FITC Institute Final Report

Appendix H

Curriculum Analysis Report:

Florida Agricultural and Mechanical University

Computer Science Program

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1. Introduction

This curriculum analysis of Computer Science (CS) program at the Florida Agricultural and Mechanical University (FAMU) is one of the tasks required of the Florida IT Career Alliance (FITC) Assessment project. This analysis answers a specific research question: To what extent are the learning outcomes specified in the FAMU CS program syllabi similar to the learning outcomes in the selected CS curriculum standards? It employs syllabus assessment as an analytical approach to examine similarities between learning outcomes specified in the program syllabi and selected curriculum frameworks—the Association for Computing Machinery and Institute of Electrical and Electronics Engineers (hereafter ACM/IEEE) 2013 CS curriculum guidelines.

Specifically, curriculum models for the computing fields began in 1965 when the ACM first published a set of recommendations (Pasha & Pasha, 2012). Every decade since then, the ACM/IEEE jointly sponsor a curriculum framework, which mainly aims to provide modern curricular guidance for undergraduate computing related programs internationally. Starting from the year 2001, this volume was fragmented into 5 disciplines: CS, Computer Engineering (CE), Information Systems (IS), Information Technology (IT), and Software Engineering (SE). The

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effort behind publishing curriculum guidelines is to help train future generations of computing professionals (The Joint Task Force on ACM/IEEE-Computer Society, 2013). This report examines the FAMU CS program by analyzing course syllabi based on the selected CS curriculum guidelines.

2. Method

2.1 Data Collection

The FAMU CS Curriculum Planning and Progress Form (See Appendix A) guides students' course selection through their four-year college degree program. The Bachelor of Science (BS) degree in CS has received accreditation by the Computing Accreditation Commission (CAC) of the Accreditation Board for Engineering and Technology (ABET). The FAMU CS program consists of 46 credit hours of required CS courses that comprises the total 15 required course (Listed in Appendix B). In addition, the CS program also includes six credit hours of elective CS courses, 19 of mathematics, 14 of laboratory science, 36 of general education requirements (including electives outside the major, and up to two credit hours of professional development). However, only the syllabi for courses comprising 46 credit hours (N=15) required for the CS program are included in this analysis.

2.2. The *Body of Knowledge* Specified in the ACM/IEEE 2013 CS Curriculum Guidelines

The ACM/IEEE 2013 CS curriculum guidelines primarily focus on two aspects of the *Body of Knowledge*:

1. The *Body of Knowledge* specifies ideal content to be covered in a curriculum as an implementation of selected CS curriculum guidelines. The *Knowledge Areas* are not intended to be in one-to-one correspondence with particular courses in a curriculum. Curricula have courses that incorporate topics from multiple *Knowledge Areas*. According to the ACM/IEEE undergraduate curriculum guidelines, "We view the hierarchical structure of the *Body of Knowledge* as a useful way to group related information, not as a structure for organizing material into courses" (The Joint Task Force on Computing Curricula: ACM/IEEE-Computer Society, 2013, p. 28). It is expected that curricula may integrate materials from multiple *Knowledge Areas*.

2. Topics in the selected CS curriculum guidelines are identified as either "*Core*" or "*Elective*" with the *Core* topics further subdivided into "*Tier-1*" and "*Tier-2*." The ACM/IEEE CS curriculum guidelines committee created the two-tier structure of the *Core* topics precisely to provide flexibility, keeping the *Core Tier-1* material to an essential minimum to allow institutions greater leeway in selecting *Core Tier-2* material to best suit their needs. Furthermore, the ACM/IEEE determined that the *Core* topics should be divided into *Tier 1* and *Tier 2* in response to pressure to expand the *Core* topics in order to allow for more specialization of topics, which was difficult for students to accomplish in the previous *Core* topics structure given the

time allotted for an undergraduate degree program. The division into *Tier 1* and *Tier 2* not only provides flexibility for curriculum implementation, but the smaller size of *Tier 1* allows for more "guidance and structure for curriculum designers" (The Joint Task Force on Computing Curricula: ACM/IEEE-Computer Society, 2013, p. 30).

2.3 Data Analysis

The unit of analysis was a course syllabus from the FAMU CS program. The learning outcomes from each syllabus were extracted using a keyword extraction algorithm developed as a part of the FITC assessment study. The analysis assesses similarities between the course learning outcomes and the *Knowledge Unit*s in the selected CS curriculum guidelines.

The keywords extracted from syllabi were matched with the topics and learning outcomes in the selected CS curriculum guidelines. The basic unit of coverage in the guidelines is a lecture hour, which may not be the same as the actual number of lecture hours devoted to the guidelines' *Core* topics at that institution. For example, if a course covers only two-thirds of the topics in a three-lecture hour *Knowledge Unit*, then the findings would list the corresponding proportion of lecture hours (e.g., two-thirds of three lecture hours = two lecture hours of coverage).

If a course covers all of the topics in a 3-lecture hour *Knowledge Unit*, the findings would list 3 lecture hours regardless of the time spent in actual instruction. If a learning outcome from the *Knowledge Unit* was covered in multiple courses, the coverage was reported only once. The number of lecture hours of coverage reported represents the lecture hours of coverage as specified in the *Body of Knowledge* deemed necessary for covering the learning outcomes that are covered in the course. The actual number of class hours spent covering the topics in each *Knowledge Unit* may be greater than or less than the number of hours reported in the summary table (see Appendix A & Appendix C).

In the table presented in Appendix C, the columns represent courses and the rows represent *Knowledge Unit*s in each *Knowledge Area*. The numbers represent the number of lecture hours dedicated to covering the topics for that *Knowledge Unit* in each course. For instance, if a three-lecture hour course covered all topics related to a particular *Knowledge Unit*, the course would receive three lecture hours for that *Knowledge Unit*. If a three-lecture hour course only covered 50% of topics for a *Knowledge Unit*, that course would receive 1.5 lecture hours for that *Knowledge Unit*. The last two columns present an overall percentage of coverage for *Core Tier-1* and *Core Tier-2* topics for each *Knowledge Area*. This method was derived from the Knowledge Units Table offered in the ACM/IEEE 2013 CS curriculum guidelines.

3. Findings

This syllabus analysis examined the extent to which the 15 required FAMU CS courses are similar to the ACM/IEEE 2013 CS *Core Tier-1* and *Core Tier-2 Knowledge Units*. Figure 1 shows the overall percentages of coverage for both *Core Tier-1* and *Core Tier-2 Knowledge Units*.

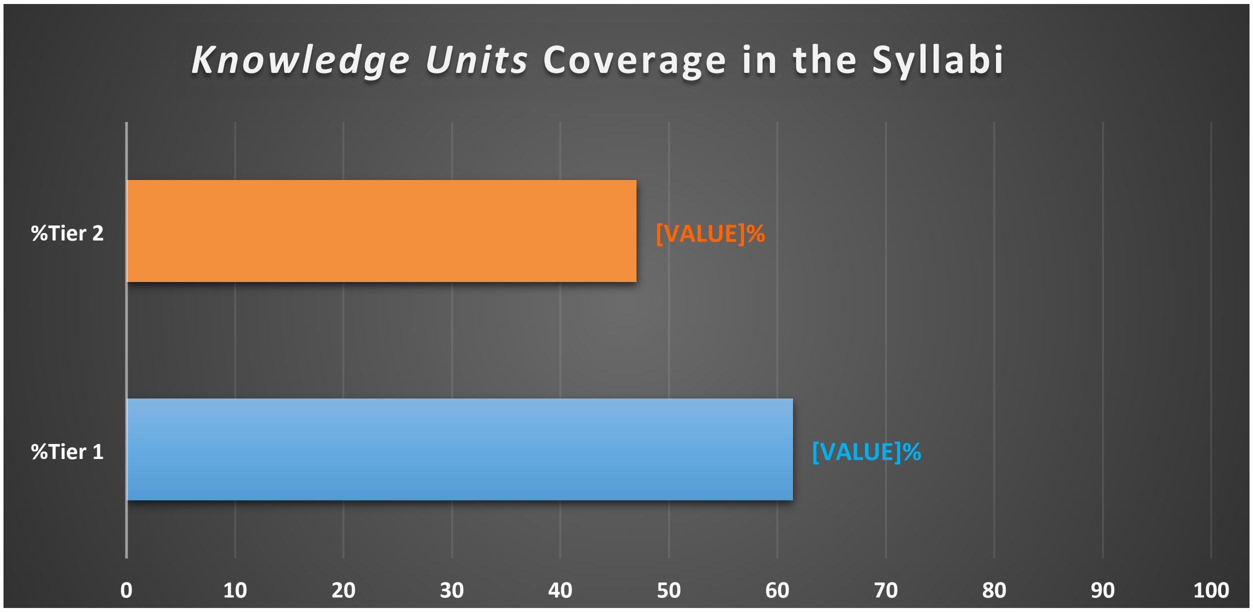

Figure 1: The ACM/IEEE 2013 CS *Knowledge Units* coverage in the FAMU CS syllabi

Figure 1 presents the overall percentage of *Knowledge Units* covered in Core Tier-1 and Core Tier-2 that were present in the syllabi analyzed. Figure 1 shows these courses (N=15) provide 61.4% coverage of *Core Tier-1 Knowledge Units* and 47% coverage of *Core Tier-2 Knowledge Units* based on the learning outcomes listed in the course syllabi.

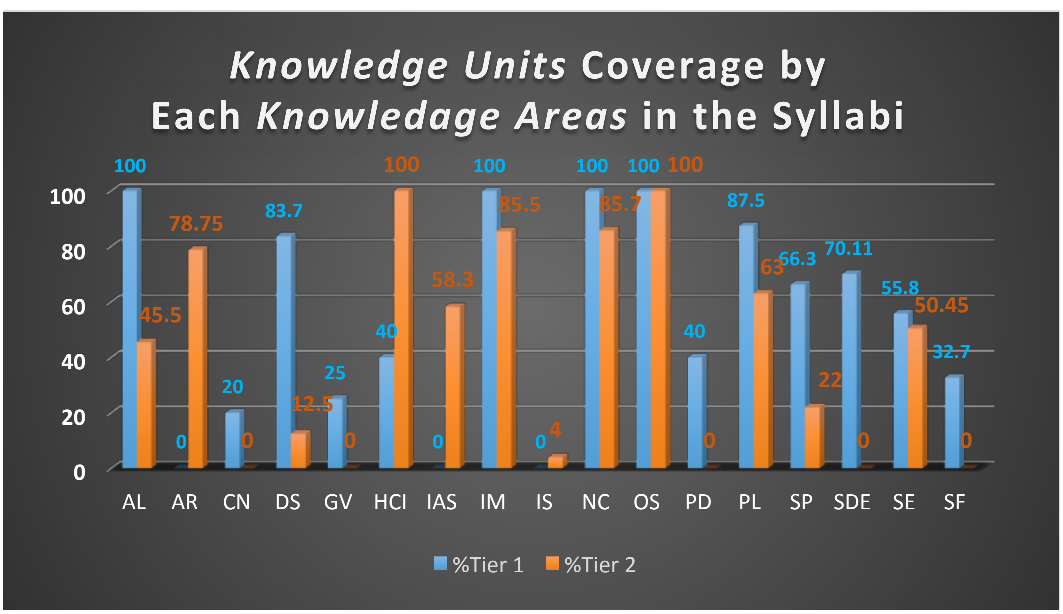

Figure 2: *Knowledge Unit* coverage by each *Knowledge Area* in the FAMU CS syllabi

Figure 2 demonstrates the percentages of *Core Tier-1* and *Core Tier-2 Knowledge Unit*s from each *Knowledge Area* that were covered in the FAMU CS course syllabi (N=15). In Figure 2, as for the Information Management (IM) Knowledge area, the blue vertical bar represents 100% of the learning outcomes in Tier-1 category are covered. And the orange bar indicated 85.5% of learning outcomes in Tier-2 category are covered in ACM/IEEE 2013 CS curriculum guidelines. The *Knowledge Areas* Computational Science (CN), Discrete Structures (DS), Graphics and Visualization (GV), Intelligent Systems (IS), Parallel and Distributed Computing (PD), Social Issues and Professional Practice (SP), and Systems Fundamentals (SF), are the top *Knowledge Areas* whose majority of the learning outcomes from *Core Tier-1* and *Core Tier-2* are not similar to the courses analyzed.

3.1 *Core Tier-1* and *Core Tier-2* Coverage

From the analysis, the four *Knowledge Areas* were 100% covered in the FAMU CS syllabi compared to the seven *Knowledge Areas* with less than 100% Coverage of Core Tier-1 Knowledge Units (Shown in Table 1).

Table 1: *Knowledge Areas* with complete coverage of *Core Tier-1 Knowledge Units* and *Knowledge Areas* with incomplete coverage of *Core Tier-1 Knowledge Units*

Knowledge Areas with 100% Coverage of Core Tier-1 Knowledge Units	Knowledge Areas with Less than 100% Coverage of Core Tier-1 Knowledge Units
Algorithms & Complexity	Information Assurance & Security
Information Management	Computational Science
Networking and Communication	Graphics and Visualization
Operating Systems	System Fundamentals
	Human Computer Interaction
	Parallel and Distributed Computing
	Software Engineering

Similarly for the coverage of *Core Tier-2 Knowledge Unit*s, the four *Knowledge Areas* were 100% covered in the FAMU CS syllabi compared to the seven *Knowledge Areas* with less than 100% Coverage of Core Tier-2 Knowledge Units (Shown in Table2).

Table 2: *Knowledge Areas* with more than 80% coverage of *Core Tier-2 Knowledge Units* and *Knowledge Areas* with less than 50% coverage of *Core Tier-2 Knowledge Units*

Knowledge Areas with More than 80% Coverage of Core Tier-2 Knowledge Units	Knowledge Areas with Less than 50% Coverage of Core Tier-2 Knowledge Units
Information Management	Graphics and Visualization

Networking and Communication Human Computer Interaction	Systems Fundamentals Parallel and Distributed Computing
Operating Systems	Intelligent Systems Discrete Structures Social Issues and Professional Practice Algorithms & Complexity

4. Discussion

4.1 Findings Discussion

To answer the research question, this syllabus analysis examined to what extent the 15 (N=15) required FAMU CS courses are similar to the selected ACM/IEEE 2013 CS curriculum guidelines. Based on the analysis, it was determined that there is similarity between the FAMU CS courses and the ACM/IEEE curriculum guidelines. The *Knowledge Areas* that were not similar to the course syllabi were:

- Intelligent Systems;
- Information Assurance & Security;
- Computational Science;
- Graphics and Visualization;
- Systems Fundamentals;
- Human Computer Interaction;
- Parallel and Distributed Computing; and
- Software Engineering.

Although they are not listed in the syllabi, it is possible that learning outcomes pertaining to these *Knowledge Areas* are being conveyed in other aspects of the course. It is also possible that these *Knowledge Areas* are conveyed in the elective courses students may take in their program sequence. As this analysis focused on course syllabi as the unit of analysis, future research may take into account the other aspects of student learning such as elective courses, assignments, formal and informal interactions between instructors and students, students' informal learning opportunities, etc. in order to gain a holistic and comprehensive understanding of the curriculum.

4.2 Limitations

This study excludes six credit hours of elective CS courses, 19 of mathematics, 14 of laboratory science, and 36 of general education requirements provided in the program, which might miss the contribution of those interdisciplinary curricula where students will gain necessary competencies to advance their science, technology, engineering and math (STEM) learning. Those courses may also help students learn and develop critical 21st Century skills in the quickly changing computing technology environment, such as knowledge and skills of problem-solving, creativity, innovation, communication and collaboration. Furthermore, the syllabus itself may not reflect the whole picture of teaching practice and student learning when only course syllabi are assessed in this analysis study.

5. Conclusion

Curriculum examination and analysis is important for all academic programs, but it is especially important for programs concerning the rapidly-shifting world of technology and computing (Mills, Valsquez, & Fadel, 2012). The strength of a program can be determined by how well prepared its graduates are for future study or employment. Organizations like the ACM/IEEE produce curricular guidelines to help academic institutions design programs that meet the needs of students.

However, the ACM/IEEE 2013 CS curriculum guidelines explicitly state that the document is not intended as a "check-box" of competencies and learning outcomes, and that schools may also consider the ways in which "the Body of Knowledge may be best integrated into a unique set of courses that reflect an institution's mission, faculty strength, student needs, and employer demands" (The ACM/IEEE Joint Task Force on Computing Curricula, 2013, p. 46).

Curriculum assessment is important, but it is only one part of a much larger picture. In order to gain a complete understanding of a program, one must consider additional elements. For instance, this analysis focused solely on course syllabi from 15 required courses in the program. This in no way comprises a holistic view of a student's academic experience. Further research could be done to take into account elective courses as well as aspects of instruction beyond the syllabus. Additionally, academic programs are charged with not only meeting the needs of students but also meeting the needs of the industry and community. In order to gain a holistic view of an academic program, those needs must also be taken into account.

Although curriculum guidelines serve as helpful aids in program development, many institutions seek to design their curriculum based on the needs of the community and local employers (Mills, Velasquez, & Fadel, 2012). In order to determine what educational and workplace competencies employers desire in CS graduates, findings from the curriculum analysis may be compared to the findings from the job post analysis and employer interviews.

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References

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Pasha, M. A., & Pasha, S. (2012). Missing elements of computer science curricula 2013. *Global Journal of Computer Science and Technology*, *12*(11-B), 9-16. Retrieved from http://computerresearch.org/index.php/computer/article/view/284/284

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APPENDICES

Appendix A: FAMU CS Curriculum Planning and Progress Form

(Last updated on June 20, 2013; retrieved from http://www.famu.edu/cis/Science-cppf_FALL2010_APPROVED.pdf)

Freshman Year		Credit Hours
BSC 1005	Biological Science with Lab*	4
ENC 1101	Freshman Communicative Skills I (or ENC 1121) *	3
MAC 2311	Calculus I [MAC 1147 or Equivalent] *	4
SPC 2608	Public Speaking*	3
	General Elective*	3
		17
AFA 3104	The African American Experience*	3
ENC 1102	Communicative Skills II (or ENC 1122) *	3
COP 3014	Fundamentals of Programming	4
MAC 2312	Calculus II [MAC 2311] *	4
	General Elective*	2
		16
Sophomore Year		
COT 3100	Discrete Structures I [MAC 2311]	3
MAC 3313	Calculus III [MAC 2312*]	5
COP 3330	Introduction to Objective-Oriented Programming [COP 3014]	3
	Social Science Elective*	3
		14
COP 3530	Program, File and Data Structures [COP 3330]	3
COT 3101	Discrete Structures II (spring only) [COT 3100]	3
	General Elective*	3
	General Elective*	3
	Humanities Elective*	3
		15
Junior Year		
CDA 3101	Comp Concepts & Org [COT 2104, COP 3014]	3
CIS 4250	Computer Ethics and Professional Responsibility	3
COT 4210	Foundations of Computer Science (fall only) [COT 3101, COP 3530]	3
PHY 2048	General Physics I [MAC 2311] *	4
PHY 2048L	General Physics I Lab*	1
	(Approved Math Course) *	3
		17
CDA 4102	Computer Architecture (spring only) [CDA 3101]	3
CNT 4504	Data Communications and Organizational Network [COT 2104]	3
COP 3710	Database Management Systems [COP 3014]	3
PHY 2049	General Physics II [PHY 2048] *	4
PHY 2049L	General Physics II Lab*	1
	Humanities Elective*	3
		17
Senior Year		

CIS 4301	Information Systems Design and Development [COP 3710]	3
COP 3060	Concepts in Advanced Application Development [COP 3530]	3
COP 4020	Programming Language (fall only) [COP 3530]	3
	Major Elective*	3
		12
CIS 4910	Information Systems Development Project [CIS 4301, COP 3060]	3
COP 3610	Operating Systems (spring only) [COP 3530, CDA 3101]	3
	(Approved Math Course) *	3
	Major Elective*	3
		12
Total		120

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Appendix B: List of 15 Required Courses in the FAMU CS Program

Required CS Course	Credit Hours
CDA 3101 Computer Concepts and Organization	3
CDA 4102 Computer Architecture	3
CIS 4250 Computer Ethics and Professional Responsibility	3
CIS 4301 Systems Analysis and Design	3
CIS 4910 Information Systems Development Project	3
CNT4504 Data Communication and Organizational Network	3
COP 3014C Fundamentals of Programming	4
COP 3060 Concepts in Advanced Application Development	3
COP 3330 Intro to Object Oriented Programming	3
COP 3530 Program, Data and File Structures	3
COP 3610 Operating System	3
COP 3710 Database Management Systems	3
COT 3100 Discrete Mathematics	3
COT 3101 Discrete Structures II	3
COT 4210 Foundations of Computer Science	3

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Appendix C: Lecture Hour Coverage of the Knowledge Units in FAMU CS Program Course

Knowledge Area/ Knowledge Unit	CDA 3101	COT 3100	COT 3101	CIS 4301	COP 3530	CIS 4910	CIS 4520	COP 3710	COP 3014C	COT 4210	CDA 4102	CNT 4504	COP 3060	COP 3330	COP 3610	% Tier 1	% Tier 2
AL/Basic Analysis		**3.2**														**100**	**45.5**
AL/Algorithmic Strategies			**2**														
AL/Fundamental Data Structures & Algorithms		**5**			**8.2**												
AL/Basic Automata, Computability & Complexity			**2.5**							**4**							
AR/Digital Logic & Digital Systems	**2**															**N/A**	**78.75**
AR/Machine Level Representation of Data	**3**																
AR/Assembly Level Machine Organization	**5**										**2.7**						
AR/Memory System Organization & Architecture	**0.7**										**2**						
AR/Interfacing & Communication											**0.6**						
CN/Introduction to Modeling & Simulation														**0.2**		**20**	**N/A**
DS/Sets, Relations & Functions			**4**	**1.3**												**83.7**	**12.5**
DS/Basic Logic			**9**														
DS/Proof Techniques			**10**														
DS/Basics of Counting			**5**	**5**													
DS/Graphs & Trees			**3**	**3**		**3.5**											
DS/Discrete Probability																	
GV/Fundamental Concepts													**0.5**			**25**	**0**
HCI/Foundations						**1.6**							**0.5**			**40**	**100**
HCI/Designing Interaction						**4**											
IAS/Foundational Concepts in Security																**0**	**58.3**
IAS/Principles of Secure Design																	
IAS/Defensive Programming																	
IAS/Threats & Attacks							**0.5**										
IAS/Network Security							**1.5**					**2**					
IAS/ Cryptography																	
IM/Information Management Concepts								**1.5**								**100**	**85.5**
IM/Database Systems						**0.5**		**1.5**									
IM/Data Modelling						**2.6**		**2.6**									
IS/Fundamental Issues																**N/A**	**4**
IS/Basic Search Strategies																	
IS/Basic Knowledge Representation & Reasoning																	
IS/Basic Machine Learning			**0.4**														
NC/Introduction												**1.5**				**100**	**85.7**
NC/Networked Applications												**1.5**					
NC/Reliable Data Delivery												**2**					

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NC/Routing & Forwarding												1.5					
NC/Local Area Networks												1.5					
NC/Resource Allocation												1					
NC/Mobility																	
OS/Overview of Operating Systems															2	100	100
OS/Operating System Principles	0.3														2		
OS/Concurrency															3		
OS/Scheduling & Dispatch															3		
OS/Memory Management															3		
OS/Security & Protection															2		
PD/Parallelism Fundamentals																40	0
PD/Parallel Decomposition																	
PD/Communication & Coordination																	
PD/Parallel Algorithms, Analysis & Programming																	
PD/Parallel Architecture																	
PL/Object-Oriented Programming					4	1			10					10		87.5	63
PL/Functional Programming									4								
PL/Event-Driven & Reactive Programming													2				
PL/Basic Type Systems					0.25				1				2				
PL/Program Representation					0.3				0.6								
PL/Language Translation & Execution																	
SDF/Algorithms & Design			5.5											2.75		70.11	N/A
SDF/Fundamental Programming Concepts	1.4								8.5								
SDF/Fundamental Data Structures					6.8								1.7	6.8			
SDF/Development Methods				1.6		1.6			6.6					1.6			
SE/Software Processes				1		0.6										55.8	50.45
SE/Software Project Management				1.3													
SE/Tools & Environments				0.3													
SE/Requirements Engineering				4		4											
SE/Software Design				0.75									2.5	0.75			
SE/Software Construction				0.6													
SE/Software Verification & Validation						2											
SE/Software Evolution														0.4			
SE/Software Reliability																	
SF/Computational Paradigms	0.5															37.2	0
SF/Cross-Layer Communications														0.75			
SF/State & State Machines	1.2																
SF/Parallelism	3																
SF/Evaluation																	
SF/Resource Allocation & Scheduling																	

SF/Proximity																	
SF/Virtualization & Isolation																	
SF/Reliability through Redundancy																	
SP/Social Context							**1**									**66.3**	**22**
SP/Analytical Tools							**1.3**										
SP/Professional Ethics						**2**	**1.8**										
SP/Intellectual Property							**1.7**										
SP/Privacy & Civil Liberties							**1.6**										
SP/Professional Communication						**0.2**											
SP/Sustainability																	