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Computer and IT skills of Australian first-year university undergraduate students

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Abstract:

The use of computers and information technology is becoming more widespread in chemical education and in the wider community and workforce. Universities are increasing the use of computers and information technology in their teaching and learning programs. The Australian situation, reported here, can be viewed as a microcosm, reflecting a world-wide trend.

The *penetration* of *general* IT literacy and ability amongst Australian undergraduate students is rising rapidly. This paper reports surveys of the *detailed* IT skills of Australian undergraduate students. To the best of our knowledge, apart from our own work, there have been no other published surveys of *specific* IT skills. Most students have some reasonable computer skills at

the start of their university studies, but the *level* of skill is not uniformly high. In fact, many IT literate students lack a *sufficient level* of skill to use the new technologies, including full use of web-based flexible learning. There is an urgent need for IT training for university students in order to achieve successful learning outcomes using IT and to satisfy the needs of future employers.

This article, which is the second in a series (*1*) of investigations on the computer skills of undergraduate students at the start of university, is an expanded version of a paper presented at the World Chemistry Congress held in Brisbane (Australia) during 1-6 July 2001.

Introduction

The use of computers and information technology is becoming more widespread in education and in the wider community and workforce (*1-6*): the same is true of chemistry and chemical education. Indeed, the recent World Chemistry Congress held in Brisbane (Australia), had "Chemistry by Computers" as one of its five major themes. Universities are increasing the use of computers and information technology (IT) in their teaching and learning programs (*6-9*). The Australian situation, reported here, can be viewed as a microcosm, reflecting a world-wide trend: see, for example, recent issues of this Journal, the *Journal of Chemical Education* and elsewhere (eg. *10*). Also see recent issues of *Chemistry International*, which have reported on the use of computers in chemistry and in chemical education in less-developed nations (eg. *11*).

Contextual Background

While computers have been used for teaching and learning for a few decades, their wide-spread use dates from the mid-1980s with the advent of the Apple Macintosh, IBM PC and PC-compatible computers. At the end of the 1980s, the Australian Education Council, on behalf of the State, Territory and Commonwealth Ministers of Education, entered into a collaborative development of statements about the curriculum of all Australian schools. This included a vision for the use of computers in teaching and learning (*12*):

> "Computers and calculators provide students with opportunities … at a younger age than they might otherwise have … [School] students should have sufficient experience of calculators and computers … to be able to make informed decisions about whether to use them … and to use them efficiently when they wish to do so" (*12*).

In 2001, students, who have encountered the use of computers throughout their entire primary and secondary (high-school) education are now entering university.

Government policy is being formulated on the assumption that (high-) school leavers and university graduates are computer literate. For example, the Australasian Ministerial Council on Education, Employment, Training and Youth Affairs (MCEETYA) has supported the broad directions of the *Education and Training Sector Action Plan for the Information Economy*, based on the assumption of IT literacy which is defined to be (*6*):

> "The set of knowledge and skills needed to use information technology at a level appropriate to a person's position, work environment and discipline and the ability to continue to develop them into the future" (*6*).

Universities are also developing and implementing policy based on the assumption that students are computer literate. In 1996 and 1997, Pennell from the University of Western Sydney, and Blackhurst, Hales and Lahm from the University of Kentucky published a list of IT skills, which they believed were necessary for university students to benefit from the modern electronic-learning environment (*8*): **Table I**.

Table I. IT skills appropriate for the general undergraduate electronic-learning environment (*8*)**.**
• Electronic mail   • Email attachments • Discussion lists; Electronic bulletin boards • Telnet, FTP or Gopher sites • Web download links • Instructional management systems • etc

Around the same time, Zielinski and Swift published a list of IT skills for university *chemistry* students (*9*): **Table II**.

Table II. IT skills appropriate for the undergraduate electronic-learning environment in chemistry (*9*)**.**
• Electronic mail • Discussion lists; Electronic bulletin boards • Word Processing • Spreadsheets / Graphing • Molecular modelling • WWW searching

Unlike the arts- and humanities-based disciplines, science and chemistry in particular) requires more than basic writing, keyboarding and word processing skills for report writing (*13*,*14*).

Table III is an extract of a physical chemistry article showing the use of superscripts, subscripts, mathematical symbols, Greek letters and equations (*15*).

Table III. Extract of a physical chemistry article showing the use of superscripts, subscripts, mathematical symbols, Greek letters and equations (*15*).
A simple harmonic valence force field, consisting of harmonic stretches, bends and torsions, was used to describe the propane substrate: $$V_{intra} = \sum_i V_{stretch,i} + \sum_i V_{bend,i} + \sum_i V_{torsion,i} \qquad (4)$$ The first two terms have been defined previously.[15,58,59] The harmonic stretching and bending force constants were obtained by the empirical prescription of Lindner:[60] $k_{str,CC} = 4.705 \times 10^2$ J m^{-2}, $k_{str,CH} = 4.702 \times 10^2$ J m^{-2}, $k_{bend,CCH} = 6.67 \times 10^{-17}$ J rad^{-2}, and $k_{bend,HCH} = 5.61 \times 10^{-17}$ J rad^{-2}. The final term in Eqn (4) is a 3-fold methyl torsional potential which was assumed to be: $$V_{torsion,i} = \frac{V_0}{n} \sum_{j=1}^{n} \cos^2\left(\frac{3\tau_{ij}}{2}\right) \qquad (5)$$ The torsional angles τ_{ij} are the nine H-C-C-H or H-C-C-C dihedral angles for each of the i-th C-C bonds.

The above discussion shows that university policy and the use of information technology (IT) in university teaching and learning are implicitly based on **the assumption that university students either already are computer literate, or are becoming computer literate**. Indeed, this assumption *seems* to be supported by a number of studies, which suggest that the *penetration* of IT literacy and ability amongst Australian undergraduate students is rising rapidly (*1*-*3*): **Table IV**.

Table IV. Percentage of students entering university with a general IT skills (*1*-*3*)**.**

Year	1998	2000		2001	
Survey	School (*2*)	U Sydney (*3*)	Deakin U (*1*) and this study		UWA this study
Ability to use the WWW	75	82	87	94	93
Ability to use email	59		85	92	93
Ability to use a word processor	93	89	99	98	97
Ability to use a spreadsheet	47	50	88	77	62

Reference (*2*) is a study by Meredyth *et al.* of Year 10 secondary students across Australia in 1998. These students were in the 4th year of secondary school and would have formed the majority of the students who started university in 2001. Reference (*3*) was a survey of all undergraduate students who entered the University of Sydney in 2000. Reference (*1*) was a survey of all students enrolled in 1st semester freshman (1st year) chemistry. In each case, the results were not obtained through objective testing, but are the students' (subjective) perceptions of their own abilities.

IT skills are generally high. However, we have anecdotal evidence that many students are having difficulties using the electronic electronic-learning environment, which seems to contradict the findings of references (*1*-*3*). Hence in 2000, we conducted a survey of beginning university undergraduate students enrolled in first-year chemistry at Deakin University, investigating the details of specific IT skills (*1*). This paper reports the continuation of our survey into a second year and extended to include undergraduate freshman medical students at the University of Western Australia (UWA).

To the best of our knowledge, our 2000 survey (*1*) is the only survey that investigates *specific* IT skills of university students (as opposed to *general* IT skills). Given the lack of hard data on *specific* IT skills, the current paper is an extension of our previous work (*1*).

Survey Results

The results of the surveys fall into three groups:

- general IT skills which reflect familiarity with the different types of computer software (*6*,*12*);
- specific IT skills associated with use of the Internet for teaching and learning activities, including (*8*,*9*):
    - electronic dissemination of material through the world-wide web, bulletin boards, on-line testing, electronic submission of student work;
    - on-line testing and electronic submission of student work;
- specific IT skills associated with use of word processors and report writing (eg. *13*).

Details of the sample student demographics and survey administration the survey design can be found in **Appendix I**; Details of the survey design can be found in **Appendix II**.

General IT Skills

The proportion of first-year-university students who have a general IT skill is listed in **Table IV**. It is clear that the percentage of university students who have knowledge of core IT skills in the areas of Web, email, and word-processing usage has increased in the last couple of years. Since the results for Sciences and Technology students at the University of Sydney were consistently 3–6% higher than the university average (*3*) we can expect approximately 90% or more of the overall university population in 2001 to have knowledge of these IT skills.

The extent of knowledge of spreadsheets is significantly lower than for the other general skills: **Table IV**. We postulate two reasons for this: firstly, the wide-spread use of graphing and programmable calculators in high schools may mean that spreadsheets may be due to the use of spreadsheets being less integrated into most high-school curricula than Web, email, and word-processing usage; and secondly there is a non-academic imperative for the use of the latter technologies for electronic communication with friends and relatives.

Specific IT skills associated with use of the Internet for teaching and learning activities

In a web document, such as this, a link to (eg) the **RACI Division of Chemical Education web site** can exist as a **hypertext link**. However, in a text-based document, the web address or URL (uniform resource locator) must be given as (eg) **<http:/www.deakin.edu.au/fac_st/bcs/RACI_ChemEd/>**.

Table V. Cross tabulation of percentage of students at Deakin University who have knowledge about Web addresses (URLs) and general Web usage.

		Knowledge of Web usage				
		2000			2001	
		Do not know	Know		Do not know	Know
Know-ledge of URLs	Do not know	9	21		5	7
	Know	2	68		1	87

2000 data is taken from our 2000 survey (*1*).

Table V shows that while the general knowledge of overall Web usage is extremely high, in 2001, 1 in 8 students still do not know how to use a web address or URL.

Electronic teaching materials and lecture notes are often disseminated to students as (Adobe Acrobat) portable document format (PDF) files (*16*). **Table VI** shows that between 1 in 2 and 2 in 3 students believe that they do not know how to read a PDF file. The *effective* knowledge base may be higher than this since over 90% of students have web skills and hence have *unconscious* knowledge of accessing a web-linked PDF file using a pre-configured web browser. Even with this caveat, it is clear that most students will encounter difficulties if the PDF file is distributed through a non-web medium (eg on diskette or CD-ROM).

Table VI. Cross tabulation of percentage of students who have knowledge about reading PDF files and general Web usage in 2001.

		Knowledge of Web usage				
		U Western Australia			Deakin University	
		Do not know	Know		Do not know	Know
Knowledge of reading PDF files	Do not know	6	45		3	65
	Know	1	49		1	31

In the modern e-learning environment, students are often asked to download electronic files from the world-wide web, bulletin boards, email attachments, instructional management systems, etc (*8*,*9*). Similarly, students are often asked to submit work as attachments to email, bulletin boards, instructional management systems, etc (*8*,*9*).

Table VII. Cross tabulation of percentage of students who have knowledge about email attachments and downloading files from the WWW in 2001.

		Knowledge of downloading files from the WWW				
		U Western Australia			Deakin University	
		Do not know	Know		Do not know	Know
Knowledge of email attachments	Do not know	22	15		26	17
	Know	6	58		5	52

Table VII shows that approximately 1 out of every 4 students can not download files from the Web *or* use email attachments. While many students might have *unconscious* knowledge of accessing a web-linked PDF file, 1 out of every 4 students will have difficulty accessing other electronic files by *any* Internet medium. Approximately 1 in 2 students will have no difficulty accessing files by any medium, while the remainder may have difficulty depending on the medium of dissemination. A very large minority will be unable to submit work as attachments.

Table VIII. Percentage of UWA students expressing preferences for on-line versus written tests in 2001.

<table>
<tr><th>Written testing</th><th>On-line testing</th><th>%</th></tr>
<tr><td>Only preference</td><td></td><td>12</td></tr>
<tr><td>Preferred</td><td>Possible</td><td>37</td></tr>
<tr><td colspan="2">No preference</td><td>39</td></tr>
<tr><td>Possible</td><td>Preferred</td><td>12</td></tr>
<tr><td></td><td>Only preference</td><td>0</td></tr>
</table>

Table VIII shows that the students at UWA exhibit a clear preference towards paper-based written tests. Since negative student attitudes will adversely affect learning outcomes, the use of on-line testing will disadvantage the 1-in-8 students whose *only* preference is for written tests.

Specific IT skills associated with use of word processors and report writing

The current survey indicates that in 2001 almost all students (>95%: see **Table IV**) are able to use word-processing software. University of Sydney data in 2000 indicates that 83% of students felt that they had "fair" to "expert" keyboarding skills (*3*). Our study indicates that UWA students can type at the same speed as they can write, with a small but significant number expressing a preference to type rather than write.

The overall *level* of specific skills associated with word-processing is not uniformly high, which is consistent with our 2000 results. However and most surprisingly, these skill levels either consistently showed a *consistent across-the-board decrease* between 2000 and 2001 — see **Table IX** and reference (*1*) — although this may a slight year-to-year variation.

Table IX. Percentage of Deakin University students with various levels of skill for specific skills associated with word-processing in 2001

	Use of superscripts and subscripts	Use of special characters and symbols	Use of equations	Use of chemical structures (diagrams)
Response a	11	5	6	23
Response b	27	20	64	69
Response c	44	68	27	7
Response d	12	6	2	
Response e	6	1		

Response a I have not heard about [this skill].
Response b I have heard about, but do not know how to use [this skill].
Response c I know how to use [this skill].
Response d I have expert knowledge on [this skill].
Response e I have sufficient expert knowledge to teach [this skill].

Surprisingly, 11% of the students claimed "I have not heard about putting superscripts and subscripts in documents". This claim is all the more the surprisingly when one considers the educational background of the survey sample — *all* the students have previously studied chemistry — and realises that superscripts and subscripts are part of the everyday language of chemistry: eg, O_2, N_2, SO_4^{2-} and PO_4^{3-} for oxygen and nitrogen molecules, and sulfate and phosphate ions respectively. This complete ignorance of superscripts and subscripts is an increase from the previous year (4%), and is part of a consistent *across-the-board* increase in ignorance and decrease in knowledge: see **Table IX** and reference (*1*). This decrease may be part of small-sample variability from year-to-year: future surveys are required.

While some disciplines may not require the use of superscripts/subscripts, special characters/symbols, equations and/or technical diagrams in their written work, but some or all of these features are required in the scientific and technologically-based disciplines. Thus **Table IV** and **Table IX** indicate that students are becoming more capable of *producing* a word-processed submissions, they are becoming less capable of producing an *acceptable scientific* submissions.

Discussion

Most students have reasonable computer skills at the start of their university studies, the *level* of skill was not uniformly high: **Table IV** and reference (*1*). This general finding is consistent with the results of other surveys (*1*-*3*). However, the *level of specific IT skills* is very variable. What actions are required?

Firstly, teaching staff and university administrators must acknowledge that students entering university in 2001 are not fully prepared to benefit from the universities' use of IT in teaching and learning (*5*). This has been a major objective of our previous (*1*) and the current work.

Given the increasing use of Web-based and electronic teaching resources (see eg. *7*,*8*,*17*), it then follows that there is an urgent need for IT training for university students in order to achieve successful learning outcomes using IT and to satisfy the needs of future employers. This is not as onerous as it initially seems to be. It can be simple and easy as using 5 minutes of class time to demonstrate how to type an URL into the appropriate box in a web browser, or to use the format font option to create a superscript or subscript. This needs to be done systematically across the curriculum. These 5 minutes of class time, if taken early in university studies, can be viewed as the proverbial "stitch in time" that prevents many problems latter in the students' academic career.

For example, one model for compulsory, across-the-board, student IT training is detailed in **Table X**.

Table X. Recommendations of a Deakin-University Working Party on computer skills training for undergraduates
• Each "unit" (ie topic or "subject") has a prescribed list of IT skills, which are deemed necessary for successful learning outcomes in that unit. • The required IT skills can vary from one degree stream to another (ie Arts *versus* Science majors). However, skills associated with "core" units, topics or subjects, will ensure that all students in a particular degree stream will have the appropriate IT skills for that particular discipline and degree stream. • Students must demonstrate that they have the required IT skills, or take flexible-learning training modules to acquire the required IT skills in the first few weeks of semester, before they are permitted to proceed in the unit, topic or subject. • A training module would take as little as 30 minutes to learn how to use email attachments, or up to a couple of hours to prepare a graph using a spreadsheet. • The training modules (or demonstration of requisite skills) are a pass/fail hurdle barrier for completion of the unit, topic or subject. They do not carry any credit points towards the degree program. Administratively, the modules are similar to teaching practicums or industrial placements, which are compulsory in some degree program, but which carry no credit points.

Within the chemistry curriculum, special emphasis should be placed on the IT skills listed in **Table XI**.

Table XI. Computer skills which require attention for chemistry undergraduates in 2001
• Using URLs. • Reading Adobe PDF files. • Downloading files from the WWW. • Using email attachments. • Using superscripts, subscripts, mathematical symbols, Greek letters, equations and diagrams in word processing documents.

Conclusions and Summary

Most Australian students have reasonable computer skills at the start of their university studies in 2001, but the *level* of skill is not uniformly high. Although this study has concentrated on two cohorts of students at Deakin University and the University of Western Australia, these samples can be viewed as a microcosm, reflecting a wider trend within Australia and internationally.

Firstly, teaching staff and university administrators must acknowledge that students entering university in 2001 are not fully prepared to benefit from the universities' use of IT in teaching and learning. Secondly, universities need to implement compulsory student IT training systematically across the curriculum. This training can be simple and easy to implement, as discussed above.

This article, which is the second in a series (*1*) of investigations on the computer skills of undergraduate students at the start of university, is an expanded version of a paper presented at the World Chemistry Congress held in Brisbane (Australia) during 1-6 July 2001.

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Appendix I. Sample Student Demographics and Administration

Two cohorts of university students were surveyed at the start of the 2001 academic year. In each case, every student enrolled in a particular university unit (subject) was required to complete the survey.

The University of Western Australia (UWA) cohort was comprised of all students in the first year of the medical degree (MBBS) program. The total sample size was 130 with 53% female and 47% male. Approximately 23% had had prior university education, but the survey did not identify these students. The survey was administered online through the locally developed FlyingFish courseware, and students were required to complete the survey immediately after logging in for the first time. Students were able to complete the survey independently if they felt able, and others were given assistance to log-in and begin the survey at an introductory training session early in semester. As students were required to access learning materials through the FlyingFish, all students completed the survey.

The Deakin University (DU) cohort was comprised of all students in the first-year unit (subject) SBC 111 (Chemistry A) within the School of Biological and Chemical Sciences at Deakin University (Geelong campus). The total sample size was 84. The survey was printed on the front and back of a single sheet of paper: 3 students failed to respond to the questions on the back of the sheet, which included information on the student demographics. Hence analysis of the data used either 81 or 84 students as the sample size, as appropriate. The majority of students (82%) were enrolled in various degree programs (BSc, BForensicSc) within the Faculty of Science and Technology, 18% were enrolled in double-degree programs (BSc/BE, BSc/BA, BSc/BCom, BSc/BTeach, BSc/LLB), while 4% did not declare their enrolment details. 78% of students had no previous tertiary education, 5% had one or more years of non-university tertiary education, 10%

had one or more years of university education, while 4% did not provide their educational background. 62% of the class were female and 38% were male.

Other researchers have noted that for voluntary surveys, there is a higher response rate from females.(*3*) However, since the surveys in this paper were conducted in class time, the predominance of females in both the DU and UWA cohorts reflects actual enrolment numbers.

Appendix II. The Survey Design

The surveys used in this study were based on the previous design (*1*) and intended to investigate the *level* of students' knowledge in the usage of IT. Survey-response options covered the range from no awareness to varying levels of expertise: see Reference (*1*):

(a) No awareness or knowledge;

(b) Awareness but no knowledge of usage;

(c) Knowledge to use the technology;

(d),(e) Expert knowledge to use the technology.

Responses (a) and (b) indicate that the student has no ability with the skill in question, while responses (c), (d) and (e) indicate varying levels of skill.

This study addressed the following *general* IT skills:

- Use of the World Wide web;
- Use of electronic mail (email);
- Use of word-processing programs; and
- Use of spreadsheets to analyse and plot numerical data.

The use of databases, the use of spreadsheets in capabilities apart from analysing and plotting numerical data, the use of (multimedia) presentation packages (eg PowerPoint), the ability to create web pages, and other general skills were not addressed.

In addition to the general skills, the survey addressed several *specific* IT skills such as the use of keyword searches on the WWW, or the use of super- and subscripts within word-processing programs. The version of the survey used at the University of Western Australia examined a smaller range of *specific* IT skills, than the Deakin University survey. (Copies of both the UWA and DU versions from available on request from the authors.)

About the authors

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