Feasibility of Mapping IT Programs and Courses to IT Skills Frameworks

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ABSTRACT

Information Technology (IT) solutions have revolutionized organizations' approaches to more effective design, development, and delivery of products and services. Intense use of IT solutions has in turn increased the dependency of organizations on IT solutions. As a consequence, reliance on technology has created an increasing demand for the availability of skilled IT personnel. Universities and other forms of tertiary institutions play a key role in developing skilled IT personnel. In recent times, internationally recognized skills frameworks have been considered as a strategic tool for industry-education alignment - by standardizing the expectations of and the scope of operations related to IT skills. This paper examines the feasibility of mapping IT programs and courses with skills frameworks. Outcomes of a pilot study are used to outline potential benefits of skills frameworks as an alignment tool. The study indicated that overall mapping of existing technology education courses/programs to skills frameworks is feasible. At the same time, the study highlighted a number of key requirements for ensuring that the mapping exercise if effective.

Keywords: IT Education, Skills Frameworks, Industry-Education Alignment, Mapping IT courses to Skills Frameworks

1. INTRODUCTION

There has been an ongoing debate on the importance of aligning Information Technology (IT) qualifications with industry needs (Asgarkhani & Shankararaman, 2014b). Institutions apply various methodologies to establish the alignment between their educational programs and skills demand within the IT sector. The reform in IT education to align more effectively with industry demands can be complicated. One of the key barriers is the mismatch of timeframes. More specifically, IT skills and the need for skills change rapidly. At the same time, educational programs for IT do not frequently change – often due to the time-consuming process of quality assurance, program and course approval.

Another complication in reforming IT education for more effective alignment with job market demands has been a lack of standards. Lack of standard definition of roles and the required skills has resulted in inconsistencies in views of skills required for IT positions. Consequently, standardization of the definition of roles and the associated skills sets can facilitate improved alignment of education and the IT industry.

Standardizing the definition and requirements of industry skills is not new. Some professional bodies in various countries had in the past attempted to develop a standardized definition of IT skills for better management of supply and demand for IT skills. For instance, the Australian and New Zealand Standard for Classification of Occupations (ANZSCO) was developed to guide the recruitment for skills. It had been used by immigration services in both New Zealand and Australia for guiding migration of skilled workforce – including IT. The Singapore Workforce Development Agency developed an IT skill framework called National Infocom Competency Framework (NICF) to facilitate the development of the skilled IT workforce (Asgarkhani, 2012; Asgarkhani & Shankararaman, 2014B).

Another skills framework for IT was established in 2003. The Skills for Information Age (SFIA – www.sfia-online.org is seen as a framework to facilitate matching skills of the workforce to the requirements of the IT sector and the business. In comparison with other frameworks, SFIA has a more comprehensive range of skills. Another perceived advantage of SFIA is the second dimension of skills; namely the level of authority for various IT skills.

Regardless of the framework, both practitioners and theoreticians claim that IT skills frameworks offer various benefits and/or applications – such as:

- Standardizing the development of contents for courses aimed at specific skills.
- Creating an opportunity for organizations to define roles and expected skills sets related to a role in a more globally defined fashion.
- Writing CVs in a form that describes the skills in a more globally recognized form.
- Organizations can assess and define professional development opportunities for capability development.
- Internationalization and globalization of what is understood of IT skills
- A clearer definition of required skills is needed for immigrants.

At the same time, benefits outlined above assume that the implementation of a specific framework (more specifically, mapping of courses and programs to a framework) can happen in all cases without any significant challenges. There seems to be a lack of standard approaches and specific requirements related to the mapping exercise.

For skills frameworks to be effective, both the education and the industry should be able to map the courses and IT roles to a particular framework effectively. Some organizations have made an effort to define their IT roles based on SFIA categories of skills - For instance, Dorsett County Council (https://www.dorsetforyou.com/).

Similarly, the effective use of skills frameworks is subject to the feasibility of mapping IT programs and courses to frameworks. This study examines the feasibility of using skills frameworks by looking at the implementation issues. More specifically, it looks at techniques, tools, and methodologies that can be deployed for the mapping of courses and programs.

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It is based on two case studies of mapping specific courses to SFIA. It highlights key challenges in the implementation of skills frameworks.

The paper often refers to "Education-Industry Alignment." It should be noted the alignment refers to standardizing the definition of roles and skills in IT in both sectors. A standardized definition of IT skills (and roles) should facilitate the most effective assessment of skills needs and help educators plan to develop IT workforce with skills in demand.

2. RESEARCH DESIGN AND METHODOLOGY

The actual research related to IT education and industry alignment is broader than what this paper presents. This paper presents the outcome of a preliminary assessment of the feasibility of using skills frameworks in the IT education sector.

Research questions related to discussions in this paper are:

- Is it feasible to define IT programs and courses by skills they develop and map skills to SFIA?
- What are the challenges in mapping an existing IT program (or course) to SFIA?

Information forming the basis of discussions in the paper are based on:

- A review of previous literature and case studies to establish key parameters of industry and education alignment.
- Study of skills frameworks and their applications in the past.
- Implementation of SFIA (manual mapping courses to SFIA skills) using a number of courses of the Bachelor of ICT program – to establish a first impression of challenges.
- Analysis of an implementation case using text mining instead of a manual mapping approach.

3. THE IT EDUCATION SECTOR – ASSESSING DEMAND FOR SKILLS

There is an ongoing debate on the suitability of IT graduates for the IT industry – both in the number of graduates and skills gained through educational programs. In other words, there have been discussions on whether or not the training and education programs in IT match industry expectations. At the same time, we are witnessing a change in culture and attitudes within the IT job sector. There is a growing emphasis on recruiting IT professionals with recognized qualifications (Asgarkhani, 2012). This is evident in a drop in the number of IT personnel who do not have a formal qualification. For instance, Cappelli in his study in 2001 outlined that only about half of IT professionals had bachelor's degrees, and only 10% of workers in programming positions had a bachelor's degree of any kind. Reports from the Department of Communications, Information Technology and the Arts Australia in 2004 show that only 9% of IT professionals did not obtain a formal IT qualification (Cappelli, 2001). The shift in the culture of employment marketplaces added pressure on higher education sector for delivering IT qualifications to a bigger number of students. At the same time, there is an expectation that programs are current and relevant.

Both industry and education sectors are concerned about the employability of some IT graduates. They argue about "a divorce between the formal existing educational institutions and the needs of IT professionals by the industry" (Baltac, 2008; Mazzeo et al., 2008; Baumgartner and Shankararaman 2013) Such disconnection has been seen as the origin of the scarcity of IT professionals in many IT skills areas Asgarkhani, 2012; Baumgartner, 2013; Fletcher, 2012; Queensland Government, National ICT Skills Summit, 2006; Rabayah and Sartawi, 2008; Robertson, 2013; UNESCO, 2006; Van der Vyver, 2009).

An investigation on graduate unemployment conducted by United Nations Educational Scientific and Cultural Organization (Statistics New Zealand, 2006) also identified mismatch of ICT qualifications with employers' needs. Findings suggest that technical skills that graduates learned were "outdated and do not match the state-of-art technologies in use at the workplace" (Nelson et al., 2006).

The IT education sector plays a key role in developing the skilled IT workforce. Tertiary educational institutions develop the portfolio of IT programs for training the future IT workforce. There exist various practices for program and curriculum development.

IT educational programs in the tertiary sector are developed by either individual institutions (such as universities) or by professional bodies and government-connected agencies. For instance, in New Zealand, the New Zealand Qualifications Authority (NZQA – www.nzqa.org.nz) has a role to ensure that New Zealand qualifications are being robust both nationally and internationally.

Universities in New Zealand develop their programs and have no direct working relationship or connection with NZQA. A similar practice was observed in some other countries (Sheng Xun et al., 2015; Asgarkhani, 2012). For instance, in Singapore, developing university courses does not require any approval from government bodies. For launching a new program approval from the University Board is sufficient (Asgarkhani and Shankararaman, 2014A). For professional programs, the approval of Singapore's NICF (National Infocomm Competency Framework) is needed.

Program development can also be guided by frameworks suggested by internationally recognized bodies. For instance, the "IS 2010" report is a framework to guide curriculum for Information Systems developed by Association for Computing Machinery (ACM – www.acm.org) and Association for Information Systems (AIS). Computer Science Curricula 2013 which outlines guidelines for undergraduate degree programs in Computer Science was developed by a joint task force on Computing Curricula by Association for Computing Machinery (ACM) and IEEE Computer Society.

The education sector uses a variety of approaches to avoid the risk of a disconnect between educational programs and industry needs. These approaches can include:

- Research by both academics and the IT sector to project the demand for skills.
- Use of statistics collected by formal government statics agencies (e.g. Statistics NZ) and government initiated research in skills needs for future developments.
- The inclusion of advisory boards from the IT sector in program development.
- Formal and informal joint industry forums to collaborate with industry and keep up to date with developments that can change skills needs in both short and long terms.

In Singapore, the National Infocomm Competency Framework (NICF) was developed in 2009, The framework was developed in collaboration with the Singapore Workforce Development Agency (WDA), the Infocomm Development Authority of Singapore (IDA) and strategic stakeholders in the Information and Communication Technologies (ICT) industry (Hagan, 2004). NICF to date has identified 587 competency standards for 314 job roles. The NICF enables training providers to develop and align their training programs and is also used as a tool for businesses to develop its human resource capabilities.

Some government-based agencies conduct investigative activities such as census and collect data that can help projection of required skills and human resources. For instance, as outlined earlier, Statistics NZ provides census data that can be used by industries to assess future development strategies. At the same time, the census is not necessarily tuned to identify needs of a specific industry.

In many educational institutions, advisory boards from the IT sector are formed to facilitate collaborative development of IT education programs. Even though this appears to be a credible approach, in reality, the success depends highly on people involved and their commitments to be involved. The success of this strategy can also depend on how seriously an institution approaches implementation and to what extent the advisory boards is involved.

Another factor that impacts IT skills development is the uptake of IT education by secondary school students. There is a need worldwide to educate secondary school educators and students to become aware of roles IT industry offers, so they make a better-informed decision about tertiary studies. For instance, the Institution of IT Professionals in New Zealand (IITP NZ) launched a national project in 2012 (ICT Connect) to engage high profile IT industry personnel to attend high schools and raise awareness of the broad range of IT roles available (www.iitp.org.nz).

In general, most issues that create barriers to a more accurate assessment of skills needs and development of more effective programs of study originate from lack of standards. Studies in skills needs can be more consistent if there are standards to follow. Similarly, if the view of the IT sector of IT roles and the understanding of the education sector of the needed skills are better aligned, there is a better chance of reduced disconnect between education and industry. IT skills frameworks' standards can facilitate a better understanding of skills needed and more effective alignment of IT sector and academics.

4. AN INTRODUCTION TO SKILLS FRAMEWORKS

Over the last decade, numerous classifications of IT skills have been developed and introduced. Some were developed by academics and introduced by the IT industry practitioners.

Skills-based programs have been part of the education systems. However, most of such programs have been implemented in the professional or vocational training sector. Thus, only in recent years skills-based teaching and learning has found its application in higher education – primarily due to the growing gap between the academic curricula of the higher education institutions and the actual demands of businesses and society. Higher education institutions are attempting to reshape their programs to consider a professional orientation – by using competency frameworks.

In their study of Information System (IS) job advertisements from 1970 to 1990, Todd, McKeen and Gallupe classified the IS job skills into 7 categories: hardware, software, business, management, social, problem solving, and development methodology. Nelson (Lauden & Lauden, 2006) categorized 30 IS knowledge/skills into six groups: organizational knowledge, organizational skills, organizational unit, general IS knowledge, technical skills and IS products. Amongst the six groups, organizational knowledge, and organizational units are the skills/knowledge related to the specific organization or business environment in which the IS practitioners work. Organizational skills include the interpersonal skills such as the ability to work in a team; ability to communicate effectively; ability to lead, control, manage and organize, to name but a few.

Today, both technical and non-technical skills are required of IT workforce. In attempting to standardize roles and responsibilities within the sector (so as to making it easier to train, develop and drive recruitment selection processes) some industries supported standards for frameworks were developed. A roles/occupation framework that has been widely used within Australia and New Zealand is ANZSCO (Australia and New Zealand Standard Classification of Occupations).

Another scheme that was developed in more recent times and seems to have gained credibility internationally is the Skills Framework for Information Age (SFIA). SFIA seems to be becoming accepted as the global framework that could lead towards standardization of IT skills. SFIA brings together a comprehensive set of skills structured into three layers. The first layer outlines the broad categories of skills followed by the second layer of sub-categories. Finally, the third layer covers attributes and characteristics of specific skills within sub-categories.

Broad SFIA categories of skills include:

- Strategy and architecture
- Business change
- Solution development and implementation
- Service management
- Procurement and management support
- Client interface

In addition to skills, SFIA has a second dimension related to responsibility levels associated with skills. There are seven levels of responsibilities in SFIA.

- Level 7 – Set strategy, inspire, mobilize
- Level 6 – Initiate, influence
- Level 5 – Ensure, advise
- Level 4 – Enable
- Level 3 - Apply
- Level 2 - Assist
- Level 1 – Follow

Compared with previously developed frameworks, SFIA has gained popularity internationally in a short time (Asgarkhani, 2012). It has been adopted by a variety of IT professional bodies (Institute of IT Professionals NZ, Australian Computer Society, and British Computer Society) as a model for certification of IT professionals for accreditation and certification. What's more, some international IT and engineering qualification certification bodies (for instance professional bodies working under Seoul Accord – www.seoulaccord.com) have adopted SFIA as a model to drive accreditation processes.

5. ASSESSING FEASIBILITY OF MAPPING IT PROGRAMS AND COURSES TO SKILLS FRAMEWORKS

This section discusses the feasibility of implementation of skills frameworks in IT programs and courses. Connecting IT educational programs with standards driven by skills frameworks requires analysis of both the contents and the learning outcomes.

Analysis of contents and learning outcomes can be done either manually or by use of automated tools – such as text mining tools.

The pilot study of the feasibility of mapping courses to skills frameworks discussed in this paper was conducted manually. However, in presenting the concluding remarks, the outcome of an experiment that used text mining was also considered. SFIA was used as the selected framework.

The mapping exercise made use of a portfolio of Information Systems courses. The outcome expected was defining the learning outcomes and skills based on skills categories of SFIA.

The experiment was conducted at the broader level of learning outcomes. More specifically, the focus was on learning profiles of course descriptors with the intention of defining a graduate profile mapped to SFIA.

The initial experiment involved three courses. This new experiment extended the exercise to be carried over five courses.

The methodology for this case study consisted of:

- Building a simple assessment model to map learning outcomes of a portfolio of courses to SFIA skills and levels of responsibility (Figure 1).
- Using the model established above to map expected learning outcomes of each course to categories of SFIA skills and the relevant level of responsibility. The mapping exercise was completed by a team of 3 experts – to improve accuracy and reliability of decisions made in this mapping exercise by the moderation of interpretations of skills by individuals.
    - The outcome of the mapping exercise was further moderated, analyzed and then led to compiling a SFIA-based profile of skills and levels of authority expected from the graduates of the Information Systems and Strategies specialization stream.

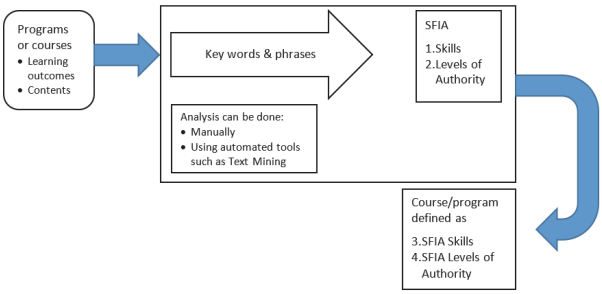

Figure 1. A Model for mapping programs and courses to SFIA

The outcome of this exercise was a graduate profile defined by using SFIA's skills and expected levels of responsibilities associated with those skills.

The model that was used for assessment of skills in every course had four components. The first two components showed SFIA main and sub-categories of skills. The third component was used the record the outcome of the assessment and mapping. The fourth element was to record levels of authority.

Strategy and Architecture

- **Information Strategy** - IT Governance, Information Management, Information Systems Coordination, and Information Analysis
- **Advice and Guidance** – Consultancy
- **Business and Strategy and Planning** – Research, Business Process Improvement, Enterprise and Business Architecture Development, Risk Management
- **Technical Strategy and Planning** – Emerging Technology Monitoring, Software Development Process Improvement, Sustainability Management for IT, Data Management

Business Change

- **Business Change Implementation** - Portfolio Management, Project Management
- **Business Change Management** – Business Analysis, Requirement Definition and Management, Business Process Testing, Business Modelling

Solution Development and Implementation

- **System Development** – Data analysis
- **Installation and Integration** – Systems Integration, Systems Installation/Decommissioning

Service Management

- **Service Strategy** – IT Management
- **Service Design** – Capacity Management, Service Level Management
- **Service Transition** – Change Management, Release, and Deployment

Client Interface

- **Client Support** – Client Services Management

Procurement and Management Support

- **Quality and Conformance** – Quality Management, Quality Assurance, Quality Standards, Conformance Review

Levels of Responsibility

Level 2-4: Assist, apply and some level of enabling. Most of learning outcomes fall within level 3 (apply).

The aim of this pilot study was to assess the feasibility of using SFIA to redefine course and program profiles so as to create more alignment with industry relevant skills.

This study was focussed on an existing profile within a tertiary sector institution. It may not necessarily address all issues that could be related to developing new learning profile aligned with SFIA. However, most of broader learnings from this experiment would still apply.

In assessing feasibility, in addition to the case study discussed above, an analysis of a similar mapping exercise was conducted. Sheng Xun et al. (2015) used an automated text mining approach to mapping the Information Systems degree at Singapore Management University (SMU) to SFIA. Despite differences in the mapping approach, the outcome seemed fairly consistent with the case study discussed earlier.

The outcome of the pilot study described above can be summarized as follows:

- SFIA is a complex model. It covers a comprehensive set of skills. SFIA can be used in a broader sense beyond IT and IS to relate to almost any technology-based learning - including the engineering field).
- In-depth understanding of SFIA is a key factor in accurate alignment of courses and programs of studies to SFIA skills.
- The pilot study highlighted that alignment of skills and learning outcomes can to some extent involve interpretations from an individual. To minimize the risk of interpretations, it is critical to moderate the outcome of analysis – involving views of more than one individual.
- This exercise was conducted on a limited number of courses (a portfolio of five). However, it required

considerable resources. Broadening the use of this model to a large number of qualifications (for instance for the purpose of accreditation) requires planning and allocation of resources that are needed to ensure effectiveness and success.

- The outcome of the study suggests that it is feasible to align existing tertiary technology programs with SFIA skills – subject to adequate planning and proper allocation of resources.

The experiment discussed above outlined the possibility of mapping graduate outcomes and course contents of IT qualifications to SFIA. However, mapping IT qualifications to SFIA alone will not address the lack of alignment between the IT and education sectors. SFIA as an alignment tool can become a reality only if IT sector roles are also mapped to SFIA skills and levels of authority.

Considerable work in both education and IT sectors need to be carried out for developing a framework for educational programs and IT roles alignment. Such framework could typically involve broad steps as follows:

- Definition of IT roles and skills based on an internationally accepted skills framework such as SFIA.
- Skills and roles in demand assessed and identified according to skills categories and authorities as outlined by SFIA.
- Educational programs developed mapping graduate profiles and course contents to SFIA when addressing the shortage of IT skills.

6. CONCLUSIONS

IT plays a crucial part in both economic and social development. Companies increasingly rely on IT to deliver product and services – that has in turn encouraged a high level of investment in IT.

With a high level of investment, there is an expectation of high returns and desirable outcomes. High returns cannot be achieved by deploying technology alone; there is a need for the adequately skilled IT workforce to operate technology solutions that enable businesses.

The high demand for skilled IT personnel is a worldwide phenomenon. Governments, the IT sector, and the education sector project needs on an ongoing basis so as to develop effective skills development strategies. Tertiary education institutions play a key part in skills development. It is essential that educational programs offered to train IT personnel are effective. Effective of programs can be best achieved by close alignment of education and industry.

Educational institutions employ a variety of approaches for more effective alignment of educational programs with industry demand for skills. In recent times, it has been suggested that standardization of the definition of IT roles within both education and IT sectors can minimize barriers to the effective development of the IT workforce. Skills frameworks (such as SFIA) are seen as effective tools to standardize the definition of T roles.

The pilot study outlined in this paper intended to examine the feasibility for mapping IT programs and courses to skills frameworks.

The outcome indicated that overall SFIA can be an effective framework. More specifically, it seemed feasible to define course learning outcomes based on SFIA categories of skills and levels of responsibilities.

The outcome presented in this paper is based on a pilot experiment only. It involved analysis of courses at a broad level. Despite concluding that use of SFIA in the education sector is feasible, it should be noted that the outcome may not apply to every case across the board. Further studies involving detailed analysis of mapping feasibility can provide educators with more accurate guidelines related to the mapping exercise.

In addition to outcomes presented in the previous section, other broad learnings from the exercise include:

- The application of frameworks seems more practical when new programs and courses are being developed.
- The mapping practice can be at risk of interpretations. There is a need for standard methods of alignment of current programs and courses – without risking confusion and leaving the alignment practice open to interpretations.
- Industry buying in is necessary – there is no point to investing time and resources on the alignment if there is no connection or acceptance of a particular framework by the industry.
- The relevance of accreditation processes can play a key part in education and industry sectors' commitment to the use of frameworks. For instance, does accreditation of a program of study make a difference to the success of that program? Do international accreditation bodies such as Seoul Accord make a difference in achieving a more effective alignment internationally?

7. REFERENCES

Asgarkhani (2012) A strategy model for assessing e-learning and technology assisted knowledge management: an overview, *International Journal of Information and Education Technology*. 2(6): 633-637. ISSN 2010-3689.

Asgarkhani & Shankararaman (2014A). Skills frameworks for industry and IT education alignment: A pilot study. Proceedings of the IEEE International Conference on Teaching, Assessment, and Learning pp 206-213.

Asgarkhani & Shankararaman (2014B) Skills Frameworks: A Tool for Reform in Information, *Proceedings of the International Conference on Computer Science Education*, Canada, 81-86.

Green & Gilbert (1995) Great Expectations: Content, Communications, Productivity, and the Role of Information Technology in Higher Education. *The Magazine of Higher Education*, 27(2), 8-18.

Baltac (2008) European universities and ICT industry. E-Government; ICT Professionalism and Competences; Service Science, *FIP International Federation for Information Processing*, Volume 280.

Mazzeo, Bellini & Motta (2008) E-government ICT Professionalism And Competences Service Science, Springer-Verlag.

Baumgartner & Shankararaman (2013) *Singapore Strategic and Skills-in-Demand List (SSL)*, 16th August 2012, Ministry of Manpower.

Baumgartner (2013) Actively linking learning outcomes and competencies to course design and delivery: experiences from an undergraduate Information Systems program in Singapore, *IEEE Global Engineering Education Conference (EDUCON 2013)*, Berlin, Germany.

Cappelli (2001) Why is it so hard to find Information Technology workers? Organizational Dynamics, 30(2), 87-99.

Fletcher (2012) "*NZ part of IT skills shortage danger", says Joyce* Retrieved 24 January, 2014 from http://www.nzherald.co.nz/connect/news/article.cfm?c_id=1501833&objectid=10819097.

Hagan (2004) Employer satisfaction with ICT graduates, The Sixth Australasian Computing Education Conference (ACE).

Lauden & Lauden (2006) Essentials of Management and Information Systems, 6th Edition, NJ: Pearson, Prentice Hall.

Nelson, Kattan & Cheney (1991) An empirical re-examination of the relationship among training, ability, and the acceptance of information technology, *Proceedings of the 1991 ACM SIGCPR Conference,* Athens, GA, 177-186.

Queensland Government (2006) National ICT Skills Summit – Issues Paper. Retrieved September 7, 2008, from http://www.iib.qld.gov.au/skillsChallenge/downloads/Issues_Paper.pdf.

Rabayah & Sartawi (2008) Enhancing the labour market prospects of ICT students in a developing country, Education & Training, 50(3), 244-259.

Roberton (2013) ICT Trends – Global & NZ Demand. CITRENZ Newsletter, October 2013. Retrieved on 12 February, 2014 from http://www.citrenz.ac.nz/wp-content/uploads/2013/10/CITRENZ-Newsletter-Oct-2013-final.pdfSelhofer, H. (2000). Skills shortage vs. job creation: a review of empirical evidence on the issue of ICTs and employment. Vierteljahrshefte zur Wirtschaftsforschung, 69(4), 510-526.

Statistics New Zealand (2006) Information and Communication Technologies in New Zealand.

UNESCO Bangkok (2006) A multi-stakeholder approach to address graduate (un)employment. Retrieved on 10th August, 2009 from http://unesdoc.unesco.org/images/0015/001529/152959e.pdf, 2006.

Van der Vyver (2009) The search for the adaptable ICT student, *Journal of Information Technology Education*, Volume 8, 19-28.

Sheng Xun, Gottipati & Shankararaman (2015) Information Technology Based Higher Education And Training, Proceedings of the IEEE Information Technology Based Higher Education and Training (ITHET) Conference (2015), Retrieved June 30, 2015, from http://ieeexplore.ieee.org/

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