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INFORMATION SYSTEMS EDUCATION JOURNAL

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Do the Knowledge and Skills Required By Employers of Recent Graduates of Undergraduate Information Systems Programs Match the Current ACM/AIS Information Systems Curriculum Guidelines?

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Abstract

This research investigates the knowledge and skills required by potential employers of students graduating from undergraduate Information Systems programs. For this study, job listings were collected and analyzed from several Internet web sites specializing in technology related employment. The job listings, collected over a four month period, were for entry level jobs that specifically required an undergraduate degree in Information Systems or a related program. The results show that potential employers are most interested in "soft skills" such as written and oral communication, teamwork, and problem solving skills as well as general technical skills. The article then compares the knowledge and skills required by potential employers to the suggested curriculum of the 2010 ACM/AIS Information Systems Curriculum Guidelines.

Keywords: Information Systems Knowledge and Skills, Information Systems Curriculum

1. INTRODUCTION

Current industry demand for employees with technology skills is well documented (Burns, Gao, Sherman, & Klein 2014). Increasingly, many of those employees in demand, especially at the entry level, are recent graduates of collegiate undergraduate Information Systems (IS) programs. Accordingly, educators in the IS field want to make sure that their programs meet the requirements of their stakeholders (Pierson, Kruck, & Teer, 2009). As the significance of information systems in the business world increases, so does the importance of the IS

curriculum (Tehrani, 2015). Additionally, while there has been some improvement in recent years, enrollment in the college majors that would prepare students for careers in technology oriented jobs is significantly less than it was at the turn of the century (Burns, Gao, Sherman, & Vengerov, 2014). One suggestion for improving enrollment is to change the IS curriculum (Tehrani, 2015).

This research has multiple goals. The first goal is to gain a general understanding of the current knowledge and skills that are most in demand by employers of the students graduating from IS programs. The second goal is to compare those skills to the most recent model IS curriculum that is used by many IS programs in colleges and universities around the world. Finally, the ultimate goal is to provide insight into a revised IS model curriculum that would prepare students to have the knowledge and skills that are highest in demand by employers.

2. LITERATURE REVIEW

At least as far back as the 1980s, IS faculty reviewed the content of job advertisements to better understand the skills graduating IS students would require in order to be successful in the workforce (Knodel, 1982). Due to the popularity of online recruiting websites, there is every reason to believe that job advertisements continue to be essential to recruiting and it is estimated that about three-fourths of IS jobs are advertised (Litecky, 2012). Litecky (2012) provide a useful summary of the many job advertisements studies, the majority of which concluded that employers were looking for so-called "hard skills" or technical skills such as programming and database management.

In addition to the analysis of job advertisements, IS researchers utilized other methodologies such as surveys of IS managers and recruiters, focus groups of IS professionals, and interviews with IT managers to investigate industry requirements. The results gleaned from these other methodologies were quite different from the job analysis studies and indicated that so-called "soft skills" such as ability to communicate were more important in obtaining a job than technical knowledge (Litecky, 2012). To try to understand and explain the "hard-soft controversy" Litecky (2012) applied Image Theory, which explains that processes occur in steps. In the case of hiring, they posited there was a first filtration step to eliminate unacceptable candidates, followed by a second step for choosing the best candidate from the select group. Because soft skills are not easy to quantify they were not useful for the filtration step and were therefore, not included in job advertisements. However, the interview comprised the second selection step and because the hirer could determine whether the candidate communicated well, had leadership qualities, and the like, these soft skills then become the determinant as to whether the candidate was actually hired. In addition, during a face-to-face interview, the hirer might be more concerned with the applicant's long-term ability to contribute to the organization, which would include soft skills, rather than just the applicant's knowledge of a particular software package.

Longitudinal studies of job advertisements which covered from the 1970s into the 2010s (Gallivan 2004), (Harris (2012) shed additional light on this dichotomy. These studies included not just print advertisements but online advertisements, from sites such as www.dice.com and www.careerbuilder.com. Gallivan (2004) discovered that although technical skills continued to dominate print ads, online ads required a mix of both technical and non-technical skills (Gallivan, 2004). Litecky (2012) noted that online job boards and non-print media do not have the space limitations of print media and cost is not determined by the number of words used in the ad. This allows advertisers to list as many skills as they wish and the result is that soft skills are specified as well as hard skills. So perhaps, soft skills have been desired by employers all along but their specification was an added advertising cost which employers were not willing to expend.

Harris' 2012 study updated two earlier studies to include data from online job advertisements posted on www.careerbuilder.com. Data from the ads were parsed into tables and the context of each skill word checked to eliminate duplicates and to verify the word was, in fact, being used as a skill word. So for example, this method ensured "Access" was being used as the name of a software package and not as an everyday word. Using SQL queries the authors calculated the frequency of each skill and manually identified emergent skills that were brand-new. They found that there was a dramatic increase in the number of advertisements and the number of skills mentioned per advertisement. So, while there were 32 skills identified in the 1970s, this study identified 194 skills. On average, each ad mentioned seven skills, about double the number mentioned when only print media was used to advertise.

The ranking of various skills also changed over time. For example, Experience, which had been consistently ranked near the top, became the top skill in 2010 and appeared in over 90% of the ads; in 1970, it had only been in 17% of the ads. (Of course, there are now more applicants in the market who have experience as computer usage and training has exploded). Nevertheless, it represents one more hurdle particularly for the recent graduate. Remarkably, Communication which had not even been in the top ten became the second most frequently requested skill. To be clear, the communication skill requested is communication as it pertains to systems analysis and design, not a generalized reading or writing skill one might obtain through an English literature course or a course on public speaking. Bachelor was the third skill indicating degrees are more highly desired than they were in the dot-com era when it ranked number 14. Generalized demand for IS workers was high at that time and the number of educated workers was lower, so it may have been a supply and demand issue. Network and Database remained in the top ten skills although some specific database packages such as Oracle declined in frequency requested. Conversely, Java emerged as number 9, reflecting the general move to the Web. Other skills that declined markedly were: Web master, Unix, C/C++, and Visual Basic. Project Management and Security also moved up in the ranks, into the top 20, to number 11 and 12, respectively. Harris notes (p. 77) that the IS 2010 Model Curriculum addressed this increase in number and diversity of skills requested by employers, by recognizing the need for elective courses which enable the student to specialize (Topi, Valacich, Wright, Kaiser, Nunamaker, Sipior, and de Vreede 2010).

Litecky (2012) took online job advertisement analysis one step further by crawling five large US web sites including Monster.com, CareerBuilder.com, Dice.com, and SimplyHired.com, retrieving ads requiring degrees such as Computer Science (CS), Management Information Systems/Computer Information Systems (MIS/CIS), and Information Technology (IT) and reviewing more than 4,000 ads. Litecky only included skills which appeared in at least 5% of the ads and grouped the skills listed iinto three broad categories: Business Skills, Soft Skills, and General Technical Skills. An example of a Business Skill would be Contracting and Legal while an example of a Soft Skill would be Judgment & Decision Making.

The most frequent business skill requested was Managing/Supervision which appeared in 48% of the ads selected, followed by Administration/Quality in 29%. Financial, Project Management, Business Strategy, Accounting, and Marketing also appeared with frequencies above 10%. These results reflect the need for IS professionals to have general business skills and continues to differentiate the IS degree from computer science, for example. In the Soft Skills category, Leadership, Problem Solving, and Written Communication were the top three requested. In General Technical Skills, Security was requested most often with a frequency of 50%. Other top skills were: Testing, Certification, Programming, Office Applications, and Software Development. Litecky notes that although only 23% of the ads mentioned certification, for IS Security jobs, 50% did so. Also Litecky notes that now much of the IT work force comes from functional areas such as Accounting rather than an IT department, particularly due to growth in the adoption of enterprise system (ES) software. He speculates that integrating SAP into the MIS curriculum could increase enrollment (p. 41).

Hite (2012) queried a variety of online job bank web sites using key word lists from previous research studies. SQL was the skill in highest demand followed by JAVA. Other top ten skills requested included: Unix and Linux, HTML/DHTML, and C++. MSVisio and Visual Studio replaced earlier multimedia design software in popularity. Photoshop replaced earlier desktop publishing software, such as MS Publisher, and the entire category fell in popularity. With regard to enterprise software, SAP led, followed by Oracle and PeopleSoft. The author concluded that educators should emphasize general categories of IT instruction, such as database creation, rather than specific software and that some skills could most appropriately be taught in technical schools and community colleges.

Despite all these efforts to dovetail the IS curriculum to employer needs there remained a long-standing belief that the IS degree did not properly equip a student to perform an entry-level job successfully (Fang, 2005). Several studies revealed there was a gap between expected and actual skill performance (Cappel, 2001/2002). The recession of 2008 and the advent of IT outsourcing refocused research to redefine not just job skills for IS majors but entry-level skills in particular. This was in part due to declining enrollment in the IS major because students believed they would not be hired, despite the need for IS skills in the marketplace. (Burns et al, 2014).

Kennan (2008) narrowed the field of inquiry by only analyzing online job ads for positions suitable for early career graduates, that is graduates of IS programs with three years of experience or less. Kennan conducted a content analysis of 400 ads culled from the three major Australian online job sites, JobServe, seek, and MyCareer over a ten week period in 2006. Kennan downloaded the data into Simstat/Wordstat, a word counting software package which creates a hierarchical dictionary of terms. After consulting the literature, a team of knowledgeable academics and students manually grouped the terms into categories. Using Jaccard's coefficent of similarity measure and cluster analysis, they determined the key words which most commonly appeared together. The dominant cluster consisted of ten categories: Business and Systems Analysis; Management; Operations, Maintenance & Support; Communication Skills; Personal Characteristics; IS Development; Computer Languages; Data & Information Management; Internet; Intranet; Web Applications; and Software Packages. This cluster represents the core IS skills and job competencies required by employers for early stage graduates.

IS Development was the most frequently occurring term (78% of ads) and included skills such as Programming and Testing. Personal Characteristics and Communications Skills appeared in 75% of the ads with "ability to learn" appearing most frequently. These two categories were closely linked indicating that employers believe communication to be essential to development. Enterprise Resource Planning and Security and Project Management were least frequently mentioned and the authors surmise these skills would appear more often in ads targeted at graduates with more experience. Almost 50% of the ads also requested experience which could be an obstacle for recent graduates. The authors conclude that finding the right balance between business and technical skills remains a primary challenge for educators.

3. CURRENT MODEL IS CURRICULUM GUIDELINES

The current undergraduate IS program curriculum guidelines were developed in 2010 by a joint effort of the Association for Computing Machinery (ACM) and the Association for Information Systems (AIS) (Topi et al., 2010). These guidelines are referred to as the 2010 model. This 2010 model serves as a standard for numerous undergraduate IS and IS related programs in institutions around the world (Tehrani, 2015).

The 2010 model is summarized by Topi et al as follows:

"This revision has four broad key characteristics that have shaped the outcome significantly. First, the curriculum reaches beyond the schools of business and management. Previous versions of the IS curriculum have been targeted to a typical North American business school; this model curriculum is, however, guided by the belief that even though business will likely continue to be the primary domain for Information Systems, the discipline provides expertise that is critically important for an increasing number of domains. Second, the outcome expectations of the curriculum have been very carefully re-evaluated and articulated first in the form of high-level IS capabilities and then in three knowledge and skills categories: IS specific knowledge and skills, foundational knowledge and skills, and domain fundamentals. Third, the curriculum is structured so that it separates the core of the curriculum from electives with the intent of supporting the concept of career tracks. Finally, the design of this curriculum includes enough flexibility to allow its adoption in a variety of educational system contexts" (Topi et al, 2010).

Ultimately the 2010 model has seven core courses:

1. Foundations of Information Systems
2. Data and Information Management
3. Enterprise Architecture
4. IT Infrastructure
5. IS Project Management
6. Systems Analysis and Design
7. IS Strategy, Management, and Acquisition

In addition, the model includes several suggested electives. The authors of the model acknowledge that a complete collection of electives is not possible in a curriculum model but they do include some suggested sample electives. The suggested elective list includes Application Development, Business Process Management, Enterprise Systems, Human-Computer Interaction, IT Audit and Controls, Data mining / Business Intelligence, Collaborative Computing, Information Search & Retrieval, Knowledge management, Social Informatics, IT Security and Risk Management.

Appendix A is a matrix from the 2010 model that includes the core courses and sample electives mapped to a number of suggested career tracks. IS programs can use the matrix to tailor their core and elective course offerings to a specific job or job category and students can use the matrix to

select a course sequence that builds a knowledge base for a specific job.

4. RESEARCH METHODOLOGY

This research was conducted using a "grounded theory" approach. Grounded theory was developed by the sociologists Barney Glaser and Anselm Strauss in the 1960's. In the grounded theory approach, conclusions are drawn and theories are produced by analyzing a body of data. In essence, the theories that are produced are "grounded" in the data (Glaser & Strauss, 1967).

For this project, job listings were collected and analyzed from several Internet web sites specializing in technology related employment. The listings were collected over a four month period from January to May 2017. In order to be included in the study, the job had to be technology based and entry level as indicated by the words "entry level" in the job listing or as indicated by requiring less than three years of experience. Also, the listing had to indicate that the job required an IS or IS related Bachelor's degree (Computer Information Systems, Information Technology Management, Business Information Systems, Management Information Systems, etc.).

For each job listing that met the criteria, a record was made of the various experience, knowledge, and skills required for the job. The knowledge and skills specified in the ads were categorized by type. The types included written, oral, and other types of communication skills, various technical skills, analytical skills, and business related skills. Also any other additional education or certifications required were recorded. The knowledge and skills for each category were then tabulated, summarized, and sorted in order of frequency of occurrence of specific words. In order to count word frequencies in each category a VBA macro published by Allen Wyatt (2016) was used. The following section shows the results of that analysis.

4. RESULTS

A total of 204 ads were examined in this study. Most of the ads were from Indeed (168), and the rest were from Monster, Dice, and Glassdoor. The ads ranged in dates from January 24 to May 11, 2017. The ads represented jobs in 36 states and the District of Columbia.

Years of Experience

Of all the ads examined, ninety-seven (97) ads specified a years-of-experience requirement, which typically ranged from 0 to 3 years.

Experience Skills

One hundred and fifty-eight ads (77%) required some experience. Overall, the most frequently words mentioned in conjunction with experience were support/supporting, technology, networks/networking, server, hardware/software, web, database(s), system(s), application(s), programming, troubleshooting, and helpdesk/help desk. The most frequently mentioned technical platforms were SQL, C/C++, Java, JavaScript, Linux and .Net, etc.

Communications Skills

One hundred thirty-two ads (65%) emphasized the requirement of excellent or strong written communications skills. One hundred thirty-seven ads (67%) required excellent or strong oral communications skills. Among those ads, one hundred thirty-one ads (64%) mentioned both oral and written communications skills. Separately, one hundred and four ads elaborated their communications requirements emphasizing the words or phrases of customer service, technical, interpersonal, team, and professional, etc.

Programming Skills

Table 1 Programming Skills

Word	Frequency
SQL	24
Java	18
Scripting	17
C	13
object-oriented	10
JavaScript	8
C++	8
.Net	7
Script	6
PowerShell	5
Shell	4
PYTHON	4
PHP	4
RUBY	3
OOP	3
PL	3
HTML	3
MySQL	3

Seventy-one ads (35%) required programming skills. The required programming languages are summarized in the following table. SQL,

Java/JavaScript, C/C++ and .Net were most frequently mentioned.

Network Skills
Fifty-six ads (27%) specified a network skills requirement, with TCP/IP, LAN/WAN, DNS, protocols, firewall, server, and switches/routers being the most frequently mentioned.

Table 2 Network Skills

Word	Frequency
TCP/IP, IP	12
WAN	9
DNS	9
Protocols	8
LAN	8
Server	6
Firewalls	6
Switches	5
http	5
Routers	4
DHCP	4
Wireless	4

Database Skills

There are 31 ads (15%) that specified database skills with the most frequent words summarized in the following table.

Table 3 Database Skills

Word	Frequency
Relational	9
SQL	7
Oracle	5
SQL Server	4

Systems Analysis and Design Skills
There are 33 ads (16%) that specified systems analysis and design skills with the most frequent words summarized in the following table.

Table 4 Systems Analysis and Design Skills

Word	Frequency
SDLC	15
Design	7
Agile	6
project management	4
UML	4
Integration	2
Methodologies	2
Scrum	2
Waterfall	2
Iterative	2

Web Skills
There are 21 ads (10%) that specified Web skills with the most frequent words summarized in the following table. HTML, CSS, and .Net lead the table.

Table 5 Web Skills

Word	Frequency
HTML	9
Development	9
CSS	4
Design	4
Internet	2
.Net	2
Hosting	1
Security	1
ASP	1
JavaScript	1

Security Skills
Seventeen ads (8%) specified cyber security skills with the most frequent words summarized in the following table.

Table 6 Security Skills

Word	Frequency
Antivirus	3
Cyber	2
Firewalls	2
Virus	2

Other Technical Skills
Other skills requirements not fitting neatly into the above categories are summarized in table seven, which is based on content from 166 ads (81%) in this study. Microsoft Office (Excel, Word, PowerPoint) are the most common skills referred to in the ads. Windows, operating systems, server/servers, also seem to be a quite common requirement, followed by general technological categories like hardware, technology, applications, development, and PC/PC's, etc.

The bulk of the table represents a variety of technical skills that companies are looking for on the market. This skills category showcases the multifaceted nature of the IT field.

Table 7 Other Technical Skills

Word	Frequency
Microsoft/MS Office	128
Windows	60
operating system(s)	49
Hardware	37
server(s)	35
Technical	33
application(s)	22
IT	14
PC/PC's	14
Technology	13
WMWare	13
Linux	13
Mac/Apple	12
Client	11
Virtualization	6
Mobile	6
Unix	5
SharePoint	4
Adobe	4
Infrastructure	4
Testing	4
Monitoring	4
Visio	4
R2	3
Mainframe	3
Microcomputer	3
ERP	3
Cloud	3
Android	3
PCS	3
iOS	3

Analytical and Business Skills

One hundred fifty-four ads (75%) specified analytical and business skills with the most frequent words summarized in the following table. Overall, they refer to a wide spectrum of soft skills such as problem solving, team work, analytical skills, time management, and self-motivation, among others.

Table 8 Analytical and Business Skills

Word	Frequency
Problem Solving	54
Team	42
Troubleshooting	42
Analytical	37
Detail	34
Independent	34
Time Management	29
Prioritize	25
Manage	25
Self Motivated	22
Business	19
Priorities	18
Supervision	14
Deadlines	13
Organized	9
Ethic	7
Analyze	7
Identify	7
Responsibilities	7
under pressure	6
Proactive	5
Logical	5
Driven	5

Certifications

Forty-one ads (20%) required or preferred certification. The most common certifications are summarized in the following table.

Table 9 Certifications

Word	Frequency
Network	14
Microsoft	13
CompTIA	7
Security	7
CCNA	5
Professional	4
Cisco	4

5. DISCUSSION

As previously stated this research has multiple goals. The first goal is to gain a general understanding of the current knowledge and skills that are most in demand by employers of the students graduating from IS programs. The second goal is to compare those skills to the most recent model IS curriculum that is used by many IS programs in colleges and universities around the world. Finally, the ultimate goal is to provide insight into a revised IS model curriculum that would prepare students to have the skills that are highest in demand by employers.

The results of this research show that the skills most in demand from employers are primarily soft skills and basic technology skills. Regarding soft skills, 75% of the prospective employers in the study were looking for employees with analytical and business skills such as problem solving and teamwork skills. Additionally, two thirds of the employers in the study were looking for employees with strong communication skills, both written and oral.

Eighty one percent of the ads were looking for general technology skills. Overall, Windows, server/servers, and Microsoft/MS Office (Excel, Word, PowerPoint) seem to be a quite common requirement, followed by other general technological categories like operating systems, technology, applications, development, and PC/PC's, etc.

Surprisingly, employers in the study were less likely to look for specific technical skills. About a third of the ads were looking for programming skills, 27% were looking for networking skills, and 15% were looking for database skills. Furthermore, only 16% were looking for systems analysis and design skills which is counterintuitive to the idea that the IS degree prepares students for the systems analyst job. Two skills that would seem to be in especially high demand in recent years, web development and cybersecurity, showed little demand in our study. Only 10% of the ads were looking for web development skills and 8% for cybersecurity.

When the skills required by employers in the study are compared to the suggested material covered in the 2010 model IS curriculum (shown in Appendix A) some interesting conclusions can be drawn. The first conclusion is that employers are primarily looking for soft skills but the model IS curriculum focuses on specific hard skills. Perhaps the argument can be made that the soft skills come from other sources. In particular soft skills may be learned through ancillary work in the core IS courses (such as group projects and presentations) or in the general education courses students are required to take.

Another interesting conclusion in the comparison of the employer required skills to the IS model curriculum involves the specific hard skills. This research shows that the hard skill most in demand by employers is programming. However, the IS model curriculum does not include programming as a core course. It does suggest that programming be included as an elective but that means that many students may choose not to take it. The model core curriculum does include network skills (as part of the "IT infrastructure" core course), database skills, and systems analysis and design skills, which are all skills that did show up in the study. Furthermore, most of the general technology skills most often sought by employers would be covered in the "Foundations of IS", "IT Infrastructure", and "Enterprise Architecture" core courses suggested by the model curriculum. The 2010 model curriculum purposely dropped the requirement for a personal productivity tools course (such as Excel or word processing) because the authors felt that most institutions required students to be proficient in these skills (Topi et al., 2010). However, our research shows that those skills are in high demand and subsequently it is important to ensure that students are getting those skills somewhere in the curriculum.

There are two categories of requirements that, according to the study, are in high demand by employers but are not explicitly or implicitly covered by the 2010 model IS curriculum. Those two areas are experience and external certifications. Twenty percent of the ads in the study were looking for applicants with an external certification and, as previously noted, 77% of the ads were looking for employees with experience.

The ultimate goal of this research is to suggest how the 2010 IS model curriculum should be amended to fulfill the requirements of employers in 2017. According to this research the following changes would be proposed. First, soft skills should be made more prominent in the curriculum. This could be accomplished through either adding a core course or adding soft skill coverage to existing core courses. Next, as programming is the highest demand technical skill, it may be a good idea to also make programming more prominent in the IS model curriculum. Again, this could be accomplished by adding a programming core course to the curriculum or by adding programming to one of the existing core courses. Finally, according to this research, the IS model curriculum should include an experiential component. This idea is already supported by many in the IS field, who feel that IS is an applied discipline and, as such, should emulate other applied fields such as medicine, engineering, and architecture by including an internship or other hands on experience in the curriculum (Moody and Buist 1999).

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Appendix A - Structure of the IS 2010 Model Curriculum (Topi et al, 2010).

Structure of the IS Model Curriculum:Information Systems specific courses

Career Track:	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q
Core IS Courses:																	
Foundations of IS	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
Enterprise Architecture	○	●	○	○	○	●	○	○	○	○	●	○	○	○	●	○	○
IS Strategy, Management and Acquisition	○	●	○	○	○	●	○	○	●	○	●	○	○	○	●	○	○
Data and Information Management	●	○	○	●	●	○	○	●	●	○	●	○	●	○	○	○	○
Systems Analysis & Design	●	●	●	○	○	○	●	○	○	○	○	○	○	○	●	●	●
IT Infrastructure	○	○	○	●	○	○	○	●	●	●	○	○	●	●	○	○	○
IT Project Management	●	○	○	○	○	●	○	○	○	○	●	○	○	○	●	●	●
Elective IS Courses:																	
Application Development	●	○	○	○	○	○	○	○	○	○	○	○	○	○	○	●	●
Business Process Management		●	●			○	○	○		○	●				○		
Collaborative Computing						○								○			○
Data Mining / Business Intelligence		●		●	●	○	○	○	●		○	○	○	○	○		○
Enterprise Systems		●	●	○	○	○	●	●	○		●	●	○	○			
Human-Computer Interaction	●					○	○				○					●	
Information Search and Retrieval		○		○	●								○				●
IT Audit and Controls	○		●	○	○	○	○	●		●	○		○	○	○		○
IT Security and Risk Management	○			○	○	○	○	●	●	○	○		●	●	○		○
Knowledge Management		●		○		○	○			○							
Social Informatics													○		○		

Key:

● = Significant Coverage

○ = Some Coverage

Blank Cell = Not Required