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Ann Latham
University of Wolverhampton

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Ann Latham
School of Computing and Information Technology
University of Wolverhampton
35/49 Lichfield Street
Wolverhampton, WV1 1EL
United Kingdom

***Abstract*-Recent research has highlighted a mismatch between the skills taught to Information Systems undergraduates in universities and the skills needed by businesses, the disparity leading to employers recruiting graduates from arts and science courses. This paper will present findings on research that has been conducted to obtain the views of employers and recent graduates on the importance and relevance of key knowledge and skills in Information Systems Education, in an attempt to determine whether Information Systems courses are effective, and whether there is a need to develop new programmes to meet the needs of tomorrow's organisations.**

I. INTRODUCTION

For a number of years, Higher Education generally and Information Systems Higher Education specifically have been criticised for not adequately preparing students for the world of work. Recently, there have been many reports of an IT skills shortage, but many companies are now demanding Information Systems graduates to demonstrate that they have "more than a technical degree". Are we preparing our graduates for this challenge?

The motivation behind this research lies in the belief that whilst computing educational programmes have existed for many years, it is unclear whether they have produced people with the necessary knowledge and skills to become effective practitioners. Although Information Systems educational programmes are continuing to emerge it is unclear whether they remain effective for the future.

The 'world of work' has seen dramatic changes over the last two decades of the twentieth century, with computers now playing a major part. There is a need for employees to be computer-literate, but there is also a need for the systems to be developed and managed and for Information Technology to serve the needs of business and organisations generally. This needs technically competent practitioners. But what does this mean for university courses in the Information Systems field?

II. A BRIEF REVIEW OF THE LITERATURE

In January 1991 a three-year Quality in Higher Education Project, sponsored by a consortium of education, government and industry, was launched, directed by Dr. Diana Green at the University of Central England. The project aimed to assess quality in Higher Education in order to inform policy. From their survey of employers [1] they found that broadly speaking employers have two requirements of graduate recruits: subject specific knowledge and skills and transferable knowledge, skills and attitudes. In 1997 the Centre for Research into Quality, led by Professor Lee Harvey at the University of Central England, was commissioned by the Department for Education and Employment, the Association of Graduate Recruiters and the Council for Industry and Higher Education to produce a report on Graduates' Work [2]. The purpose of the research was to explore the nature and extent of the knowledge, skills and abilities that graduates need in order to be successful in the workplace of the future. The report makes the point that the possession of a range of skills and personal and interactive attributes is at least as important, if not more important, than the possession of qualifications. The research acknowledged that a particular degree subject is essential for some professions, whilst for others the important consideration is that the person has the ability to have studied for a degree. In most instances the subject matter of the degree was not of importance, since employers stated that they were looking for specific skills and attributes that enabled individuals to do the job, not subject-specific knowledge that could rapidly become outdated. Douglas Hague in *The Independent* (1 September 1993) suggested that "today, innovation is more vital than ever", and questioned the need for any undergraduate course to be as specialised as it is.

The study of Information Systems has emerged over the latter years of the twentieth century, but there is still no common consensus as to what constitutes 'Information Systems'. This has been considered in some detail by many authors, but there is no widely accepted definition. There are probably as many definitions of Information Systems as there are texts on the subject [3]. In its definition, the UK Academy for Information Systems stresses the association with other areas of study in related fields: "The study of Information Systems and their development is a multi-disciplinary subject and addresses the range of strategic, managerial and operational activities involved in gathering, processing, storing, distributing and use of information, and its associated technologies, in society and organisations" [4].

Computer Science is concerned with the way in which computers function as hardware and software, whereas Information Systems is concerned with understanding what is or might be achieved with these technological systems, and the effects of these systems in the human / organisational / social world [5]. Keen [6] differentiates Information Systems from computer science – "Information Systems implementation means more than just technical installation; [it is] how to make systems work organisationally as well".

Information Systems has its roots in many disciplines, computer science being just one. It is concerned with wider issues than computer science and therefore demands a different skills set. For the Information Systems professional the computer is seen as a tool, and its interest is in terms of its main functionality. The computer is not the focus. The Information Systems professional is concerned not only with exploiting the technology but also with the effects of the technology and the changes that it brings to organisations.

John Leighfield, Chair of the Alliance for Information Systems Skills, is reported [7] as saying that the skills shortage issue is more about the quality of the people rather than the number of people. He goes on to say that what is needed is "IT people who can interact, who can be team players, who can communicate effectively, think strategically and implement efficiently," and IT people who are "bright, enthusiastic, and committed". The most important thing he looks for when employing staff in an IT department is the personal qualities of the individual to enable him or her to participate meaningfully in the business. He contends that the fundamental issue for Information Systems managers is to choose the right people.

As early as 1989, Keene [8] predicted that career paths in IT would diverge, with most professionals working in the areas of applications and support and far fewer employed in a technical capacity. He considered technical people to be vital to maintain complex technical systems and to advance the frontiers of knowledge, but claimed that the majority of Information Systems professionals would work in applications areas. In 1993, an article in *Computing* (3 June 1993) advocated that as technological advances continued more organisations found their Information Technology staff no longer had adequate skills and suggested that those with technical skills alone would no longer be employable.

The latter years of the twentieth century has seen the emergence of Information Systems as a subject within the undergraduate and postgraduate programmes of many universities, and increasingly as a distinct department within such institutions [9]. However, according to Galliers [10], there is a mismatch between the needs of industry and the academic curriculum of Information Systems provided by many universities. In *Computer Weekly*, 24 September 1998, Bill Goodwin reported that a survey had found that more than two-thirds of employers believed that the UK's academic institutions are producing students with 'inappropriate' Information Technology skills, and that three quarters of the firms accused academic institutions of producing Information Technology enthusiasts lacking in business skills. In *The Times*, 15 October 1997, John Kavanagh reported that industry dissatisfaction with what Information Technology graduates are taught was starting to boil over. Industry leaders were concerned that Information Technology graduates were coming out of Higher Education without the right skills. Having criticised for some time the graduate's lack of personal presentation and communication skills, the pace of change in Information Technology meant they were now questioning the technical make-up of degree courses. "There is a significant short fall between what universities and employers would like" said David Burrows, Skills and Services development manager, Microsoft UK (*Computer Weekly*, 25 March 1999). Universities need to debate the relevance of academic curriculum and the future employability of graduates!

Debate within the Information Systems community includes views about an Information Systems curriculum, and the balance between theoretical education and practical training. Nicholson [11] advocates that the future practitioners need to understand the background to theory and methodological critique. Whilst knowledge is necessary, it is not sufficient to ensure the successful application of Information Systems [12]. Information Systems is something that is practised and so it is important that practice enriches the knowledge taught. Success depends on understanding that technology is a means to an end, and this lesson needs to be taught to graduates, who are to be future Information Systems professionals.

III. RESEARCH METHODOLOGY

This paper reports upon part of the research carried out to investigate the emergence of Information Systems Education in the United Kingdom (UK), and the challenges for the future. Although the research has a UK bias, there is no reason to believe that the findings cannot be extrapolated to the rest of Europe.

One major goal of the research was a broad survey of the Information Systems educational needs of UK businesses. This survey was exploratory, aiming to collect a rich set of data. The first research instrument used was postal questionnaires, so that the information obtained could be analysed and patterns extracted. The use of this research instrument for two of the stakeholders (employers and graduates) is reported in this paper. To complement the findings, structured interviews were carried out with a number of employers.

Prior to the surveys it was necessary to determine the target populations. The sample of employers was obtained from the 1996 Ivanhoe Career Guide in Information

systems [13] and questionnaires were sent to the IT manager in each company.

One part of the questionnaire was intended to obtain views as to the importance of specific knowledge/skills for an Information Systems graduate. This section was divided into: Computing Knowledge and Skills
Business Knowledge and Skills
Business Computing Knowledge and Skills
Personal Skills
Other Knowledge and Skills
Respondents were asked to rate the importance of each knowledge/skill on a 5-point Likert scale, with 1 = not at all, 2 = fairly important, 3 = important, 4 = very important and 5 = essential. Employers were asked to rate the importance of each knowledge/skill at the current time and in the future. Graduates were asked to rate the importance of each knowledge/skill during their degree studies and subsequently at work.

IV. SURVEYS

A total of 185 questionnaires were sent to employers and 72 replies were received, giving a response rate of 39%. One questionnaire did not contain any identification details and another two did not contain details of the number of employees in the company or employed in Information Systems. Table 1 below shows the classification of the 69 companies according to size and whether Information Systems is their core business or not.

TABLE 1
Classification of companies

Size of Company (number of employees)	No. of Respondents	No. of Respondents where IT is core business
Small (<20)	2	2
Medium (21-250)	16	6
Large (>250)	51	2

Every employer who responded to the questionnaire was subsequently sent questionnaires to pass on to recent Information Systems graduates within their company. Thirty-one completed questionnaires were returned. In addition, thirteen responses were received, informing the researcher that they had no recent graduates, they now outsourced their computing and therefore no longer employed Information Systems graduates or, in the case of two companies, that they do not employ Information Systems graduates.

V. SURVEY ANALYSIS

For both the employers and graduate groups, and for each knowledge/skill topic identified, arithmetic means were calculated together with the associated standard deviations. Using the arithmetic mean ratings, each topic was ranked from 1 (most important) to 61 (least important).

The results of the analysis for both the employers and graduates can be found in tables 2 to 11 below. The rankings of the "top-ten" topics for each category are highlighted, and the topic areas are highlighted where there is a difference of twenty or more positions between the employers' and graduates' ranking or a difference of twenty or more positions between the graduates' ranking for degree and work.

TABLE 2
Employers - Computing Topics

	EMPLOYERS			
	Current		Future	
	Mean	Rank	Mean	Rank
Applications Programming - 3GL	2.67	44	2.23	58
Applications Programming - 4GL	3.29	18=	3.32	30
Systems Programming	2.28	53	2.27	56=
Real-time Programming	2.25	54=	2.38	53
Systems Analysis	3.71	7	3.87	10=
Systems Design	3.75	5=	3.82	12
A System Development Methodology	3.75	5=	3.92	7=
Comparative System Development Methodologies	3.00	33	3.19	35
Computer Architecture/Hardware	2.96	37	2.87	42=
Operating Systems	2.99	34	2.83	45
PC Databases	3.21	25	3.49	26=
Database Management Systems	3.47	11	3.76	14
Data Communications and Networks	3.26	20=	3.87	10=
Human Computer Interaction	3.13	28=	3.55	22
Artificial Intelligence/Expert Systems	2.20	57	2.67	49
Computer Graphics	2.57	45	3.01	38
Computer Security/Privacy/Auditing	3.25	22	3.71	17
End User Computing	3.29	18=	3.77	13
Rightsizing	2.80	41	2.87	42=
Project Management	3.64	9	3.99	5
Use of Packages	3.45	14	3.73	15=
History/Evolution of IS	2.15	59	2.11	61

TABLE 3
Graduates - Computing Topics

	GRADUATES			
	Degree		Work	
	Mean	Rank	Mean	Rank
Applications Programming - 3GL	3.23	15	2.97	21
Applications Programming - 4GL	2.77	30=	3.20	15
Systems Programming	2.77	30=	2.90	24
Real-time Programming	2.13	51	2.17	44
Systems Analysis	3.83	7	3.13	17
Systems Design	3.80	9	3.47	7
A System Development Methodology	3.90	6	2.83	26=
Comparative System Development Methodologies	3.00	20	1.93	47
Computer Architecture/Hardware	2.87	22=	2.59	33
Operating Systems	2.81	28	3.40	9
PC Databases	3.06	17	3.73	4
Database Management Systems	2.87	22=	3.10	18
Data Communications and Networks	3.03	18=	2.93	22=
Human Computer Interaction	3.40	13	2.76	29=
Artificial Intelligence/Expert Systems	2.70	34=	1.34	60
Computer Graphics	2.32	45=	1.80	52
Computer Security/Privacy/Auditing	2.39	44	2.87	25
End User Computing	2.68	38	3.07	19
Rightsizing	1.89	54	1.88	49
Project Management	3.13	16	3.30	13
Use of Packages	2.69	37	3.39	10
History/Evolution of IS	2.55	40	1.63	57

The first point to note is that the topic areas of systems analysis and design and the use of a systems development methodology are viewed as extremely important by employers and were also considered extremely important in their degree programmes by graduates. In the workplace graduates considered systems design to be the most important of these three, with the use of a systems development methodology only reaching 26th position.

Employers see data communications and networks and project management as playing an increasingly important role in the work of graduates. Third generation applications programming (3GLs) and systems programming were not ranked highly by employers, but graduates considered 3GLs to be important in both their degrees and in their subsequent work, and also ranked systems programming significantly higher than the employers did.

Graduates have found that PC databases, operating systems and the use of packages have been extremely important during their work, but that these were not given such high priority in their degree courses. Employers acknowledged that the use of packages is very important, but they did not rank PC databases or operating systems as highly as the graduates did.

Looking now at the topics where there is a difference in ranking of greater than twenty positions between graduates' degrees and work, we can see that comparative systems methodologies and artificial intelligence are ranked considerably higher in their degrees, whilst graduates found that computer security, end user computing and the use of packages were more important during their work than they had been on their degree courses.

TABLE 4
Employers - Business Topics

	EMPLOYERS			
	Current		Future	
	Mean	Rank	Mean	Rank
Business Organisational Theory	2.97	35=	3.24	32
Finance and Accounting	2.82	39	2.92	40=
Marketing	2.71	43	2.92	40=
Human Resource Management	2.56	46=	2.74	47
Business Strategy	3.13	28=	3.58	21
Business Law	2.11	60	2.35	55
Management Models and Strategies	2.72	42	3.07	37

TABLE 5
Graduates - Business Topics

	GRADUATES			
	Degree		Work	
	Mean	Rank	Mean	Rank
Business Organisational Theory	2.19	50	2.33	35
Finance and Accounting	1.81	56	1.90	48
Marketing	1.68	59	1.70	56
Human Resource Management	1.61	60	1.72	54=
Business Strategy	1.87	55	2.07	45
Business Law	1.74	57	1.53	59
Management Models and Strategies	2.32	45=	1.87	50

Despite many employers saying that they look for graduates with business skills, the functional business areas identified do not score highly. The requirement seems to be for a general understanding and awareness of business. The highest ranked business topic identified by graduates in the workplace was Business Organisational Theory, and it is interesting that only this and Business Strategy scored an arithmetic mean greater than two.

The only topic where the rankings differed by more than twenty positions was Business Strategy; employers considered this to be of greater importance than graduates did.

TABLE 6
Employers - Business/Computing Topics

	EMPLOYERS			
	Current		Future	
	Mean	Rank	Mean	Rank
Role of Information in Organisations	3.43	15=	3.89	9
Positioning of IS/IT in Organisations	3.18	26	3.49	26=
Information Systems Management	3.24	23=	3.52	23
Information Systems Strategy	3.38	17	3.73	15=
Management of Change	3.49	10	4.18	3
Strategic Information Systems Planning	3.24	23=	3.64	20
Decision Support Systems	2.94	38	3.27	31
Business Process Re-engineering	3.06	30=	3.49	26=
Quality Assurance	3.43	15=	3.65	19
Outsourcing	2.51	48=	2.87	44
Tendering	2.56	46=	2.80	46
Social Issues of Computing	2.34	51	2.57	50
Legal Issues of Computing	2.51	48=	2.73	48
Performance Evaluation	2.97	35=	3.17	36
Office Automation	3.06	30=	3.21	33=

TABLE 7
Graduates - Business/Computing Topics

	GRADUATES			
	Degree		Work	
	Mean	Rank	Mean	Rank
Role of Information in Organisations	2.83	27	3.03	20
Positioning of IS/IT in Organisations	2.80	29	2.76	29=
Information Systems Management	2.87	22=	2.83	26=
Information Systems Strategy	2.70	34=	2.62	32
Management of Change	2.87	22=	2.72	31
Strategic Information Systems Planning	2.53	41	2.28	38=
Decision Support Systems	2.30	47=	2.24	40
Business Process Re-engineering	2.23	49	2.31	36=
Quality Assurance	2.90	21	3.31	12
Outsourcing	2.07	52	2.52	34
Tendering	1.52	61	2.18	43
Social Issues of Computing	2.30	47=	1.72	54=
Legal Issues of Computing	2.43	43	2.03	46
Performance Evaluation	2.70	34=	2.93	22=
Office Automation	2.03	53	2.21	41=

Knowledge of the use and management of information in business is seen as important for Information Systems graduates, but surprisingly, topics such as outsourcing and procurement (tendering) are not considered to be important by employers, although graduates have found them to be more important in their work than they were in their degree.

Management of change is highly ranked by employers. In the future employers see this as ranked third, but graduates report that in their work it has only ranked in 31st position. Strategic Information Systems planning and office automation are also ranked in higher positions by employers than they are by graduates.

TABLE 8
Employers - Personal Skills

	EMPLOYERS			
	Current		Future	
	Mean	Rank	Mean	Rank
Group Work	3.79	4	4.23	2
Communication	4.10	1	4.44	1
Oral Presentations	3.68	8	3.93	6
Written Reports	3.81	2=	3.92	7=
Essays	2.23	56	2.17	60
Numeracy	3.46	12=	3.51	24=
Negotiation	3.26	20=	3.51	24=
Interviewing	3.06	30=	3.24	33=
Time Management	3.81	2=	4.00	4
Managing Meetings	3.15	27	3.38	29
Leadership	3.46	12=	3.69	18

TABLE 9
Graduates - Personal Skills

	GRADUATES			
	Degree		Work	
	Mean	Rank	Mean	Rank
Group Work	4.19	3	4.28	2
Communication	4.23	2	4.48	1
Oral Presentations	4.06	5	3.45	8
Written Reports	4.35	1	3.59	5
Essays	3.65	10	1.54	58
Numeracy	3.81	8	3.36	11
Negotiation	2.84	26	3.48	6
Interviewing	2.58	39	2.21	41=
Time Management	3.58	11	4.10	3
Managing Meetings	2.77	30=	2.79	28
Leadership	3.03	18=	3.21	14

Some personal skills, notably group work, communication, oral presentations, written reports and time management are considered extremely important skills by both employers and graduates, and were an extremely important part of the graduates' degrees.

The only two topic areas where graduates noted a difference in importance between work and their degrees were essays and negotiation. Essays featured highly in the graduates' degrees, but were not considered to be important for work by employers or graduates. However, graduates found that in their work they did need negotiation skills, but that this had not received such importance during their degrees.

TABLE 10
Employers - Other Topics

	EMPLOYERS			
	Current		Future	
	Mean	Rank	Mean	Rank
Discrete Mathematics and Logic	2.42	50	2.49	51
Probability and Statistics	2.31	52	2.37	54
Operational Research	2.17	58	2.27	57
Economics	2.08	61	2.20	59
Research	2.25	54	2.44	52
Self Study Project Work	2.81	40	2.97	39

TABLE 11
Graduates - Other Topics

	GRADUATES			
	Degree		Work	
	Mean	Rank	Mean	Rank
Discrete Mathematics and Logic	3.26	14	2.31	36=
Probability and Statistics	2.74	33	1.79	53
Operational Research	2.48	42	1.83	51
Economics	1.71	58	1.31	61
Research	3.42	12	2.28	38=
Self Study Project Work	4.13	4	3.14	16

None of these 'other' knowledge and skills featured highly in importance by employers or by graduates in their workplace. However, self-study project work and research featured highly in the graduates' degrees. Mathematics and statistics were ranked significantly higher in the graduates' degrees than in the workplace.

VI. WHAT DOES THIS MEAN?

There is consensus amongst Information Systems practitioners that the skills of the modern Information Systems practitioner are multifarious. There is agreement between employers and graduates that good inter-personal skills are essential for working in the field of Information Systems. It is interesting to note that graduates acknowledged the importance of these skills during their degree education. Universities appear to have responded to demands to increase the teaching of these skills. There is also agreement between the two stakeholders that specific functional business knowledge does not rank highly.

Of concern is the disparity in the importance of computing topics taught in degree programmes and the computing used in the workplace. Although not shown in the tables in this paper, the standard deviations for these knowledge/skills were generally high, showing a variance in the views of respondents. What is evident, however, is that there is no consensus on what essential computing topics should be taught to Information Systems undergraduates. This reflects the diversity of jobs that an Information Systems practitioner can be expected to undertake.

The complexity and multi-disciplinarity of Information Systems makes identifying a common curriculum both difficult and contentious. There is, however, a need for a balanced curriculum between computer science and aspects of social science. Information Systems staff need to be technically competent, but they also need the personal skills of being able to communicate with others.

Despite the acknowledged importance of inter-personal skills, some employers did consider computing skills to be more important. This was investigated further by carrying out structured interviews with a number of employers.

In small companies where IT is the core business the ability to communicate was identified as the most important requirement. This was not expected, but upon further investigation it was found that in such companies it is usual for all staff to liaise and to work with customers, thus explaining this finding. If an IT person is employed in a small company where IT is not the core business, then this person would be supporting the systems and therefore technical knowledge is considered essential.

The opposite was found to be the case for large companies. In large companies where IT is the core business, most staff are involved in performing technical duties such as programming, so recent graduates would need good technical knowledge and skills. In large companies where IT is not the core business, the IT staff will need to support the business applications within the company. A knowledge of business, together with the ability to communicate with users, is necessary.

The requirements of medium sized IT companies were seen to be similar to that for large IT companies, with technical skills and knowledge being the most important. Interestingly, medium sized companies where IT was not their core business seemed to require IT and Personal Skills in approximately equal proportions. Obviously, technical knowledge and skills are required as they are the IT specialists within the company, but at the same time they are often acting as IT support to the users, and therefore good personal skills are demanded.

TABLE 12
Generalisation of requirements
according to company size and core business

	Small company < 20 employees	**Medium company 20 – 250 employees**	**Large Company >250 employees**
IT is core business	Personal Skills	IT Knowledge and Skills	IT Knowledge and Skills
IT is not core business	IT Knowledge and Skills	"All-rounder" IT Knowledge and Skills and Personal Skills	Personal Skills

VII. CONCLUSIONS

Information Systems graduates must be multi-skilled. They need to be organisationally as well as technically competent, and need a mix of knowledge and skills that will enable them to work effectively in a modern organisation and also equip them for life-long learning.

There is a coherent offering of Information Systems courses in the UK covering the three imperatives for industry which are business, technology and personal and professional skills. However, there is still a significant mismatch between what is produced by academia and supplied to the industry. There is a need to close the gap between what students learn and what companies need them to know. To address the gap, education may need its own re-engineering effort with a reconsideration of who the primary customer of the university is

- the student?
- the companies that employ graduates?
- the university administration?
- the accrediting agencies?

and a re-evaluation of how best to serve that customer.

Information Systems graduates need to be multi-skilled and flexibility is important. Information Systems Education has been criticised for being too 'theoretical'. However, Information Systems professionals in the future will face increasingly complex organisations, more changes in the technological environment and a greater need for business effectiveness. They should have not only sufficient knowledge and skills based on a wide range of theoretical and practical experience, but should also be aware of the integration of theory and practice.

Educational programmes within Information Systems are different and at first sight a critic might suggest that this is because the subject is not cohesive and comprises any topic that is of interest to an academic. A closer inspection shows that the underlying theme common to all programmes is that Information Systems calls upon many areas of knowledge and this knowledge is gained through the incorporation of topics from other domains of knowledge. A small core of subject material is required, and then courses should reflect the experience of staff and the different requirements of different employers. It might be appropriate in sandwich courses to treat the final year as a 'post-experience' year, this final year of study providing opportunities for students to update, reflect and apply experiences from their placements against their academic curriculum.

The challenge for course designers is to design a diversity of Information Systems curricula to meet the different career path goals of Information Systems professionals, and the needs of the industry. Information Systems is changing and our teaching of Information Systems must reflect this change. It is our responsibility to educate would-be Information Systems professionals to a high standard technically, but we must also develop their understanding of the business world and the problems that they are likely to encounter within organisations. Technical, business and social skills will need to be used harmoniously.

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