# IT Curriculum: Coping with Technology Trends & Industry Demands

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## ABSTRACT

The field of Information Technology (IT) has evolved more rapidly over the past 15 years than ever thought possible. To keep up with industry demands, IT educators have had to react accordingly and with enough foresight to identify those trends that are short lived and those that are here to stay. In this paper, we identify a four-layer IT Stack with associated core techniques within each layer. The evolution of the core techniques over time is then discussed with respect to industry trends, changes in ACM/IEEE IT curricula, and the topics of technical oriented papers presented at the ACM SIGITE conference since 2003. Finally, a case study chronicling the evolution of an Information Technology MS program is presented, along with recommendations for modeling future IT curriculum.

## CCS CONCEPTS

• Computing education • Computing education programs • Information technology education

## KEYWORDS

Information technologies; big data; cloud computing; curriculum, data analytics; human computer interaction; internet of things,; network; virtualization

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## 1 Introduction

In chronicling the evolution of technology trends in Information Technology (IT) over the past 15 years and the demands put on the IT professionals in industry, we identify four layers of technologies as an IT Stack in this study: Human Computer Interaction, Data, Networking and Fundamentals. We then list core techniques per layer and discuss if the dependency of techniques occurs only within the layer and/or across different layers. These types of insights will offer useful guidelines for future IT curriculum design and development.

One way of recognizing the inclusion of specific technologies in IT programs over time is to compare published IT curriculum guidelines. The first IT curriculum guidelines were published in 2008 by ACM/IEEE Computer Society [6]. It was later restructured and revised in 2017 [3]. We will discuss these ACM/IEEE IT curricula to learn about the evolution of technology trends and the industry demands.

IT educators have a keen interest in technology trends and industry demands in order to have their students well prepared for their future after graduation. As a result, state-of-the art technologies have been continuously introduced into IT curricula at different institutions. They can be implemented at different levels, which may vary from degrees and/or their concentrations/tracks to courses and capstone projects, and to the specific modules/topics of individual courses. To study how the evolution of technology trends has motivated IT education, we have surveyed papers published in ACM SIGITE annual conferences from the years 2003 to 2017. Categorizing the papers by pedagogical objectives and IT Stacks/Technologies, we analyze how technologies have evolved over the past 15 years in IT education.

The remainder of the paper is organized as follows. We begin by defining the IT stack of technologies to capture the evolution of technology trends in IT in Section 2. We identify technology evolution using two IT curriculum guidelines published in 2008 and 2017 in Section 3. We then analyze the evolution by surveying papers published in SIGITE conferences in Section 4. We use a case study to demonstrate how a particular curriculum has evolved while going through three major phases during the past 15 years in Section 5. Important findings along with useful guidelines for future IT curriculum design and development are summarized in Section 6. We conclude the paper in Section 7.

## 2 IT Technology Trends & Industry Demands

Through a comprehensive analysis of technology trends and industry demands of information technology, we identify a set of core techniques and organize them into a multi-layer IT Stack, which is detailed in Table 1.


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**Table 1. IT Stack**

| IT Stack | IT2008 | IT2017 |
|---|---|---|
| **Human Computer Interaction** | | |
| • Accessibility | x | x |
| • Usability | x | x |
| • User experience design | | x |
| • Ubiquitous computing | | |
| • Social computing | x | x |
| • Wearable computing | x | x |
| **Data** | | |
| • Relational databases (SQL) | x | x |
| • Unstructured and semi-structured data (NoSQL & others) | | x |
| • Information retrieval & NLP | x | x |
| • Distributed and parallel computing (MapReduce/Hadoop) | | x |
| • Data science, data mining, machine learning (Big data) | x | x |
| **Networking** | | |
| • Cloud | | x |
| • IoT | | x |
| • Mobile computing | x | x |
| • Virtualization | x | x |
| • Wireless access technologies | x | x |
| **Fundamentals** | | |
| • Programming | x | x |
| • Security | x | x |
| • Software development | x | x |
| • Web technology | x | x |

The Networking Layer plays an overarching role in the technical evolution of IT, as it not only provides access to devices that require connectivity to the Internet, but also, with improvements in access technology comes new methods of network resource deployment and security. Both the Human Computer Interaction (HCI) Layer and the Data Layer are predicated upon advances in the Networking Layer and their respective evolution is typically in response to the new technologies afforded by the increased ubiquity of computing thanks to the wireless access technologies.

As wireless access technologies have evolved, end users realize increases in network capacity and data rates. As a result, IT professionals must support applications on computing devices that have become more mobile and ubiquitous in nature. Give users access to more network capacity, they will undoubtedly find a way to use it.

The main reason that the Networking Layer, via wireless access technologies, leads further technical innovations in the HCI and Data Layers is due to the forward thinking of standards bodies, like the IEEE, that define standards, such as 802.11xx, and that industry has major involvement in defining cellular standards like 5G. For example, [1], which analyzed the major tech trends in 2008, goes into great detail about the evolution of WiFi technologies. In the prior 10 years, by following the standardization path laid out by the IEEE, wireless data rates of WiFi systems went from 1-2 Mbps with 802.11a to upwards of 54 Mbps with 802.11g. Not to mention the fact that the IEEE was on the precipice of releasing the 802.11n standard in the following year, which promised data rates of upwards of 600 Mbps.

In 2008, the concept of mobility was just beginning to equate to mobility beyond a user's back yard and out into the rest of the world. The iPhone had been released in mid-2007 and was referred to in [1] as "an iPod-phone hybrid device". At that point in time, 3G cellular technology was the state of the art, providing data rates of 3 Mbps, where available. However, 3G was not as pervasive as 4G and LTE are today, resulting in much lower cellular data rates of 14.4 kbps seen in 1G and 2G for many users. As such, application ubiquity was generally limited to locations with WiFi infrastructure, where the iPhone and iPod could achieve requisite data rates for streaming audio and video, for example, hence why the iPhone was generally considered an iPod that can make phone calls and nothing more.

Moving ahead to 2011, [8] begins to identify the social web, the semantic web, massive online gaming, and even "smart objects" as current to future trends in IT. At this time, 802.11n was widely deployed and 4G, with data rates approaching 100 Mbps, became available in many areas. Finally, the network capacity needed for the masses to achieve ubiquity in computing was achieved.

It is worth noting that at this point in time, within the HCI Layer, usability, user experience design (UXD), and accessibility largely focused on desktop/laptop computing and those core technologies had just begun to move deeply into wearable and ubiquitous computing since they were becoming closer to reality due to wireless access technology improvements. In the Data Layer, structured data accessed by relational databases were the norm, although semi and unstructured data were increasing in size and scope with NoSQL databases like MongoDB and other database solutions for the new data paradigm popping up in the years prior.

Between 2015 and today, the IT professional and demands from industry have shifted towards the Data Layer with the HCI Layer attempting to keep up [1,9]. Once again, this was possible due to the evolution of the Networking Layer through virtualization and Cloud and mobile computing that have made access to massive computing power more accessible to small companies and individual users. It is no longer the case that a company must own a data center to actually create a data center.

Social media, through Facebook, Twitter, Snapchat, and Instagram, has created massive amounts of multimedia data as well as the IoT revolution with sensor readings from "things", must now be made seamlessly accessible and processed instantaneously to satisfy user and application demands. A newfound interest in machine learning due to the proliferation of data has resulted in major industry demand from IT professionals.

With the relative ease of access to major computing power, companies are now able to process data that was often collected, but never analyzed, in reasonable amounts of time. The HCI Layer has also evolved in response to the availability of computing power and resultant data analyses in the design of wearable and ubiquitous computing systems since much more user expectation can be placed on these devices in terms of responsiveness. For example, wearable personalized healthcare devices can constantly stream data via several wireless technologies, such as Bluetooth Low Energy, Wi-Fi, 4G/LTE, and expect responses back from Cloud services without interruption and with little latency from almost anywhere.

Interestingly, as noted, the Networking Layer leads the Data and HCI Layers with advances in wireless access technologies and computing resource deployment, but it also lags the Data and HCI Layers, and even itself, in terms of security. The well laid plans of the IEEE and industry to plan out evolutions in 802.11xx and cellular, respectively, have not been able to follow suit with security largely because it is simply not possible to envision how application developers and users will utilize their newfound network capacity. As such, IT professionals involved with security are always in a reactive mode, attempting to provide security solutions after the fact. This is especially evident today with the explosion in smart devices on the IoT where security was an afterthought and is just now being considered.

# 3 ACM/IT Curricula on Technology Trends

One way of comparing the inclusion of specific technologies in IT programs over time is to compare published IT curriculum guidelines; first published in 2008[6]. It was later restructured and revised in 2017 [3].

## 3.1 IT Curriculum Guidelines

With the continued growth of the IT discipline, it became important to define the role of IT within the computing disciplines. The IT Curriculum Guidelines report was first issued in 2008 [6]. By the time the document was released, additional technologies had been introduced such as smart phones, video streaming websites, and e-readers. IT2008 centered on the five pillars of IT: programming, networking, HCI, databases and web systems. It was based on IT fundamentals and guided by professionalism, information assurance, and security. IT2008 used the IT Body of Knowledge as a basis for developing outcomes. In the following ten years, the IT field expanded so that it is embedded in almost everything, notably impacting mobile apps, social platforms, user experiences, the Internet of things (IoT), big data, cybersecurity and Automation [3].

In 2017, the curriculum guidelines were redeveloped to encompass the additional technologies as mentioned above. Outcomes were developed using a competency-based model and a subset of the Enterprise Information Technology Body of Knowledge (EITBOK) that was under development with IEEE. Table 1 includes columns showing the differences between IT2008 and IT2017 by the technologies in the IT stack including human computer interaction, data, networking and fundamentals

## 3.2 Competency-Based Model

In addition to the newer technologies that have been introduced, it is important to note that the 2017 document uses an IT competency-based model emphasizing knowledge (mastery of content), skills (capabilities and strategies for higher order thinking) and dispositions (personal qualities associated with success) in a professional context. This avoids perpetuating the practice of exclusively using the knowledge lens and centering curriculum solely on the body of knowledge [3]. Our focus is on the technology included in the curriculum, however.

## 3.3 BS vs. MS Programs

Both curriculum documents are focused on undergraduate curricula. In IT2017, the BS IT domains of knowledge are divided into essential and supplemental domains as shown in Table 2. The MS programs cover similar domains but provide more advanced, in-depth, treatment on these topics. In addition, many MS programs put more focus on the supplemental domains, providing further training to students who are solid in the essential domains.

## 3.4 Curricula Summary

In looking at the IT2008 and IT2017 curricula guidelines, we can see that several technologies have been added to the IT Stack. In HCI, there has been a movement toward designing the user experience (UXD) rather than just interacting with a computer as computing becomes more ubiquitous. Also, social computing, only mentioned briefly in IT2008, is more extensive in IT2017. In the data area, although relational databases are still critically important, new uses of data, big data, advanced analytics and the handling of unstructured data have led to newer types of non-relational (NoSQL) databases which are becoming increasingly important. Although noted in both 2008 and 2017, data science (analytics) has expanded from data mining to machine learning and more advanced analytics, and is used in robotics and automation. In the Networking Layer, virtualization has pushed into cloud computing and content has increased related to the development and use of cloud environments. IoT has also been added and has had an impact on all of the layers (data analytics and ubiquitous computing). In the fundamentals layer, security is getting more emphasis in IT2017, as are agile methods in software development. Web technologies have become more firmly entrenched in applications and moved into web and mobile technologies.

**Table 2. Essential vs. Supplemental Domains**

| Essential IT Domains | Supplemental IT Domains |
|---|---|
| Cybersecurity principles | Applied networks |
| Global professional practice | Cloud computing |
| Information management | Cyber security emerging challenges |
| Integrated systems technology | Data scalability and analytics |
| Networking | Internet of things |
| Platform technologies | Mobile applications |
| System paradigms | Software development and management |
| Software fundamentals | Social responsibility |
| User experience design | Virtual systems and services |
| Web and mobile systems | |

# 4 Technology Trends Reflected on SIGITE Papers

The ACM SIGITE conference is an important forum to discuss, develop, evolve, and promote the IT education. Therefore, papers published and presented in SIGITE provide evidence on how IT educators have been coping with the technology trends and industry demands in order to best prepare students for a successful future career. We conduct a comprehensive analysis of SIGITE papers over the past 15 years and summarize our key insights.

## 4.1 SIGITE Technology Papers

We have collected 191 papers from the ones published in ACM SIGITE annual conferences from 2003 to 2017. These were mostly peer-reviewed papers except for 14 Posters, 6 Panel Discussions, and 3 Lightning Talks. Each paper is motivated by a specific technology defined within the IT stack. We also categorized the papers by their pedagogical objectives for: Curriculum, Track, Course, Lab, Capstone, Research and Assessment. A number of papers would recommend either new or enhanced Curriculum like a degree program, Track such as a concentration within a degree program, Course or Lab. Otherwise papers either share their experiences from Capstone or Research projects or offer insights from Assessments of existing curricula or courses.

Sample papers included in this study are as follows: 1) [5] designed a new graduate program in information security and analytics motivated by industry demand, 2) [4] recommended to enhance their MS/IT program in order to cover the Security concept by spreading required topics across core and elective courses, which is called a multi-threaded approach, 3) [7] also enhanced their undergraduate IT curriculum by proposing a new programming course using a visual programming environment focusing on multimedia applications, 4) a new cloud-based systems lab was built to expand the number of classes taught and enable remote access to the lab in [2], and 5) a new course, Teaching Security Management for Mobile Devices was presented in [10]. This new course was motivated by an increasing concern for mobile device security as mobile malware and virus are rapidly increasing in frequency and sophistication.

This study excluded papers not technology focused. Instead, they cover other pedagogical aspects, such as course design, learning enhancement, student engagement, faculty development, curriculum issues and accreditation of an IT program.

Table 3 summarizes the frequency of the 191 papers by IT Stack/Technology and Pedagogical Objectives. The highest number of papers (40.3%) is from the Fundamental Layer followed by the Networking Layer papers (35.1%). The Data and HCI layer papers are published by 14.1% and 10.5% respectively. As far as Pedagogical Objectives rankings are concerned, IT educators & collaborators have published 67 papers (35.1%) to discuss for either recommending new or enhancing existing courses; 39 papers (20.4%) for their Research/Project; 30 papers (15.7%) for new or enhancing Labs followed by 24 Curriculum, 17 Assessment, 11 Track and 3 Capstone papers.

## 4.2 Technology Trends

In order to observe technology trends from the limited number of 191 papers published annually over 15 years from 2003 to 2017, the annual frequencies are aggregated into three 5-year periods: 2003-2007, 2008-2012 and 2013-2017 as shown in Table 4.

**Table 4. Technology Trends over three 5-year Periods**

| IT Stack | Periods | | | |
|---|---|---|---|---|
| Layer/Technology | '03-'07 | '08–'12 | '13-'17 | |
| HCI | | | | Total |
| Accessibility/UXD/etc. | 5 | 1 | 6 | **12** |
| Social Computing | 0 | 2 | 6 | **8** |
| Data | | | | |
| Database | 6 | 3 | 3 | **12** |
| Analytics/NoSQL/Mining | 2 | 3 | 10 | **15** |
| Networking | | | | |
| Cloud | 0 | 8 | 4 | **12** |
| IoT | 0 | 0 | 5 | **5** |
| Mobile Computing | 4 | 9 | 10 | **23** |
| Virtualization | 5 | 5 | 8 | **18** |
| Wireless | 7 | 2 | 0 | **9** |
| Fundamentals | | | | |
| Programming | 6 | 6 | 5 | **17** |
| Security | 13 | 5 | 12 | **30** |
| Software Development | 10 | 2 | 1 | **13** |
| Web Technology | 6 | 9 | 2 | **17** |
| Total | **64** | **55** | **72** | **191** |

**Table 3. SIGITE Tech Papers by IT Stack and Pedagogical Objectives**

| | | Pedagogical Objectives | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| IT Stack/Technology | | Curriculum | Track | Course | Lab | Capstone | Research | Assessment | Total | % |
| HCI | Accessibility, UXD etc. | 4 | 1 | 3 | 1 | 0 | 2 | 1 | 12 | |
| | Social Computing | 0 | 1 | 0 | 1 | 0 | 4 | 2 | 8 | |
| | Subtotal | 4 | 2 | 3 | 2 | 0 | 6 | 3 | 20 | 10.5% |
| Data | Analytics/NoSQL/Mining | 5 | 0 | 3 | 0 | 0 | 7 | 0 | 15 | |
| | Database | 0 | 0 | 7 | 1 | 0 | 3 | 1 | 12 | |
| | Subtotal | 5 | 0 | 10 | 1 | 0 | 10 | 1 | 27 | 14.1% |
| Networking | Cloud | 1 | 0 | 3 | 3 | 0 | 4 | 1 | 12 | |
| | IoT | 2 | 0 | 1 | 0 | 0 | 2 | 0 | 5 | |
| | Mobile Computing | 2 | 1 | 12 | 2 | 1 | 1 | 4 | 23 | |
| | Virtualization | 0 | 0 | 2 | 15 | 0 | 0 | 1 | 18 | |
| | Wireless | 2 | 0 | 2 | 3 | 0 | 1 | 1 | 9 | |
| | Subtotal | 7 | 1 | 20 | 23 | 1 | 8 | 7 | 67 | 35.1% |
| Fundamentals | Programming | 1 | 0 | 11 | 0 | 0 | 3 | 2 | 17 | |
| | Security | 3 | 3 | 12 | 3 | 0 | 7 | 2 | 30 | |
| | S/W Development | 3 | 3 | 1 | 0 | 1 | 4 | 1 | 13 | |
| | Web Technology | 1 | 2 | 10 | 1 | 1 | 1 | 1 | 17 | |
| | Subtotal | 8 | 8 | 34 | 4 | 2 | 15 | 6 | 77 | 40.3% |
| | **Total** | 24 | 11 | 67 | 30 | 3 | 39 | 17 | 191 | 100.0% |
| | % | 12.6% | 5.7% | 35.1% | 15.7% | 1.6% | 20.4% | 8.9% | 100.0% | |

Key findings on technology trends are as follows:

**Networking Layer**: As discussed in Section 2, the Networking Layer is overarching in the evolution of other technology trends like Data and HCI layers. These are the second highest number of papers (35.1%) published following the Fundamentals Layer (40.3%). Both Mobile computing and Virtualization technology trends show increasing trends while Wireless shows decreasing patterns. Cloud computing started to appear at the peak in the second time period ('08-'12) and continues in the third period. The recent technology hype of IoT demonstrates its appearances in the most recent time period ('13-'17).

**Fundamentals Layer**: Programming and Security related papers seem to have been published consistently across the three time periods over the past 15 years as expected because they offer fundamental knowledge to IT majors. However, even though papers published on Software Development and Web Technology are high in the first two time periods ('03-'12), both show weak appearances in the third period ('13 – '17).

**HCI & Data Layers**: As Database (SQL) technology in the Data Layer shows a decreasing trend as expected, Data Analytics (unstructured data, data science, data mining & machine learning) shows the most increasing trend among other technologies. High demands of Data Analytics along with the Social Computing may actually be predicated upon advances in the Networking Layer as discussed in Section 2. Figure 1 demonstrates technology trends of HCI and Data Layers.

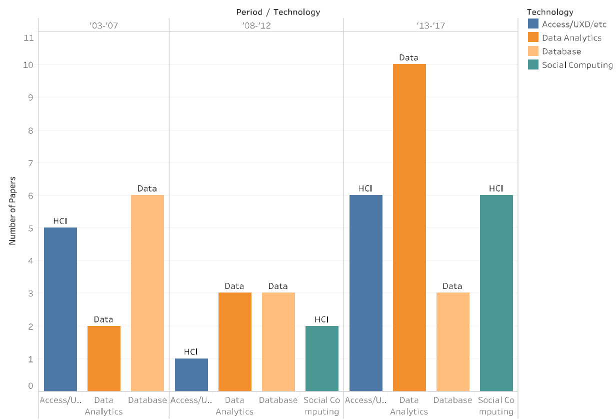


**Figure 1. HCI & Data Layers**

## 5 Case Study

In this section, we use the Master of Science of Information Technology (MS-IT) program at our institution as a case study to demonstrate how the IT curriculum has evolved along with technology trends and industrial demand. The MS-IT curriculum has been frequently updated to make sure it is well connected with the state of the art in the IT field. In this study, we keep track of the curricular changes of the MS-IT program for around 15 years. Besides highlighting the major changes in the curriculum, we also aim to identify the underlying reasons that led to these changes.

The MS-IT program was launched in the late nineties and started to become a very popular program starting from early 2000. Since then, the program has gone through three major phases: Phase I – Establishment (early 2000-2008), Phase II – Specialization (2008-2013), and Phase III – Integration (2013 to now). The major characteristics of each phase will be detailed below.

### 5.1 Phase I: Establishment

From early 2000 to 2008, the MS-IT program established itself as a solid and popular graduate program in the nation with strong enrollment. During this phase, the program put a strong emphasis on web site design and multimedia development. This focus was well aligned with the fast development of web technology back then. As a result, many organizations started to use the web as a major platform to deliver their business functionalities. While web site design and multimedia development was offered as one of the concentrations of the MS-IT program, it provided a great variety of options, including five different course sequences, where each sequence consists of 3-4 courses that cover a different aspect in web technologies. In particular, these course sequences include (i) Interactive Multimedia Development, (ii) Multimedia Application Development, (iii) Web Application Development, (iv) XML Data Management, and (v) Interface Architecture. E-commerce was another popular concentration in Phase I of the MS-IT program, which provided two course sequences, including E-Commerce Management and Technical E-Commerce. Some other important concentrations included Database, Application Development, Software Project Management, Human Computer Interaction, Networking, and System Administration. Each of these concentrations only provided a one-course sequence.

### 5.2 Phase II: Specialization

A major characteristic in this Phase of the MS-IT program was specialization. As computing/IT has gradually become a major driving force in modern industry, some major branches of computing/IT have begun to form their own disciplines. For example, both human computer interaction and networking/system administration were separated from the MS-IT program, which led to three individual programs, including MS-IT, MS-HCI, and MS-NSA. A key rationale of this separation was to train students with highly specialized skills in order to cover different aspects of IT expertise and meet more specific industrial demands. Meanwhile, as these three programs all played an integral role in the original MS-IT program, collectively, they offer a comprehensive coverage of the key layers in the IT stack as identified Section 2. In particular, the MS-HCI program covered fundamental techniques in usability engineering, usability testing, user-centered design, as well as several application domains, such as game design, interactive multimedia development, and learning & human performance. The MS-NSA program covered foundations of wired and wireless networks, emerging network technologies, network design and performance, along with advanced topics, such as network management, advanced routing protocols, enterprise networking, and enterprise service provisioning. Meanwhile, it also offered a quite comprehensive coverage of various security related topics, such as enterprise security, computer viruses and malicious software, computer system security, and advanced computer forensics. With HCI and NSA separated from the program, the MS-IT program put its primary focus on web site design and development, database theory and practices, application development, and software project management. Besides, there were two additional major changes. First, the web site design and development provided much less options with only two course sequences left. This may be partially due to the decreased industrial demand in website design and development. Another contributing factor was that some of the previously available courses had been merged into the MS-HCI program, especially those focusing on usability and user-centered design. The second major change was the addition of a new concentration in geographic information science and technology

### 5.3 Phase III: Integration

The MS-IT program entered its third phase in 2013. The name of the program was changed to MS-IST (Information Sciences & Technologies) during the same process. The primary focus of the program also shifted to Big Data and data analytics. The core of the program was revamped to help students build a solid technical foundation for a successful future career in a data centric era. Key topics covered by the core include NoSQL databases, information retrieval, fundamentals of data analytics, and text mining. These topics significantly extend the MS-IT curriculum in data management, which was primarily focused on relational databases, to cover state of the art data science techniques. This curricular change provided a timely adjustment of the MS-IT (now MS-IST) program to catch the current technological trend and demands in IT industry. As massive amount of data have been continuously collected, leveraging the power of data goes beyond merely storing and retrieving a desired piece of information. Instead, analyzing large volumes of data for knowledge discovery to support decision-making has become more and more important. In addition to data analytics, the MS-IST program also offers another two concentrations in data management and web development.

A key trend in this phase of the program is integration, which is reflected from two perspectives. From the students' side, they started to take courses from different concentrations or even from different disciplines. For example, a popular choice among our MS-IST students is to combine courses from both data management and analytics concentrations so that they can develop a full skill set in modern data science that covers storing, managing, retrieving, and analyzing large-scale data. Many students also choose business, finance, and courses from other application domains. This integrated skill set that combines domain expertise and knowledge in computing and data analytics make them highly demanded in the IT industry. From the curricular perspective, the department started to offer courses or course sequences that cover topics across different layers in the IT stack. For example, a number of IoT related courses have been recently developed that cover both the infrastructure and networking side of IoT as well as collecting and storing IoT data for large-scale analytics. We expect such a course sequence to attract students from both MS-IST and MS-NSA programs. Students taking these courses will learn full-stack techniques that best address the needs of the IoT industry.

## 6 Discussion

Through the analysis of major technology trends in IT, as well as the case study of the MS-IT program at our institution, we have some important findings that can provide useful guidance for future IT curriculum design and development. First, the dependency of technologies occurs both within and across different layers of the information technology stack. Sometimes, the cross-layer dependency plays a more important role for technological advances. For example, virtualization was a central technology that made the cloud-computing paradigm a reality. The cloud, in turn, paved the way for the significant advances in data science, making large-scale data management and analytics a common practice nowadays. Furthermore, the massive storage and compute power brought by the cloud provides a fundamental infrastructure support for the advances of other cutting edge technologies, including deep learning and IoT. The temporal dependency among virtualization, cloud, data analytics, and IoT is clearly in line with their corresponding numbers of SIGITE papers appeared in different time periods, as summarized in Table 4.

These trends show that future IT curriculum design and development should focus more on cross-layer technology integration. The curriculum should place more emphasis on integrating related technologies from different IT stack layers, which will train highly demanded future IT professionals. Certain courses should be designed in a way to accommodate more diverse background from students. As computing becomes more and more ubiquitous, it enters almost every sector in industry and everyone's daily life. A key trend to make computing more beneficial is to train IT professionals with domain expertise. Therefore, it is important to develop an IT curriculum that is more accessible to non-computing students with strong domain expertise.

## 7 Conclusion

IT educators are constantly in an uphill battle in their attempts to not only react to industry demands, but also, choose the correct industry trends to react to. We have presented a four-layer IT Stack with associated core techniques in each layer that was used as an anchor point in presenting key trends across industry, the ACM/IT curriculum, and ACM SIGITE technical paper topics over the past 15 years. As a case study, we showed the evolution of our institution's MS-IT program over the same time period and made recommendations for future IT curriculum evolution, including making IT programs more accessible to those with domain expertise in fields that are not traditionally computing oriented.

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