Aligning Introductory Chemistry with the needs of the Faculty of Veterinary Science

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Introduction

Constructivist theory is now the dominant theoretical paradigm within education psychology and underpins contemporary science education (Walker and Debus 2002). Its fundamental precept is that learning is not a passive process of knowledge transmission, but instead requires the learner to actively construct knowledge through processes of sense-making (Brown 1994; Palincsar 1998). Knowledge is a creation of the mind and hence meanings and interpretations arise from the interaction with the world. Consequently, the knowledge construction process is heavily influenced by factors including prior knowledge and personal beliefs (von Glasersfeld 1993), motivation, cognitive styles and the social and cultural context (Alexander 2007; Palincsar 1998).

Bereite first coined the term *inert knowledge* to describe the problem where students fail to apply the relevant knowledge to the appropriate situation (Vosniadou 1996). Within the teaching context, *inert knowledge* often occurs when students are taught new information or ideas in isolation and the connections with prior knowledge are not emphasised. Hence, this new information is perceived to be irrelevant and is not used in the appropriate situation (Segal, Chipman and Glaser 1985). According to Renkl, Mandl and Gruber (1996) extensive research into inert knowledge reveals that it can be explained by examining the learning approaches students adopt and the way the students construct knowledge.

Meaning and knowledge is not imposed or transmitted by direct instructions from the teacher to the learner, but instead is created by the learner's learning activities, their "approaches to learning". Often, students adopt a surface approach to learning (rote learning) which is only useful to regurgitate information within a very limited context (Biggs 1987). According to Renkl and co-workers (1996), this has a twofold effect, firstly students lack sufficient *conditional knowledge* of 'when' and 'why' to access and use certain information and knowledge. Secondly, knowledge learnt through surface approaches is situated within a very limited context and there is restricted transfer between multiple situations (Biggs 1999). This is referred to as *compartmentalisation*, where knowledge is constructed in isolation and consequently it is trapped within that context and this makes it inaccessible for transfer. The lack of connection between knowledge constructs can result from cognitive overload, where students adopt surface approaches to learning to cope with the huge amount of information (Chambers 1992). High teaching speed and excessive syllabus content can be contributing factors to cognitive overload and inhibit deep understanding of new knowledge.

Conclusions from research into *inert knowledge* emphasise the need to stress the relevance of information in order to create active knowledge. This is particularly important in chemistry education, as chemical concepts can often be quite abstract and their applications are not immediately obvious. Lecturers need to emphasise the links between new information and stored knowledge to aid students in building intricate networks of knowledge and appreciate its relevance.

Present study

The School of Chemistry and Faculty of Veterinary Science at The University of Sydney have collaborated to offer a comprehensive foundation chemistry course (CHEM1405), which is directed at first year Veterinary Science students. CHEM1405 is a one-semester long chemistry unit of study designed to support subsequent studies of biochemistry, animal nutrition, physiology and pharmacology. The unit provides a chemical background that assists students to develop a robust understanding of the diagnosis and treatment of animal diseases. The syllabus spans chemical theories in inorganic, physical and organic chemistry with a strong emphasis on biological applications. The CHEM1405 unit comprises 39 hours of lectures (18 lectures covering inorganic and physical chemistry and 21 lectures in organic chemistry) plus 27 hours of practical laboratory work (equivalent to nine three hour sessions) and 13 hours of tutorial.

The School of Chemistry takes an active role in the evaluation of its curricula and has re-evaluated the CHEM1405 curriculum to ensure that it reflects the changing needs of the Faculty of Veterinary Science. With feedback through student and peer review, the CHEM1405 curriculum was designed to be innovative and relevant to the Veterinary Science students and to engage them. This study is part of an ongoing monitoring process to ensure that the unit matches the initial goals of the School of Chemistry and meets the changing needs of students. This study will investigate the educational effectiveness of the unit and evaluate how students have responded to preliminary changes to the course as well as administrative changes. These changes include:

- alteration to the curriculum to give a stronger emphasis on biological and veterinary applications;
- reduced tutorial class size;
- different student cohort (Veterinary Science students only); and
- different lecturers.

Tutorials were initially much like a traditional large group lecture setting with just a single lecturer for the whole cohort. The new curriculum has three different streams of tutorials at the same time, two small tutorial groups and one large tutorial group to reduce tutorial class size.

These changes were made to assist students to recognise the relevance of chemistry to their intended career as veterinarians, and to increase their levels of engagement. The aim of this project is to assess the impact of these changes on student attitudes, assessment performance and study approaches as well as students' perceptions of the topics covered in the unit.

Method and data collection

In this study, qualitative and quantitative methods are used to examine the impact of changes to CHEM1405 on student attitudes, performance and study approach. Critical to the study is the student survey which consists of multiple choice and free response questions. Quantitative data (multiple choice answers from student surveys, examination performance results) are used in combination with qualitative data (free response answers from student surveys and anonymous student observation) to gain a better understanding of survey answers and provide a valuable consensus among the students. Both these quantitative and qualitative data are compared with baseline data obtained from the corresponding surveys conducted for the CHEM1405 cohort in 2007.

Participants in this study are first year veterinary science students enrolled in the CHEM1405 unit of study at The University of Sydney. Entry into the Veterinary Science programs requires a competitive university admission index (UAI) of 98.40. Bachelor of Veterinary Science is academically demanding and students are expected to have a strong grasp of fundamental chemistry concepts. The assumed prior knowledge for the course is chemistry at the Higher School Certificate

(HSC) or equivalent university entry level. Students with a weak chemistry background are recommended to do the chemistry bridging course which has proven to be beneficial (Youl, Read, George, Masters, Schmid and King 2005).

Results and discussion

A total of 85 (88%) veterinary science students enrolled in the course completed the 2008 student survey. The multiple choice answers from the survey were at times conflicting. While 59% of the students believed that chemistry was important and is involved in a veterinarian's career, only 24% thought that further studies of chemistry would be beneficial once they begin work. This is reinforced by the increase in number of students who are unsure of the involvement of chemistry in their career from 12% in 2007 to 28% in 2008. Furthermore, 46% of students responded with the answer 'Maybe' to the question whether further studies of chemistry was beneficial and only 15% responded with 'Definitely not' or 'Definitely would'.
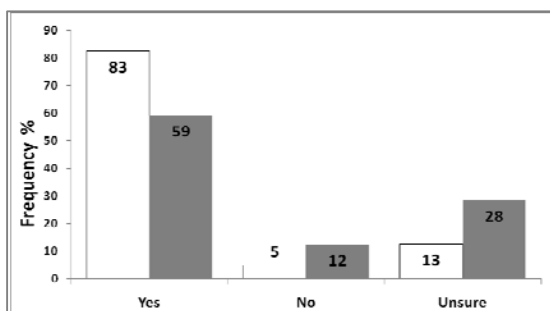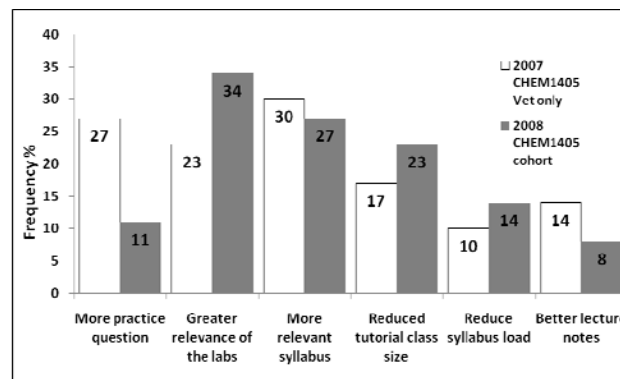

Figure 1. Distribution of responses to the multiple choice question 'Do you think your career as a Vet is likely to involve chemistry?'. Data are presented as a percentage of the student's who responded (n = 40 in 2007, n = 81 in 2008).
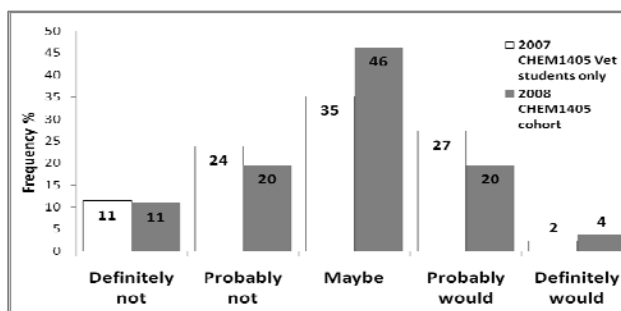
Figure 2. Distribution of responses to the multiple choice question 'Do you think that further study of chemistry during your degree would be of benefit to you once you begin working?'. Data are presented as a percentage of the student's who responded (n = 40 in 2007, n = 81 in 2008).
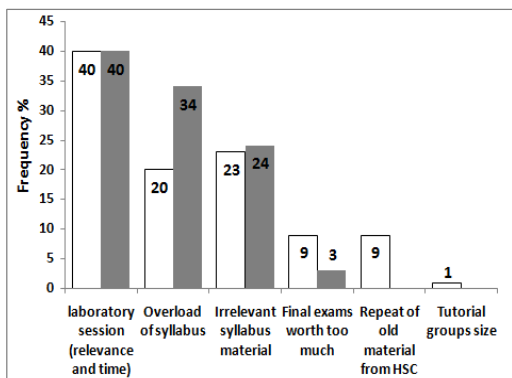
Figure 3. Distribution of answers to the free response question 'What do you feel are the least positive aspects of the CHEM1405 unit?'. Data are presented as a percentage of the student's who responded (n = 34 in 2007, n = 67 in 2008).


Figure 4. Distribution of responses to the free response question 'What changes would you suggest could have been made that would have improved your experience of studying chemistry?'. Data are presented as a percentage of the student's who responded (n = 32 in 2007, n = 64 in 2008).

The free response answers from the survey reveal that the relevance of the syllabus was a major issue. From the 2008 survey data, 40% of the students felt that the least positive aspect of the unit was the lack of relevance of the laboratory sessions and 24% of the students felt the least positive aspect of the unit was the relevance of the syllabus. These figures are similar to the values from the 2007 survey; however these data must be treated with caution, as only 34 from the 101 veterinary science students (34%) responded to this question in 2007 compared with the 69% participation rate on this question for the 2008 survey. The issue of greater relevance of the unit is also perpetuated in

the second free response question; 34% of the 64 students responding to the question in 2008, felt that making the laboratory session more relevant would improve their chemistry experience. Also, 27% of the students in 2008 felt that making the syllabus more relevant would improve their chemistry experience.

Another emerging theme from the free response answers is the perceived overload of the syllabus. There is a significant increase in students who felt that the least positive aspect of the course was that the course content was excessive, increasing from 20 % of the surveyed students in 2007 to 34% in 2008. A typical student response was that 'more time [is needed] to cover the content, it seems overly rushed with only a brief focus on each topic'.
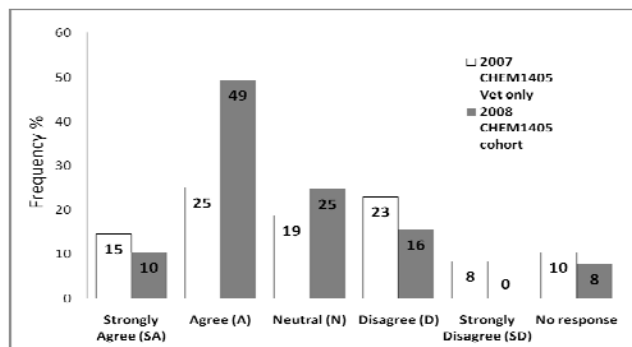
Figure 5. Distribution of answers to the multiple choice question 'Studying chemistry involves a lot of rote learning'. Data are presented as a percentage of the student's who responded (n = 48 in 2007, n = 83 in 2008).

Table 1.Data from student perceived importance (5 point scale: 1 = Irrelevant, 2 = Unimportant, 3 = Moderately important, 4 = Important and 5 = Very important; n = 45 in 2007 and n = 83 in 2008).

Topic in CHEM1405	Mean (standard deviation)	
Ordered by 2008	2007	2008
Acid/Base Theory, pH & Buffers	4.14 (0.85)	4.16 (0.78)
Carbohydrates	4.33 (0.87)	4.15 (1.00)
DNA & Tautomers	3.58 (1.36)	4.14 (1.16)
Amino acids, Peptides & Proteins	4.33 (0.78)	4.10 (0.97)
Solutions & Osmosis	4.27 (0.79)	4.00 (0.93)
Organic chemical transformations	3.64 (1.14)	3.86 (0.88)
Chemical Kinetics	3.11 (0.92)	3.80 (1.02)
Atomic Structure & the Biological Periodic Table	3.72 (0.85)	3.60 (1.11)
Chemical Equilibrium	3.59 (1.19)	3.55 (0.98)
Spectroscopy & Identifying Substances	2.82 (1.08)	3.51 (0.97)
Stereoisomer	2.84 (1.22)	3.33 (0.99)
Bonding Lewis Structures & Geometry	3.25 (1.16)	3.29 (1.01)
Chemical Energy & Thermodynamic	3.34 (1.14)	3.24 (1.01)
Colloids & Surface Chemistry	2.79 (0.81)	3.12 (0.88)

Students' perception of learning approaches was also probed in the survey. Data from the 2007 survey reveal that 40 % of students at least agreed (Strongly agreed or Agreed) that studying chemistry involves a lot of rote learning, while in 2008 this number has increased to 59 % of students. Also evident from Figure 5, is the decrease from 31 % to 16 % of students who disagree and/or strongly disagree with the statement that studying chemistry involves a lot of rote learning.

The revised CHEM1405 curriculum was designed to be more relevant to the degree of Veterinary Science but results show that students still fail to fully appreciate the relevance of the course. More biological content was added to the new syllabus and there is now a greater emphasis in linking abstract concepts and chemistry ideas with biological context and veterinary applications. It has passed close scrutiny from the Faculty of Veterinary Science and is considered to be consistent with their program. The major problem here is that the students' perceived importance and perceived relevance of the topics in the course do not align and overlap with those of the School of Chemistry and Faculty of Veterinary Science. Content analysis reveals that there was a slight increase in student perceived importance of all the topics in 2008 (M = 3.70, SD = 0.37) compared to those of the 2007 cohort (M = 3.54, SD = 0.56), but it was not statistically significant, t (13) = 1.82, p = 0.092. A positive outcome of the new syllabus is that the spread of the perceived importance of the topics in the 2008 cohort is less than in the 2007 cohort, with the mean of the lowest perceived important topic

being 3.12 (colloids and surface chemistry) in 2008 compared with a mean of 2.79 (colloids and surface chemistry) in 2007. Nevertheless, student perception of the low relevance of the course is still an issue in the new syllabus. This could be explained by two major contributing factors: high level of student uncertainty and content overload.

The large numbers of 'unsure' and 'maybe' responses and at times conflicting responses (within the one individual student survey) highlights a high level of uncertainty among the students as to the role of chemistry in their degree. Most of the veterinary science students (77%) are recent high school leavers whose exposure to the breadth of veterinary professionals may be limited. This raises the question whether students' perceptions that the unit lacks relevance are based on misinformation and a lack of experience of what is necessary in the field of Veterinary Science? Regardless of the validity of these perceptions, students are less likely to engage with material which seems not relevant (Johnstone 1997). This issue must be addressed, if the unit is to actively engage students and it would be ideal if what is perceived to be relevant by the students is aligned with the curriculum. More explicitly informing students of how chemistry is related to veterinary science would be beneficial in helping students appreciate the importance of chemistry for their degrees. Furthermore, first semester chemistry is studied along with animal husbandry, cell biology and veterinary anatomy and physiology. Studying chemistry within this context may seem out of place and might add to the misconception that chemistry is not relevant to their degree.

The data from the 2008 survey revealed that course overload was a major issue among the surveyed students. The Faculty of Veterinary Science allocates only one semester for teaching of all first year chemistry concepts. Heavy workload tends to preclude students from engaging with and understanding the material they are learning. Instead, many students adopt surface approaches to learning as a strategy for dealing with high workloads (Kirschner, Sweller and Clark 2006). In the 2008 survey, 59% of students at least agreed that rote learning was involved in studying Chemistry. This does not mean that these students will only adopt rote learning strategies, but it does suggest that many students may utilise rote learning over deep learning approaches to some degree. A preference for rote learning over deep learning approaches is likely to result in inert knowledge and hence minimal appreciation of the relevance of the learnt material due to lack of transfer (Salomon and Perkins 1989). This concept is encapsulated by the following student quote on the least positive aspect of the CHEM1405 unit: 'Disjoint learning – only learn small unrelated areas of chemistry which largely seems to have little relevance to the vet[erinary] course'. While there was positive student feedback on the new tutorial system, further improvements are needed for the larger tutorial group. The larger tutorials in a big lecture theatre may discourage students from asking questions and gaining a deeper understanding of the concepts. Of the survey respondents, 23% indicated that reduction in tutorial size would improve their chemistry experience. This is supported by the following student comment: 'having the tutorial in lecture theatres with too many people makes asking questions and getting help harder'.

Increasing the relevance of the syllabus is based on the premise that students can more easily relate and hence engage with the course material and ultimately develop a deep and meaningful understanding of the material. According to Mayer (1997), perception filters reduce the torrent of stimuli to manageable portions, attending to information which seems important, interesting and sensational. However, the full effectiveness of the more relevant syllabus was hindered by students' lack of experience in the veterinary profession and the overload of the course. As a result students' perceived importance does not correspond to that of the School of Chemistry. However, the question remains whether for those students who perceived the syllabus to be relevant to their degree it has resulted in deep meaningful learning. Anonymous participant observation in lectures and tutorials shows that student engagement and student participation levels were independent of the topic and its relevance to their degree. Student responses to all topics were similar, regardless of the degree of relevance and students seem to adopt the attitude that understanding of all the topics was important

and hence they did not 'switch on or off' in response to the topic covered. This observation is supported by the survey (Table 1), where students ranked inorganic (M = 3.65, SD = 0.37) and physical (M = 3.54, SD = 0.43) topics as important as the organic (M = 3.85, SD = 0.35) topics and there is no statistical evidence of selectivity based on relevance (F[2,13] = 0.85, p = 0.45). A possible explanation of this is that Veterinary Science students, who are high achievers, may adopt an achievement approach to learning and are motivated by high marks and not increased relevance. This seems like a plausible explanation, as almost all the students are high achievers based on their competitive UAI entry requirement, but no direct evidence has been collected in this study so far. It may also be beneficial to investigate in a further study whether a reduction in workload is likely to lead to Veterinary Science students being more in tune with the Faculty's perceived importance of all covered concepts. If this were the case the outcome would be beneficial for students, academics and ultimately animals in need of professional care.

Acknowledgements

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