Research Report

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Science and Technology Stakeholders' Ranking of Graduate Competencies Part 3: Graduate Perspective †

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Previous research has investigated stakeholder views of the importance of workplace competencies for business students, graduates, and employers. We recently reported on similar study of science and technology employers and students. Here we report the views of a cohort of recent science and technology graduates. The study suggests that these recent graduates hold views in general agreement with their employer and student counterparts. But it seems that the recent graduates' views have shifted away from that of students to become more in accord with employers. This suggests that additional workplace experience begins the process of enculturation into the workforce as graduates become part of a community of practice. (*Asia-Pacific Journal of Cooperative Education*, *2003*, *4(2)*, *23-35)*.

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This paper reports on science and technology recent graduates' perceptions of specific work place competencies. Recent work reveals differences in perceptions of the importance of certain desirable graduate competencies for science and technology students and employers (Coll, Zegwaard & Hodges, 2002a, 2002b) and their business counterparts (Burchell, Hodges & Rainsbury, 2001).

The aim of the present study was to build on previous studies of science and technology students and employers, to see if recent graduates have differing views from either undergraduate students or employers. This was deemed of importance in that we wanted to see if views of graduate competencies change as students become graduates and new employees. Research in science education suggests that student prior conceptions greatly influences their learning and perceptions of learning (Pfundt & Duit, 1997) and it was of interest to see if similar prior conceptions, in this case of graduate competencies, are influential in students' thinking after graduation.

Theoretical Basis of the Study

The theoretical basis of this study is that described in detail in previous work (Coll, Zegwaard & Hodges, 2002a, 2002b), and which was in turn based on similar studies of business counterparts including employers, students, recent graduates and academics (Burchell, Hodges & Rainsbury, 2001; Rainsbury, Hodges, Burchell & Lay, 2002). Hence, here we only briefly summarize the theoretical basis of the study. We are interested in stakeholders' ranking of desirable graduate competencies: the latter which we see as underlying personal characteristics of an individual (Boyatzis, 1982; Spencer & Spencer, 1993), how an

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individual draws upon such characteristics, and the relationship between contextual task performance and individual attributes (Birkett, 1993; Rudman, 1995; Stephenson, 1997). A competent individual is an individual who has both generic skills, along with specific skills and attributes relevant to tasks to be undertaken. Individual attributes are seen to comprise both cognitive skills (such as technical knowledge, skill and ability) and behavioral skills (such as personal characteristics, i.e., attitude, value and motives).

The graduate competencies used in this study are derived from a taxonomy presented by Birkett (1993), which include cognitive skills and behavioral skills. Cognitive or 'hard' skills comprise of technical skills, analytical skills and appreciative skills (Page, Wilson & Kolb, 1993). Behavioral skills, or 'soft' skills, comprise personal skills (such as how one responds and handles various situations), interpersonal skills (such as securing outcomes through interpersonal relationships), and organizational skills (securing outcomes through organizational networks) (Caudron, 1999; Kemper, 1999; McMurchie, 1998). For both cognitive and behavioral skills, the skills may be ordered according to increasing complexity, and be considered to be cumulative in that the skills build upon each other. For example, if an individual applies technical skills well, the next level might then be to develop analytical and problem-solving skills. Any successful or competent individual will likely hold a combination of cognitive and behavioral skills (Birkett, 1993).

Many authors now see hard and soft skills as complementary (Spencer & Spencer, 1993) and Hackett, Betz and Doty (1985) identified a number of skills that sub-serve the broader function of soft skills. These include things such as the ability to communicate well, to relate effectively to others, to plan and manage the demands of one's job, to exercise leadership, and to cope with stress effectively. Some are of the view that employers commonly neglect the development of soft skills because of perceptions of difficulty in their measurement, or difficulty in demonstrating a link between them and desired work outcomes. Furthermore, soft skills are seen by some to be more difficult to develop than hard or technical skills (Arnold & Davey, 1994; Caudron, 1999; Georges, 1996).

The work reported here was informed by sociocultural views of learning (Werstch, 1991). We wish here to develop an understanding of perceptions of desirable graduate competencies for the participants in this study. Sociocultural views of learning suggest that past research has not paid enough attention to the social mediation of mental construction (such as individuals' perceptions and beliefs). Wertsch (1991) summarizes the basis of a sociocultural approach as one in which learning is seen as "inherently situated in social interactional, cultural, institutional, and historical context. Such a tenet contrasts with approaches that assume, implicitly or explicitly, that it is possible to examine mental processes such as thinking or memory independently of the sociocultural setting in which individuals and groups function" (p. 86).

In the context of this study, sociocultural views of learning suggest that learning is conveyed by the setting, the institutional framework in which the encounter takes place, the participants' dialogue and attitudes, their sense of social identity the objects manipulated and the type of interpersonal relationship established. Hence, one might expect that recent graduates' views of desirable graduate competencies are influenced by their experiences since graduation. Recent graduates in work might, for example, become enculturated into the views held by that particular community of practice. Likewise, those who have gone on into post-graduate study in a tertiary educational institution might adopt or assume the culture and views of a science department in a tertiary institution in which they were doing their research.

Methodology

Background for the Study

Our view is that co-op programs seek to develop individuals with specific competencies and skills as detailed elsewhere (see, Coll, Zegwaard & Hodges, 2002a, 2002b; Zegwaard & Hodges, 2003). According to Spencer and Spencer (1993) a number of generic competency categories account for 80 - 95% of the distinguishing features of superior performers in technical and managerial positions. These are the competencies investigated here, and are classified into hard and soft skills utilizing Birkett's (1993) taxonomy, with cognitive skills being equated to hard skills, and behavioral skills to soft skills.

Research Objectives

The overall aim for this study is to complement recent research carried out on science and technology employers (Coll, Zegwaard & Hodges, 2002a) and students (Coll, Zegwaard & Hodges, 2002b) as well as that of a similar study carried out on business sector employers (Burchell, Hodges & Rainsbury, 2001) and graduates (Rainsbury, Hodges, Burchell & Lay, 2002). We thus sought to identify science and technology graduates' views of the importance of specific graduate competencies required in the work place. Based on the literature definitions of competency, the research utilized a theoretical framework derived from the notion of competency, specifically the competencies identified by Spencer and Spencer (1993), with four additions, ability and willingness to learn; written communication; personal planning and organizational skills; and computer literacy, suggested by Meade and Andrews (1995) and Sweeney and Twomey (1997).

Survey Instrument

The generic competencies used in the study are provided in Appendix A. The survey instrument that was used is that used by Burchell, Hodges and Rainsbury (2001), Coll, Zegwaard and Hodges (2002a, 2002b), Rainsbury, Hodges, Burchell and Lay (2002) and Zegwaard and Hodges (2003) (Appendix B). The participating graduates were asked to rate the importance of a list of 24 competencies (using a 7-point Likert scale, 1 = unimportant and 7 = important). The

competencies were listed in random order on the instrument and the graduates were asked to rate the importance of each competency, both now and what they think it might be in 10 years time (the latter was added to allow graduates to say if they imagined some competencies would become more important in the future). Participants also were able to provide written comments on the survey form, and to add other competencies they deemed important. The survey form sent to the graduates also contained definitions for each of the 24 competencies listed.

Context of the Study

The University of Waikato was established in 1964 in Hamilton, New Zealand a city located in area renowned for its agricultural and horticultural research and production, and is the 4th largest city of New Zealand. Since its founding the University has steadily grown and expanded and currently has around 14,000 equivalent full time students (EFTS). The School of Science (later to become the School of Science and Technology) was founded in 1969, and became well established and internationally recognized in the area of science and technology. The School, which has currently about 1000 EFTS, offers three undergraduate degrees, Bachelor of Science (BSc), Bachelor of Science (Technology) (BSc(Tech)), and Bachelor of Engineering (BE), of which the later two are cooperative education degrees. The BSc is a three-year science degree, whilst the BSc(Tech) is a four-year science degree which has 12 months of relevant work experience (Kirk & Chapman, 1992); currently ca. 60% of undergraduate students in the School are enrolled in a BSc(Tech). The BE (which recently subsumed the Bachelor of Technology – BTech degree) is a four-year engineering focused degree, and includes six months of relevant work experience (Coll, 1996); numbers are currently around 50 EFTS and showing promising growth. The *Cooperative Education Unit*, a team of academic staff who hold joint appointments between the subject discipline and the Unit, facilitates about 170 student placements in a given year and, due to the long history of the program, a large number of potential employers are available (Coll & Eames, 2000). The School also offers two graduate degrees, the Masters of Science (MSc) and Masters of Science (Technology) (MSc(Tech)), as well as the Doctor of Philosophy (PhD), with currently around 200 EFTS in these three degrees, and recently introduced a Masters of Engineering (ME). Since the establishment of the School of Science and Technology graduates from the School have taken senior science positions, many of which now employ students through the co-op programs.

Sample Demographics

Participants comprised graduates who completed their qualifications at the University of Waikato no longer than three years ago. These graduates had completed degrees in a range of different science disciplines (e.g., biological sciences, the Earth sciences, chemistry, physics & electronics, and materials & process engineering) as well as some interdisciplinary specified programs (e.g., animal behavior, biochemistry, resource and environmental planning). The distribution of disciplines of those who responded reflects typical enrolments for each of the disciplines/programs. The majority of the graduates (76%) in the study had completed either a BSc or BSc(Tech), with some (18%) having completed higher studies such as an MSc, MSc(Tech) or a post-graduate diploma. Of those that responded to the survey 63% indicated that they graduated no more than one year ago, 29% two years ago and 8% three years ago. Of those that responded 51% indicated that they were currently employed in science, 28% were completing further studies, 12% were employed but not in science, and 9% were unemployed. Statistical analyses of responses using demographic data were carried to determine if there were differing perceptions between graduates who were employed and those undertaking graduate studies. It is important to note that 52% of those that replied indicated that they gained some relevant work experience as part of a co-op placement. The gender distribution was 43% male and 57% female, respectively.

Instrument Administration

The survey was distributed using a mail-out procedure repeated six weeks later, which increased the response rate by a third. A third mail-out was considered but deemed not cost-effective (Cohen, Manion & Morrison, 2000). The total number of graduates surveyed was 490, of which 143 replied, giving a response rate of 29%. The original mail-out was larger, however, with some 57 letters returned with indications that the address was incorrect or changed with no known forwarding address. The survey was sent to the last known address of recent graduates - which was the address at the time of graduation - therefore it is likely that the return rate reflects some out-of-date information as graduates move to new locations and employment. The response rate was lower than that of the related studies carried on science and technology employers, students and faculty members (Coll, Zegwaard & Hodges, 2002a, 2002b; Zegwaard & Hodges, 2003), but similar to other reported mail-out surveys (see e.g., Rainsbury, Hodges, Burchell & Lay, 2002).

Data Analysis

Estimated mean values were calculated for all of the competencies, and in addition competencies were categorized into hard and soft skills – according to Birkett's (1993) taxonomy. The term estimated mean is used here as this data is ordinal level (i.e., non-continuous, e.g., Likert scale, rather than continuous data such as age, or weight); hence, means are estimated and can only be used to show the ranking of the data (Busch & Turner, 1993). The mean importance for hard and soft skills were determined by summing the mean importance of each competency within that category (i.e., hard or soft), and dividing by the number of competencies for each category. The estimated means were examined for statistically significant differences using conventional statistical methods. Tests for statistical significance for any differences observed were carried out

between graduates' perceptions for today and for 10 years time, and separate analyses were carried out to investigate differences based on demographics (e.g., difference in those employed in science and those completing further graduate studies).

Results and Discussion

Graduate Rating of Desirable Competencies - Today

The research findings are summarized in Table 1 and Figure 1. These data consist of estimated means for each of the graduate competencies listed in the survey instrument, and thus represent the participants' rating of the importance of these competencies for new graduates entering the workforce today and new graduates entering the workforce in 10 years time. The estimated means of importance for today for the competencies ranged from 4.49 to 6.22. Coll, Zegwaard and Hodges (2002a, 2002b), Rainsbury, Hodges, Burchell and Lay (2002) and Zegwaard and Hodges (in press) interpreted an estimated mean of less than 4 to indicate that the respondents saw this as unimportant. In the present study none of the competencies were rated below 4, therefore, on this basis these recent graduates view all competencies as important. This was summarized, sometimes rather bluntly, by several respondents, with a common response being "they are all important skills to have to make a person an effective employee," and another commenting "did you really expect any of the categories to decrease in value in 10 years?"

Some of the graduates were highly emphatic about the importance of all competencies:

> If you haven't guessed *all* [original emphasis] competencies are important. Maybe the only thing that will change is that currently you can get away with sub-standard performance in [some] categories – in the future you won't be able to – the next crop of graduates will be better balanced [and] more rounded.

The 10 top ranked competencies for today were (in decreasing order); *ability and willingness to learn*; *team work and cooperation*; *analytical thinking*; *personal planning and organization*; *computer literacy*; *written communication*; *initiative*; *achievement orientation*; *concern for order quality and accuracy*; and *self confidence*.

It is interesting to note that these recent graduates ranked *ability and willingness to learn* as the most important competency (estimated mean 6.22). The estimated mean for this competency was 0.28 higher than the next ranked competency. This contrasts with modest differences between the means of other highly ranked competencies (e.g., the second ranked competency was only 0.02 above the third). This high ranking of *ability and willingness to learn* is similar to that held by science and technology employers and students (Coll, Zegwaard & Hodges, 2002a, 2002b), who had strong perceptions that *ability and willingness to learn* was the most important currently desired competency (estimated means 6.09 and 6.66; 0.18 and 0.33 higher than the next ranked competency, respectively). Likewise, science and technology faculty (Zegwaard & Hodges, 2003) rated *ability and willingness to learn* as the most important competency (estimated mean of 6.17). However, because of the strong views faculty had of *written communication*, this was only 0.08 higher than the next ranked competency. Recent graduates and employers in the business sector (Burchell, Hodges & Rainsbury, 2001; Rainsbury, Hodges, Burchell & Lay, 2002) also held that *ability and willingness to learn* was the most important, whilst business sector students ranked it fifth. Similarly, Gow and McDonald (2000) concluded that adaptability to change and ability to learn new tasks are essential skills for graduates in the 21st century. Several science and technology graduates made comments suggesting that they perceive that the future will bring change to their sector; therefore in the minds of the participants it was important for new graduates to learn new skills:

> Businesses are expanding and personal are becoming more specialized. I believe that people should become more multi-skilled and I think some businesses are starting to agree and ensure that knowledge is vast across fields of personal.

The graduates ranked *team work and cooperation* second highest, similar to science and technology employers, and in contrast with students who did not see this competency as particularly important. Hence, it appears that even a few years of exposure to employment has influenced the graduates' perceptions about the importance of team work. *Analytical thinking*, *personal planning and organization*, *computer literacy*, and *written communication* are four hard skills that ranked very highly by graduates, and were viewed similarly by employers.

The graduates rated developing others, *directiveness* and *organizational awareness* the lowest (estimated means 4.49, 4.56 and 4.70, respectively) in importance consistent with the views of science and technology employers and students. Business sector graduates also attributed low importance to these competencies (Burchell, Hodges & Rainsbury, 2001; Rainsbury Hodges, Burchell & Lay, 2002). One graduate gave comments regarding these competencies: "Directiveness not seen as so important now – more emphasis on team work and contributing as an equal group member."

A few respondents suggested additional technical competencies, such as 'knowledge of techniques' and 'knowledge of equipment', which focused on familiarity with techniques and methods rather than the higher level of understanding of the mechanisms and science behind the techniques. However, despite *technical expertise* being ranked the lowest hard skill for both today and 10 years time (17th and 16th overall ranking, respectively), these recent graduates thought *technical expertise* will become more important in 10 years time (an increase in estimated mean of 0.38). Interestingly, comments made by participants indicated that technical expertise and 'capability' would be replaced by 'standardized methods' and 'technology'.

Table 1
Science and technology graduate rating of workplace competencies (estimated means based on a 7 point Likert scale where 1 = unimportant and 7 = important, n=143)

	Today			Ten Year's Time		
Soft Skills	Mean	Std. Deviation	Std. Error Mean	Mean	Std. Deviation	Std. Error Mean
Team work and cooperation	5.94	1.063	0.089	5.98	1.106	0.095
Flexibility	5.51	1.102	0.092	5.93	1.109	0.096
Relationship building	5.53	1.161	0.097	5.87	1.089	0.094
Concern for order, quality and accuracy	5.60	1.151	0.096	5.89	1.053	0.091
Impact and influence on others	4.73	1.271	0.107	5.04	1.355	0.117
Initiative	5.66	1.279	0.107	6.00	1.192	0.103
Customer service orientation	4.92	1.374	0.115	5.43	1.328	0.115
Developing others	4.49	1.403	0.118	5.00	1.481	0.127
Directiveness	4.56	1.391	0.117	5.08	1.332	0.115
Team leadership	4.84	1.330	0.112	5.32	1.331	0.115
Self control	5.51	1.263	0.106	5.86	1.229	0.106
Organizational commitment	4.76	1.279	0.107	5.11	1.360	0.117
Ability and willingness to learn	6.22	0.897	0.075	6.47	0.799	0.069
Interpersonal understanding	5.27	1.243	0.104	5.52	1.195	0.104
Self confidence	5.58	1.183	0.099	5.79	1.155	0.099
Information seeking	5.57	1.078	0.090	5.71	1.281	0.110
Achievement orientation	5.62	1.131	0.095	6.06	0.999	0.086
Organizational awareness	4.70	1.192	0.100	5.06	1.152	0.099
Hard Skills						
Computer literacy	5.86	1.131	0.095	6.67	0.667	0.057
Conceptual thinking	5.45	1.184	0.099	5.83	1.077	0.092
Technical expertise	5.25	1.247	0.104	5.63	1.251	0.107
Analytical thinking	5.92	0.912	0.076	6.08	0.906	0.078
Personal planning and organizational skills	5.90	0.981	0.082	6.10	0.941	0.081
Written communication	5.71	1.117	0.093	5.64	1.306	0.113

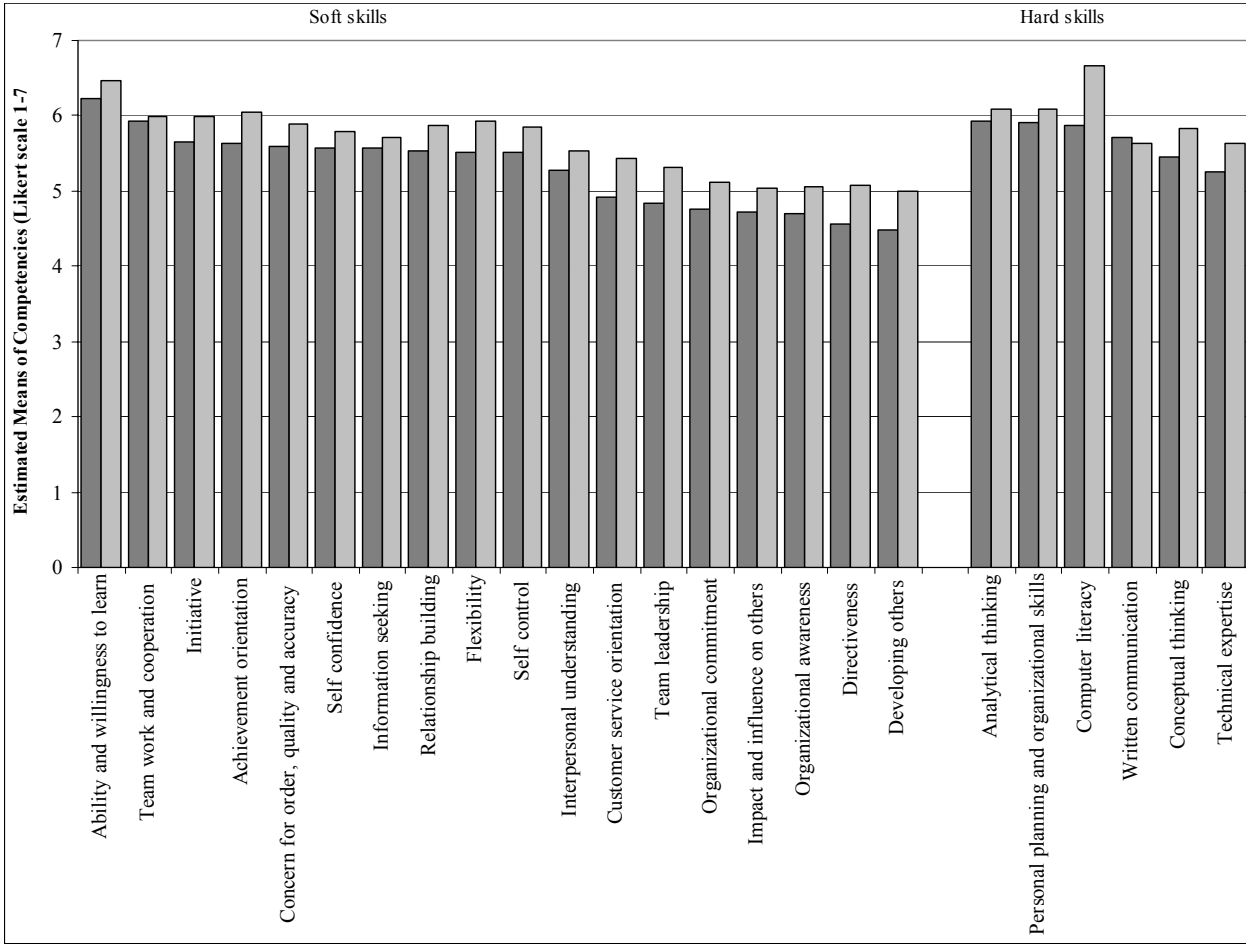

Figure 1
Science and technology graduate rating of workplace competencies today (dark grey) and in 10 years time (light grey) (n=143)

For example, one graduate pointed out that in his view technical "methods are becoming standardized and optimized to the point where really only the manual labor is required. Most of the techniques we use come in 'kitset' form," and others pointed to the influence of computers on technical skills, with one respondent commenting "in 10 years time computers will do all our thinking, problem-solving [and] reasoning for us."

Some interesting differences in views were seen between science and technology graduates and business graduates. Burchell, Hodges and Rainsbury (2001), reported that business graduates ranked a number of the soft skills highly; *customer service orientation* (ranked 2nd), *self confidence* (4th) and *flexibility* (7th) were all ranked substantially higher by business graduates than their science and technology graduate counterparts. This may be a feature of the greater importance in business for developing strong client relationships and being responsive and flexible in meeting customers' needs. Science and technology graduates ranked two competencies substantially higher than business graduates - *achievement orientation* (8th & 14th, respectively) and *analytical thinking* (3rd & 16th, respectively). This is perhaps not surprising and is likely to reflect the nature of the work typically undertaken in the science and technology fields.

The research findings suggest that these recent graduates held rather holistic views of the workplace, seeing workplace culture and norms as important. For example, many respondents made comments focusing on the teamwork and the ability to fit within a workplace setting. A number of interesting and rather insightful additional 'competencies' also were provided by the respondents such as; 'social class', 'patience', 'justification training', 'political awareness' and 'professionalism'. Remarkably, a number of respondents even suggested that 'political correctness' would be a useful additional 'competency'. It was also proposed that more workgroup and group projects, despite being unpopular, should be carried out at university to develop greater teamwork, interpersonal and leadership skills.

Comparison Based on Gender

Analysis of difference between views held by male (n=62) and female (n=81) showed no statistically significant difference in their overall perceptions (overall estimated mean of 5.32 & 5.43). Both males and females viewed hard skills to be more important than soft skills (statistically significant, $p<0.1$), however, females tended to rate hard skills overall more highly than males (overall estimated mean for females 5.79 & males 5.54, respectively, statistically significant, $p<0.1$), This difference in views, however, did not carry over to soft skills - where no real difference was observed between males and females with the exception of *flexibility* (estimated mean for females 5.70 & males 5.25 respectively, statistically significant, $p<0.1$). *Personal planning and organizational skills* evidenced the biggest disparity in views based on gender, with females rating this more highly (estimated mean 6.14), than males (estimated mean 5.60, statistically significant, $p<0.1$).

Comparison of Co-op Graduates with Non-Co-op Graduates

Some 52% of the respondents indicated that they had carried out work experience as part of a co-op degree. Of those that carried out work experience, 11% indicated that they had three months of relevant work experience, 23% had six months (representing former BTech graduates and those who fast-tracked from a BSc(Tech) to a masters degree), 12% had nine months and 36% had 12 months (representing those who completed a BSc(Tech) degree). Of those who had carried out co-op placements, 55% were currently employed in the area of science, in contrast with 44% for those that had not completed co-op placements. The remainder mostly are carrying out further studies. Interestingly, there was little difference in the overall ranking of competencies between these two groups. However, recent graduates who had completed co-op placements did tend to rate competencies higher overall (overall estimated mean 5.47) than those who had not completed placements (overall estimated mean 5.27), although this was not statistically significant. Graduates who had completed co-op placements rated *directiveness*; *initiative*; *impact and influence on others*; *self confidence*; *relationship building*; and *analytical thinking* and more highly than those who did not carry out co-op placements (difference in estimated means of 0.60, 0.44, 0.41, 0.38, 0.38 & 0.36, respectively). Although these differences are statistically significant ($p<0.1$) only for *directiveness* and *analytical thinking* it may indicate that co-op graduates see competencies associated with being self-driven, focused and being able to relate to people as more important than non-co-op graduates.

Comparison of Working Graduates and Graduates Engaged in Further Study

Statistical analyses were carried to determine if there were differences in perceptions of those graduate participants that were employed and those that were engaged in post-graduate studies. In general, there was very little difference between these two groups, with were two notable exceptions. One interesting finding was that graduates who were completing further studies rated *written communication* and *information seeking* more highly than those who were in employment (statistically significant, $p<0.1$). This perception may have arisen as a result of the fact that these graduates were undertaking further studies at the time and may have been influenced by that they were completing either a masters or a post-graduate diploma at the time of the survey - both of which have a significant emphasis on research and written components as part of a dissertation or thesis. Furthermore, science and technology faculty also rated *written communication* highly (ranked 2nd highest), therefore, this may in part reflect enculturation of post-graduate students into the academic way of thinking (Zegwaard, & Hodges, 2003).

In contrast, graduates who were in employment rated flexibility higher than graduates who were completing further studies (estimated mean of 5.69 and 5.13, respectively; $p<0.1$). This is a particularly interesting

finding, as neither science and technology employers, students nor faculty rated this competency highly (ranked 10th, 14th & 12th, respectively). This may be due to the complexity of a new working environment, when graduates first start work they may perceive a need for greater flexibility. This supposition is supported by several comments made by participants who suggested additional competencies such as 'multi-skilling', 'acceptance to change' and 'ability to adapt quickly' as desirable graduate competencies. Interestingly, graduates who were neither employed nor carrying out post-graduate studies (n=12) rated flexibility with an estimated mean of 5.58, however, variation in views among this group was high.

Comparison of Hard and Soft Skills

Comparison of graduate rating found a statically significant difference between perceptions of the importance of hard skills and soft skills (overall estimated mean 5.68 & 5.28, respectively, statistically significant, $p<0.1$). Hence, it seems that these graduates see hard skills as more important, with the exception of *conceptual thinking* (ranked 15th) and *technical expertise* (17th). This mirrors the views of science and technology employers who also rated hard skills highly and contrasts with science and technology students who perceived hard and soft skills both as important. It is interesting to note here that despite hard skills being rated by graduates more highly than soft skills, the two highest individually ranked competencies were *ability and willingness to learn* and *team work and cooperation* – both soft skills.

Graduates Rating of Desirable Competencies – Ten Years Time

Participants' rating of the importance of these competencies for new graduates entering the workforce in 10 years time also are presented in Table 1 and Figure 1. The estimated means of the competencies for new graduates in 10 years time ranged from 5.00 to 6.67, where no competency was rated as unimportant (i.e., less than 4). All competencies, except *written communication*, were seen by graduates as likely to be more important in 10 years time, with the overall estimated mean changing from 5.38, for today, to 5.73 (statistically significant, $p<0.1$). The order of ranking of the competencies was similar, with a few notable differences. The biggest increase in perceived importance was for *computer literacy* (difference 0.81; statistically significant, $p<0.1$), changing in ranking from 5th to 1st. Several participants commented on these changes in competencies for the future:

> I believe that technology and businesses are changing all the time. Computers are becoming more important and more valuable to businesses, and therefore personal users [of] this equipment will also need to have more knowledge in their use of them.
>
> The reason I have listed the 10 years' time as more important is due to the increasing competitiveness in scientific industry. This is reflected today in students requiring higher qualifications to obtain employment in science.
>
> Computer literacy will become a great deal more important in 10 years time as technology increases and changes. Today some people do not own or even know how to use computers – in 10 years time everyone will.
>
> In 10 years time most things will be more computer based and/or controlled. At present you can get away with not knowing or sort of knowing but in 10 years time I think it will be very important to be computer literate.

Other notable increases in the rating of competencies from today to 10 years time were for *directiveness*; *customer service orientation*; *developing others*; and *team leadership* (increase of 0.52, 0.51, 0.51 & 0.48, respectively, statistically significant, $p<0.1$). However, these competencies were not ranked highly today, and, despite the significant increases, their overall ranking remained relatively unchanged in 10 years time (from a ranking of 23, 18, 24, 19 today, to 21, 18, 24, 19, respectively in 10 years time).

Several of the graduates indicated they that believe pressure and stress at work will increase in 10 years time. Consequently, they perceived a greater need for communicating knowledge effectively among work colleagues.

> Within 10 years time I believe that workplace pressures will have increased. It will be more competitive industry with increased technological advances and more pressure to work harder and better. The need to deal with industry politics and people in a more efficient manner may become important.
>
> Interpersonal skills and willingness to show knowledge are currently, and will remain, important. Ability to present and communicate knowledge effectively are key skills. More is gained by actively - aggressively - seeking help and assistance.
>
> More skills in presenting your own research findings to scientific staff whose knowledge is much greater than your own.
>
> All the knowledge in the world is no good if you cannot communicate your ideas effectively - unless of course you are Stephen Hawkins.

Written communication was not perceived to either significantly increase or decrease in rated importance in 10 years time. However, it changed in ranking from 6th to 15th, as a result of other competencies increasing in perceived importance. At the University of Waikato science academic staff consider students' writing skills poor and as having worsened over time (Zegwaard & Hodges, 2003).

Given this, it is of some concern, that these recent graduates, like their student counterparts, do not perceive that written skills will increase in importance in 10 years. It is particularly relevant to note that the BSc(Tech) students are required to carry out two management courses, typically the two prescribed level 2 and level 3 science and technology management courses, which cover the topics of business communication, non-verbal communication, and writing for professional purposes (University of Waikato, 2003). These two courses were developed in response to employer and faculty feedback (Chapman, 1994; Kirk & Chapman, 1992), and since the communication section has been expanded further to attempt to address these issues more extensively (Coll & Chapman, 2000). However, non-co-op students are not expected to undertake this course and possibly to address the issue of communication it may be valuable if all undergraduate students undertake a course in communication. Examination of the written comments on the surveys may also shed some light on the graduate's perceptions. For example, it is important to note that some participants see *written communication* as 'paper work' and 'hand-writing', which they perceived to be less important in the future, considering that computers and email in particular would supplant handwriting as means of communication. This is a narrower meaning intended of the term *written communication* as used in the instrument, which had a wider meaning including the use of computers and email (see definitions of competencies in Appendix A):

> Computer technology may take over written information so an employee will need to increase computer knowledge.
>
> Written communication - hand writing - may be taken over by computer email, etc.
>
> The use of email generally replaces the main form of communication so people skills not vitally important.

Conclusions

The research findings reported here suggest that recent science and technology graduates considered all the competencies presented to them in this survey as important, and rated *ability and willingness to learn* most highly the same as science and technology students, employers and faculty (Coll, Zegwaard & Hodges, 2002a, 2002b; Zegwaard & Hodges, 2003) and business sector students, employers (Rainsbury, Hodges, Burchell & Lay, 2002) and graduates (Burchell, Hodges & Rainsbury, 2001). It appears that these graduates ranked *ability and willingness to learn* highly because they perceive that the industry will change quickly and they consider that they must be prepared to change.

The graduate participants see all competencies; expect *written communication*, as likely to become more important in 10 years time, with *computer literacy* being perceived to become the most important in the future. These graduates also consider hard skills to be more important than soft skills, rating *analytical thinking*, *personal planning and organization*, *computer literacy* and *written communication* highly, similar to the views held by science and technology employers.

Recent graduates who had carried out co-op placements had similar views to those who had not had co-op placements; however, graduates who had completed co-op placements tend to rate competencies overall higher. Interestingly, graduates who had carried co-op placements seemed to rate competencies associated with being self-driven and focused more highly. These graduates also had a higher proportion employed in science than those who had not carried out co-op placements. It also appears that views of workplace competencies held by graduates who had completed co-op placements are influenced by other effects (i.e., employment) after graduation.

An interesting finding of the research was that recent graduates perceive that technology will have major influences on their future careers; highlighted by numerous comments made about the influence of greater technology and computer usage. The perception was that skills in these areas would become more important as computers will control large areas of our working lives, and the ability to do some technical tasks (e.g., methods) will be taken over by technology. This was further shown by increased perceived importance of *computer literacy* in 10 years time.

It seems that graduates have a perception of competencies that share similarities with both science and technology employers and students. The overall ranking of competencies as perceived by recent graduates seem to indicate they are in a transition zone, where their views are becoming more like that of employers. The findings also show that recent graduates are in the early stages of their career, where change, learning new tasks, flexibility and achievement orientation are important components of their careers. Furthermore, recent graduates appear to be focused on the ability to fit in the work environment and to be accepted as part of a work group, placing importance on their professional behavior and ability to communicate

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Appendix A

Generic competencies that account for 80-95% of the distinguishing features of superior performers (Spencer & Spencer, 1993)

Competency	Description	
Achievement and action		
Achievement orientation	Task accomplishment, seeks results, innovation, competitiveness, impact, standards, efficiency	Soft
Concern for order, quality and accuracy	Monitoring, concern for clarity, reduce uncertainty, keeping track	Soft
Initiative	Bias for action, decisiveness, strategic orientation, proactive, seizes opportunities, self motivation, persistence	Soft
Information seeking	Problem definition, diagnostic focus, looking deeper, contextual sensitivity	Soft
Interpersonal understanding	Empathy, listening, sensitivity to others, diagnostic understanding, awareness of others feelings	Soft
Customer service orientation	Helping and service orientation, focus on client needs, actively solves client problems	Soft
Impact and influence		
Impact and influence on others	Strategic influence, impression management, showmanship, persuasion, collaborative influence	Soft
Organisational awareness	Understands organisation, knows constraints, power and political astuteness, cultural knowledge	Soft
Relationship building	Networking, establish rapport, concern for stakeholders e.g. clients, use of resources, contacts use	Soft
Managerial		
Developing others	Training, developing others, coaching, mentoring, providing support, positive regard	Soft
Directiveness	Assertiveness, decisiveness, use of power, taking charge, firmness of standards, group control and discipline	Soft
Teamwork and co-operation	Fosters group facilitation and management, conflict resolution, motivating others, good climate	Soft
Team leadership	Being in charge, vision, concern for subordinates, build sense of group purpose, group motivation	Soft
Cognitive		
Analytical thinking	Thinking for yourself, reasoning, practical intelligence, planning skills, problem analysing, systematic	Hard
Conceptual thinking	Pattern recognition, insight, critical thinking, problem definition, can generate hypotheses, linking	Hard
Technical expertise	Job related technical knowledge and skills, depth and breadth, acquires expertise, donates expertise	Hard
Personal effectiveness		
Self control	Stamina, resistance to stress, staying calm, high EQ, resists temptation, not impulsive, can calm others	Soft
Self confidence	Strong self concept, internal locus of control, independence, ego strength, decisive, accepts responsibility	Soft
Flexibility	Adaptability, ability to change, perceptual objectivity, staying objective, resilience, behavior is contingent	Soft
Organizational commitment	Align self and others to organizational needs, business-mindedness, self sacrifice	Soft

Appendix B
The Survey Instrument Used in the Study

SECTION B
COMPETENCY DESCRIPTIONS

Please read the following descriptions of each competency before completing question B.1.

Teamwork & cooperation (fosters group facilitation and management, conflict resolution, motivation of others, creating a good workplace climate)
Flexibility (adaptability, perceptual objectivity, staying objective, resilience, behaviour is contingent on the situation)
Relationship building (networking, establish rapport, use of contacts, concern for stakeholders eg clients)
Computer literacy (able to operate a number of packages and has information management awareness)
Conceptual thinking (pattern recognition, insight, critical thinking, problem definition, can generate hypotheses, linking)
Technical expertise (job related technical knowledge and skills, depth and breadth, acquires expertise, donates expertise)
Organisational awareness (understands organisation, knows constraints, power and political astuteness, cultural knowledge)
Concern for order, quality & accuracy (monitoring, concern for clarity, reduces uncertainty, keeping track of events and issues)
Impact & influence on others (strategic influence, impression management, showmanship, persuasion, collaborative influence)
Initiative (bias for action, decisiveness, strategic orientation, proactive, seizes opportunities, self motivation, persistence)
Customer service orientation (helping and service orientation, focus on client needs, actively solves client problems)
Developing others (training, developing others, coaching, mentoring, providing support, positive regard)
Directiveness (assertiveness, decisiveness, use of power, taking charge, firmness of standards, group control and discipline)
Team leadership (being in charge, vision, concern for subordinates, builds a sense of group purpose)
Analytical thinking (thinking for self, reasoning, practical intelligence, planning skills, problem analysing, systematic)
Self control (stamina, resistance to stress, staying calm, high Emotional Quotient, resists temptation, not impulsive, can calm others)
Organisational commitment (align self and others to organisational needs, businessmindedness, self sacrifice)
Ability and willingness to learn (desire and aptitude for learning, learning as a basis for action)
Interpersonal understanding (empathy, listening, sensitivity to others, diagnostic understanding, awareness of others' feelings)
Self confidence (strong self concept, internal locus of control, independence, positive ego strength, decisive, accepts responsibility)
Personal planning and organisational skills
Written communication
Information seeking (problem definition, diagnostic focus, looking deeper, contextual sensitivity)
Achievement orientation (task accomplishment, seeks results, employs innovation, has competitiveness, seeks impact, aims for standards and efficiency)

Appendix B *Continued*

B.1 Please complete the table below, indicating from your perspective the *importance* for science and technology graduates entering the workforce, of each of the competencies listed. Please circle the number of your choice. (Refer attached description of each competency.)

COMPETENCY	**IMPORTANCE TODAY**							**IMPORTANCE IN 10 YEARS TIME**						
	Unimportant → Important							**Unimportant → Important**						
	1			→			**7**	**1**			→			**7**
Teamwork & cooperation	1	2	3	4	5	6	7	1	2	3	4	5	6	7
Flexibility	1	2	3	4	5	6	7	1	2	3	4	5	6	7
Relationship building	1	2	3	4	5	6	7	1	2	3	4	5	6	7
Computer literacy	1	2	3	4	5	6	7	1	2	3	4	5	6	7
Conceptual thinking	1	2	3	4	5	6	7	1	2	3	4	5	6	7
Technical expertise	1	2	3	4	5	6	7	1	2	3	4	5	6	7
Organisational awareness	1	2	3	4	5	6	7	1	2	3	4	5	6	7
Concern for order, quality and accuracy	1	2	3	4	5	6	7	1	2	3	4	5	6	7
Impact and influence on others	1	2	3	4	5	6	7	1	2	3	4	5	6	7
Initiative	1	2	3	4	5	6	7	1	2	3	4	5	6	7
Customer service orientation	1	2	3	4	5	6	7	1	2	3	4	5	6	7
Developing others	1	2	3	4	5	6	7	1	2	3	4	5	6	7
Directiveness	1	2	3	4	5	6	7	1	2	3	4	5	6	7
Team leadership	1	2	3	4	5	6	7	1	2	3	4	5	6	7
Analytical thinking	1	2	3	4	5	6	7	1	2	3	4	5	6	7
Self control	1	2	3	4	5	6	7	1	2	3	4	5	6	7
Organisational commitment	1	2	3	4	5	6	7	1	2	3	4	5	6	7
Ability and willingness to learn	1	2	3	4	5	6	7	1	2	3	4	5	6	7
Interpersonal understanding	1	2	3	4	5	6	7	1	2	3	4	5	6	7
Self confidence	1	2	3	4	5	6	7	1	2	3	4	5	6	7
Personal planning and organisational skills	1	2	3	4	5	6	7	1	2	3	4	5	6	7
Written communication	1	2	3	4	5	6	7	1	2	3	4	5	6	7
Information seeking	1	2	3	4	5	6	7	1	2	3	4	5	6	7
Achievement orientation	1	2	3	4	5	6	7	1	2	3	4	5	6	7
Please add others, if required:														
	1	2	3	4	5	6	7	1	2	3	4	5	6	7
	1	2	3	4	5	6	7	1	2	3	4	5	6	7
	1	2	3	4	5	6	7	1	2	3	4	5	6	7