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Comments

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INDUSTRY AND FACULTY SURVEYS CALL FOR INCREASED COLLABORATION TO PREPARE INFORMATION TECHNOLOGY GRADUATES

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ABSTRACT

Academic and industry collaborations can help improve computing curricula and student learning experiences. Such collaborations are formally encouraged by accreditation standards. Through the auspices of ACM and IEEE-CS, the IT2017 task group is updating curriculum guidelines for information technology undergraduate degree programs, similar to the regular updates for other computing disciplines. The task group surveyed curriculum preferences of both faculty and industry. The authors, with the group's cooperation, compare US faculty and US industry preferences in mathematics, IT knowledge areas, and student workplace skill sets. Faculty and industry share common ground, which supports optimism about their productive collaboration, but are also distinct enough to justify the effort of actively coordinating with each other.

INTRODUCTION

Computing programs benefit from industry participation in curriculum design and supporting experiential learning opportunities for students [6]. Accreditation of computing degree programs values the productive role that industry advisory boards play [4]. Capstone projects and many course projects tackle authentic problems from real clients to expose students to professional practices that employers expect of computing graduates [3].

Despite efforts to prepare college students adequately for professional careers, gaps persist between student and employer perceptions of student preparation for their future careers. The most recent national surveys commissioned by the American Association of Colleges and Universities [2] found that students and employers are alike in their perception of how well prepared students are to stay current with new technologies. However, in other key areas, such as communication, applying knowledge and skills to real world situations, critical thinking, and solving complex problems, students overestimate their preparation.

This paper focuses on computing faculty and IT industry professionals, their attitudes about the relevance of the undergraduate curriculum, and about what professional skills students should achieve. The authors enjoyed the cooperation of the ACM/IEEE-CS IT2017 task group, which is preparing an update of the curriculum guidelines for undergraduate degree programs in information technology, due by 2017 [5]. The task group conducted separate simultaneous surveys of IT faculty and industry professionals. The current authors received access to about two hundred survey responses from US faculty and from ninety US industry IT professionals.

In the rest of the paper we describe the two surveys, summarize three chief results, discuss parallels and contrasts between the American faculty and industry groups, and conclude with brief remarks about the benefits of continued cooperation between academia and industry.

THE SURVEYS

The surveys were designed by the IT2017 task group to gain insights into what the IT discipline within the computing profession means to academia and industry. They were hosted on the Survey Monkey platform and distributed through email blasts in Spring 2015. Survey responses were given routine data cleaning by a statistician to eliminate spurious responses, to correct typographical errors and expand common abbreviations in free-text responses, and to recode "other" responses into admissible answers when possible.

ACM administered the faculty survey by reaching out to over 16,000 computing faculty in four-year undergraduate IT programs worldwide. The survey asked 16 questions with a mix of multiple-choice and free form responses. This paper's authors accessed the responses from three survey questions: Question #1 about the country of the academic program, Question #6 about math requirements, and Question #13 about content areas of interest in the IT curriculum.

Three email blasts to contacts acquired from the International Book Information Service (IBIS) and one email blast to members of the ACM Special Interest Group for Information Technology Education (SIGITE) produced 589 responses. Of these, 205 (34.8%) were from US. The US response rate was 3.8% (205 returns from 5400 contacts).

The industry survey was composed by a subgroup of the IT2017 committee and an industry consultant. They adapted six of the faculty questions for an industry audience. This adaptation included rewording some of the prompted responses. Two of those questions, Question #4 on math requirements and Question #6 on content areas, are used in this paper. The subgroup added one new question, Question #7 about skill sets, which is also used here.

The Association for Information Technology Professionals (AITP) distributed the industry survey to 1,871 members who worked outside of academia. A total of 91 members responded (5% response rate), with 90 from the United States. Table 1 shows the distribution of sizes of the IT departments in which the US respondents work.

Less than 10 employees	41	46%
Between 10 and 30 employees	17	19%
Between 30 and 50 employees	5	6%
Between 50 and 100 employees	7	8%
Over 100 employees	20	22%

Table 1, Sizes of US industry survey respondents' IT departments

RESULTS

Crucial areas of mathematics

Both groups were asked, "For a strong and rigorous undergraduate degree program in information technology, indicate the areas of mathematics you believe are necessary to produce a competent IT graduate in the mid-2020s. Check all that apply." The two surveys had slightly different lists for prompted answers, both including a free-text "Other (please specify)" option. 187 US faculty and all 90 US industry participants responded to the question.

Table 2 shows the response prompts, along with counts and percentages of responders who voted for each item, and rank among the seven items (besides “Other...”) with identical or similar prompts in both surveys. No item in the faculty prompt list matched “Financial modeling and budgeting” on the industry list. The prompt “Business mathematics/calculus” in the industry survey, which is marked with an asterisk in the table, was matched for ranking analysis with “Business mathematics” in the faculty survey.

	Prompted options	Votes	%	Rank		Rank	%	Votes
Industry survey	Statistics	68	76%	1	Faculty survey	1	87%	163
	*Business mathematics/calculus	61	68%	2		5	32%	60
	Financial modeling and budgeting	61	68%	-		-	-	-
	Probability	46	51%	3		3	55%	103
	Linear algebra	26	29%	4		6	31%	58
	Discrete mathematics	25	28%	5		2	70%	131
	Applied calculus	20	22%	6		4	39%	73
	Finite mathematics	18	20%	7		7	26%	48
	Other (please specify)	10	11%	-		-	5%	9

Table 2. US industry and faculty choices of crucial math areas

Crucial knowledge areas

Both groups were also asked, “Consider the following list of knowledge areas for information technology as developed by the IT2017 Task Group. Indicate the 8 most important areas you believe will be essential or fundamental for IT graduates to know in the mid-2020s.” (Emphasis was placed on “8 most important areas” by underlining in the industry survey and capitalization in the faculty survey). Once again, the surveys had slightly different lists for prompted answers. Both included a free-text “Other (please specify)” option. 186 US faculty and all 90 US industry participants responded to this question.

	Prompted options	Votes	%	Rank		Rank	%	Votes
Industry survey	*Cybersecurity and Digital Forensics	67	74%	1	Faculty survey	7	52%	97
	Cloud Computing	58	64%	2		5	59%	109
	Web Systems and Technologies	57	63%	3		1	81%	150
	Virtualization	55	61%	4		13	39%	72
	System Integration and Architecture	54	60%	5		11	44%	81
	**Information Assurance and Security	53	59%	6		3-4	75%	139
	Information Management	52	58%	7		8	52%	96
	Networking	49	54%	8		2	77%	143
	Social and Professional Issues	44	49%	9-10		12	41%	76
	Programming	44	49%	9-10		3-4	75%	139
	Big Data	43	48%	11		6	57%	106
	Human Computer Interaction	40	44%	12		10	48%	90
	Internet of Things	33	37%	13		14	20%	38
	System Administration and Maintenance	32	36%	14		9	49%	91
	Integrative Programming Technologies	25	28%	15		15	18%	33
	Platform Technologies	19	21%	16		16	12%	23
	Green Computing	17	19%	17		17	6%	12
	Other (please specify)	5	6%	-		-	11%	21

Table 3. US industry and faculty choices of crucial knowledge areas

Table 3 shows the response prompts, along with counts and percentages of respondents voting for each item, and rank among the seventeen items (besides "Other...") with similar prompts in both surveys. "Cybersecurity and Digital Forensics" in the industry survey, marked with an asterisk in the table, was matched with "Cybersecurity: Digital Forensics and Response" in the faculty survey. "Information Assurance and Security" in the industry survey, marked with a double asterisk, was matched with the faculty's "Information Assurance and Cybersecurity."

Crucial skill sets

Industry participants (but not faculty) were asked, "Indicate the top <u>six skill sets</u> you believe your organization will require of new IT graduates in the mid-2020s." Emphasis was in the original. Participants were offered thirteen prompted options, as well as "Other (please specify)." All 90 US industry participants responded to the question. Table4 shows the response prompts offered, along with counts and percentages of respondents voting for each item, and rank among the thirteen prompted items (besides "Other...").

Industry prompts	votes	%	rank
Project management	70	78%	1
Information (cyber) security	66	73%	2
Soft skills	59	66%	3
Business analytics	53	59%	4
Database administration and architecture	46	51%	5
Data analytics	44	49%	6
Networking	40	44%	7
Cloud Computing	38	42%	8
Programming	36	40%	9
Helpdesk support	22	24%	10
Quality assurance	21	23%	11
PC/desktop support	20	22%	12-13
Rudiments of finance	20	22%	12-13
Other (please specify)	9	10%	-

Table 4. US Industry predictions of mid-2020's IT skill-set requirements

DISCUSSION

There was a reasonable degree of agreement between United States industry and faculty rankings of the seven prompted math subject areas which they shared. Using Spearman's "sum of the squared differences in rank" statistic as an index of agreement, the two groups score +0.54 on a scale from -1 (perfect disagreement, inverse rankings) to +1 (perfect agreement, identical rankings). United States faculty and industry polling ranks of the prompted knowledge areas score a similar Spearman's value of +0.62.

Table 2, the surveys' choices of crucial math areas, illustrates how substantial agreement leavened by some pointed disagreement might arise. Both groups agree about their top collective priority, statistics. They also agree about their least priority, finite mathematics. They even agree in the middle, where probability polls third among both. The most pronounced disagreement concerns discrete mathematics *versus* business mathematics, each topic polling second on one list and fifth on the other. Business math polled high on the industry list, discrete mathematics on the academic. Support for the math topic that appeared only in the industry survey, financial modeling and budgeting, an aspect of "business mathematics," equaled the votes for business mathematics/calculus, as the prompt appeared in the industry survey ballot.

This pattern suggests that disagreement may depend on whether content is more useful for learning the how and why of IT, or more useful for later career application in combination with IT skills. Content like statistics, which is generally useful at both career stages, learning and doing, would plausibly be easier for both groups to support.

Table 3 depicts reasonable agreement about the importance ranking of the seventeen prompted knowledge areas between US industry and faculty. Their top eight ranks have six areas in common: Cybersecurity and Digital Forensics, Cloud Computing, Web systems and Technologies, Information Assurance and Security, Information Management, and Networking. Similarly, their bottom five ranks have four areas in common: Internet of Things, Integrative Programming Technologies, Platform Technologies, and Green Computing.

Among the six areas in the top eight ranks, "Networking" and "Cybersecurity and Digital Forensics" had the largest difference in support from the faculty and industry groups (Table 5, above the double line). Comparably large difference of support was also recorded for the "Programming" area, which made it among the top five areas for faculty, but ranked below top eight for industry; and the "Virtualization" and "System Integration" areas, which ranked 4 and 5 for industry, but placed among last nine for faculty (Table 5, below double line).

Prompted options	Industry ranks	Faculty ranks	Industry %	Faculty %
Networking	8	2	54%	77%
*Cybersecurity and Digital Forensics	1	7	74%	52%
Programming	9-10	3-4	49%	75%
System Integration and Architecture	5	11	60%	44%
Virtualization	4	13	61%	39%

Table 5. Extract from Table 3, knowledge areas with substantial but remarkably different support

Using slightly different names in the two surveys for the two areas that encompass information assurance, cybersecurity, and digital forensics (marked with single or double asterisks in Table 3) might explain the difference in support for those areas. The uneven support for the other areas in Table 5 might indicate an academic focus on foundational areas, such as networking and programming, and their importance to scaffold more specialized areas that are of high interest to industry, such as virtualization and system integration and architecture.

Turning to industry predictions of skill set requirements (Table 4), three of the four bottom-ranked skills (helpdesk support, PC/desktop support and rudiments of finance) are often pursued in two-year rather than four-year programs. Of the ten other prompted skills, five relate closely to prompted knowledge areas. Three of the five either did well among both skill sets and industry's preferred knowledge areas (cybersecurity in various phrasings) or relatively poorly on both rankings (networking and programming). Data analytics ran a bit better among skills (6 of 13) than big data, among knowledge areas (11 of 17). Cloud computing did much better among industry's knowledge area ranking (2 of 17) than among skill sets (8 of 13).

Although not identical in content, the good showing of business analytics seems in line with the industry's top preferences among math areas, statistics and business math. Similarly, database skills' placement (6 of 13) and information management's (7 of 17) were comparable.

There is no surprise that two skill sets did especially well, project management (1 of 13) and soft skills (3 of 13). Domain independent rather than peculiar to computing disciplines, these directly transferable skills have been consistently and highly valued in industry surveys [1, 2].

CONCLUSIONS

When asked about their preferences among mathematics subject areas and their predictions of which knowledge areas will be crucial in the near future, faculty and industry participants resembled each other. When industry respondents were asked about what skill sets will be needed in the same near-future time frame, their answers were generally as might be expected based on their curriculum preferences. Industry's strong support for two of the domain independent skills, "soft" skills and project management, is consonant with a general tendency for United States baccalaureate education to balance depth and breadth.

If agreement was all there was, then there would be little need for formal consultations apart from planning specific cooperative ventures, like internships. However, the survey also found some high-level differences. Broadly speaking, and predictably, faculty placed higher value on topics that are useful for learning more (such as discrete mathematics and programming, for example), while industry gave more weight to topics immediately applicable to producing more (like business mathematics and cybersecurity).

A skill gap persists between employers' expectations and graduates' demonstration of key competencies in communication, problem solving, and application of technical knowledge to authentic problems. The study in this paper reassures computing faculty and industry professionals that ongoing dialog and collaboration in curriculum development is mutually beneficial. Periodic updates of computing curricula by ACM and partnering professional societies rely on industry feedback. Academic programs integrate a variety of experiential learning opportunities through internships and industry-sponsored projects. Faculty and industry professionals alike have the responsibility to continue to communicate to each other the relevance of what they do the best in their respective domains, and create and support more effective pathways to transfer content mastery into professional practices.

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