An Evaluation of Relevance of Computing curricula to Industry Needs

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ABSTRACT

The research documented in this paper attempted to answer the question of how relevant the content of the Computing courses offered within programs of the Computing Department at the National University of Samoa (NUS) were to meet the needs of industry and the workforce. The RINCCII study which was conducted in 2013 to 2014, surveyed 13 institutions and 19 graduates from the Computing programs. Findings from the survey indicated that the current course offerings within the Computing department are relevant to the needs of industry and the workplace. However there are aspects or topics which need inclusion or better coverage. The study also recommended regular surveys to gauge relevance of curricula to needs of industry.

Keywords: computing curriculum, relevance to industry

1. INTRODUCTION

Information Communication Technology is a field which is not only diverse but also dynamic and rapidly changing ([1]; [2]; [3]). A major issue and concern is the need to avoid obsolescence and adapt to changing needs within the industry. The motivation to undertake this research arose primarily from an interest in the effectiveness and relevance of the programs offered by the Computing Department in order to meet the needs of local industry and society. The current research attempted to answer the question:

How relevant is the content of Computing courses offered within programmes of the Computing department of the National University of Samoa to meet the needs of industry and the workforce?

2. LITERATURE REVIEW

Computer science is an enormously vibrant field. From its inception just half a century ago, computing has become the defining technology of our age. The field, moreover, continues to evolve at an astonishing pace. As new technologies are introduced, existing ones become obsolete almost as soon as they appear ([1]; [4]).

It is frequently suggested that computer science curricula are generated in a vacuum with little or no regard for the "real-world needs" of the student's ultimate employer ([5]; [6]). Members of the academic and industrial communities are continually discussing the issue of the gap" between the training computer science graduates receive in academic institutions and the background industry requires of its new employees in computing related positions. Such discussions generally fall into one of two categories: (i) descriptions of the gap, and (ii) curriculum descriptions.

(i) Descriptions of the gap.
Discussions are frequently held at educational technology forums which attempt to characterize the gap by describing industry's needs and evaluating computer science curricula with respect to meeting these needs ([6]; [7]; [5]). Broadly stated, the gap can be described as: Computer science graduates that are not able to solve large, "real world" computing problems, adequately document their work or function well as members of a team ([7]; [8]).

(ii) Curriculum descriptions.
Many articles exist in the computing education literature ([9]) which describe new courses, usually of the work/study or internship variety, and which attempt to bridge the academic/industry gap. The emphasis in such courses is usually not on a particular area of computer science (such as operating systems) but rather on "real world" problems, documentation and team work.

Computer science education too often focuses on individual contributions rather than on managed group efforts that depend

on defined standards, methodologies and software processes. However, such group efforts are the norm in the software industry. New graduates often know little about what are regarded as "best practices" in the software engineering profession (e.g., practices related to use of software processes, measurement and analysis, team building, front-end development methods, quality engineering, software maintenance, and testing). This problem of inadequate preparation of current graduates is further intensified by the increasing demand for software engineers and other computing professionals [10].

Furthermore, in addition to the issues previously raised, the question has recently been raised whether computer science programs should prepare their graduates to be "tool users" or "tool builders". A classic example of this is the creation of websites which can be created using tools such as Dreamweaver and Publisher or alternatively can be built by programming using languages such as JavaScript, Java and HTML.

Technical advances over the past decade have increased the importance of many curricular topics, such as the following:
• The World Wide Web and its applications
• Networking technologies, particularly those based on TCP/IP
• Graphics and multimedia
• Embedded systems
• Relational databases
• Interoperability
• Object-oriented programming
• The use of sophisticated application programmer interfaces (APIs)
• Human-computer interaction
• Software safety
• Security and cryptography
• Application domains

As these topics become increasingly important, it is tempting to include them as undergraduate requirements. Unfortunately, the restrictions of most degree programs make it difficult to add new topics without taking others away. It is often impossible to cover new areas without reducing the amount of time devoted to more traditional topics whose importance has arguably faded with time.
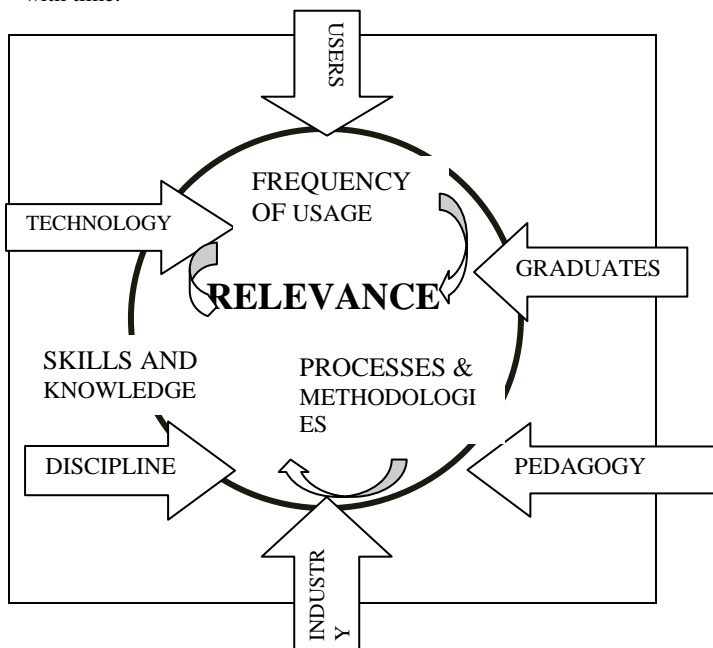

Fig.1 Key players and factors impacting relevance of curricula to industry.

The Computing Curricula 2005 Task Force ([9]) has therefore sought to reduce the required level of coverage in most areas to make room for new content.

Computing education is also affected by changes in the cultural and sociological context in which it occurs. The following changes, for example, have all had an influence on the nature of the educational process:
• Changes in pedagogy enabled by new technologies.
• The dramatic growth of computing throughout the world.
• The increasing economic influence of computing technology.
• Greater acceptance of computer science as an academic discipline.
• Broadening of the discipline.

From the scope of the literature, the key players in determining relevance of Computing curricula to the needs of local industry and society are i) the graduates, ii) the users of technology iii) the industry and ICT professionals, iv) the discipline. v) pedagogy, and vi) technology (refer Figure1).

The survey evaluated the perceptions of relevance of these key players and factors and as such decided the target respondent groups for this survey (refer Methodology section).

The survey evaluated relevance by gauging the frequency of usage of applications and tools that had been taught during the course of the curriculum. Secondly, the survey investigated the relevance of courses to the needs of industry by evaluating the usefulness of skills and knowledge within the program content to the skills and knowledge used in industry and the workplace. Thirdly the survey gauged the relevance of courses to industry by assessing whether computing processes and methodologies taught in the curricula have been useful and applicable to the industry and workplace.

Hence relevance within the context of this research is defined and measured in terms of i) frequency of usage of taught applications and tools within industry and the workplace, and ii) usefulness of skills and knowledge, computing processes and methodologies taught to the skills and knowledge, computing processes and methodologies used in the workplace (Refer Figure 1). It must be noted that these two levels of measuring relevance overlap and are interrelated.

4. METHODOLOGY

The current research is investigative in nature. Surveys were distributed to i) institutions which utilize ICT in Samoa but do not currently employ NUS computing students and graduates, ii) institutions or workplaces who are employers of NUS Computing graduates, and iii) NUS Computing graduates. Two versions of the survey were distributed. One version was for institutions and the second version was distributed to NUS computing graduates. The only difference between the two versions is the first section on background information and personal information. With the exception of some minor changes, the proposed survey is the same as the one which was administered in 2008 [11].

The survey was conducted in Upolu within the CBD as the bulk of ICT usage is within this area. For each institution which employed NUS graduates, surveys were distributed to immediate supervisors of NUS Computing graduates and current students, and also to NUS Computing graduates and/or current students. For institutions which utilize ICT but do not employ NUS graduates, surveys were distributed to the head of the ICT section or department. In conducting the survey, consent was sought and participants assured of the confidentiality of the information provided. In the end, the team

was able to obtain 32 responses. Of these 19 were from NUS computing graduates working in 12 different institutions in urban Apia; 3 from institutions employing NUS Computing graduates and 10 from institutions which do not employ NUS computing graduates.

Analysis:
Data from the surveys were mostly empirical data on the frequency of usage and relevance of curricular topics but there were also open ended questions on areas in the curricula needing coverage and/or improvement. Frequency of usage was measured using likert scale items from 1 to 4 with 1 corresponding to never used and 4 corresponding to daily usage. Relevance of topics was measured using likert scale items from 1 to 4 with 1 corresponding to not relevant and 4 corresponding to very relevant. Data from the surveys were analysed using SPSS and Excel. Data was presented graphically using bar graphs and also using frequency tables. For statistical analysis, standard statistics such as means, standard deviations and other tests such as chi-square were performed to determine any relationships and trends in the data and also the degree of relevance of the programs. The level of statistical significance was set at $p = 0.05$.

5. RESULTS AND DISCUSSION

The presentation of results is mostly in the order in which they appear in the questionnaire.

Organisational Systems
Table 1 shows the types of systems present in the 13 institutions that were surveyed. There is an increase in the number of systems utilised in the various institutions when compared to the 2008 survey. In the 2008 survey, very few had communication technologies such as video conferencing. Such information is important in guiding the skills required and what systems need to be taught within the computing curricula.

Table 1 Systems present in Institutions

Systems	A	B	C	D	E	F	G	H
processing accounts	✔	✔	✔	✔	✔	✔	✔	✔
Order entry & payroll	✔		✔	✔	✔	✔	✔	✔
inventory	✔	✔	✔	✔	✔	✔	✔	✔
scheduling	✔		✔	✔	✔	✔	✔	✔
wordprocessing	✔	✔	✔	✔	✔	✔	✔	✔
spreadsheets	✔	✔	✔	✔	✔	✔	✔	✔
databases	✔	✔	✔	✔	✔	✔	✔	✔
calculators	✔	✔	✔	✔	✔	✔	✔	✔
internet	✔	✔	✔	✔	✔	✔	✔	✔
telephone	✔	✔	✔	✔	✔	✔	✔	✔
faxes	✔	✔	✔	✔	✔	✔	✔	✔
videoconference	✔	✔	✔	✔	✔	✔	✔	
teleconference		✔	✔	✔	✔	✔	✔	
tv	✔	✔	✔	✔	✔	✔	✔	✔
Cablewireless radiomicrowave	✔	✔	✔	✔	✔	✔	✔	✔

Computer Skills Frequency of Usage
The tables below indicate frequency of usage or utilization of the various technologies in the institutions and by graduates surveyed.
The most frequently used technologies such as mobile phone, internet, email, spreadsheets and word processing were used by most of the institutions on a daily basis while at the other end of the spectrum, information systems and programming, presentation tools and graphics were used the least frequently. The mean frequency of usage across all participants was used as a measure of relevance with the higher means indicating greater usage (refer Table 3).

Table 2 Mean Frequency of Usage of Technologies and Software

Technology	N	MEAN	Std. Deviation
Email	32	3.97	0.18
Mobilephone	32	3.97	0.18
Worldwideweb	32	3.94	0.25
Wordprocessing	32	3.87	0.42
Spreadsheet	32	3.75	0.51
Scanners	32	3.47	0.76
PresentationTools	32	3.44	0.88
Socialnetworks	32	3.19	1.03
Digitalcamera	32	3.06	0.95
Hand held devices	32	2.91	1.23
DesktopPublishing	31	2.77	1.02
Videoconferencing	32	2.75	1.05
Graphicsprogram	32	2.63	1.05
Computing Programming	32	1.84	1.01
Multimedia development	31	1.68	0.98
Valid N (listwise)	31		

On average, the most frequently used and hence the most relevant topics were word processing, spreadsheets, databases, operating systems and presentation software followed by networking and graphic tools. The least used and topics with the least relevance were programming and multimedia development. These responses were very similar to the responses from the previous graduate survey ([11]).

Operating Systems (OS)
Most of the users have used file management, control panel settings, installing programs, hardware devices, network sharing extensively, including remote desktop connections, media and audio settings, Firewall, Command prompt for troubleshooting, Registry editing, regedit Time settings, Disk defragmentation, cleanup, and management services, the setup of network and user accounts, and the use of the device manager. Operating systems used were mostly Windows XP, Windows server, Windows NT, Windows 2003- 2012, Linux.
About 96% of the responses from all institutions indicated operating systems to be relevant, marginally relevant or very relevant to their work needs.

Suggestions for Improvement Responses from

participants indicated that this was a topic they all considered as very important in the workplace. Suggestions for improvement were extensive and included:

    i. Need for basic knowledge of operating systems, exposure to the latest operating systems including open source (Linux, Ubuntu), virtual OS.
    ii. Compatibility of various operating systems and between operating systems and hardware.
    iii. Installation and maintenance of user accounts
    iv. Security management
    v. Flexibility and reliability of operating systems
    vi. File management
    vii. Windows servers

Networks

Features of networking used in the workplace include network design, troubleshooting networks, routing protocols; making and laying cables, programming routers and switches, internet connections, broadband network bridges, remote access, setting up of IP addresses and IP domains, permissions. 90 % of the respondents indicated that networks were either marginally relevant, relevant or very relevant to their work requirements.

Suggestions for Improvement The majority of the responses indicated the need for knowledge of basic network concepts, and a strong need for more practicals on networking skills such as cable connections, LAN, WAN connections, setting up of IP domains, hubs, routers and switches including wireless. There were also suggestions for the offering of CCNA, A+ and MCSE certifications as part of the curriculum. Some of the suggestions included features such as troubleshooting hardware and software are recommendations which come under operating systems.
Inclusion of problem solving, analytic skills and critical thinking skills were also suggestions for improvement and this aligns well with recommendations from Simmons and Simmons [5] and [7].

Word Processing

Word-processing skills used in the workplace of the 32 respondents range from basic formatting to advanced features such as webpages, graphics, styles, macros and mail-merge.
The majority of the respondents (97%) rated word processing as relevant or very relevant.

Suggestions for Improvement Most of the respondents thought that the coverage was adequate and had no suggestions for improvement. Three of the respondents also recommended the need for NUS to teach up to date versions of word processing. Other respondents pointed out that word processing should not be taught as part of the degree program. Features recommended for inclusion include mail merge, integration of MS applications with Outlook, styles, auto format, autocorrect, import/export, table of contents and watermarks.

Desktop Publishing

Features of desktop publishing tools used in the workplace are covered in the section on graphic tools. About 83% of the respondents found desktop publishing to be relevant, marginally relevant or very relevant to their work in the workplace.

Suggestions for improvement Desktop publishing is not explicitly taught at the degree level at NUS but as part of word processing features. However desktop publishing is taught

as part of the Certificate of Computer Operating (polytechnic level) which prepares students to be computer operators, data entry operators. Also, web publishing is taught as part of the Human Computer interaction course (HCS386). Recommendations for improvement in desktop publishing include:

    i. Design of brochures for flyers, pamphlets, wall calendars, manuals/annual reports through use of Adobe, CS5 and Publisher
    ii. Web publishing
    iii. Teaching of video editing software
    iv. The need to resume the teaching of desktop publishing at NUS.

Spreadsheets

Responses indicated extensive use of spreadsheets in the workplace. Features of spreadsheets used in the workplace range from basic skills such as formulae, graphs, tables, filters to more advanced features such as merging, pivot tables, exporting, importing data, linked worksheets, and functions such as vlookup, countif. Majority of the respondents (90%) found spreadsheets as relevant, marginally relevant or very relevant.

Suggestions for Improvement The majority of NUS graduates indicated that all spreadsheet features covered in their degree are adequate for their work needs. However a few of them recommended the need to focus on more advanced features such as cross tabs, macros, linking and merging worksheets. These recommendations were also supported by responses from institutions.

Presentation Tools

The most widely used presentation tool in the workplace is PowerPoint. Features of PowerPoint used in the workplace included slide transitions, animations, action buttons, presentation notes, and narrations. 93% of respondents found presentation tools as relevant, marginally relevant or very relevant to their work.

Suggestions for Improvement PowerPoint presentation is not taught explicitly at the degree level although it is required and used for project presentations in class for quite a few courses. However PowerPoint is taught as part of the trades level Certificate in computer operations. Majority of the respondents indicated that all of the features covered as part of these presentations adequately meet their needs in the workplace. It was also mentioned that this is used as the main form of presentation in industry. Suggestions for improvement included the need to cover any newer versions of slide layouts, shortcuts, inserting sound and animations.

Graphic Tools

Features of graphic tools used in the workplace included design of logos, brochures, postcards, posters, advertising, business cards, notices, newsletters, invitations, graphics websites and slide shows, image retouching, photo editing. Soft wares used include Dreamweaver, Photoshop suite, Publisher, IBM WebSphere. Ninety percent of respondents found graphic tools as relevant, marginally relevant or very relevant to their work.

Suggestions for Improvement Graphic tools were taught as a community course at NUS by graphic experts but discontinued after their departure. Graphic tools are taught though at the trades level Certificate in computer operations.

The majority of the respondents indicated the strong need to resume teaching of these skills at the degree level. Features to be covered are all those indicated earlier in the Graphics tools section.

Databases
Features of databases used in the workplace include Creating databases, queries, forms, reports, macros, drag and drop programming, SQL programming, searching databases. The point to note is that relatively to other topic areas, most of the content of databases covered in the curriculum are used in the workplace. Aspect not covered in the syllabus is web integration of databases and while Access is used in the curriculum, some workplaces are using other database management systems such as CSPro. 93% of respondents found databases as relevant, marginally relevant, or very relevant to their work in the workplace.

Suggestions for Improvement Most of the respondents found the curriculum content to be adequate and indicated that everything covered in the curriculum was relevant. Suggestions for improvement included more focus on SQL programming, introduction to CSPro, introduction of MySQL and other database platforms, and web based database applications.

Information systems
The majority of respondents indicated that they used Information systems and features used were all features currently taught within the curriculum. These included Systems development life cycle, case tools, systems analyses, systems design, and systems evaluation. 89% of the respondents found information systems relevant, marginally relevant or very relevant to their workplace needs.

Suggestions for Improvement Recommendations from institutions without NUS graduates included all features which are currently covered in the Information systems courses. Other recommendations such as scalability, confidentiality and security were more relevant for the management of information systems course.

Management of Information systems Features of management of information systems used in the workplace were all features taught in the curriculum such as Porters Competitive forces, value chain, Rockart's CSF, Nolan's stages of growth, Mintzberg theory on bureaucracy, ICT strategic planning, Risk management, Disaster recovery. Eighty five percent of the respondents found management of information systems as relevant, marginally relevant or very relevant.

Suggestions for Improvement All of the features recommended for inclusion exist in the current management of information systems course. An important recommendation is one which suggested a strong emphasis on security, and on strategic planning and risk management as there is a strong push in the ministries for these skills.

Computer Programming
Programming languages used in the workplace included Visual Basic, Java, JavaScript, VBScript, Html, .Net, PHP, SQL, RPG and C++. However, it must be noted that most of these listed were used by only one or two workplaces and with two institutions reporting not using any languages at all. The majority of institutions indicated that they do not use programming in the workplace. Those institutions which use programming in the workplace use it for programming web pages and one respondent indicated the use for programming databases. Sixty six percent of survey respondents indicated computer programming as relevant, marginally relevant or very relevant. This has remained relatively unchanged from the first graduate survey where 63% indicated programming as relevant. Of all the topics in the curriculum computer programming is the one with the lowest number and percentage of respondents indicating as relevant.

Suggestions for Improvement The majority of respondents (2/3) did not post any responses as most of them do not use programming in the workplace with the exception of programming webpages. Recommendations for the inclusion of Dreamweaver, and ASP.NET need to be looked at as other recommendations such as html programming and SQL programming are already included in the curriculum. A useful recommendation by one respondent indicated:
"*Know the basics of programming languages, diff languages have diff features, limitations, and platforms on which programs runs on, requirement, design the program functions based on identified requirements, implementation concepts, architecture and coding structure, maintenance and devpt, do testing...*"

Human Computer Interaction
Features used in the workplace include interface design life cycle, design of interfaces (forms, reports), evaluation of interfaces, web page design, use of Visual basic for programming interfaces, windows widgets with the majority of the respondents indicating web design as the major use of HCI in the workplace.
80% of the respondents indicated that Human Computer Interaction is relevant, marginally relevant or very relevant to the workplace.

Suggestions for Improvement Over half of the respondents did not give a response to this question. Recommendations included the need to offer web design at NUS which is already being implemented. An important recommendation is the need to cover web based integration with databases as this aspect is missing from the curriculum.

Statistical tests
Chi-square tests to test for i) any significant differences in responses between students on the frequency of usage of the technologies and ii) to test for any significant differences in responses between students on the relevance of the curriculum topics to the workplace failed to achieve significance.
Chi-square tests to test for i) any significant differences in responses between institutions on the frequency of usage of the technologies and ii) to test for any significant differences in responses between institutions on the relevance of the curriculum topics to the workplace did not achieve significance.

6. SUMMARY & CONCLUSION

The goal of the current study was to evaluate how relevant the Computing courses taught at NUS are to the needs of industry and the workplace. Two measures were used to evaluate the relevance of the curriculum to the workplace: a) frequency of utilisation of the various technologies and b) percentage of respondents who found the curriculum as marginally relevant, relevant or very relevant.

In terms of frequency of utilization (refer Table 2), the most frequently used and hence the most relevant topics were word processing, spreadsheets, databases, operating systems and presentation software followed by networking and graphic tools. The least used and topics with the least relevance were programming and multimedia development. These responses were very similar to the responses from the previous graduate survey ([11]).

Percentage relevance was obtained by adding the percentage of the respondents who found the topic as relevant or very relevant.

In terms of percentage relevance respondents found the majority of the aspect In terms of percentage relevance respondents found the majority of the aspects of the various topics in the curriculum either relevant or very relevant to their employment in the workplace with percentage relevance ranging from 66% to 97%. (refer Table 3)s of the various topics in the curriculum either relevant or very relevant to their employment in the workplace with percentage relevance ranging from 66% to 97%. (refer Table 3)

Table 3. Percentage Relevance of Topics

Topic	Percentage relevance	Mean	Std. Deviation
Word processing	97%	3.62	0.67
Spreadsheets	90%	3.48	0.69
Operating systems	96%	3.46	0.84
Databases	93%	3.46	0.92
presentation tools	93%	3.39	0.92
Networking	90%	3.17	1.07
Graphic tools	90%	3.14	1.06
Desktop publishing	83%	2.97	1.09
Management systems	85%	2.89	1.12
Human Computer Interaction	80%	2.88	1.09
Information systems	89%	2.85	1.06
Programming	66%	2.38	1.18

Using percentage relevance as a measure, respondents found Word processing, Networking, Operating systems, databases and presentation tools as most relevant but programming, relatively not as relevant.

The outcomes of this research have provided useful information about the relevance of the current content within the curriculum and can be applied within the context of improving our course offerings within our programs. In conclusion, the current study has shown that the current Computing curriculum is to a large extent relevant to the needs of industry. However it also indicates the curriculum coverage is not sufficient and there are recommendations for improvements identified by this study which need to be taken on board. It is recommended that the gap between graduates' skills and industry needs must to be addressed by a concerted effort by both the NUS computing curriculum and on the job training offered by industry.

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