



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

**Geoffrey T. Crisp**, Department of Chemistry, The University of Adelaide  
geoffrey.crisp@adelaide.edu.au

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.

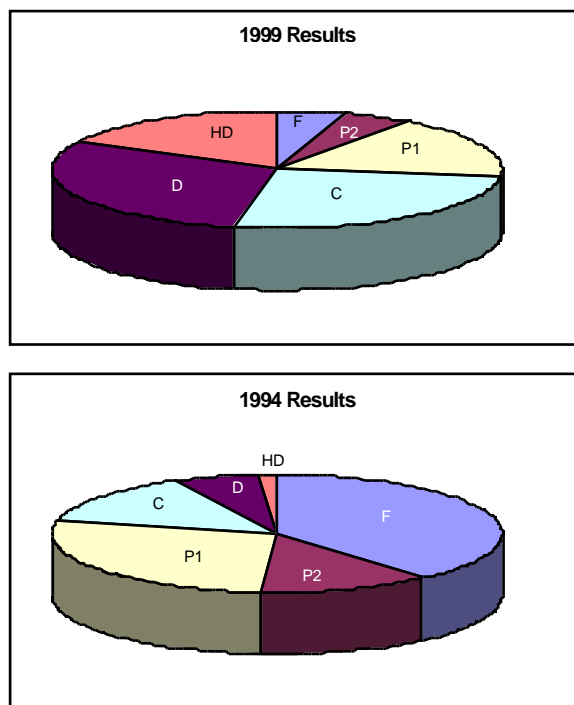


Figure 1. Chemistry I grades in 1994 and 1999

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: <b>Shape and Structure</b>	Second half of semester 2: <b>Bio-organic and Polymer Chemistry</b>
<ul style="list-style-type: none"> <li>• electronic structure of the atom</li> <li>• periodic relationships</li> <li>• molecular geometry and shapes</li> <li>• basic concepts of chemical bonding</li> <li>• valence bonding theory</li> <li>• structure determination, including: ultraviolet-visible spectroscopy; mass spectrometry; infrared spectroscopy; and nmr spectroscopy</li> </ul>	<ul style="list-style-type: none"> <li>• revision of bonding and stereochemistry</li> <li>• chemistry of insect pheromones and chemical communication</li> <li>• biological additions to carbonyls</li> <li>• chemistry of physiologically active nitrogen compounds</li> <li>• mechanism of reactions, substitution and leaving groups</li> <li>• synthesis of pharmaceuticals and insect pheromones</li> <li>• introduction to polymer types</li> <li>• alkene polymers</li> <li>• polyesters and polyamide</li> </ul>

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.

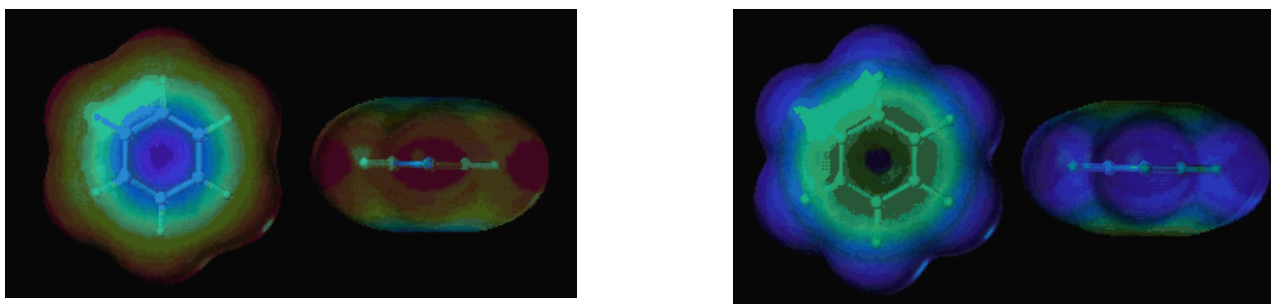


Figure 2. Electron density in aromatic compounds

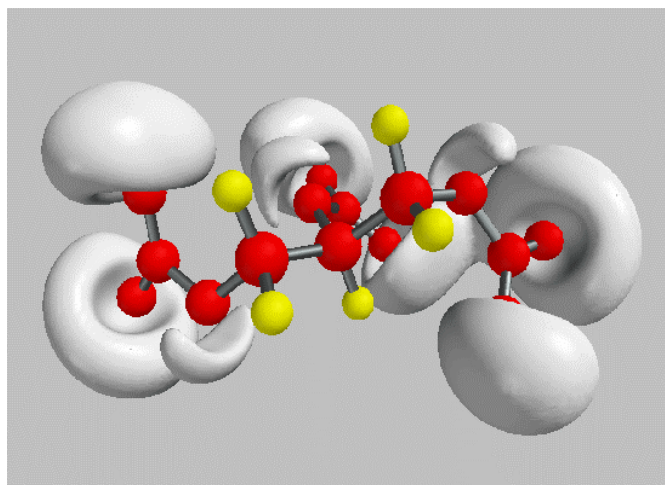


Figure 3. Non-bonded electrons on an oxygen atom

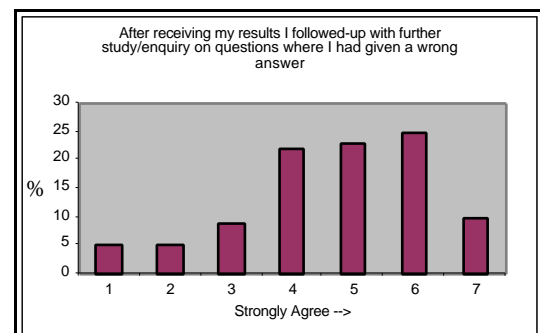
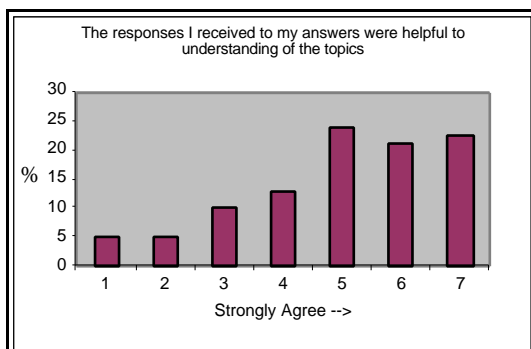
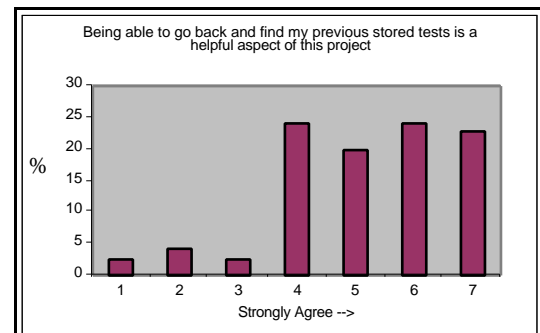
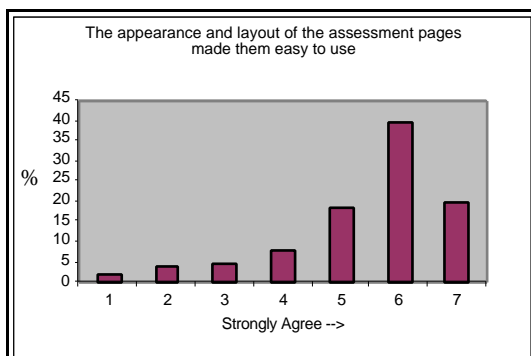
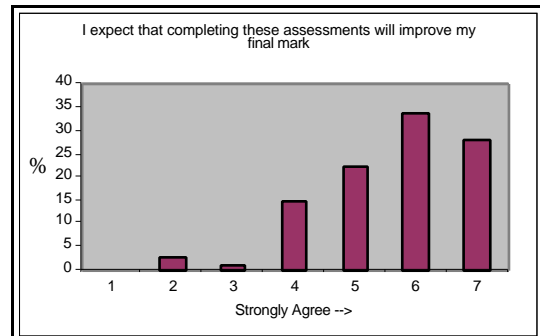
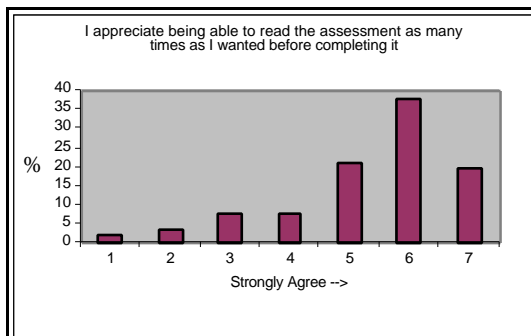
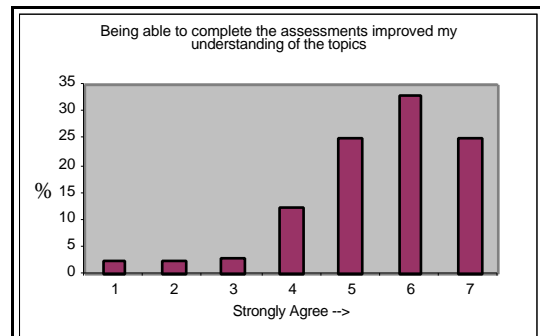
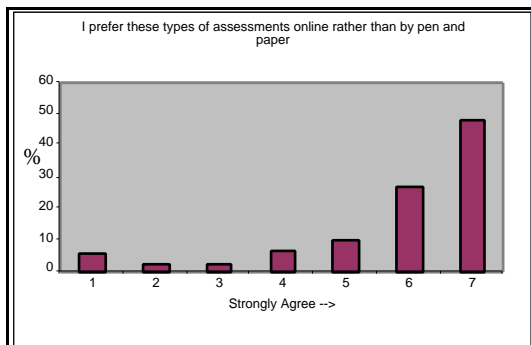
We have conducted surveys of the first year Chemistry I (Science majors) classes over a 3 year period and obtained feedback concerning the use of computer aided instruction and assessment. A review by the Advisory Centre for University Education on the introduction of web-based assessment was performed 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.





# Evaluating teaching materials and educational software for their commercial potential: Issues for academics and teachers to consider

**James Dalziel**, Department of Psychology, The University of Sydney and WebMCQ Pty Ltd  
Jamesd@psych.usyd.edu.au

*The commercial potential of newly developed teaching materials and educational software is a frequent undercurrent in discussions of modern education. While commercialisation of teaching materials does not necessarily require computer systems, in practice the vast majority of current interest has been provoked by recent developments in computing, and more particularly, the rise of the Internet. This paper reviews some of the major issues that teachers and academics face when considering the commercialisation of educational materials, and presents a framework to assist in the evaluation of potential commercial products and services for the modern educational world. From an educational developer's perspective (academic or teacher), relevant issues include: the ownership of educational materials (intellectual property), the relationship between educational developers and their employers, the role of copyright and patents, and the positive and negative aspects of collaboration. The importance of business planning in the early stages of evaluating the commercial potential of educational materials is emphasised, as is the importance of partnerships with other appropriate organisations. An evaluation of the current commercial opportunities for educational materials is framed within an understanding of current directions in national and global education.*

## Introduction

Evaluation is now widely recognised as a critical component of the development of new educational materials and technologies (Alexander, McKenzie and Geissinger, 1998). This may include formative evaluations during the development process (where students, colleagues and/or professional bodies may be consulted) as well as summative evaluations to examine the effectiveness of new systems following their formal use in educational programs. Despite the fact that Alexander and her colleagues (1998) have indicated that many recent government-funded projects in Australia have been unable to clearly demonstrate how the projects evaluated their effectiveness, evaluation is clearly an important dimension of ensuring the academic quality of new educational materials and technologies. The past year has seen a number of important new initiatives in this area in Australia, such as the CUTSD funded ASCILITE evaluation project (Phillips, 1999).

However, an often overlooked element of evaluation of educational materials and technologies is that of commercial potential, as distinct from academic merit. While commercial considerations are unavoidable at some level in most projects (given the costs of hardware, software, staff for programming and development, and legal expenses), many developers have failed to consider the wider commercial potential of their work within their initial planning. This is surprising given the increasingly difficult funding situation of universities and the high costs of many of these projects. The reason for the limited exploration of economic potential, at least in part, is due to the lack of experience of academics and teachers in the commercial (as opposed to academic) considerations involved in educational development.

The purpose of this paper is to provide a preliminary introduction to some of the issues involved in these kinds of commercial considerations. The suggestions presented here are made from the perspective of an academic who has been involved in an education commercialisation process over the past three years which has involved broad-ranging considerations of business planning, legal issues, intellectual property rights and alliances with corporate partners. While a commercial approach is anathema to some academics, it is suggested that economic issues will become increasingly important over the next few years until a point will be reached where no substantial investment in educational technology development will be possible without addressing these concerns. If this prediction is

correct, then academics and teachers with an ongoing interest in this field will need to learn new skills and develop an understanding of the peculiar requirements of evaluation from a commercial perspective.

## **Education and commercialisation: the context**

Many developers of learning materials and educational software (both academics and teachers) have to be at least partially aware of the potential commercial value of their endeavours, even in the absence of an articulated commercialisation plan prepared by their institution or its affiliates. Informal discussions between educational developers at information technology education conferences have increasingly included commercial as well as academic considerations of newly developed learning materials. In the past year, a number of education conferences in Australia have acquired corporate sponsorship from 'new education providers' seeking to collaborate with educational developers who have often worked for many years with little recognition from their own institutions or external corporations. As Katz (1999), Duderstadt (1999), and others have argued, this is part of a revolution occurring within education resulting from the confluence of 'for profit' education with the possibilities for 'anytime anyplace' learning provided by the Internet. While the influence of market forces on the traditional business of education would have arisen without the assistance of the Internet, the combination of these forces for the future of education is explosive.

In terms of the wider context, funding of education in Australia and elsewhere has been shifting from a reliance on government support to an increasingly 'user pays' based approach. While there are good reasons to believe that this shift will have certain detrimental effects on education and society as a whole, there is now little expectation that this trend can be substantially reversed in the near future. In addition to changes in public policy, private investors have recently begun to look to education as a major area of investment, with research groups such as International Data Corporation indicating that on-line education spending will reach almost \$800 Million by 2002 in Australia alone (IDC, 1998). Regardless of whether academics and teachers want large scale private investment entering their domain, external analysts are increasingly recommending it to savvy investors, such as a recent Banc of America Securities report which states 'the landscape of learning has never looked more promising for companies in the business of education' (Block and Dobell, 1999).

In addition, the nature of decision making within educational institutions appears to be moving from a collegial to a managerial approach. This has been driven not just by economic factors such as reduced public funding, but also by developments in management practice and theory within large corporations. Universities are now recognised by society as large businesses with yearly budgets often in the hundreds of millions of dollars and as a result, greater accountability is being required of universities by the community and government. This view of universities as large businesses is influencing traditional institutional decision-making processes.

Within all of these developments, individual academics and teachers are being increasingly asked to make judgements which involve considerations beyond simply the academic merit of a course or technology. In evaluating educational materials and software, they may now be expected to have skills in areas such as market research, project management, intellectual property and the development of business plans. Indeed, many of the unsuccessful projects discussed in Alexander et al.'s (1998) review failed due to problems in these areas.

There are different approaches to these issues depending on whether one looks from the point of view of an external education corporation, a university or school, or from the viewpoint of individual developers. Given that many educational developers have already, or will in the near future, become involved in commercially driven projects (either through their own developments or through collaboration with or secondment to other projects), it is appropriate to review some of the issues



that arise from the individual perspective. These are examined below under the two major headings of 'Intellectual property' and 'Business planning'.

## **Intellectual property**

Few academics or teachers are clear on how to evaluate their rights in relation to any intellectual property they may develop in the sphere of educational materials and software. There are many reasons for this, but one of the more important problems is the sheer variety and lack of clarity in institutional policies concerning the status of educational materials and software, particularly when this relates to web-based materials (Bale, 1999). While some institutions argue that any work created within the course of employment (or in the US, 'work made for hire', see Burk, 1997) is owned by the institution, many others are less clear on this topic, while some have more sophisticated arrangements acknowledging different kinds of work ('typical' work versus work beyond the 'normal call of duty'), and different opportunities for commercialisation. There is good reason to believe that in the near future, policies regarding the ownership and usage rights of educational materials will become an important distinguishing factor between universities, with staff drawn to those institutions where, all things being equal, the intellectual property developed by staff is treated with respect and clarity.

Developers need to have a clear understanding of the policies that relate to their particular local context, and they should seek clarification of uncertainty at the beginning of the development process. It is much more difficult to solve intellectual property problems towards the end of a project due to the ambiguity and differing points of view that tend to arise when these issues are not addressed from the start.

Some of the difficulties of the current situation arise from the fact that what was once an idea or oral presentation has now become a fixed digital product which may then be subject to copyright. For example, when the famous Sydney philosopher John Anderson extemporised during lectures earlier this century, there may have been no copyrightable material arising from this activity (provided his oral presentation was not based on previously prepared physical notes, as was sometimes the case). In this example, despite the quality of the thoughts conveyed, the institution would not necessarily have had any intellectual property which might have raised the kinds of concerns addressed here. In contrast, the current use in education of word processors and the Web tends to create many digital products which, at least potentially, have value to both their creator and the institution as copyrightable intellectual property. Due to the technological changes of recent decades, it is only natural that universities may need to update and change their prior policies relating to the intellectual property created by staff.

While ownership is often a focal point for disagreement between individuals and institutions, there are a range of additional issues which deserve consideration, some of which can make ownership less problematic (Crews, 1999). These issues include reward, control, and usage rights. In terms of reward, an educational developer may be willing to give up claims to ownership provided that some form of reward is provided. While financial reward is one obvious solution, other rewards of value to academics and teachers include recognition and promotion, and time release or support for other work which has been affected by involvement in an education project. Financial reward can take a number of forms, such as one-off payments, additional salary loadings paid for special projects, or various kinds of percentage rewards systems, such as royalties, equity in companies formed to commercialise a successful venture, or a combination of fixed and sliding percentages depending on ongoing work and/or commercial outcomes.

It is important to recognise that many universities have pre-existing policies for the commercialisation of research outcomes (typically via patents), and that sometimes these structures

can be adapted to suit educational developments. However, this strategy is often problematic, as educational developments generally reside more within the intellectual property protection field of copyright rather than patents. The simple question of whether a CD-ROM is more like a textbook or an invention brings this issue into sharp relief (Thompson, 1999).

There are a number of different types of control issues which may arise in this area, such as whether a developer has the right to change materials in the future to keep them up-to-date or to amend errors. In some cases it may be appropriate for a developer to retain a right to refuse additions to earlier material, or to delete existing material where it becomes inappropriate. The issue of acknowledgment is also important, such that the original creators' names or institutions may not be removed regardless of any other subsequent modifications.

Control, as well as reward and ownership issues can potentially be solved via careful designation of 'usage rights' – a process Kenneth Crews refers to as the 'unbundling of rights' (Crews, 1999; Bale, 1999; CSU-SUNY-CUNY, 1997). Crews' model involves careful negotiation between all parties about specific rights to use developed materials. It typically starts from a basis that both individual developers and institutions have a variety of expectations of how materials may be used, and that many of these can be accommodated without conflict when they are articulated in specific rather than general terms (Crews, 1999). Where conflicts do arise, these can often be solved via specific usage rights involving locations and time periods.

For example, an academic who develops a course especially for distance learning and is paid additional income for this work may give up the right to be able to use this course material at another university for a specified period of years. However, after this period (say five years), the academic may be free to use the original material at another location if desired. If a university anticipates local competition in a particular course area, then restrictions can be based on the places (rather than the time period) in which material could be reused – for example, the developed course could not be used within the same city or country. Another facet of the current example could be that the academic assigns exclusive usage rights to the university, but with a clause that allows the academic to write and have published a textbook on this subject as an exception to any other restrictions. The point of the 'unbundling of rights' approach is to avoid sweeping claims from either side, and to focus on specific, identifiable outcomes, and then to resolve these directly. While it is more complex than the simple 'the institution owns everything' approach, it can be a fairer recognition of often considerable creative investment of academics and teachers in their contributions to educational materials and courses. To be able to successfully negotiate these arrangements, developers need to be able to evaluate both commercial and academic aspects of their creations.

It is important that educational developers not lose sight of the 'bigger picture' when dealing with intellectual property issues. There is no point arguing about 'who owns what' if this results in material being shelved so that it never becomes widely used. Academics and teachers should recognise the many advantages of having the involvement of larger institutions (both educational and corporate) in the process of commercialisation. In many cases, developers will be unable to provide the necessary infrastructure (e.g. servers, Internet access, etc.) or ongoing support (e.g. help desk, backups, etc.) for developments unless they work together with their institution, which means that positive, fair and respectful negotiations are an important step towards a successful commercialisation. In some cases, institutions will have made considerable direct investment in the development of new materials and/or technologies (over and above 'typical' investment in development), and thus may have a reasonable case for sharing in any rewards. For an excellent overview of issues for consideration from both individual and institutional points of view, see The Node's 'The Rights Stuff: Ownership in the Digital Academy' (Bale, 1999).



## Business planning

While budgetary planning issues are not unfamiliar to many developers, the use of a full business case to justify educational technology projects is fairly uncommon among academics and teachers. It is unlikely that this will continue to be the case, as dwindling government investment and greater expectations of future returns will shift the focus from budget spending to income generation. As a result, business planning is likely to become a skill that many developers will need to demonstrate. Given the level of detail typically required for a full business plan, it is likely that institutions will develop 'gating' processes by which preliminary proposals are evaluated initially, and based on combined commercial and academic merit, these will be developed into full business proposals. An iterative approach to this process is to be highly recommended, as the precision involved in costing these projects becomes greater as a number of 'gates' of evaluation are applied.

Business plans have a range of common elements, and although these are rarely exactly the same across different fields, the following list is an example of the major headings needed for an educational project business case: executive summary, background, description of innovation/course, project/management team, market analysis, marketing plan, research and development plan (for technology developments), strategic alliances, project/business milestones, risk factors, financial modelling and appendices. Of these, some are relatively self-explanatory, but others may be unfamiliar to many academics and teachers, and hence deserve particular attention. These include market analysis, strategic alliances, risk factors and financial modelling.

Few current projects involve genuine market analysis prior to initiation. While market analysis should not influence the assessment of the academic merit of a project, it can be a significant commercial hurdle where a development is planned for a highly competitive or low financial return market. Market analysis can also reveal existing products which may abrogate the need for new development (the notorious 'not invented here' syndrome is unlikely to be defensible in the future). The point of including this topic within initial business planning is that some projects would not proceed as a result of the findings of this stage. Despite the academic merit of a proposed project, if it will not be commercially viable due to insufficient demand, then in most cases it would not proceed. In those special cases where a university believed that a development had intrinsic value despite its lack of potential to recoup project costs, then this consideration should be weighed carefully against any other financially viable projects which as a result might not be funded.

Strategic alliances is a useful consideration for large projects which are unlikely to recoup their costs from use within a single institution. Whether these alliances are with other universities, or with publishers or 'new education providers', they provide the potential for a wider dissemination of projects materials or technology through licencing. In many cases, alliance partners will bring additional benefits in marketing and distribution which may not be available to individual universities. Strategic alliances may also provide a basis for additional funding of project costs, or in-kind contributions which may offset other expenses (such as marketing).

Risk factors are a much overlooked area within current educational development projects. There are many kinds of risks that may affect a project, both external (new competitors) and internal (hardware, software and staffing problems). Too many current projects rely on a single person to drive development, which brings with it risks of illness, misadventure or problems if this person leaves the institution. There is already a recognition that better project management is needed (Alexander et al., 1998), and this may lead to less risks, or better responses to problems should they arise.

Finally, financial modelling is typically required of a business plan, so as to show at what point a venture 'breaks even', and what possible returns may arise over the medium term. Few educational

developments to date have adopted this approach, which may be one of the reasons for the lack of willingness of governments and institutions to continue to fund new developments in the face of a financial ‘bottomless pit’. Like market analysis, financial modelling is important because it may result in a project not proceeding due to unsolvable revenue difficulties. An additional aspect of this process is ‘sensitivity analysis’, where the model is subjected to different initial conditions to observe the impact on later viability. For example, a new on-line masters course may hope to get 30 new students per year, and on this basis, make a small profit. Sensitivity analysis involves making different assumptions about the initial student intake (for example, 15 rather than 30 students per year), and examines the impact of this change on the final revenue model.

As can be appreciated from the detail required by the above material, the original developers of educational materials or technology may not wish to (or may not be able to) evaluate all the issues required for a business plan. In some ways this is understandable, as the skills needed for commercialisation are often different to those required for the original educational development. It is important for academics and teachers to understand that commercialisation typically involves collaboration with a wide range of partners who bring different skills to the development process. In liaising with others over commercialisation, it helps for the academics or teachers to have an understanding of the business planning process. At the same time, collaboration brings new strengths to the development team, but at the same time dilutes the significance of the original developer within any final commercial success.

## **National and global opportunities**

In conclusion, there are a range of current opportunities for newly developed educational materials and technology. The largest of these is arguably the provision of general educational software platforms to assist education, particularly over the Web. However, this is a highly competitive area, and several large companies (such as *WebCT* and *Blackboard.com*) have already gained a significant share of this market such that there is little room for new successful commercialisations in this field unless they radically alter the existing ‘playing field’ of course platform tools. A second category of opportunity is combined content and delivery platform products, such as CD-ROMs and hybrid web and CD-ROM/DVD packages which act as both content teacher and software navigation system. While there are still global opportunities for excellent products of this kind, they are generally very expensive to produce, and may struggle to be profitable in areas where other well developed packages already exist. Market analysis will be critical for this kind of development.

The broadest area of current opportunity is for on-line courses in the wide variety of topics currently taught ‘face to face’ within educational institutions. While in many cases the possible returns from these on-line courses will not match those generated by general course platform tools or CD-ROMs, they do provide an area for commercialisation that is open to many current developers. Within this field, there are several ways of gaining positive financial returns from these developments. One is through an expansion of the existing student base of a course (provided that this leads to increased funding to the course providers), such as through access to overseas students. A second approach is to licence the content of the new courses to other educational institutions or to global publishers who have the reach needed to distribute materials to others who may wish to use them. A third (and in many areas very attractive) approach is to adapt course materials to suit adult and community education, continuing professional education or ‘just-in-time’ (JIT) training materials for corporations. While each of these approaches have various strengths and weaknesses, and may not be appropriate in certain content areas, they provide a framework for evaluating the potential commercial opportunities available to carefully planned and constructed educational materials and technologies.



In summary, this paper has argued that future evaluation of the development of educational materials and technologies will include not only academic considerations, but also commercial evaluation of business planning and the potential for financial return. Within this process, developers will be increasingly confronted with issues of intellectual property, and this paper has attempted to identify some of the important issues to be evaluated from the perspective of individual academics and teachers. In particular, the 'unbundling of rights' is proposed as one potential method of resolving difficulties in this area. The national and global opportunities for course delivery platform software, combined educational content and navigation software, and on-line course materials have been identified, with a particular focus given to on-line courses, and their potential to generate financial returns via an increased student base, licencing of materials, and repackaging of content for adult and community, professional and 'just-in-time' training. This approach assumes that the world of higher education will be radically altered over the next decade by the impact of 'for profit' education and the rise of the Internet in learning (Katz, 1999; Duderstadt, 1999). It will be interesting to see how individuals and institutions 'place their bets' on this assumption.

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## Doing it differently in science: An evaluation of the process

Sharon P. Fraser and Elizabeth M. Deane, School of Science, University of Western Sydney  
s.fraser@uws.edu.au e.deane@uws.edu.au

### Project background: the learning context

With the benefit of a CUTSD Grant for 1999, the authors sought to develop an integrated programme supporting the development of key learning competencies in undergraduate science students at the University of Western Sydney (UWS) Nepean. The subject chosen to contextualise this programme, was a second year biological sciences subject, Immunology, which in itself aimed to provide students with an understanding of the development and functioning of the immune system, as well as expertise in a range of clinical assessment and research techniques involving immunological principles. The targeted competencies included:

- group leadership and membership;
- oral and written communication;
- critical analysis;
- problem solving;
- reflective skills; and
- independent learning.

We recognised that students do not ‘pick up’ such competencies as they learn (Collins, Brown and Newman, 1989; Lave, 1988), and so they were specifically taught and practiced throughout the semester, in multiple different contexts. The delivery of the subject was through cooperative learning approach, in order to both assist students with their learning, and to help simulate the collaborative environment common in the science workplace (Johnson, Johnson and Smith, 1998).

To achieve our objectives, the essentials of the knowledge base were delivered external to the allocated lecture periods, workshops replaced lectures and the information normally presented in a lecture format was available via audio tapes, textbook, a study guide and web site. During workshops, students worked cooperatively in teams undertaking a number of different tasks designed to develop the aforementioned competencies as well as explore the knowledge domain. For example, one key activity was to critically analyse three immunology research papers, and subsequently present their analysis to their peers for critical feedback. Teams also worked cooperatively to develop practical solutions to a chosen laboratory problem, and subsequently in their laboratory-based investigation of that problem during an intensive weekend laboratory session. Support for student learning was achieved via direct access to both academic and technical staff as well as on-line through the communication software included in the School of Science Virtual Resource Centre web site (<http://cadfl.nepean.uws.edu.au/science/vrc/> – password required), this enabled students to contact each other, and their lecturer/tutor at any time.

Mid-semester and final examinations were retained, though they contained less direct recall material than in previous years. Additional assessment tasks, designed to measure the acquisition of specified generic or professional competencies, were spread throughout the semester and allocated significant marks (see Table 1).

### What was there to evaluate?

When any new programme is introduced to students, it is essential that it is thoroughly evaluated, from both their perspective and that of the staff involved in its delivery. In this case, as the



programme was developed with the support of CUTSD funds, formal evaluation was an integrated and integral part of its development and integration. Aspects of the subject that required evaluation included: the programme – its design and delivery; the learning environment – including the lecturer/tutor and support services; and the learning outcomes – the clarity of intent and success in achieving them. Each of these was used to make decisions about the programme’s future.

Assessment Item	Weighting
Quizzes	Formative assessment only
Mid-semester test	25%
End-of-semester test	25%
Cooperative learning assignment	15%
Laboratory problem: cooperative learning	15%
Oral presentation – laboratory problem	10%
Poster	10%

Table 1. Assessment tasks and their allocated weighting as incorporated into the subject design

## Evaluating the evaluation – the person and the process

Many traditional evaluation processes were incorporated into the programme during its design and development, these included the use of:

- summative assessment outcomes – including the team collage and poster;
- student questionnaires;
- follow-up student focus groups;
- staff reflection – documented;
- staff focus groups – both academic and technical;
- video footage – of the weekend laboratory sessions and subsequent student presentations; and
- observation – of the cooperative learning process.

During the course of the semester it became apparent that an effective evaluation of the subject required both a process of evaluation, outlined above, and a person whose role it was to undertake/oversee it. It is the role of the latter in this process that has caught our interest.

Initially our CUTSD application promised the use of Observation methods (Guba and Lincoln, 1981) and the presence of an ‘Independent Observer’, whose task it would be to monitor aspects of cooperative learning during both workshop and laboratory sessions. However, in our project, this person became more of an ‘Independent Facilitator’ and was ultimately pivotal to both the evaluation and implementation of the project. This facilitator was characterized as independent of both the teaching and support staff who delivered the subject, but being well known to them, a free flowing, two-way communication was established. Though assisting in the development of the subject learning assessment tasks, she was independent of any assessment of these tasks. This resulted in the students communicating thoughts and feelings to her that may not have been possible with the subject lecturer/tutor, and allowed for the sharing of insights that may normally have remained unsaid. This is perceived to have enhanced the depth of subject evaluation that was possible. The facilitator was thus characterized as independent of any vested interests, personal, political or philosophical, allowing for a more dispassionate viewing of the learning environment both during its delivery and after its completion. However, although she was independent of the people and process in these ways, she most certainly had an holistic involvement in the implementation of the subject, therefore could not be called an observer, hence our coining of the term: ‘Independent Facilitator’.

We conclude that it can be valuable having such a person involved in the delivery of a new subject, as s/he brings a different viewpoint and focus to the programme, and most importantly, has the time to facilitate its effective delivery. In order to function in a manner conducive to the implementation

and evaluation of an effective learning programme, the 'Independent Facilitator' should have the following characteristics:

- content knowledge;
- an understanding of the learning process;
- interpersonal skills;
- a flexibility of approach;
- an ability to reflect, analyse and solve problems;
- an ability to identify needs as they arise; and
- the sensitivity not to impose his/her ideas and opinions on others, or to make value judgements.

## **Evaluation: informing the future**

Both the 'Independent Facilitator' and the process of evaluation, provided invaluable feedback about the achievement of the learning goals, and the popularity and viability of the new teaching and learning strategy. The combined feedback, from all evaluation procedures, suggests that the programme has been well received by students, both in the goals we were trying to achieve and the way the learning experience was structured. It was relatively successful in enabling students to develop the learning competencies outlined previously, as determined by both student perceptions of their own skills, and as observed by the staff involved in the delivery of the programme. Though cooperative learning requires a more active engagement by students in the learning process than normal, often proving more difficult in practice than in theory, both staff and the majority of students (79%) recognized the importance of grappling with learning/working in this manner. Any changes that will be made to the delivery will be minor, addressing weaknesses in programme timing and resource management. This will include:

- more structured guidance and feedback for the written communication tasks, including more explicit summative assessment of these skills; and
- an emphasis on teamwork and oral communication presentation will be retained and an analysis of how such an emphasis affects non-English speaking background (NESB) students will be evaluated.

One staff member believes that we may have sacrificed some content expertise in our desire to develop professional competencies, however she also believes that this cohort of students '...will make great 3<sup>rd</sup> years, due to their ability to solve problems'. Only time, experimentation and further evaluation, will tell whether we have the balance right. The future of the programme may be less rosy however. Both the subject lecturer and 'Independent Facilitator' have either left the School of Science or are in the process of leaving, with few remaining staff with an interest in either the philosophy of the methodology, or in the types of learning outcomes being addressed, namely generic or professional competencies of science. As with a number of such initiatives, their success and continuation hangs off one or two pivotal members of staff and unless they become institutionalized in the academic unit, they do not continue. In this instance, the programme's evaluation indicates that it has been successful in achieving many of its objectives, and hence such evaluation outcomes can be used as an incentive to those who follow to adopt its recommendations and assist in the continued evolution of the programme as both the student cohorts and learning context change.

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## Evaluation of improved outcomes in physics service courses

P. D. Jarvis, J. E. Humble, R. D. Watson, I. A. Newman, E. Chelkowska, School of Mathematics and Physics, University of Tasmania and S. Stack, Elizabeth College, Hobart  
John.Humble@utas.edu.au

### Background

Since the early 1960s, first year physics at the University of Tasmania in Hobart has been split into a 'mainstream' unit for students wishing to progress towards further physics studies and a terminating unit acting as a service course primarily for students in the biological and health sciences. Whilst having various names over the years, to reflect differing balances of user requirements, the generic title of Physics for Life Sciences is often used for the latter. A significant difficulty is the wide range of student backgrounds, interest and academic ability in an enrolment which has typically been around 60 to 80 students in recent years.

Our group was awarded a 1999 CUTSD grant to investigate teaching techniques in this area. The broad aim was how best to address perceptions of poor student performance in and satisfaction with the course as previously presented. The project was designed to be non-technological in nature, based on 'constructivism', building on students' prior knowledge and background, achieve a conceptual change in the students' understanding of physics using constructivism as a referent, and inculcate ideas of science as a process of inquiry. The perceived problems were:

By staff	By students
Variety of student courses Variety of student academic backgrounds Lack of student interest Poor SETL (Student Evaluation of Teaching and Learning) results	Difficulty of material Lack of apparent 'relevance'

### The units and the student body

By 1999, 'Physics For Life Sciences' comprised the 12.5% semester 1 unit KYA171 *Applied Physics* (prerequisite: TCE Year 11 *Physical Sciences*) and its second semester follow-on unit KYA172 *Biological Physics* (prerequisite: TCE Year 12 *Physics* or KYA171). KYA171 was compulsory for Horticulture, Agriculture and Surveying students, whilst KYA172 was compulsory for Agriculture and Pharmacy students. Both units were optional for other students in the Faculty of Science and Engineering. There was thus a wide range of student backgrounds and interests.

### The approaches

Using the constructivist approach to teaching we particularly sought group participation, encouragement of questions and discussion in lectures, group work in some lectures, explicit teaching of problem solving strategies, explicit checking of learning progress for student awareness and formative feedback, and identification of different learning modes.

### Evaluation

Six measures were recorded: comparisons with grades in previous years; formal SETLs; staff workbooks; anecdotal comments from staff in laboratories and other conversations with students;

post-hoc student focus groups; and a University Constructivist Learning Environment Survey (UCLES) (P. C. Taylor, private communication). Not surprisingly, it proved difficult to achieve unambiguous results from these data. Part, but by no means all, of the difficulties arose from differences in expectations between physicists and educationalists. The latter are accustomed to less precise results than physicists normally require from experiments. This difficulty was compounded by the use of several staff and several techniques. Nevertheless the project succeeded on almost all measures.

*Final assessed grades* were better, possibly significantly so, from the previous year. Grade Averages (1 = Pass, 2 = Credit, 3 = Distinction, 4 = Higher Distinction) were: (numbers of students in brackets)

	1998	1999
KYA171	1.60 (61)	1.75 (53)
KYA172	1.83 (70)	2.10 (77)

*Student satisfaction*, as measured by formal *SETLs* also improved over the previous year. The statistical reliability of this outcome is hard to confirm but it does provide a useful indicator. Of the ten questions asked of students only one showed a poorer result in 1999 than 1998, that relating to the consistency of teaching. We gained the strong impression that many students expect a consistent teaching approach through a unit and are unhappy if the approach is changed.

The *UCLES* results provided qualitative measures of student satisfaction in two categories, student learning and university teachers. They indicated, as expected, that students' perceptions of their learning environment fell short of their preferred quality in all cases. The smallest discrepancy between perceived and preferred situations was noted for negotiation and the highest for relevance of learning. Scores in the university teachers' category indicated high expectations of the quality of interpersonal relationship with physics teachers. From the constructivism perspective these results are thought-provoking, but do not suggest final strategies because of the complexity of learner-sensitive teaching.

*Staff workbooks* of all activities were valuable qualitatively but hard to use quantitatively. They proved to be more useful as a record of what had been attempted than as an indicator of what had been achieved.

*Anecdotal comments* were also of value. Most were positive. In particular, students liked the increased attention and feedback. Comments, both here and in the focus groups, also emphasised the differing perceptions of 'relevance' between students and staff. Almost all students in a physics service course want the presented material to be 'relevant'. Fewer can define or explain what they mean by this. Some mean relevant to their course, others relevant to their interests, still others seem to mean 'Engagement'.

*Post-hoc student focus groups* were another strong indicator. Most of the participants appreciated the constructivist techniques and the discussions that flowed from them.

## Conclusions

Evaluating outcomes proved to be harder than we had expected, even though we had been aware at the outset that we could not expect the types of certainties that one requires of an experiment in the physical sciences. In particular, the discovery that different measures can give contradictory results was worrying. We did confirm, however, the pivotal role of students' backgrounds in evaluating and interpreting the effectiveness of the project. The act of measuring affects the quantity being observed!



There are two broad categories of students, those interested in building an understanding of physics and those wanting clear information in order to pass examinations. The latter predominate in our 'Physics for Life Sciences' units. Teaching must therefore be tailored to their requirements.

## Gallery of Speakers

