Is it possible to design a relevant syllabus for Level I Chemistry?

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Our Department has been involved in a major review of our Level I Chemistry subject over the past 3-5 years. The reasons for the review included a realisation that both staff and students needed to be aware of new paradigms in learning and teaching and that changes in pedagogy would necessitate changes in the presentation format of subjects as well as their method of assessment. Rapid changes in computer technologies are causing staff and students to reconsider the format of their learning and teaching environment. We must regularly assess the importance of current concepts and appropriate modes of delivery for educationally relevant material. In addition to the factual information that students must assimilate, chemical educators need to provide students with a framework within which the information can be used in a constructive manner.

There has been a significant shift amongst academic staff in their approach to learning and teaching over the past decade. This has resulted in an awareness of the different paths by which students learn. A summary of some of these changes is outlined in Table 1 below.

	OLD	NEW
Knowledge is:	transferred from teacher to students	jointly constructed by students and teachers
Students are:	passive, waiting for the information	active, discoverers, constructors
Teaching staff:	classify and sort students	develop students' competencies
Relationships between teacher and student	impersonal	personal
Context	competitive, individualistic	cooperative, emphasized, teamwork
Assumption	any expert can teach	teaching is complex, requires training

Table 1. New and old paradigms in learning and teaching

Academic staff should encourage learning strategies that will be of benefit to lifelong education. Society expects graduates who display critical thinking ability and not simply competent laboratory technicians. New discoveries and significant advances in science do not spring from repetition. Research is founded on trying something new, doing the unusual. This is how the

teaching of chemistry can keep pace with research, by being innovative and imaginative rather than repetitive. Surveys of students have consistently indicated their preference for a contextual framework for the subject content. One issue we are concerned with at the present time is how much influence should student feedback have on the content of a subject? Some areas of our subjects are not as 'popular' as others. Should this influence the design of the syllabus or should we pay more attention to placing the content in context?

As a result of changes to the Chemistry I syllabus coupled with the introduction of computer assessment for tutorials and practicals, we have seen a significant improvement in student grades. A comparison between the Chemistry I results in 1994 and 1999 is shown below (Figure 1) and highlights this improvement. Although the issue of student grades is complex, and the reasons for the changes in student performance multifaceted, the overall result is an improvement in student self-confidence and belief that the discipline of chemistry is appropriate for them.

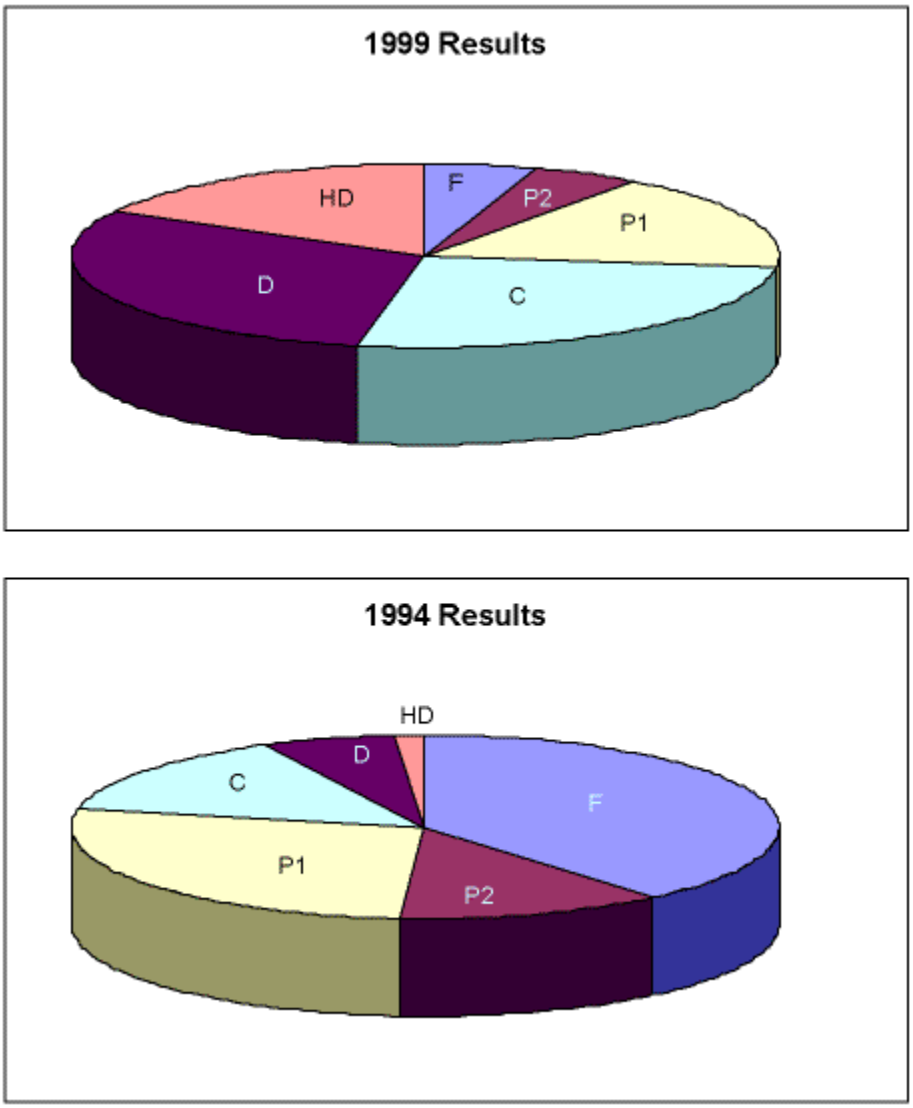


Figure 1. Chemistry I grades in 1994 and 1999

Our syllabus for Chemistry I today has many features in common with other universities in Australia. As an example, the following lists the syllabus content for the first half of semester 1 and the last half of semester 2.

First half of semester 1: **Shape and Structure**

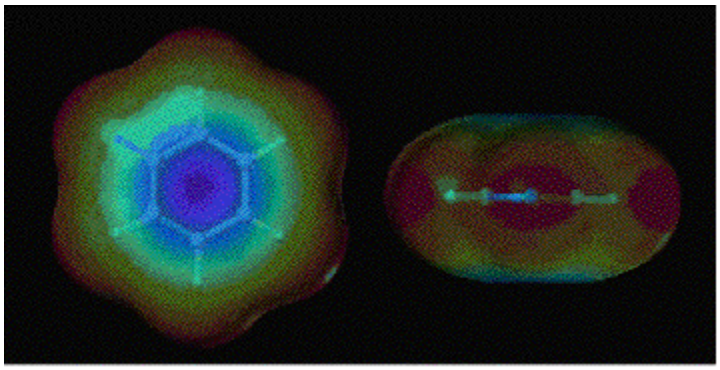
- electronic structure of the atom
- periodic relationships
- molecular geometry and shapes
- basic concepts of chemical bonding
- valence bonding theory
- structure determination, including: ultraviolet-visible spectroscopy; mass spectrometry; infrared spectroscopy; and nmr spectroscopy

Second half of semester 2: **Bio-organic and Polymer Chemistry**

- revision of bonding and stereochemistry
- chemistry of insect pheromones and chemical communication
- biological additions to carbonyls
- chemistry of physiologically active nitrogen compounds
- mechanism of reactions, substitution and leaving groups
- synthesis of pharmaceuticals and insect pheromones
- introduction to polymer types
- alkene polymers
- polyesters and polyamide

Although the topics are very familiar to any academic teaching introductory chemistry the rationale behind each of them is not obvious from the titles. We have insisted that concepts must be reinforced throughout the year, the reason for including a particular topic is that it relates to a key concept. Topics that are not related to a key concept and will not be reinforced elsewhere in the subject are not included.

The visual aspects of chemistry rather than abstract ideas or historical derivations should be emphasised. What the student does with the information is just as important as the information itself. We have departed from the formalism that emphasises that students cannot understand new or advanced topics before having a thorough understanding of all previous, basic concepts. This formal approach restricts students to an historical perspective to chemical problem solving rather than approaches that are likely to be of benefit in the future. For example in Figure 2 the colours are used to highlight the difference in electron density in aromatic rings. Electron rich areas are shown in red and electron poor areas are shown in blue. This enables students to better visualise the effect electron donating and withdrawing groups will have during reactions. Chemists often draw two dots on an atom to represent lone pair or non-bonded electrons. How would a student visualise the significance of the two dots? In Figure 3 we show the shape of those non-bonded electrons to reinforce the concept that they have shape and direction.



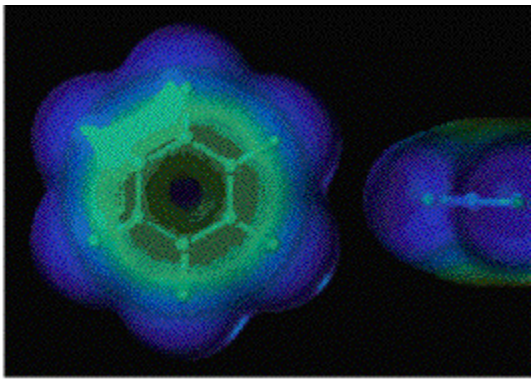


Figure 2. Electron density in aromatic compounds

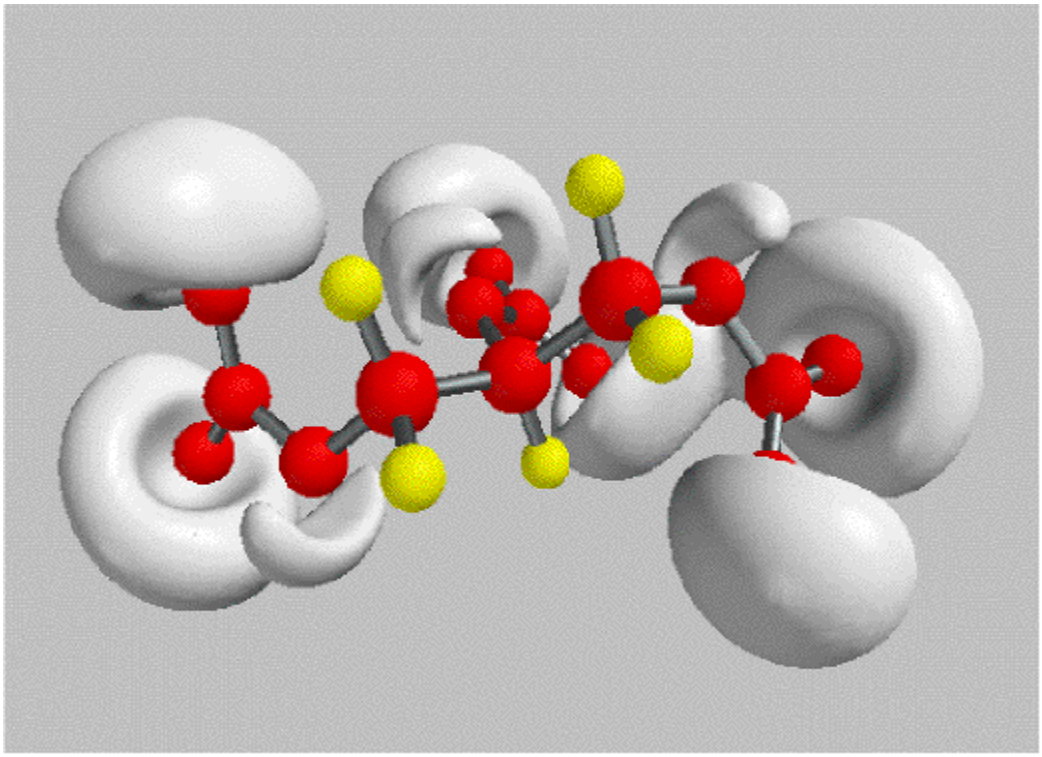


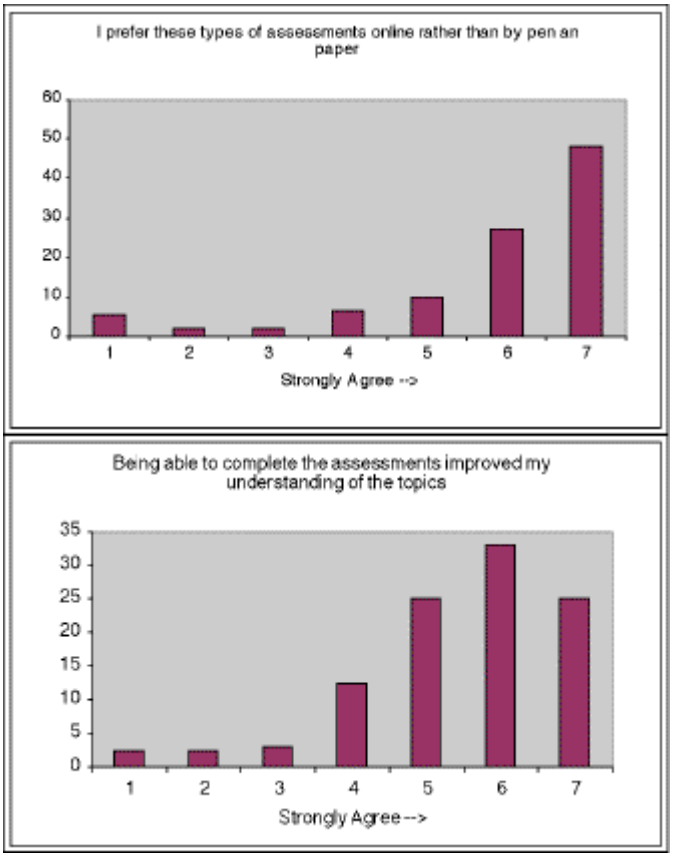
Figure 3. Non-bonded electrons on an oxygen atom

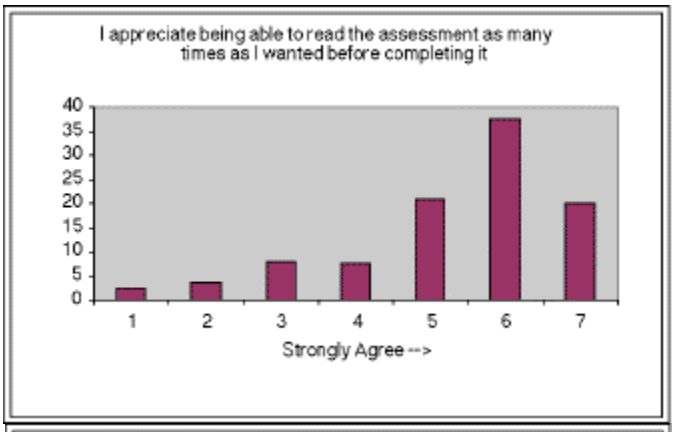
We have conducted surveys of the first year Chemistry I (Science majors) classes over a 3 year period and obtained feedback concerning the use of computer aided instruction and assessment. A review by the Advisory Centre for University Education on the introduction of web-based assessment was performed at the end of 1999 (see graphs below). Students had some very positive and some negative comments to make regarding the use of the Web for learning and assessment. The analysis of student grades for the past 6 years indicates an increasing proportion of students passing (Figure 1) as well as an increasing median mark. What is the significance and consequence of this? The corresponding analysis of advanced chemistry subjects does not always match that at the introductory level.

In summary, the following principles could be applied to designing an Introductory Chemistry syllabus:

- establish identifiable goals that are stated and reinforced with the students;
- distinguish between 'essential' and 'optional' material;
- reinforce the core concepts;
- provide a framework for the content;
- remove anything that is not used later in the subject;
- provide opportunities for collaboration and 'redeemable assessment';
- provide clear models for concepts;
- do not teach from textbooks; and
- keep it simple.

The results of the ACUE evaluation of the web-based assessment is summarised below and shows strong support for this format. We are continuing to improve the on-line assessment through interactive java applets that are embedded into the assessment tasks.




I appreciate being able to read the assessment as many times as I wanted before completing it
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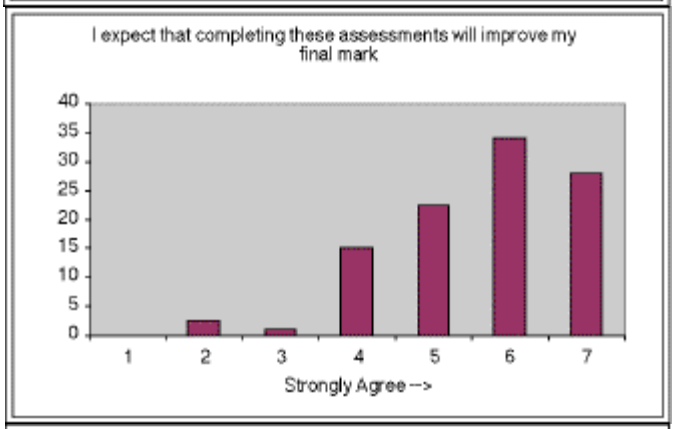
Strongly Agree -->


I expect that completing these assessments will improve my final mark
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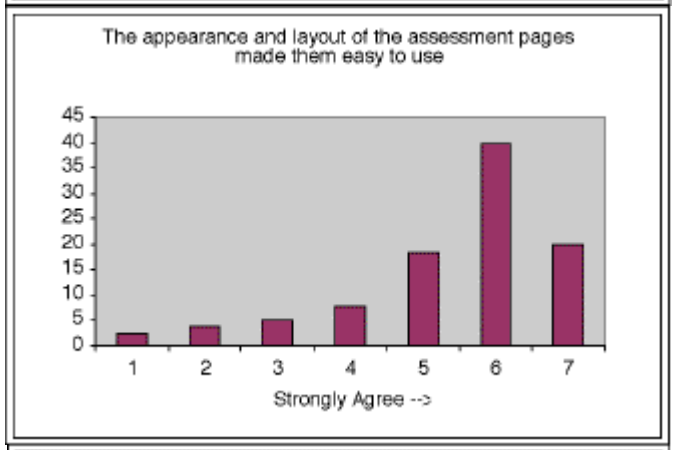
Strongly Agree -->


The appearance and layout of the assessment pages made them easy to use
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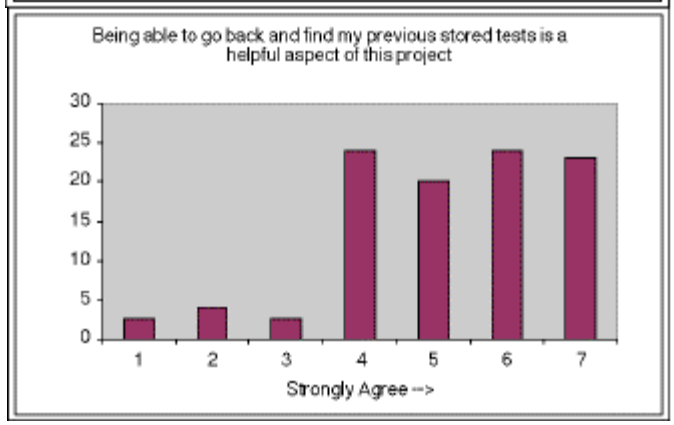
Strongly Agree -->


Being able to go back and find my previous stored tests is a helpful aspect of this project
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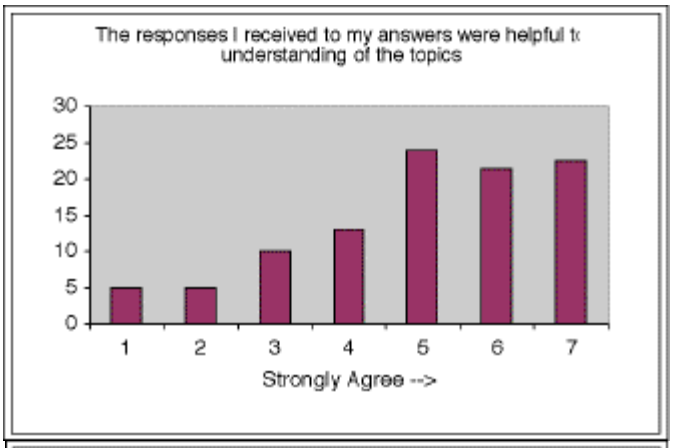
Strongly Agree -->


The responses I received to my answers were helpful t
understanding of the topics
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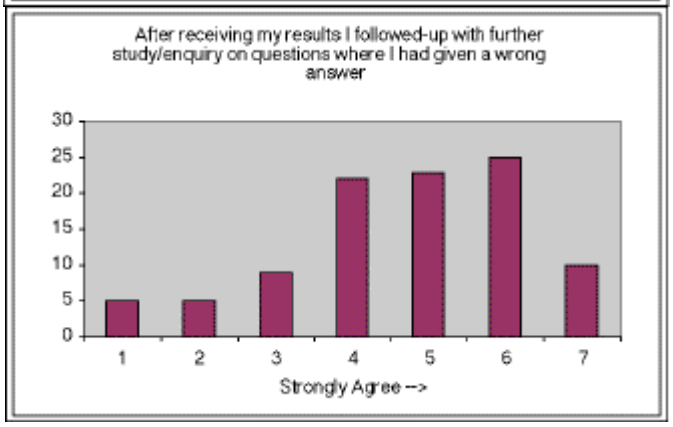
Strongly Agree -->


After receiving my results I followed-up with further
study/enquiry on questions where I had given a wrong
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Strongly Agree -->