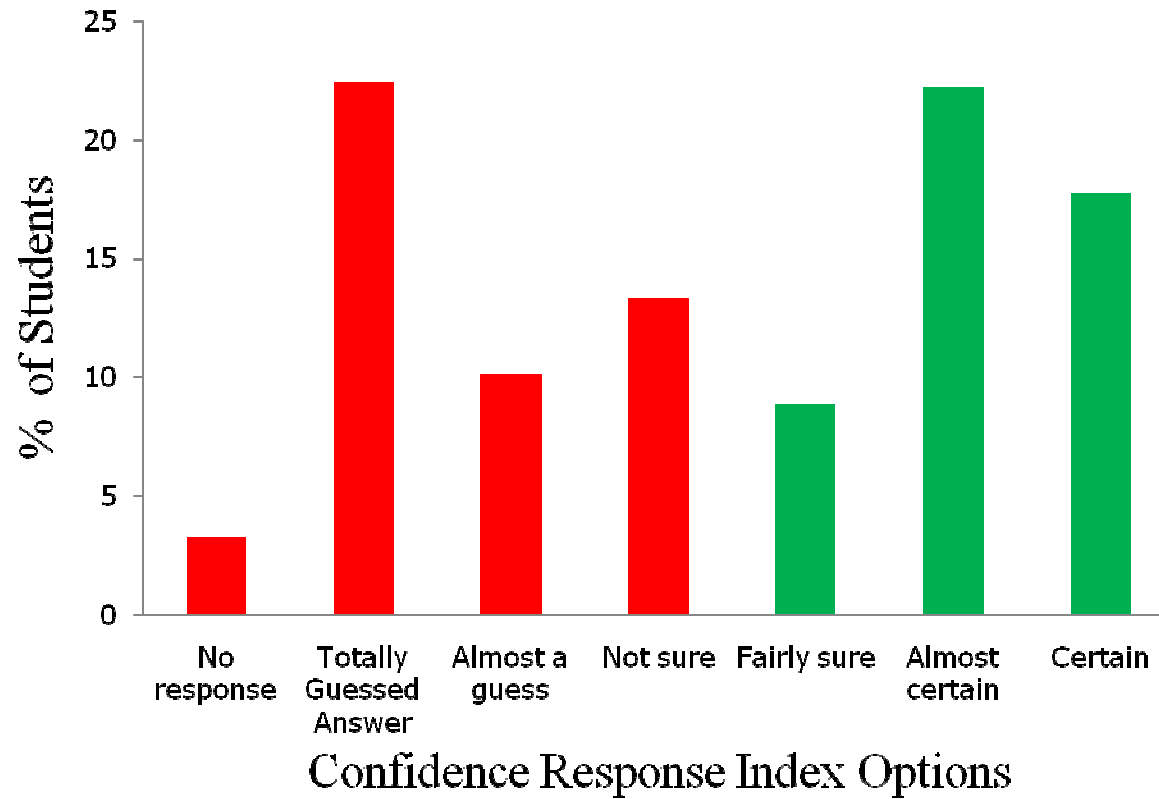


Correct	Incorrect
% of Students	% of Students
53.57	46.42

N= 84

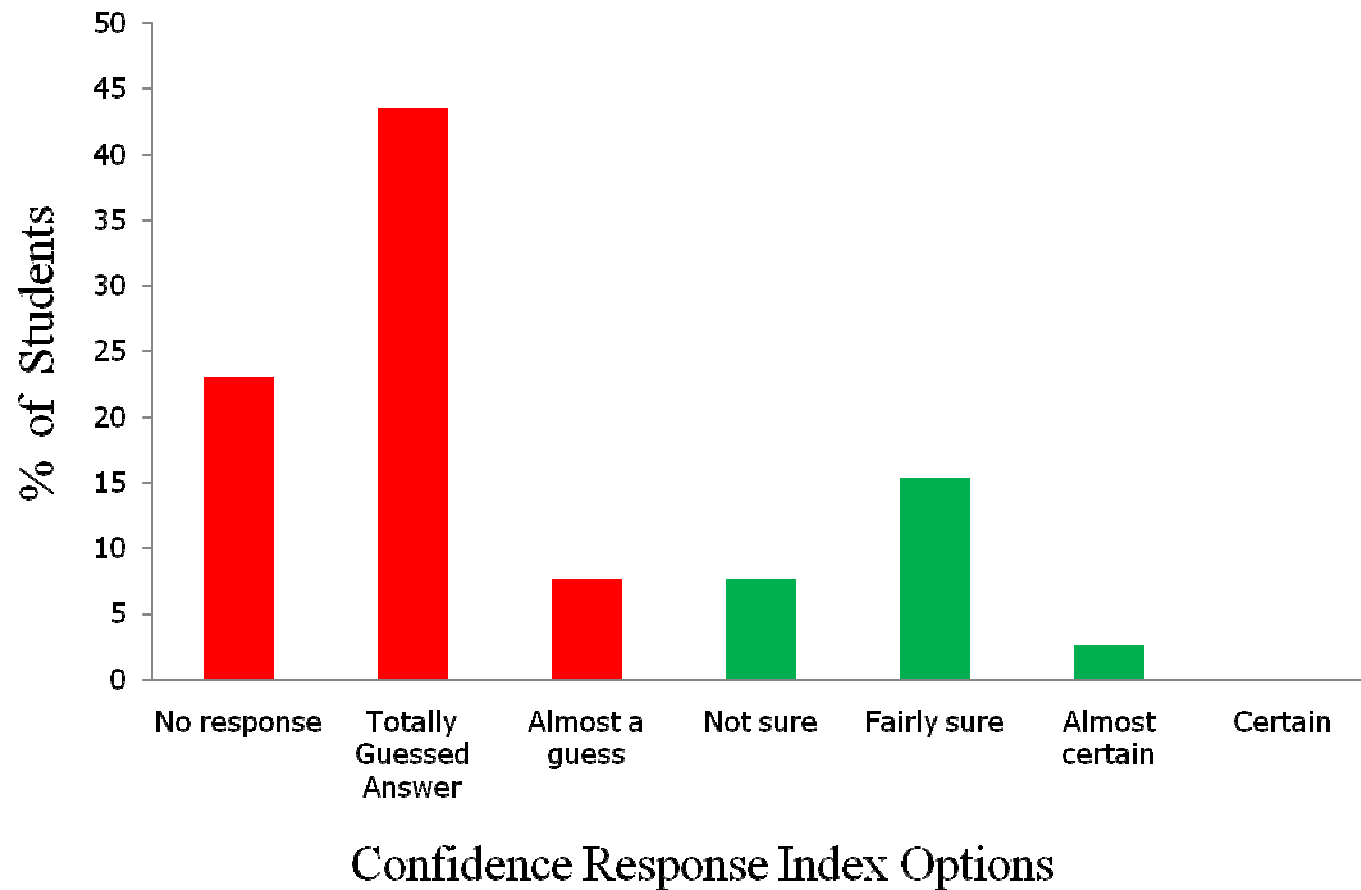


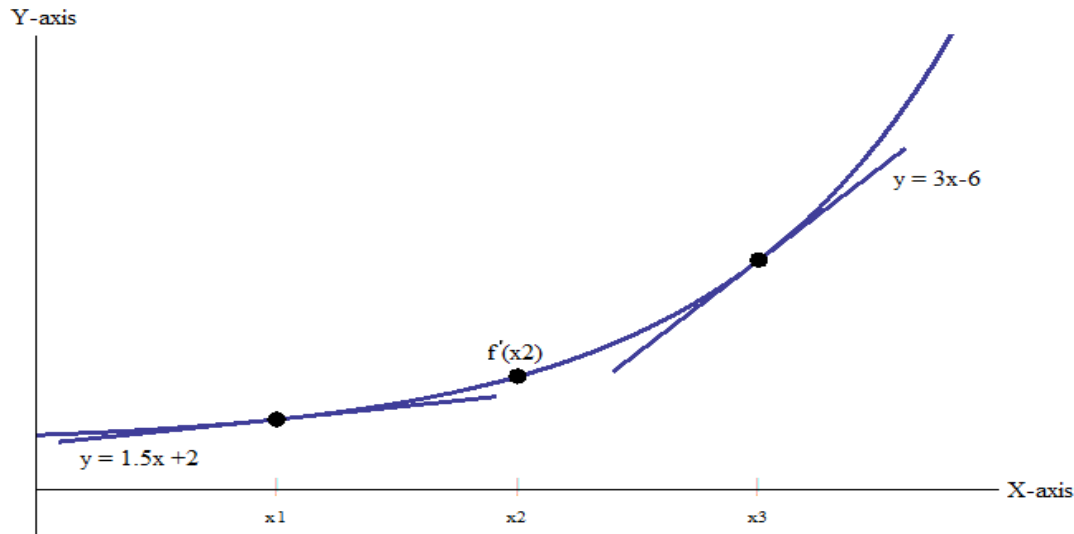
CRI for Students who Answered Q.5 Correctly





CRI for Students who Answered Q.5 Incorrectly





Correct	Incorrect
% of Students	% of Students
53.57	46.42

N= 84

Conclusions Drawn From Q.5 on The Whole:

N=84

Outcomes

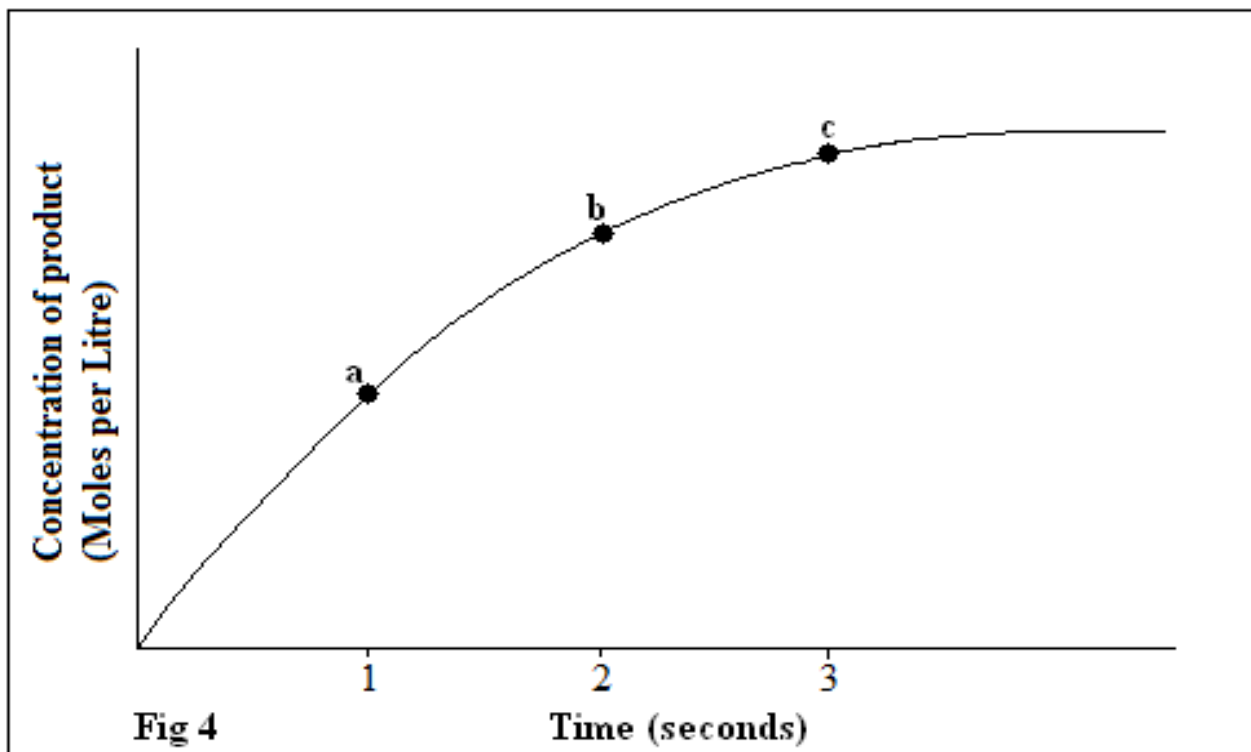
- Correct Answer and Low CRI; Implies a lack of knowledge
- Correct Answer and High CRI; Implies knowledge of correct concepts
- Wrong Answer and Low CRI; Implies a lack of knowledge
- Wrong Answer and High CRI; Implies misconceptions

% of Sample

- 27.38%
- 26.19%
- 38.09%
- 8.33%

Chemistry Context:

Q. Using the graph shown in Fig.4, rank the instantaneous rate of change of product after 1 second, 2 seconds and 3 seconds in order of increasing magnitude.

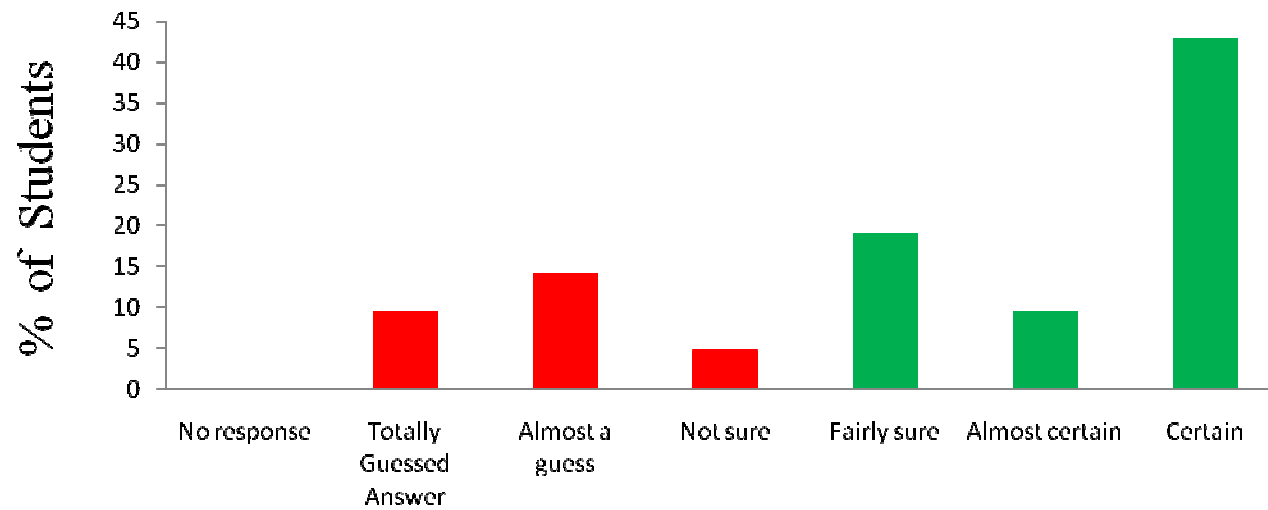


Correct	Incorrect
% of Students	% of Students
36.20	63.79

N= 58



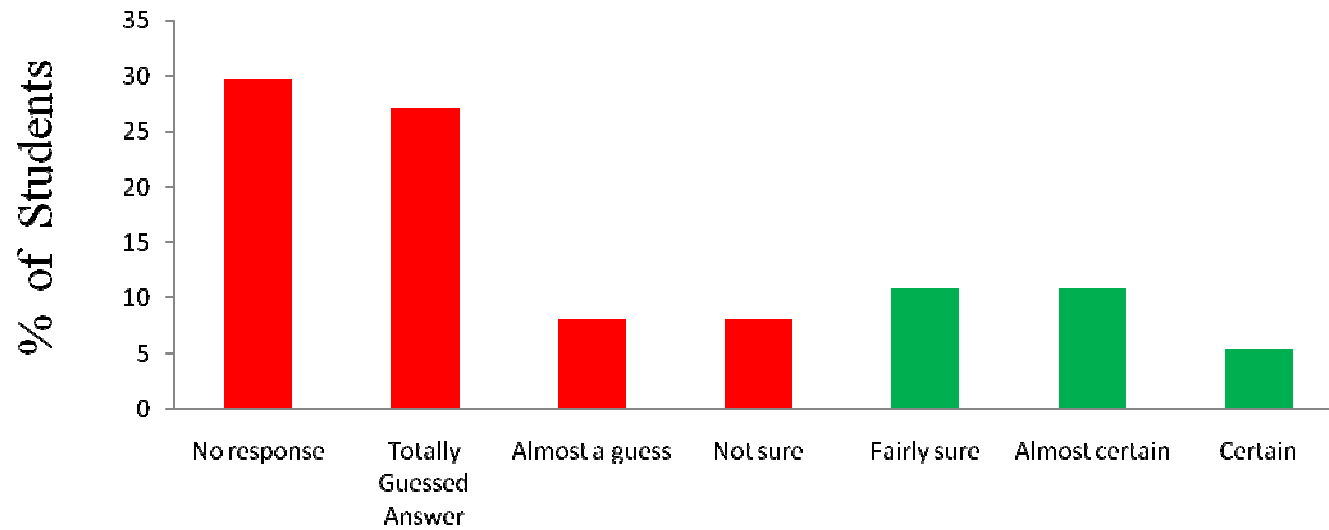
CRI for Students who Answered Q.4 Correctly



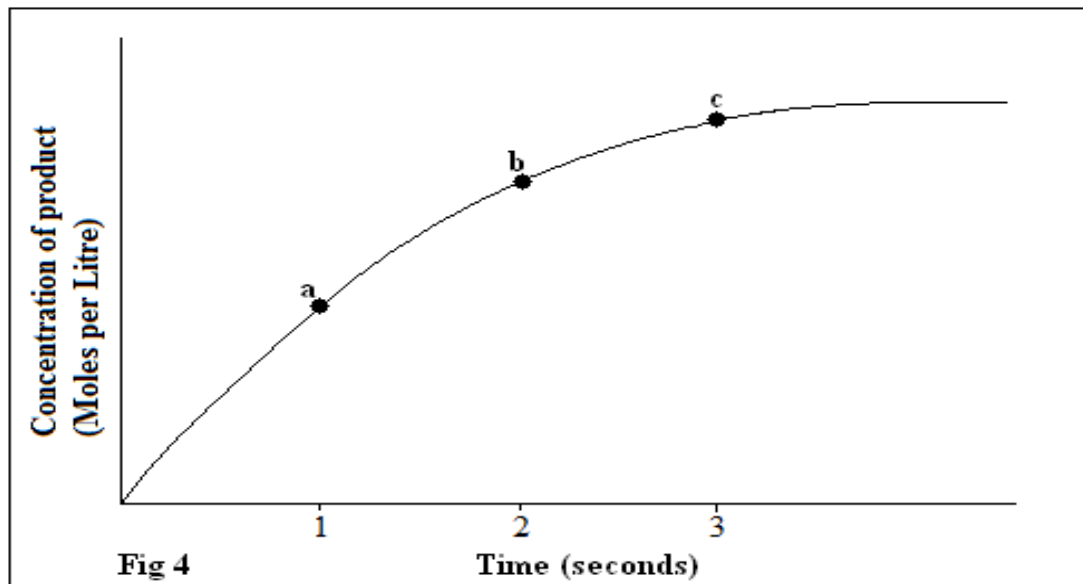
Confidence Response Index Options



CRI for Students who Answered Q.4 **Incorrectly**



Confidence Response Index Options



Correct	Incorrect
% of Students	% of Students
36.20	63.79

N= 58

Conclusions Drawn From Q.4 on The Whole:

N=58

Outcomes

Correct Answer and Low CRI; Implies a lack of knowledge

Correct Answer and High CRI; Implies knowledge of correct concepts

Wrong Answer and Low CRI; Implies a lack of knowledge

Wrong Answer and High CRI; Implies misconceptions

% of Sample

10.35%

25.86%

46.55%

17.24%

Looking for associations - correctness

- N=45 students answered both questions.
- Look for association in correctness of response – construct contingency table below.
- χ^2 test indicates **absence of association** at 95% confidence level.

	Chem Q4 ✓	Chem Q4 X	Total
Maths Q5 ✓	9(10)	17(16)	26
Maths Q5 X	8(7)	11(12)	19
Total	17	28	45

Looking for associations - confidence

- N=45 students answered both questions.
- Look for association in CRI (low or high) – construct contingency table below.
- $\chi^2 = 6.31 > 3.84$: reject null hypothesis that there is no association; **association exists**.

	Chem Q4 Low CRI	Chem Q4 High CRI	Total
Maths Q5 Low CRI	21(17)	10(14)	31
Maths Q5 High CRI	4(8)	10(6)	14
Total	25	20	45



	Association present			Association present		
Kinetics	Correctness			Confidence		
	Yes	No	Test Fails	Yes	No	Test Fails
Slopes - calculations			X*			X
Slopes - graphical interpretation			X	X		
Calculating derivatives			X*			X
Derivatives and slopes of tangents		X		X		
Multiplying fractions		X				X
Manipulating indices			X*			X

Test Fails

- X under 'test fails' means that criteria for application of χ^2 -test for association are not all met.
- X^* means that:
 - more than 20% of the expected values are less than 5;
 - all differences between observed and expected values are in the direction that indicates association.



	Association present			Association present		
Thermodynamics	Correctness			Confidence		
	Yes	No	Test Fails	Yes	No	Test Fails
Sketching graph of $1/x$	X			X		
Evaluating integral of $1/x$			X			X
Graphical representation of integral of $1/x$			X		X	



Summary

- Robust evidence for association between proficiency in mathematics and proficiency in chemical mathematics has not been found...but note X* results in 'Test Fails' column.
- Evidence for association in students' confidence levels is emerging.



To do list.

- Move beyond χ -squared test to milk the data a bit more.
- Identify areas where mathematical proficiency is associated with proficiency with maths in chemistry.
- [Incorporate qualitative data – Part B responses.]