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A decorative graphic on the left side of the cover consists of a yellow-green triangle pointing downwards and a purple triangle pointing upwards, both meeting at a diagonal white line.

# Information Technology Curricular Guidance for Transfer Programs

May 2020

# Information Technology Transfer Curricula 2020

## Curriculum Guidelines for Two-Year Transfer Programs in Information Technology

2020 May 15

Association for Computing Machinery (ACM)  
Committee for Computing Education in Community Colleges (CCECC)



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# Information Technology Transfer Curricula 2020

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## Executive Summary

This report—*Information Technology Transfer Curricula 2020: Guidelines for Two-Year Transfer Programs in Information Technology* (also known as IT-Transfer2020)—represents the results of the work performed by the IT-Transfer2020 Task Group from July 2018 to December 2019 with input from industry and IT professional societies.

Similarly to the Task Group on Information Technology Curricula, which created IT2017, the IT-Transfer2020 Task Group holds the view that IT programs should prepare students with knowledge, skills, and dispositions in IT professional contexts that emphasize development of *IT competencies*—that is, what students know, how they demonstrate performance, and how disposed they are to apply what they know. The main goal of the IT-Transfer2020 Task Group was to produce a subset of the IT2017 curricular framework and guidelines that would guide how two-year colleges would structure their IT transfer programs to help prepare transfer students for successful upper division study in programs that implement the IT2017 guidance. The Task Group shares the IT2017 Task Group’s definition of the IT discipline as the study of systemic approaches to select, develop, apply, integrate, and administer secure computing technologies to enable users to accomplish their personal, organizational, and societal goals.

Like IT2017, IT-Transfer2020 proposes a full competency-based approach to learning IT using essential and supplemental IT domains while enabling academic departments and faculty members to develop IT programs that articulate convincingly what students should be able to achieve by the time they transfer to a four-year institution. Like their four-year counterparts, two-year institutions have a responsibility to prepare students for an evolving future by establishing foundational competencies coupled with the flexibility to adapt to new technological innovations that await them after graduation. To that end academic departments and faculty members should regularly communicate with their transfer institution counterparts to evaluate and modify their lower division curriculum, not only to keep up with rapid changes in the field and computing education in general, but also to help ensure a smooth transfer experience for students.

The IT-Transfer2020 Task Group is confident that the subset of the essential and supplemental IT domains defined in IT2017 it has selected and vetted will provide appropriate content guidance to IT transfer programs at two-year colleges and to their transfer partner institutions while allowing for sufficient flexibility to meet local requirements and needs.

IT-Transfer2020 Task Group



## Chapter 1. Introduction

In 2017 the Association for Computing Machinery (ACM) and the IEEE Computer Society (IEEE-CS) published the Information Technology Curricula 2017 Curriculum Guidelines for Baccalaureate Degree Programs in Information Technology (IT2017), the latest curricular report for baccalaureate programs in Information Technology (IT) [8]. Shortly after IT2017's publication the chair of the Task Group on Information Technology Curricula and the ACM Committee for Computing Education in Community Colleges (CCECC) discussed creating a complementary report that would provide guidance to IT programs offered at two-year colleges designed to have program completers transfer to a four-year college or university where they would complete their bachelor's degree in IT. The ACM CCECC similarly formed a task group, known as the IT Transfer Task Group and consisting of seven IT faculty representing both two-year and four-year institutions in the United States, to determine the subset of the IT2017 curricula that should be taught in IT Transfer programs offered at two-year colleges. This report—*Information Technology Transfer Curricula 2020: Guidelines for Two-Year Transfer Programs in Information Technology* (also known as IT-Transfer2020)—which is the first report of its kind published by the ACM for the Information Technology discipline, represents the results of the work performed by the IT-Transfer2020 Task Group from July 2018 to May 2020 with input from industry and IT professional societies.

The IT-Transfer2020 guidance is very much aligned with IT2017, and its three primary goals are a) to have students develop IT competencies in a two-year IT Transfer program that will allow them to effectively transfer to a baccalaureate IT program, b) to have students achieve professional success in their future careers, and c) to facilitate informed communication and coordination between faculty and administrative colleagues at transfer partner institutions.

Similarly to IT2017, IT-Transfer2020 does not provide a set of mandatory standards but rather offers guidelines for how IT transfer programs at two-year colleges should develop and implement modern IT curricula in partnership with four-year institutions where students who have completed their lower division IT transfer program requirements are likely to transfer to complete their baccalaureate degree.

In addition to adopting the IT2017 definition of the IT discipline, the IT-Transfer2020 Task Group shares and endorses the vision, goals, guiding principles, framework approach, and IT Competency Model outlined in IT2017. The Task Group therefore strongly suggests that those who use this guidance also familiarize themselves with IT2017 since IT-Transfer2020 *cannot* be effectively implemented without considering the overall context provided by IT2017.

The IT-Transfer2020 Task Group is hopeful that this IT-Transfer2020 report will help departments create effective IT Transfer programs or help them improve the programs they already offer in coordination with their transfer institution partners. And while transfer relationships between two- and four-year colleges are most common in the United States of America, this guidance can similarly be used in other countries to coordinate pathways that lead from other institutions offering postsecondary IT education to universities which award baccalaureate degrees in the IT discipline.

## 1.1 Transitions into Baccalaureate IT Programs

For most academic disciplines, the traditional pathway to a baccalaureate degree program is entry after high school, with specific entry requirements varying by country, school, program. And while a number of recent secondary school graduates follow that traditional route, many IT programs must also consider non-traditional students who may enter the program at points other than the beginning, who come from diverse of backgrounds, and who may have prior work experience.

Community colleges and other two-year colleges play a vital role in higher education in the United States and Canada. According to American Association of Community Colleges' Fast Facts 2020 publication, 41% of all U.S. undergraduate students were enrolled at a two-year college in fall 2018 [1]. And to further clarify the connection between community colleges and universities, the National Student Clearinghouse Research Center published a *Snapshot Report™, Contribution of Two-Year Public Institutions to Bachelor's Completions at Four-Year Institutions* in Spring 2017 which also states that, "In the 2015-16 academic year, 49 percent of all students who completed a bachelor's degree at a four-year institution [in the United States] had been enrolled at a two-year public institution at some point in the previous 10 years." [6] These numbers indicate the special importance for baccalaureate degree-granting institutions to create effective articulation agreements with nearby community colleges so that transfer students can more rapidly reach their academic goals. In addition, university-based IT programs which effectively collaborate with academic partner institutions will be able to strengthen their upper division enrollments and thereby more substantially contribute to helping meet the need for qualified graduates in IT and related disciplines.

The ACM Committee for Computing Education in Community Colleges (CCECC) has published several curricular guidance documents for associate degree (two-year) programs in the ACM-recognized computing disciplines. Among these are the *Guidelines for Associate Degree Programs to Support Computing in a Networked Environment* [5] published in 2000, when the committee was still named the ACM Two-Year College Education Committee, and more recently the *Information Technology Competency Model of Competencies and Assessment for Associate-Degree Curriculum* [4] published in 2014 (IT2yr2014). The IT-Transfer2020 Task Group endorses these guidance documents and recommends that IT programs also consider them while using this guidance to create a smooth transfer experience for students from one IT program to another. Appendix B contains a mapping between IT2yr2014 and IT-Transfer2020, and Appendix E features a program example where students complete an associate degree (first and second years) at a community college and then transfer to a four-year institution to complete their bachelor's degree.

Outside the United States transfer from two-year to four-year higher education institutions is less common. In Japan, for example, graduates of junior technical colleges can enroll in the third year of four-year academic institution through a selection process. However, the number of such students is less than 10% of the entire student population. In general, the proportion of non-traditional students is much higher in graduate schools compared to four-year higher education institutes in Japan [8].



## **1.2 Transfer vs. Applied Two-Year Degrees**

It is important for the reader to understand that the IT-Transfer2020 guidance applies to IT transfer programs which prepare students for transfer to a four-year college or university where they will complete their baccalaureate degree in IT. Separate guidance exists for applied two-year IT programs which are typically offered at two-year colleges and which prepare completers for entering or re-entering the workforce via an entry-level IT position or allow existing IT workers to update their skill set. For guidance on applied two-year IT programs please refer to IT2yr2014.

## **1.3 Accommodating General Education Requirements**

In addition to their major courses, most colleges and universities in the United States, Canada, and Australia require students to take General Education courses which contribute “to the educational foundation of skills, knowledge, habits of mind, and values that prepares students for success in their majors and in their personal and professional lives after graduation.” [7]. While postsecondary institutions in many countries do not require students to complete a set of GE courses, these courses often comprise a substantial portion of the lower division curriculum at U.S. colleges. For example, the Intersegmental General Education Transfer Curriculum (IGETC) pattern which California Community College students can use to fulfill all lower-division general education requirements at any CSU or University of California campus requires completion of a minimum of 37 semester or 49 quarter units of lower division work [3]. During its discussions, the IT-Transfer2020 Task Group kept these GE requirements in mind and therefore chose to keep this guidance as flexible as possible while recommending a solid lower division foundation for transfer students.

## **1.4 Industry Certifications**

While applied two-year IT programs are more likely to prepare students for common industry certifications than IT Transfer programs that would most benefit from this guidance, the IT-Transfer2020 Task Group amplifies the IT2017 Task Group’s acknowledgement of the value of vendor and industry certifications and encourages students to pursue them as they see necessary. Two-year colleges which implement this guidance should also strive to include preparation for current industry certifications, such as CompTIA A+, CompTIA Network+, CompTIA Security+, CompTIA Linux+, Cisco Certified Networking Associate (CCNA), Microsoft Technology Associate (various options), and AWS Certified Cloud Practitioner.

## **1.5 Infused Cybersecurity**

To be fully effective Cybersecurity mechanisms must not only be designed and installed into all technology components and business processes, but they should also be viewed and treated as an integrated system of Cyber defenses that must be sufficiently flexible to incorporate required updates and sufficiently agile to respond to evolving Cyber threats. While two domains in this guidance specifically address Cybersecurity content and competencies, it is also infused in other domains, and users of this guidance should integrate Cybersecurity-related content throughout the curriculum.

## **1.6 Complementing IT Skills with Professional, Communication, and Teamwork Skills**

To be successful most IT professionals must be able to complement their IT skills with professional skills, communication skills, and teamwork skills. Many industry partners continue to lament, however, that many graduates, and especially those with technical degrees, lack the necessary “soft skills” required to succeed in the workplace. Please refer to p. 37 of the IT2017 report [8] for important considerations about how academic programs might help students acquire these skills.

## **1.7 Work Experience and Work-based Learning**

Since technical knowledge, even alongside the requisite soft, communication, and teamwork skills, may not be enough in certain industry environments, students should gain as much hands-on experience as possible prior to graduation. Common avenues to practice practical skills include lab exercises, internships, co-ops, and work experience. Students will likely derive the greatest benefit from work experience or work-based learning after they have transferred to their baccalaureate-granting institution. Additionally, two-year colleges which offer both applied and transfer IT programs can leverage their industry advisory board to help provide students with important networking opportunities that may lead to work-based learning opportunities.

## Chapter 2. Information Technology Transfer Curricular Framework

What follows is the development of an Information Technology Curricular Framework that defines the competencies IT students should possess.

### 2.1 Structure of the IT Curricular Framework

The IT Curricular Framework enables IT departments to implement, evaluate, and revise IT programs according to their institutional mission and program goals. The framework is organized in IT domains, which collectively represent the scope of IT and which thus allow for a degree of flexibility in implementing the program content. It is important to note that an IT domain is *not* a course. Mapping IT domains to program course requirements considers factors pertaining to the implementation of the framework, as discussed in the IT2017 report.

#### 2.1.1 Tags for IT Domains

The IT2017 Task Group assigned identifying tags to each IT domain. The “ITE” prefix designates essential IT domains in IT2017, whereas the “ITS” prefix indicates that an IT domain was designated as supplemental in IT2017. Each IT domain has a three-letter abbreviation, such as IOT for representing Internet of Things, or NET for representing Networks. As a result, each domain contains two parts separated by a hyphen. For example, we use ITE-UXD to represent “user experience design” as an essential IT domain, ITS-VSS for representing “virtual systems and services” as a supplemental IT domain, and ITM-DSC for representing “discrete structures” as a mathematical domain related to information technology.

### 2.2 Distilling the IT Curricular Framework

This section of the report addresses the elements of the curricular framework for information technology. These elements consist of the IT curriculum (essential and supplemental domains), mathematics, science, and other curricular requirements.

#### 2.2.1 IT Curriculum: Essential and Supplemental Domains

Following the lead of IT2017, the IT-Transfer2020 curricular framework presented in this report consists of essential and supplemental IT domains. Essential domains encompass competencies that anyone obtaining a baccalaureate degree in the field *must* acquire, and supplemental domains encompass competencies in domains in which students do more specialized work according to the goals of a program. An IT Transfer program curriculum should cover all essential IT domains and a selection of the supplemental IT domains. This structure allows tailoring the area of specialization for a degree program to meet the needs of a local community.

IT2017 defines 80 competencies which it connects to 19 essential and supplemental IT domains. Forty-seven of the IT2017 competencies are connected to ten essential domains, and 33 additional competencies are associated with nine supplemental domains.

The IT Transfer 2020 Task Group carefully analyzed the 80 competencies defined in IT2017 and constructed a modified subset of 27 essential and 31 supplemental competencies that should be taught in an IT Transfer program. Of these 58 IT-Transfer competencies, 16 were adopted from IT2017 without modification, and 42 were adapted either in content, in Bloom’s level, or both, as appropriate for an IT Transfer program, from an additional 31 corresponding IT2017 competencies. Representing content from all of the 19 IT domains defined in IT2017, the 58 IT-Transfer2020 competencies are listed in the 19 domain cards below, separated by their categorization as essential or supplemental. To help facilitate communication between transfer institutions about which competencies students should achieve prior to or after transfer, each domain card also lists several statements that it IT2017 Task Group used to define each domain’s scope.

The essential IT domains from IT2017 are shown in Table 2.1, and the supplemental IT domains from IT2017 in Table 2.2, along with the number of associated essential and supplemental IT-Transfer2020 competencies.

*Table 2.1. Essential IT Domains*

| <b><i>Essential IT Domains and IT-Transfer2020 Competencies</i></b> |                               |   |  |
|---|-------------------------------|---|--|
| <b>Tag</b>  | <b>IT2017 Domain</b>          | <b>IT-Transfer2020 Essential Competencies</b> | <b>IT-Transfer2020 Supplemental Competencies</b> |
| ITE-CSP   | Cybersecurity Principles      | 2   | 1  |
| ITE-GPP   | Global Professional Practice  | 3   | 2  |
| ITE-IMA   | Information Management        | 1   | 2  |
| ITE-IST   | Integrated Systems Technology | 2   | 2  |
| ITE-NET   | Networking                    | 3   | 1  |
| ITE-PFT   | Platform Technologies         | 3   | 2  |
| ITE-SPA   | System Paradigms              | 2   | 1  |
| ITE-SWF   | Software Fundamentals         | 2   | 3  |
| ITE-UXD   | User Experience Design        | 1   | 1  |
| ITE-WMS   | Web and Mobile Systems        | 1   | 4  |
|   | <b>Total Competencies:</b>    | <b>20</b>                                     | <b>19</b>  |

Table 2.2. Supplemental IT Domains

| <b>Supplemental IT Domains and IT-Transfer2020 Competencies</b> |                                     |   |  |
|---|-------------------------------------|---|--|
| <b>Tag</b>  | <b>IT2017 Domain</b>                | <b>IT-Transfer2020 Essential Competencies</b> | <b>IT-Transfer2020 Supplemental Competencies</b> |
| ITS-ANE   | Applied Networks                    | 0   | 1  |
| ITS-CCO   | Cloud Computing                     | 1   | 2  |
| ITS-CEC   | Cybersecurity Emerging Challenges   | 2   | 1  |
| ITS-DSA   | Data Scalability and Analytics      | 0   | 1  |
| ITS-IOT   | Internet of Things                  | 0   | 1  |
| ITS-MAP   | Mobile Applications                 | 0   | 2  |
| ITS-SDM   | Software Development and Management | 0   | 1  |
| ITS-SRE   | Social Responsibility               | 2   | 1  |
| ITS-VSS   | Virtual Systems and Services        | 2   | 2  |
|   | <b>Total Competencies:</b>          | <b>7</b>                                      | <b>12</b>  |

## 2.3 IT Domain Clusters

The IT2017 Task Group chose to consolidate the descriptions of IT domains into a set of scope statements, competencies, and subdomains, and it called this consolidation an *IT domain cluster*, identified by an IT domain tag and name. The IT2017 Task Group also chose to assign proper contexts of “authentic workplace-bound experiences that foster employer involvement”, but the IT-Transfer2020 Task Group determined that such context was not necessarily required for competencies that would be met by lower division courses of a transfer program.

The IT2017 Task Group further chose to have the IT2017 competencies use performance verbs to generate ideas for performance goals and professional practice. Since, however, most two-year colleges require their curriculum documents to use Bloom’s Revised Taxonomy [2], the IT-Transfer2020 Task Group determined that having the competencies start with the verbs used in Bloom’s taxonomy would make them more useful for this purpose of this guidance.

### 2.3.1 Essential IT Domains

The following charts (“domain cards”) reflect the scope statements and competencies of each **essential** IT domain. The first parenthetical at the end of each competency is intended to further clarify the specific content area(s) of an IT domain that the competency addresses. The second parenthetical indicates the Bloom’s verb level of each competency.

Figure 2.1. Essential IT Domains

| <b>ITE-CSP Domain: Cybersecurity Principles</b>  |
|--|
| <p><b>Scope</b></p> <ol style="list-style-type: none"><li>1. A computing-based discipline involving technology, people, information, and processes to enable assured operations</li><li>2. A focus on implementation, operation, analysis, and testing of the security of computing technologies</li><li>3. Recognition of the interdisciplinary nature of the application of cybersecurity including aspects of law, policy, human factors, ethics, and risk management in the context of adversaries</li><li>4. The practice of assuring information and managing risks related to the use, processing, storage, and transmission of information or data and the systems and processes used for those purposes</li><li>5. Measures that protect and defend information and information systems by ensuring their availability, integrity, authentication, confidentiality, and non-repudiation</li></ol> |
| <p><b>Essential Competencies</b></p> <p>[CSP-E01] Evaluate the purpose and function of cybersecurity technology, identifying the tools and systems that reduce the risk of data breaches while enabling vital organization practices. <i>(Cybersecurity functions) (Evaluating)</i></p> <p>[CSP-E02] Apply appropriate tools and concepts to minimize the risk to an organization's cyberspace to address cybersecurity threats. <i>(Tools and threats) (Applying)</i></p>   |
| <p><b>Supplemental Competencies</b></p> <p>[CSP-S01] Implement a risk management approach for responding to and recovering from a cyber-attack on systems which contain high-value information and assets such as an email system. <i>(Response and risks) (Applying)</i></p>  |

## ITE-GPP Domain: Global Professional Practice

### Scope

1. Importance of identifying and understanding essential skills required for a successful career within the industry, including professional oral and written communication skills
2. Identification of ways teamwork integrates throughout IT and ways IT supports an organization
3. Social and professional contexts of information technology and computing, and adherence to ethical codes of conduct

### Essential Competencies

[GPP-E01] Use effective communication skills and cultural awareness in a team setting to help advance organizational goals in a global environment. (*Communication and teamwork*) (*Applying*)

[GPP-E02] Evaluate the specific skills necessary for maintaining continued employment in an IT career. (*Employability*) (*Evaluating*)

[GPP-E03] Carry out IT policies within an organization that include privacy, legal, and ethical considerations. (*Legal and ethical*) (*Applying*)

### Supplemental Competencies

[GPP-S01] Produce a project plan for an IT project, including a cost/benefit analysis, risk considerations, and related issues. (*Project management*) (*Applying*)

[GPP-S02] Discuss current practices used to optimize the systems development life cycle, such as DevOps and agile approaches. (*Current industry practices*) (*Understanding*)

| <b>ITE-IMA Domain: Information Management</b>  |
|--|
| <p><b>Scope</b></p> <ol style="list-style-type: none"><li>1. Tools and techniques for efficient data modeling, collection, organization, retrieval, and management</li><li>2. How to extract information from data to make data meaningful to the organization</li><li>3. How to develop, deploy, manage, and integrate data and information systems to support the organization</li><li>4. Safety and security issues associated with data and information</li><li>5. Tools and techniques for producing useful knowledge from information</li></ol>    |
| <p><b>Essential Competencies</b></p> <p>[IMA-E01] Create simple and intermediate queries to construct and modify objects that store, manipulate, and analyze data. <i>(Testing and performance) (Creating)</i></p>   |
| <p><b>Supplemental Competencies</b></p> <p>[IMA-S01] Design and implement a physical model based on appropriate organization rules for a given scenario including the impact of normalization and indexes. <i>(Requirements and development) (Creating)</i></p> <p>[IMA-S02] Perform major database administration tasks such as create and manage database users, roles and privileges, backup, and restore database objects to ensure organizational efficiency, continuity, and information security. <i>(Testing and performance) (Applying)</i></p> |



## ITE-IST Domain: Integrated Systems Technology

### Scope

1. Scripting languages, their uses, and architectures
2. Application programming interfaces
3. Programming practices to facilitate the management, integration and security of the systems that support an organization

### Essential Competencies

[IST-E01] Design, including debugging and testing, a script that includes sequence, selection, repetition, and parameter passing. (*Integrative programming and scripting*) (*Creating*)

[IST-E02] Implement secure coding techniques, such as input validation, wrapper code, securing method access, and buffer overflow prevention. (*Defensible integration*) (*Applying*)

### Supplemental Competencies

[IST-S01] Describe how to code and store characters, images, and other forms of data in computers, and why data conversion is often a necessity when merging disparate computing systems. (*Data mapping and exchange*) (*Understanding*)

[IST-S02] Describe how a commonly used intersystem communication protocol works, including its advantages and disadvantages. (*Intersystem communication protocols*) (*Understanding*)

## ITE-NET Domain: Networking

### Scope

1. Topology of ad hoc and fixed networks of all sizes
2. Role of the layered model in standards evolution and interoperability
3. Physical layer through routing layer issues
4. Higher layers related to applications and security, such as functions and design
5. Approaches to designing for and modeling latency, throughput, and error rate

### Essential Competencies

[NET-E01] Compare the characteristics of various communication protocols and how they support application requirements within a telecommunication system. (*Requirements and Technologies*) (*Analyzing*)

[NET-E02] Describe different network standards, components, and requirements of network protocols within a distributed computing setting. (*Network Protocol Technologies*) (*Understanding*)

[NET-E03] Explain different main issues related to network management. (*Network Management*) (*Understanding*)

### Supplemental Competencies

[NET-S01] Contrast various networking topologies in terms of robustness, expandability, and throughput used within a cloud enterprise. (*Technologies*) (*Analyzing*)

## ITE-PFT Domain: Platform Technologies

### Scope

1. Comparison of various operating systems available, including their respective characteristics, advantages, and disadvantages
2. Selection, deployment, integration and administration of platforms or components to support the organization's IT infrastructure
3. Fundamentals of hardware and software and how they integrate to form the essential components of IT systems

### Essential Competencies

[PFT-E01] Describe how the historical development of hardware and operating system computing platforms produced the computing systems we have today. (*Computing systems*) (*Understanding*)

[PFT-E02] Choose the most effective operating system based on a computer's intended use. (*Operating systems*) (*Evaluating*)

[PFT-E03] Diagram the main parts of a computer, including interconnections. (*Architecture and organization*) (*Applying*)

### Supplemental Competencies

[PFT-S01] Perform at least one operating system installation on a computer. (*Operating systems*) (*Applying*)

[PFT-S02] Illustrate how to store and retrieve data using a computer. (*Architecture and organization*) (*Applying*)

## ITE-SPA Domain: System Paradigms

### Scope

1. Skills and tools to gather requirements, source code development, evaluation and integration of components into a single system, and system validation
2. Design, selection, application, deployment, and management of computing systems to support an organization
3. Skills and concepts essential to the administration of operating systems, networks, software, file systems, file servers, web systems, database systems, and system documentation, policies, and procedures
4. Fundamentals of project management and the interplay between IT applications and related organizational processes
5. System integration issues, including integration in a system of systems and federation of systems, role of architectures in systems integration, performance, and effectiveness
6. Education and support of users of computing systems

### Essential Competencies

[SPA-E01] Implement appropriate procedures and technologies to enforce administrative policies within a corporate environment. (*Operational activities*) (*Applying*)

[SPA-E02] Use appropriate and emerging technologies to improve the performance of computer systems. (*Performance analysis*) (*Applying*)

### Supplemental Competencies

[SPA-S01] Implement effective and appropriate system administration policies with sensitivity to the goals and constraints of an organization. (*System governance*) (*Applying*)

| <b>ITE-SWF Domain: Software Fundamentals</b>   |
|--|
| <b>Scope</b> <ol style="list-style-type: none"><li>1. Skills and fundamental programming concepts, data structures, and algorithmic processes</li><li>2. Programming strategies and practices for efficient problem solving</li><li>3. Programming paradigms to solve a variety of programming problems</li></ol>  |
| <b>Essential Competencies</b> <p>[SWF-E01] Produce a program that implements an appropriate style, intended input behavior, correct program components, and includes descriptions of program functionality. (<i>App development practices</i>) (<i>Applying</i>)</p> <p>[SWF-E02] Develop algorithms to solve a computational problem. (<i>Algorithm development</i>) (<i>Creating</i>)</p>  |
| <b>Supplemental Competencies</b> <p>[SWF-S01] Explain how programs implement algorithms in terms of instruction processing, program execution, and running processes. (<i>Algorithm development</i>) (<i>Understanding</i>)</p> <p>[SWF-S02] Implement appropriate data structures, while using multiple levels of abstraction, to create a new program that requires teamwork and is socially relevant. (<i>Program development</i>) (<i>Applying</i>)</p> <p>[SWF-S03] Implement a mobile or web app with appropriate user experience design, functionality, and security analysis while using standard libraries, unit testing tools, and version control in a team environment. (<i>App development practices</i>) (<i>Applying</i>)</p> |

| <b>ITE-UXD Domain: User Experience Design</b>  |
|--|
| <p><b>Scope</b></p> <ol style="list-style-type: none"><li>1. Understanding of advocacy for the user in the development of IT applications and systems</li><li>2. Development of a mind-set that recognizes the importance of users, context of use, and organizational contexts</li><li>3. Employment of user-centered methodologies in the design, development, evaluation, and deployment of IT applications and systems</li><li>4. Application of evaluation criteria, benchmarks, and standards</li><li>5. User and task analysis, human factors, ergonomics, accessibility standards, experience design, and cognitive psychology</li></ol> |
| <p><b>Essential Competencies</b></p> <p>[UXD-E01] Develop a simple application that maximizes usability by using relevant tools and techniques, such as prototyping. <i>(Design tools and techniques) (Creating)</i></p>   |
| <p><b>Supplemental Competencies</b></p> <p>[UXD-S01] Develop an interactive application that optimizes usability while applying a user-centered design cycle with related tools and techniques. <i>(Design tools and techniques) (Creating)</i></p>  |

## ITE-WMS Domain: Web and Mobile Systems

### Scope

1. Web-based applications including related software, databases, interfaces, and digital media
2. Mobile applications including related software, databases, interfaces, and digital media
3. Contemporary web technologies, social media

### Essential Competencies

[WMS-E01] Describe the major components of a web system and how they function together, including the web server, database, analytics, and front end. (*Web system infrastructure*) (*Understanding*)

### Supplemental Competencies

[WMS-S01] Analyze how a responsive web application utilizes a web framework and presentation technologies in support of a diverse online community. (*Web application development*) (*Analyzing*)

[WMS-S02] Develop a mobile app that is usable, efficient, and secure on more than one device. (*Mobile app development*) (*Creating*)

[WMS-S03] Analyze a web or mobile system and correct security vulnerabilities. (*Web and mobile security*) (*Analyzing*)

[WMS-S04] Implement storage, transfer, and retrieval of digital media with appropriate file, database, or streaming formats. (*Digital media storage and transfer*) (*Applying*)

### 2.3.2 Supplemental IT Domains

The following IT domains were designated as supplemental in IT2017. The following charts (“domain cards”) reflect the scope statements and competencies of each supplemental IT domain. The first parenthetical at the end of each competency is intended to further clarify the specific content area(s) of an IT domain that the competency addresses. The second parenthetical indicates the Bloom’s verb level of each competency.

Figure 2.2. Supplemental IT Domains

| ITS-ANE Domain: Applied Networks   |
|--|
| <p><b>Scope</b></p> <ol style="list-style-type: none"> <li>1. Purpose and role of proprietary network protocols, and comparing proprietary networks with open standard protocols</li> <li>2. Protocols and languages in network programming; socket-based network application programs design and implementations</li> <li>3. Components of Voice over IP (VoIP) networks and protocols, and configurations of voice gateways for supporting calls using various signaling protocols</li> <li>4. Routing and protocols on the internet, IPv6, and internet protocols of the future</li> <li>5. Basic mobile network architectures and protocols used in wireless communications</li> </ol> |
| <p><b>Supplemental Competencies</b></p> <p>[ANE-S01] Investigate security and performance issues related to wireless networks. (<i>Security and performance</i>) (<i>Applying</i>)</p>   |



## ITS-CCO Domain: Cloud Computing

### Scope

1. Cloud computing paradigm
2. Cloud computing fundamentals, security principles, and applications
3. Theoretical, technical, and commercial aspects of cloud computing
4. Architecture and cloud software development
5. Emerging technologies and existing cloud-based infrastructure, such as fog computing

### Essential Competencies

[CCO-E01] Discuss various concepts and technologies related to cloud computing.  
*(Technologies) (Analyzing)*

### Supplemental Competencies

[CCO-S01] Distinguish cloud service categories, including public, private, and hybrid clouds, and be aware of privacy regulation impact on cloud application requirements. *(Legal and Design) (Analyzing)*

[CCO-S02] Discuss various factors, including basic architecture, that affect the performance of cloud applications. *(Technology) (Understanding)*

### ITS-CEC Domain: Cybersecurity Emerging Challenges

#### Scope

1. The emerging challenges in a computing-based discipline involving technology, people, information, and processes to enable assured operations and to support the growing need for forensic activities in a contest, adversarial environment
2. Security considerations of cloud computing
3. Digital forensics including the recovery and investigation of material found in digital devices, often in relation to computer crime
4. Security implications for information technologies enabled and controlled by software and influenced by the supply chain.

#### Essential Competencies

[CEC-E01] Implement common standards, procedures, and applications used to protect the confidentiality, integrity, and availability of data and information systems. (*System integrity*) (*Applying*)

[CEC-E02] Analyze human facets that enable the exploitation of computing-based systems. (*Human dynamics*) (*Analyzing*)

#### Supplemental Competencies

[CEC-S01] Perform common malware analysis procedures on mobile and desktop computer systems. (*Malware and forensic analysis*) (*Applying*)

### ITS-DSA Domain: Data Scalability and Analytics

#### Scope

1. Key technologies used in collecting, cleaning, manipulating, storing, analyzing visualizing, and extracting useful information from large and diverse data sets
2. Data mining and machine learning algorithms for analyzing large sets of structured and unstructured data
3. The challenges of large-scale data analytics in different application domains

#### Supplemental Competencies

[DSA-S01] Use appropriate data analysis methods to solve real-world problems. (*Requirements and development*) (*Applying*)

### ITS-IOT Domain: Internet of Things

#### Scope

1. Basic knowledge and skills to engage in innovative design and development of IoT solutions
2. Trends and characteristics in the IoT field
3. Analysis of challenges and application patterns for user interaction in IoT settings
4. IoT effects for signal processing, data acquisition, and wireless sensor networks
5. Relationships between IoT and intelligent information processing
6. Internet operations compared with IoT operations

#### Supplemental Competencies

[IOT-S01] Use wireless sensors within an ad-hoc network architecture to capture data within a multimedia system. (*Wireless data acquisition*) (*Applying*)

### ITS-MAP Domain: Mobile Applications

#### Scope

1. Mobile application technologies with experiences to create mobile applications
2. Mobile architectures, including iOS and Android
3. Creation of mobile applications on different platforms
4. Evaluation and performance improvement of mobile applications
5. Designing friendly interfaces for mobile applications

#### Supplemental Competencies

[MAP-S01] Discuss various implementation strategies for web applications, including an application programming interface (API) and a platform-independent interpreted code. (*Technologies*) (*Understanding*)

[MAP-S02] Produce a functional server-side application using several techniques for server-side programming. (*Design and Development*) (*Applying*)

### ITS-SDM Domain: Software Development and Management

#### Scope

1. Software process models and software project management
2. Software development phases: requirements and analysis, design and construction, testing, deployment, operations, and maintenance
3. Modern software development and management platforms, tools, and services

#### Supplemental Competencies

[SDM-S01] Use tools and services to develop computing systems that consider platform constraints, support version control, track requirements and bugs, and automate building. *(Development) (Applying)*

### ITS-SRE Domain: Social Responsibility

#### Scope

1. Social, governmental regulations and environmental context of IT and computing
2. Importance of Team Dynamics, Ethics and Professionalism to an organization's success
3. Information Technology and the role of Risk Management
4. Energy Management and Standards leading to "Green Computing"

#### Essential Competencies

[SRE-E01] Discuss the roles that teamwork, ethics, and legal considerations play in an IT organization. *(Teamwork, legal and ethical considerations) (Understanding)*

[SRE-E02] Summarize how governmental and environmental regulations affect an organization's environment. *(Government and environment) (Understanding)*

#### Supplemental Competencies

[SRE-S01] Evaluate various security breaches and their effect on business operations. *(Risk management) (Evaluating)*

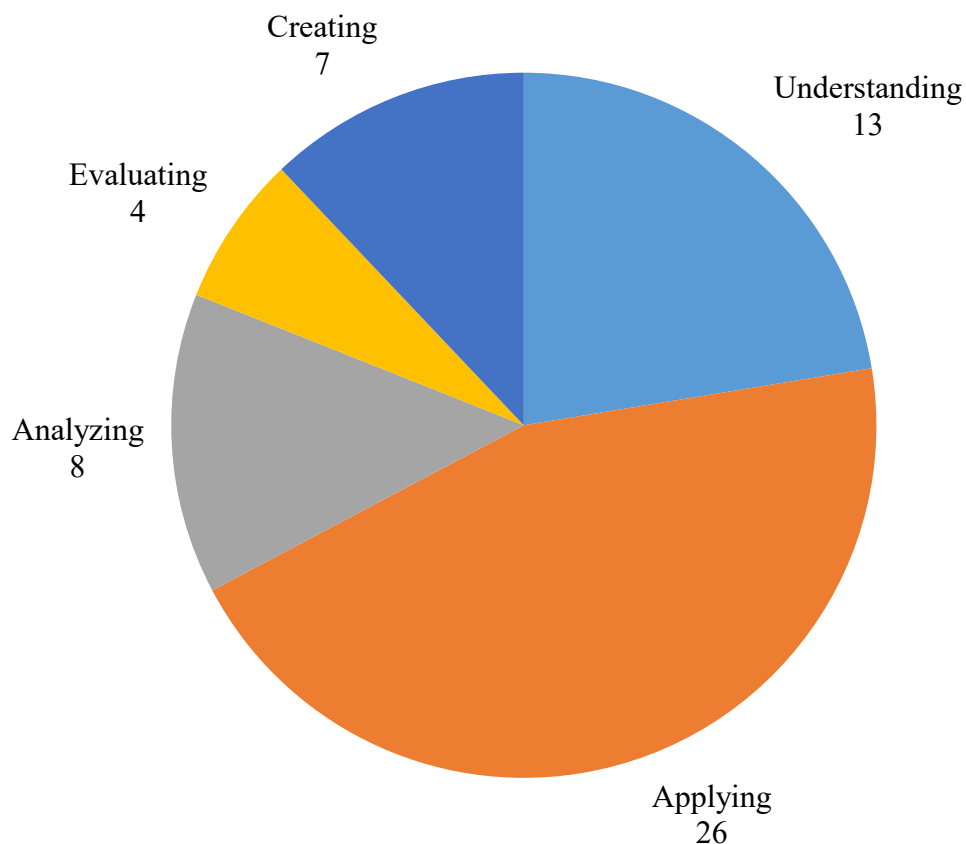
| ITS-VSS Domain: Virtual Systems and Services  |
|---|
| <p><b>Scope</b></p> <ol style="list-style-type: none"> <li>1. Virtualization and its related open source components</li> <li>2. Deployment skills to build virtualization and clustered solutions</li> <li>3. Networked storage for virtualization infrastructure needs</li> <li>4. Platform as a Service (PaaS), such as containers and serverless technologies</li> </ol> |
| <p><b>Essential Competencies</b></p> <p>[VSS-E01] Contrast virtualized and non-virtualized platforms. <i>(Technologies) (Analyzing)</i></p> <p>[VSS-E02] Implement virtualization for desktops and servers. <i>(Install technologies) (Applying)</i></p>  |
| <p><b>Supplemental Competencies</b></p> <p>[VSS-S01] Implement a storage environment including appropriate performance measurement tools. <i>(Technologies and performance) (Applying)</i></p> <p>[VSS-S02] Explain virtualization for applications and network platforms. <i>(Install technologies) (Understanding)</i></p>  |

### 2.3.3 Bloom's Level Distribution

Just over two-thirds (39) of the 58 competencies defined in IT-Transfer2020 use Bloom's verbs at the *Understanding* and *Applying* levels, which is not unexpected for the first two years of a baccalaureate program in an applied discipline such as IT. And since many IT program graduates will likely work in Systems or Programmer Analyst positions during at least some of their career, a combined 12 competencies using verbs at the *Analyzing* and *Evaluating* levels appears similarly appropriate while also leaving room for the innovative aspects of the IT discipline with seven competencies featuring verbs at the highest Bloom's level, *Creating*. Notably, all IT-Transfer2020 competencies are above the lowest Bloom's level, *Remembering*. Thirty-nine competencies belong to the ten domains deemed Essential (ITE) in IT2017 whereas 19 competencies are associated with Supplemental (ITS) domains, though some of the latter are categorized as Essential for IT Transfer programs for various reasons, such as their increasing importance since the release of IT2017.

The chart below illustrates the distribution of the Bloom's verb levels for the IT-Transfer2020 competencies, and the number listed next to each pie slice indicates how many of the 58 total competencies are associated with that Bloom's level.

Figure 2.3. Bloom's Level Distribution for IT-Transfer2020 Competencies



#### 2.3.4 Supplemental IT2017 Competencies deemed essential in IT-Transfer2020

The IT Transfer 2020 Task Group determined that some of the topics for which competencies were listed in IT2017 supplemental domains were sufficiently important to be deemed as essential in IT-Transfer2020. In most of these cases the corresponding IT2017 competencies a) were adjusted to focus on more specific content, b) were split into essential and supplemental components, or c) had their Bloom's level reduced. In some cases, the task group found that a corresponding competency's importance to the IT discipline had increased since the IT2017 guidance was published.

#### 2.3.5 Related Mathematics

The IT-Transfer2020 Task Group echoes the IT2017 Task Group's recommendation that a robust information technology program should include at least Discrete Structures or Discrete Mathematics, which does *not* need to be Calculus-based and can be taken prior to or after transfer, along with a variety of other mathematical experiences to prepare students to become competent IT professionals. Some programs may include Statistics in the lower division to help students meet the requirements of their transfer programs. Table 3.3, taken from the IT2017 report, depicts a single essential Mathematics domain with its accompanying subdomains. IT Transfer programs should closely coordinate their mathematics requirements with those of the transfer institutions.

Figure 2.4. Related IT Essential Mathematics

| <i>IT Essential Mathematics</i> |  |
|---------------------------------|--|
| <b>ITM-DSC</b>                  | <b>Discrete Structures</b>                   |
| ITM-DSC-01                      | Perspectives and impact                      |
| ITM-DSC-02                      | Sets   |
| ITM-DSC-03                      | Functions and relations                      |
| ITM-DSC-04                      | Proof techniques                             |
| ITM-DSC-05                      | Logic  |
| ITM-DSC-06                      | Boolean algebra principles                   |
| ITM-DSC-07                      | Minimization                                 |
| ITM-DSC-08                      | Graphs and trees                             |
| ITM-DSC-09                      | Combinatorics                                |
| ITM-DSC-10                      | Iteration and recursion                      |
| ITM-DSC-11                      | Complexity Analysis                          |
| ITM-DSC-12                      | Discrete information technology applications |

### 2.3.6 Related Science

The IT-Transfer2020 Task Group also joins the IT2017 Task Group in *not* recommending specific science domains related to IT programs but in suggesting that students who are enrolled in an IT Transfer program engage in as much lower division science as required by the transfer institution.

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## Appendix A. Assessment Rubrics

Table A.1. Assessment Rubrics

| <i>IT-Transfer2020 Assessment Rubrics</i>  |   |   |
|--|---|---|
| <i>Emerging</i>  | <i>Developed</i>  | <i>Highly Developed</i>   |
| <b>ITE-CSP Domain: Cybersecurity Principles</b>  |   |   |
| Analyze the purpose and function of cybersecurity technology, identifying the tools and systems that reduce the risk of data breaches while enabling vital organization practices. <i>(Cybersecurity functions) (Bloom’s level: Analyzing)</i> | Evaluate the purpose and function of cybersecurity technology, identifying the tools and systems that reduce the risk of data breaches while enabling vital organization practices. <i>(Cybersecurity functions) (Bloom’s level: Evaluating)</i><br>[CSP-E01] | Design a cybersecurity system using the tools and systems that reduce the risk of data breaches while enabling vital organization practices. <i>(Cybersecurity functions) (Bloom’s level: Creating)</i>   |
| Describe systems, tools, and concepts to minimize the risk to an organization's cyberspace to address cybersecurity threats. <i>(Tools and threats) (Bloom’s level: Understanding)</i>   | Apply appropriate tools and concepts to minimize the risk to an organization's cyberspace to address cybersecurity threats. <i>(Tools and threats) (Bloom’s level: Applying)</i><br>[CSP-E02]   | Integrate systems and tools to minimize the risk to an organization's cyberspace to address cybersecurity threats. <i>(Tools and threats) (Bloom’s level: Analyzing)</i>  |
| Explain a risk management approach for responding to and recovering from a cyber-attack on a system which contains high-value information and assets, such as an email system. <i>(Response and risks) (Bloom’s level: Understanding)</i>      | Implement a risk management approach for responding to and recovering from a cyber-attack on a system which contains high-value information and assets, such as an email system. <i>(Response and risks) (Bloom’s level: Applying)</i><br>[CSP-S01]           | Distinguish risk management approaches for responding to and recovering from a cyber-attack on a system which contains high-value information and assets, such as an email system, that optimize preserving forensic evidence. <i>(Response and risks) (Bloom’s level: Analyzing)</i> |

| <b><i>IT-Transfer2020 Assessment Rubrics</i></b>   |  |  |
|--|--|--|
| <b><i>Emerging</i></b>   | <b><i>Developed</i></b>  | <b><i>Highly Developed</i></b>   |
| <b>ITE-GPP Domain: Global Professional Practice</b>  |  |  |
| Describe effective communication skills in a team setting to help advance organizational goals in a global environment. <i>(Communication and teamwork) (Bloom's level: Understanding)</i> | Use effective communication skills and cultural awareness in a team setting to help advance organizational goals in a global environment. <i>(Communication and teamwork) (Bloom's level: Applying)</i><br>[GPP-E01] | Integrate effective communication skills and cultural awareness in a team setting to help advance organizational goals in a global environment. <i>(Communication and teamwork) (Bloom's level: Analyzing)</i> |
| Explain the specific skills necessary for maintaining continued employment in an IT career. <i>(Employability) (Bloom's level: Understanding)</i>  | Evaluate the specific skills necessary for maintaining continued employment in an IT career. <i>(Employability) (Bloom's level: Evaluating)</i><br>[GPP-E02]   | Evaluate the specific skills necessary for advancing professionally in an IT career. <i>(Employability) (Bloom's level: Evaluating)</i>  |
| Discuss IT policies within an organization that include privacy, legal, and ethical considerations. <i>(Legal and ethical) (Bloom's level: Understanding)</i>                              | Carry out IT policies within an organization that include privacy, legal, and ethical considerations. <i>(Legal and ethical) (Bloom's level: Applying)</i><br>[GPP-E03]  | Analyze an organization's IT policies with regard to privacy, legal, and ethical considerations. <i>(Legal and ethical) (Bloom's level: Analyzing)</i>   |
| Interpret a project plan for an IT project, including a cost/benefit analysis, risk considerations, and related issues. <i>(Project management) (Bloom's Level: Understanding)</i>         | Produce a project plan for an IT project, including a cost/benefit analysis, risk considerations, and related issues. <i>(Project management) (Bloom's Level: Applying)</i><br>[GPP-S01]                             | Analyze a project plan for an IT project, including a cost/benefit analysis, risk considerations, and related issues. <i>(Project management) (Bloom's Level: Analyzing)</i>                                   |
| Define current practices used to optimize the systems development life cycle, such as DevOps and agile approaches. <i>(Current industry practices) (Bloom's level: Remembering)</i>        | Discuss current practices used to optimize the systems development life cycle, such as DevOps and agile approaches. <i>(Current industry practices) (Bloom's level: Understanding)</i><br>[GPP-S02]                  | Implement current practices used to optimize the systems development life cycle, such as DevOps and agile approaches. <i>(Current industry practices) (Bloom's level: Applying)</i>                            |

| <b><i>IT-Transfer2020 Assessment Rubrics</i></b>  |   |   |
|---|---|---|
| <b><i>Emerging</i></b>  | <b><i>Developed</i></b>   | <b><i>Highly Developed</i></b>  |
| <b>ITE-IMA Domain: Information Management</b>   |   |   |
| Evaluate working SQL statements for simple and intermediate queries to create and modify data and database objects to store, manipulate and analyze enterprise data. <i>(Testing and performance) (Bloom's level: Evaluating)</i>   | Create simple and intermediate queries to construct and modify objects that store, manipulate, and analyze data. <i>(Testing and performance) (Bloom's level: Creating)</i><br>[IMA-E01]  | Create working SQL statements for advanced queries to create and modify data and database objects to store, manipulate and analyze enterprise data. <i>(Testing and performance) (Bloom's level: Creating)</i>  |
| Explain a physical database model based on appropriate organization rules for a given scenario including the impact of normalization and indexes. <i>(Requirements and development) (Bloom's level: Understanding)</i>  | Design and implement a physical model based on appropriate organization rules for a given scenario including the impact of normalization and indexes. <i>(Requirements and development) (Bloom's level: Applying)</i><br>[IMA-S01]  | Analyze a physical database model based on appropriate organization rules for a given scenario including the impact of normalization and indexes. <i>(Requirements and development) (Bloom's level: Analyzing)</i>  |
| Summarize major database administration tasks such as create and manage database users, roles and privileges, backup, and restore database objects to ensure organizational efficiency, continuity, and information security. <i>(Testing and performance) (Bloom's level: Understanding)</i> | Perform major database administration tasks such as create and manage database users, roles and privileges, backup, and restore database objects to ensure organizational efficiency, continuity, and information security. <i>(Testing and performance) (Bloom's level: Applying)</i><br>[IMA-S02] | Examine major database administration tasks such as create and manage database users, roles and privileges, backup, and restore database objects to ensure organizational efficiency, continuity, and information security. <i>(Testing and performance) (Bloom's level: Analyzing)</i> |
| <b>ITE-IST Domain: Integrated Systems Technology</b>  |   |   |
| Write a script that includes selection, repetition, and parameter passing. <i>(Integrative programming and scripting) (Bloom's level: Applying)</i>   | Design, including debugging and testing, a script that includes sequence, selection, repetition, and parameter passing. <i>(Integrative programming and scripting) (Bloom's level: Creating)</i><br>[IST-E01]   | Design, debug, and test a secure script that includes selection, repetition, and parameter passing. <i>(Integrative programming and scripting) (Bloom's level: Creating)</i>  |

| <b><i>IT-Transfer2020 Assessment Rubrics</i></b>   |  |  |
|--|--|--|
| <b><i>Emerging</i></b>   | <b><i>Developed</i></b>  | <b><i>Highly Developed</i></b>   |
| Summarize appropriate techniques for secure coding, including wrapper code, code, securing method access, and preventing buffer overflow. <i>(Defensible integration)</i><br><i>(Bloom's level: Understanding)</i>           | Implement secure coding techniques, such as input validation, wrapper code, securing method access, and buffer overflow prevention. <i>(Defensible integration)</i><br><i>(Bloom's level: Applying)</i><br>[IST-E02]   | Integrate appropriate techniques for secure coding, including wrapper code, code, securing method access, and preventing buffer overflow. <i>(Defensible integration)</i><br><i>(Bloom's level: Analyzing)</i>   |
| Describe how to code and store characters, images, and other forms of data in computers. <i>(Data mapping and exchange)</i> <i>(Bloom's level: Understanding)</i>  | Describe how to code and store characters, images, and other forms of data in computers, and why data conversion is often a necessity when merging disparate computing systems. <i>(Data mapping and exchange)</i><br><i>(Bloom's level: Understanding)</i><br>[IST-S01] | Examine how to code and store characters, images, and other forms of data in computers, and why data conversion is often a necessity when merging disparate computing systems. <i>(Data mapping and exchange)</i><br><i>(Bloom's level: Analyzing)</i> |
| Describe how a commonly used intersystem communication protocol works. <i>(Intersystem communication protocols)</i><br><i>(Bloom's level: Understanding)</i>   | Describe how a commonly used intersystem communication protocol works, including its advantages and disadvantages. <i>(Intersystem communication protocols)</i> <i>(Bloom's level: Understanding)</i><br>[IST-S02]   | Investigate how a commonly used intersystem communication protocol works, including its advantages and disadvantages. <i>(Intersystem communication protocols)</i> <i>(Bloom's level: Applying)</i>  |
| <b>ITE-NET Domain: Networking</b>  |  |  |
| Explain the characteristics of various communication protocols and how they support application requirements within a telecommunication system. <i>(Requirements and Technologies)</i> <i>(Bloom's level: Understanding)</i> | Compare the characteristics of various communication protocols and how they support application requirements within a telecommunication system. <i>(Requirements and Technologies)</i> <i>(Bloom's level: Analyzing)</i><br>[NET-E01]                                    | Evaluate the characteristics of various communication protocols and how they support application requirements within a telecommunication system. <i>(Requirements and Technologies)</i> <i>(Bloom's level: Evaluating)</i>                             |

| <b>IT-Transfer2020 Assessment Rubrics</b>  |  |   |
|--|--|---|
| <b><i>Emerging</i></b>   | <b><i>Developed</i></b>  | <b><i>Highly Developed</i></b>  |
| Describe different network standards, components, and requirements of network protocols. ( <i>Network protocol technologies</i> ) (Bloom's level: <i>Understanding</i> )                     | Describe different network standards, components, and requirements of network protocols within a distributed computing setting. ( <i>Network protocol technologies</i> ) (Bloom's level: <i>Understanding</i> )<br>[NET-E02] | Implement different network standards, components, and requirements of network protocols within a distributed computing setting. ( <i>Network protocol technologies</i> ) (Bloom's level: <i>Applying</i> ) |
| List different main issues related to network management. ( <i>Network Management</i> ) (Bloom's level: <i>Remembering</i> )   | Explain different main issues related to network management. ( <i>Network Management</i> ) (Bloom's level: <i>Understanding</i> )<br>[NET-E03]   | Investigate different main issues related to network management. ( <i>Network Management</i> ) (Bloom's level: <i>Applying</i> )  |
| Summarize various networking topologies in terms of robustness, expandability, and throughput used within a cloud enterprise. ( <i>Technologies</i> ) (Bloom's level: <i>Understanding</i> ) | Contrast various networking topologies in terms of robustness, expandability, and throughput used within a cloud enterprise. ( <i>Technologies</i> ) (Bloom's level: <i>Analyzing</i> )<br>[NET-S01]                         | Evaluate various networking topologies in terms of robustness, expandability, and throughput used within a cloud enterprise. ( <i>Technologies</i> ) (Bloom's level: <i>Evaluating</i> )                    |
| <b>ITE-PFT Domain: Platform Technologies</b>   |  |   |
| List important historical events related to hardware and operating system computing platforms. ( <i>Computing systems</i> ) (Bloom's level: <i>Understanding</i> )                           | Describe how the historical development of hardware and operating system computing platforms produced the computing systems we have today. ( <i>Computing systems</i> ) (Bloom's level: <i>Understanding</i> )<br>[PFT-E01]  | Analyze how the historical development of hardware and operating system computing platforms produced the computing systems we have today. ( <i>Computing systems</i> ) (Bloom's level: <i>Analyzing</i> )   |
| Contrast possible operating systems based on a computer's intended use. ( <i>Operating systems</i> ) (Bloom's level: <i>Analyzing</i> )  | Choose the most effective operating system based on a computer's intended use. ( <i>Operating systems</i> ) (Bloom's level: <i>Evaluating</i> )<br>[PFT-E02]   | Choose the most effective operating system based on a computer's intended use in a hybrid cloud environment. ( <i>Operating systems</i> ) (Bloom's level: <i>Evaluating</i> )                               |

| <b><i>IT-Transfer2020 Assessment Rubrics</i></b>  |   |   |
|---|---|---|
| <b><i>Emerging</i></b>  | <b><i>Developed</i></b>   | <b><i>Highly Developed</i></b>  |
| Explain the main parts of a computer, including interconnections. ( <i>Architecture and organization</i> ) (Bloom's level: <i>Understanding</i> )   | Diagram the main parts of a computer, including interconnections. ( <i>Architecture and organization</i> ) (Bloom's level: <i>Applying</i> )<br>[PFT-E03]   | Categorize the main parts of a computer, including interconnections. ( <i>Architecture and organization</i> ) (Bloom's level: <i>Analyzing</i> )  |
| Describe how to install at least one operating system on a computer. ( <i>Operating systems</i> ) (Bloom's level: <i>Understanding</i> )  | Perform at least one operating system installation on a computer. ( <i>Operating systems</i> ) (Bloom's level: <i>Applying</i> )<br>[PFT-S01]   | Contrast various client and server operating system installations on desktop, server, and mobile computers. ( <i>Operating systems</i> ) (Bloom's level: <i>Analyzing</i> )               |
| Explain how to store and retrieve data using a computer. ( <i>Architecture and organization</i> ) (Bloom's level: <i>Understanding</i> )  | Illustrate how to store and retrieve data using a computer. ( <i>Architecture and organization</i> ) (Bloom's level: <i>Applying</i> )<br>[PFT-S02]   | Distinguish between various data storage and retrieval methods using a computer. ( <i>Architecture and organization</i> ) (Bloom's level: <i>Analyzing</i> )                              |
| <b>ITE-SPA Domain: System Paradigms</b>   |   |   |
| Explain appropriate procedures and technologies to enforce administrative policies within a corporate environment. ( <i>Operational activities</i> ) (Bloom's level: <i>Understanding</i> ) | Implement appropriate procedures and technologies to enforce administrative policies within a corporate environment. ( <i>Operational activities</i> ) (Bloom's level: <i>Applying</i> )<br>[SPA-E01] | Integrate appropriate procedures and technologies to enforce administrative policies within a corporate environment. ( <i>Operational activities</i> ) (Bloom's level: <i>Analyzing</i> ) |
| Explain appropriate and emerging technologies to improve the performance of computer systems. ( <i>Performance analysis</i> ) (Bloom's level: <i>Understanding</i> )                        | Use appropriate and emerging technologies to improve the performance of computer systems. ( <i>Performance analysis</i> ) (Bloom's level: <i>Applying</i> )<br>[SPA-E02]                              | Choose appropriate and emerging technologies to improve the performance of computer systems. ( <i>Performance analysis</i> ) (Bloom's level: <i>Evaluating</i> )                          |

| <b><i>IT-Transfer2020 Assessment Rubrics</i></b>  |  |   |
|---|--|---|
| <b><i>Emerging</i></b>  | <b><i>Developed</i></b>  | <b><i>Highly Developed</i></b>  |
| Discuss effective and appropriate system administration policies with sensitivity to the goals and constraints of an organization. <i>(System governance) (Bloom's level: Understanding)</i>  | Implement effective and appropriate system administration policies with sensitivity to the goals and constraints of an organization. <i>(System governance) (Bloom's level: Applying)</i><br>[SPA-S01]                                     | Examine effective and appropriate system administration policies with sensitivity to the goals and constraints of an organization. <i>(System governance) (Bloom's level: Analyzing)</i>                                      |
| <b>ITE-SWF Domain: Software Fundamentals</b>  |  |   |
| Describe a program that implements an appropriate style, intended input behavior, correct program components, and includes descriptions of program functionality. <i>(App development practices) (Bloom's level: Understanding)</i> | Produce a program that implements an appropriate style, intended input behavior, correct program components, and includes descriptions of program functionality. <i>(App development practices) (Bloom's level: Applying)</i><br>[SWF-E01] | Examine how a program implements an appropriate style, intended input behavior, correct program components, and includes descriptions of program functionality. <i>(App development practices) (Bloom's level: Analyzing)</i> |
| Assess algorithms to solve a computational problem. <i>(Algorithm development) (Bloom's level: Evaluating)</i>  | Develop algorithms to solve a computational problem. <i>(Algorithm development) (Bloom's level: Creating)</i><br>[SWF-E02]   | Develop complex algorithms to solve a computational problem. <i>(Algorithm development) (Bloom's level: Creating)</i>   |
| Recognize how programs implement algorithms in terms of instruction processing, program execution, and running processes. <i>(Algorithm development) (Bloom's level: Remembering)</i>   | Explain how programs implement algorithms in terms of instruction processing, program execution, and running processes. <i>(Algorithm development) (Bloom's level: Understanding)</i><br>[SWF-S01]   | Illustrate how programs implement algorithms in terms of instruction processing, program execution, and running processes. <i>(Algorithm development) (Bloom's level: Applying)</i>   |
| Describe appropriate data structures, while using multiple levels of abstraction, to create a new program that requires teamwork and is socially relevant. <i>(Program development) (Bloom's level: Understanding)</i>              | Implement appropriate data structures, while using multiple levels of abstraction, to create a new program that requires teamwork and is socially relevant. <i>(Program development) (Bloom's level: Applying)</i><br>[SWF-S02]            | Compare appropriate data structures, while using multiple levels of abstraction, to create a new program that requires teamwork and is socially relevant. <i>(Program development) (Bloom's level: Analyzing)</i>             |



| <b><i>IT-Transfer2020 Assessment Rubrics</i></b>   |   |   |
|--|---|---|
| <b><i>Emerging</i></b>   | <b><i>Developed</i></b>   | <b><i>Highly Developed</i></b>  |
| Implement a mobile or web app with appropriate functionality while using standard libraries and version control in a team environment. <i>(App development practices)</i> <i>(Bloom's level: Applying)</i>         | Implement a mobile or web app with appropriate user experience design, functionality, and security analysis while using standard libraries, unit testing tools, and version control in a team environment. <i>(App development practices)</i> <i>(Bloom's level: Applying)</i><br>[SWF-S03] | Examine a mobile or web app for appropriate user experience design, functionality, and security while using standard libraries, unit testing tools, and version control in a team environment. <i>(App development practices)</i> <i>(Bloom's level: Analyzing)</i> |
| <b>ITE-UXD Domain: User Experience Design</b>  |   |   |
| Implement a simple application according to basic usability standards by using relevant tools and techniques, such as prototyping. <i>(Design tools and techniques)</i> <i>(Bloom's level: Applying)</i>           | Develop a simple application that maximizes usability by using relevant tools and techniques, such as prototyping. <i>(Design tools and techniques)</i> <i>(Bloom's level: Creating)</i><br>[UXD-E01]   | Develop a complex application that maximizes usability by using relevant tools and techniques, such as prototyping. <i>(Design tools and techniques)</i> <i>(Bloom's level: Creating)</i>   |
| Implement an interactive application that optimizes usability while applying a user-centered design cycle with related tools and techniques. <i>(Design tools and techniques)</i> <i>(Bloom's level: Applying)</i> | Develop an interactive application that optimizes usability while applying a user-centered design cycle with related tools and techniques. <i>(Design tools and techniques)</i> <i>(Bloom's level: Creating)</i><br>[UXD-S01]   | Develop an interactive application that optimizes usability while applying a user-centered design cycle with related tools and techniques in a team environment. <i>(Design tools and techniques)</i> <i>(Bloom's level: Creating)</i>                              |
| <b>ITE-WMS Domain: Web and Mobile Systems</b>  |   |   |
| List the major components of a web system, including the web server, database, analytics, and front end. <i>(Web system infrastructure)</i> <i>(Bloom's level: Remembering)</i>                                    | Describe the major components of a web system and how they function together, including the web server, database, analytics, and front end. <i>(Web system infrastructure)</i> <i>(Bloom's level: Understanding)</i><br>[WMS-E01]   | Diagram the major components of a web system and how they function together, including the web server, database, analytics, and front end. <i>(Web system infrastructure)</i> <i>(Bloom's level: Applying)</i>  |



| <b><i>IT-Transfer2020 Assessment Rubrics</i></b>  |  |   |
|---|--|---|
| <b><i>Emerging</i></b>  | <b><i>Developed</i></b>  | <b><i>Highly Developed</i></b>  |
| Implement a responsive web application utilizing a web framework and presentation technologies in support of a diverse online community. <i>(Web application development) (Bloom's level: Applying)</i> | Analyze how a responsive web application utilizes a web framework and presentation technologies in support of a diverse online community. <i>(Web application development) (Bloom's level: Analyzing)</i><br>[WMS-S01] | Evaluate how a responsive web application utilizes a web framework and presentation technologies in support of a diverse online community. <i>(Web application development) (Bloom's level: Evaluating)</i> |
| Develop a mobile app that is usable and secure. <i>(Mobile app development) (Bloom's level: Creating)</i>   | Develop a mobile app that is usable, efficient, and secure on more than one device. <i>(Mobile app development) (Bloom's level: Creating)</i><br>[WMS-S02]   | Develop a mobile app that is usable, efficient, secure, and optimized for multiple devices. <i>(Mobile app development) (Bloom's level: Creating)</i>   |
| Modify a web or mobile system to correct security vulnerabilities. <i>(Web and mobile security) (Bloom's level: Applying)</i>   | Analyze a web or mobile system and correct security vulnerabilities. <i>(Web and mobile security) (Bloom's level: Analyzing)</i><br>[WMS-S03]  | Evaluate a web or mobile system for security vulnerabilities and correct them. <i>(Web and mobile security) (Bloom's level: Evaluating)</i>   |
| Explain storage, transfer, and retrieval of digital media with appropriate file, database, or streaming formats. <i>(Digital media storage and transfer) (Bloom's level: Understanding)</i>             | Implement storage, transfer, and retrieval of digital media with appropriate file, database, or streaming formats. <i>(Digital media storage and transfer) (Bloom's level: Applying)</i><br>[WMS-S04]                  | Compare storage, transfer, and retrieval options for digital media with appropriate file, database, or streaming formats. <i>(Digital media storage and transfer) (Bloom's level: Evaluating)</i>           |
| <b>ITS-ANE Domain: Applied Networks</b>   |  |   |
| Explain security and performance issues related to wireless networks. <i>(Security and performance) (Bloom's level: Understanding)</i>  | Investigate security and performance issues related to wireless networks. <i>(Security and performance) (Bloom's level: Applying)</i><br>[ANE-S01]   | Analyze security and performance issues related to wireless networks. <i>(Security and performance) (Bloom's level: Analyzing)</i>  |

| <b><i>IT-Transfer2020 Assessment Rubrics</i></b>   |   |   |
|--|---|---|
| <b><i>Emerging</i></b>   | <b><i>Developed</i></b>   | <b><i>Highly Developed</i></b>  |
| <b>ITS-CCO Domain: Cloud Computing</b>   |   |   |
| Explain the concept of cloud computing. <i>(Technologies)</i><br><i>(Bloom's level: Understanding)</i>   | Discuss various concepts and technologies related to cloud computing. <i>(Technologies)</i><br><i>(Bloom's level: Analyzing)</i><br>[CCO-E01]   | Choose appropriate cloud service categories for a given scenario. <i>(Technologies)</i><br><i>(Bloom's level: Evaluating)</i>   |
| Explain cloud service categories, including public, private, and hybrid clouds, and be aware of privacy regulation impact on cloud application requirements. <i>(Legal and Design)</i> <i>(Bloom's level: Understanding)</i>     | Distinguish cloud service categories, including public, private, and hybrid clouds, and be aware of privacy regulation impact on cloud application requirements. <i>(Legal and Design)</i> <i>(Bloom's level: Analyzing)</i><br>[CCO-S01] | Assess cloud service categories, including public, private, and hybrid clouds, and be aware of privacy regulation impact on cloud application requirements. <i>(Legal and Design)</i> <i>(Bloom's level: Evaluating)</i>    |
| Identify various factors, including basic architecture, that affect the performance of cloud applications. <i>(Technology)</i> <i>(Bloom's level: Remembering)</i>   | Discuss various factors, including basic architecture, that affect the performance of cloud applications. <i>(Technology)</i> <i>(Bloom's level: Understanding)</i><br>[CCO-S02]  | Investigate various factors, including basic architecture, that affect the performance of cloud applications. <i>(Technology)</i> <i>(Bloom's level: Applying)</i>  |
| <b>ITS-CEC Domain: Cybersecurity Emerging Challenges</b>   |   |   |
| Interpret common standards, procedures, and applications used to protect the confidentiality, integrity and availability of information and information systems. <i>(System integrity)</i> <i>(Bloom's level: Understanding)</i> | Implement common standards, procedures, and applications used to protect the confidentiality, integrity, and availability of data and information systems. <i>(System integrity)</i> <i>(Bloom's level: Applying)</i><br>[CEC-E01]        | Contrast common standards, procedures, and applications used to protect the confidentiality, integrity and availability of information and information systems. <i>(System integrity)</i> <i>(Bloom's level: Analyzing)</i> |
| Discuss human facets that enable the exploitation of computing-based systems. <i>(Human dynamics)</i> <i>(Bloom's level: Understanding)</i>  | Analyze human facets that enable the exploitation of computing-based systems. <i>(Human dynamics)</i> <i>(Bloom's level: Analyzing)</i><br>[CEC-E02]  | Assess human facets that enable the exploitation of computing-based systems. <i>(Human dynamics)</i> <i>(Bloom's level: Evaluating)</i>   |

| <b><i>IT-Transfer2020 Assessment Rubrics</i></b>  |  |  |
|---|--|--|
| <b><i>Emerging</i></b>  | <b><i>Developed</i></b>  | <b><i>Highly Developed</i></b>   |
| Differentiate common malware analysis procedures on mobile and desktop computer systems. <i>(Malware and forensic analysis) (Bloom's level: Understanding)</i>  | Perform common malware analysis procedures on mobile and desktop computer systems. <i>(Malware and forensic analysis) (Bloom's level: Applying) [CEC-S01]</i>  | Examine common malware analysis procedures on mobile and desktop computer systems. <i>(Malware and forensic analysis) (Bloom's level: Analyzing)</i>   |
| <b>ITS-DSA Domain: Data Scalability and Analytics</b>   |  |  |
| Describe appropriate data analysis methods to solve real-world problems. <i>(Requirements and development) (Bloom's level: Understanding)</i>   | Use appropriate data analysis methods to solve real-world problems. <i>(Requirements and development) (Bloom's level: Applying) [DSA-S01]</i>  | Compare appropriate data analysis methods to solve real-world problems. <i>(Requirements and development) (Bloom's level: Analyzing)</i>   |
| <b>ITS-IOT Domain: Internet of Things</b>   |  |  |
| Explain how wireless sensors are used within an ad-hoc network architecture to capture data within a multimedia system. <i>(Wireless data acquisition) (Bloom's level: Understanding)</i>                         | Use wireless sensors within an ad-hoc network architecture to capture data within a multimedia system. <i>(Wireless data acquisition) (Bloom's level: Applying) [IOT-S01]</i>  | Examine how wireless sensors are used within an ad-hoc network architecture to capture data within a multimedia system. <i>(Wireless data acquisition) (Bloom's level: Analyzing)</i>                              |
| <b>ITS-MAP Domain: Mobile Applications</b>  |  |  |
| List various implementation strategies for web applications, including an application programming interface (API) and a platform-independent interpreted code. <i>(Technologies) (Bloom's level: Remembering)</i> | Discuss various implementation strategies for web applications, including an application programming interface (API) and a platform-independent interpreted code. <i>(Technologies) (Bloom's level: Understanding) [MAP-S01]</i> | Compare various implementation strategies for web applications, including an application programming interface (API) and a platform-independent interpreted code. <i>(Technologies) (Bloom's level: Analyzing)</i> |
| Produce a functional server-side application using at least one technique for server-side programming. <i>(Design and Development) (Bloom's level: Applying)</i>  | Produce a functional server-side application using several techniques for server-side programming. <i>(Design and Development) (Bloom's level: Applying) [MAP-S02]</i>   | Integrate several techniques for server-side programming to produce a functional server-side application. <i>(Design and Development) (Bloom's level: Analyzing)</i>   |

| <i><b>IT-Transfer2020 Assessment Rubrics</b></i>   |  |  |
|--|--|--|
| <i><b>Emerging</b></i>   | <i><b>Developed</b></i>  | <i><b>Highly Developed</b></i>   |
| <b>ITS-SDM Domain: Software Development and Management</b>   |  |  |
| Explain tools and services to develop computing systems that consider platform constraints, supports version control, tracks requirements and bugs, and automates building. <i>(Development)</i> <i>(Bloom's level: Understanding)</i> | Use tools and services to develop computing systems that consider platform constraints, support version control, track requirements and bugs, and automate building. <i>(Development)</i> <i>(Bloom's level: Applying)</i> [SDM-S01] | Compare tools and services to develop computing systems that consider platform constraints, supports version control, tracks requirements and bugs, and automates building. <i>(Development)</i> <i>(Bloom's level: Analyzing)</i> |
| <b>ITS-SRE Domain: Social Responsibility</b>   |  |  |
| Define the roles that teamwork, ethics, and legal considerations play in an IT organization. <i>(Teamwork, legal and ethical considerations)</i> <i>(Bloom's level: Remembering)</i>   | Discuss the roles that teamwork, ethics, and legal considerations play in an IT organization. <i>(Teamwork, legal and ethical considerations)</i> <i>(Bloom's level: Understanding)</i> [SRE-E01]                                    | Contrast the roles that teamwork, ethics, and legal considerations play in an IT organization. <i>(Teamwork, legal and ethical considerations)</i> <i>(Bloom's level: Analyzing)</i>   |
| Recognize how governmental and environmental regulations affect an organization's environment. <i>(Government and environment)</i> <i>(Bloom's level: Remembering)</i>   | Summarize how governmental and environmental regulations affect an organization's environment. <i>(Government and environment)</i> <i>(Bloom's level: Understanding)</i> [SRE-E02]   | Examine how governmental and environmental regulations affect an organization's environment. <i>(Government and environment)</i> <i>(Bloom's level: Analyzing)</i>   |
| Analyze various security breaches and their effect on business operations. <i>(Risk management)</i> <i>(Bloom's level: Analyzing)</i>  | Evaluate various security breaches and their effect on business operations. <i>(Risk management)</i> <i>(Bloom's level: Evaluating)</i> [SRE-S01]  | Develop countermeasures against various security breaches to minimize their effect on business operations. <i>(Risk management)</i> <i>(Bloom's level: Creating)</i>   |
| <b>ITS-VSS Domain: Virtual Systems and Services</b>  |  |  |
| Explain virtualized and non-virtualized platforms. <i>(Technologies)</i> <i>(Bloom's level: Understanding)</i>   | Contrast virtualized and non-virtualized platforms. <i>(Technologies)</i> <i>(Bloom's level: Analyzing)</i> [VSS-E01]  | Choose the most appropriate virtualized and non-virtualized platform for various business requirements. <i>(Technologies)</i> <i>(Bloom's level: Evaluating)</i>   |

| <b><i>IT-Transfer2020 Assessment Rubrics</i></b>   |   |   |
|--|---|---|
| <b><i>Emerging</i></b>   | <b><i>Developed</i></b>   | <b><i>Highly Developed</i></b>  |
| Explain virtualization for desktops and servers. <i>(Install technologies) (Bloom's level: Understanding)</i>  | Implement virtualization for desktops and servers. <i>(Install technologies) (Bloom's level: Applying)</i><br>[VSS-E02]   | Compare virtualization for desktops and servers. <i>(Install technologies) (Bloom's level: Analyzing)</i>   |
| Describe a storage environment including appropriate performance measurement tools. <i>(Technologies and performance) (Bloom's level: Understanding)</i> | Implement a storage environment including appropriate performance measurement tools. <i>(Technologies and performance) (Bloom's level: Applying)</i><br>[VSS-S01] | Assess a storage environment including appropriate performance measurement tools. <i>(Technologies and performance) (Bloom's level: Evaluating)</i> |
| Explain virtualization for network platforms. <i>(Install technologies) (Bloom's level: Understanding)</i>   | Explain virtualization for applications and network platforms. <i>(Install technologies) (Bloom's level: Understanding)</i><br>[VSS-S02]                          | Implement virtualization for applications and network platforms. <i>(Install technologies) (Bloom's level: Applying)</i>                            |



## **Appendix B. IT-Transfer2020 vs. IT2yr2014**

On October 14, 2014, the ACM CCECC published the Information Technology Competency Model of Core Learning Outcomes and Assessment for Associate-Degree Curriculum (IT2yr2014) which provides guidance on the competencies that every student who completes a career-oriented associate degree in Information Technology should achieve. An associate degree in IT typically prepares students for an entry-level position in user support/helpdesk or network administration functions of an IT organization. IT professionals who wish to advance their career often find it difficult to do so without a baccalaureate degree, and therefore many choose to continue their academic studies after several years in the workplace. Analyzing the differences between the guidance for workforce-oriented programs and that for IT Transfer programs is therefore an important effort.

The 50 learning outcomes outlined in IT2yr2014 represent core IT “competencies that a student in any [two-year] IT-related program must demonstrate.” [4] When aligning the IT2yr2014 learning outcomes with the IT-Transfer2020 competencies within each of the IT domains adopted from IT2017, it becomes apparent that the degree of overlap with the essential IT-Transfer2020 competencies is relatively high. Substantial differences in content coverage exist in the IT domains of Software Fundamentals (ITE-SWF) and Web and Mobile Systems (ITE-WMS), which IT-Transfer2020 covers at substantially greater depth, and in the areas of Digital Media and Customer Service, which IT2yr2014 covers heavily but for which a substantially lower number of competencies is listed in IT-Transfer2020. The juxtaposition of the IT-Transfer2020 competencies with the IT2yr2014 learning outcomes in Table B.1 illustrates the commonalities and differences between the two guidance documents. As part of their coordination between programs, IT transfer partner institutions should consider how they might efficiently assist associate degree holders who wish to earn a baccalaureate IT degree to meet that program’s learning outcomes. Options for accomplishing this might include the design and regular offering of one or more “bridge” courses at either the upper or lower division, or a requirement for students who have completed career-oriented programs to take certain courses that would typically serve as an elective for students in IT Transfer programs.

Table B.1. Comparison between IT-Transfer2020 Competencies and IT2yr2014 Learning Outcomes

| <i>IT-Transfer2020 Competencies</i>   | <i>IT2yr2014 Learning Outcomes</i>   |
|---|--|
| <b>ITE-CSP Domain: Cybersecurity Principles</b>   |  |
| <p>[CSP-E01] Evaluate the purpose and function of cybersecurity technology, identifying the tools and systems that reduce the risk of data breaches while enabling vital organization practices. <i>(Cybersecurity functions)</i></p> <p>[CSP-E02] Apply appropriate tools and concepts to minimize the risk to an organization's cyberspace to address cybersecurity threats. <i>(Tools and threats)</i></p> <p>[CSP-S01] Implement a risk management approach for responding to and recovering from a cyber-attack on systems which contain high-value information and assets such as an email system. <i>(Response and risks)</i></p>  | <p>[IT.3] Explain the process of authentication and authorization between end-user devices and computing network resources.</p> <p>[IT.9] Use a variety of practices for making end-user IT systems secure.</p> <p>[IT.26] Differentiate among various techniques for making a computer network secure.</p>  |
| <b>ITE-GPP Domain: Global Professional Practice</b>   |  |
| <p>[GPP-E01] Use effective communication skills and cultural awareness in a team setting to help advance organizational goals in a global environment. <i>(Communication and teamwork)</i></p> <p>[GPP-E02] Evaluate the specific skills necessary for maintaining continued employment in an IT career. <i>(Employability)</i></p> <p>[GPP-E03] Carry out IT policies within an organization that include privacy, legal, and ethical considerations. <i>(Legal and ethical)</i></p> <p>[GPP-S01] Produce a project plan for an IT project, including a cost/benefit analysis, risk considerations, and related issues. <i>(Project management)</i></p> <p>[GPP-S02] Discuss current practices used to optimize the systems development life cycle, such as DevOps and agile approaches. <i>(Current industry practices)</i></p> | <p>[IT.42] Use communication, negotiation, and collaboration skills as a member of a diverse team.</p> <p>[IT.44] Produce technical documentation responsive to an identified computing scenario.</p> <p>[IT.46] Discuss significant trends and emerging technologies and their impact on our global society.</p> <p>[IT.47] Demonstrate professional behavior in response to an ethically-challenging scenario in computing.</p> <p>[IT.48] Summarize the tenets of ethics and professional behavior promoted by international computing societies.</p> |



| <i>IT-Transfer2020 Competencies</i>   | <i>IT2yr2014 Learning Outcomes</i>  |
|---|---|
| <b>ITE-IMA Domain: Information Management</b>   |   |
| <p>[IMA-E01] Create simple and intermediate queries to construct and modify objects that store, manipulate, and analyze data. <i>(Testing and performance)</i></p> <p>[IMA-S01] Design and implement a physical model based on appropriate organization rules for a given scenario including the impact of normalization and indexes. <i>(Requirements and development)</i></p> <p>[IMA-S02] Perform major database administration tasks such as create and manage database users, roles and privileges, backup, and restore database objects to ensure organizational efficiency, continuity, and information security. <i>(Testing and performance)</i></p>   | <p>[IT.10] Describe the data management activities associated with the data lifecycle.</p> <p>[IT.11] Diagram a database design based on an identified scenario.</p> <p>[IT.12] Differentiate between public and private data.</p> <p>[IT.13] Discuss applications of data analytics.</p> <p>[IT.14] Discuss issues relevant to dealing with very large data sets, both structured and unstructured.</p> <p>[IT.15] Identify database administration tasks.</p> <p>[IT.16] Produce simple database queries.</p> <p>[IT.17] Use data analytics to support decision making for a given scenario.</p> <p>[IT.36] Discuss data governance and its implications for users as well as IT professionals.</p> |
| <b>ITE-IST Domain: Integrated Systems Technology</b>  |   |
| <p>[IST-E01] Design, including debugging and testing, a script that includes sequence, selection, repetition, and parameter passing. <i>(Integrative programming and scripting)</i></p> <p>[IST-E02] Implement secure coding techniques, such as input validation, wrapper code, securing method access, and buffer overflow prevention. <i>(Defensible integration)</i></p> <p>[IST-S01] Describe how to code and store characters, images, and other forms of data in computers, and why data conversion is often a necessity when merging disparate computing systems. <i>(Data mapping and exchange)</i></p> <p>[IST-S02] Describe how a commonly used intersystem communication protocol works, including its advantages and disadvantages. <i>(Intersystem communication protocols)</i></p> | <p>[IT.29] Demonstrate the techniques of defensive programming and secure coding.</p> <p>[IT.33] Use a programming or a scripting language to share data across an integrated IT system.</p>  |

| <i>IT-Transfer2020 Competencies</i>   | <i>IT2yr2014 Learning Outcomes</i>   |
|---|--|
| <b>ITE-NET Domain: Networking</b>   |  |
| <p>[NET-E01] Compare the characteristics of various communication protocols and how they support application requirements within a telecommunication system. (<i>Requirements and Technologies</i>)</p> <p>[NET-E02] Describe different network standards, components, and requirements of network protocols within a distributed computing setting. (<i>Network Protocol Technologies</i>)</p> <p>[NET-E03] Explain different main issues related to network management. (<i>Network Management</i>)</p> <p>[NET-S01] Contrast various networking topologies in terms of robustness, expandability, and throughput used within a cloud enterprise. (<i>Technologies</i>)</p> | <p>[IT.23] Describe the layers, protocols and components of the OSI model.</p> <p>[IT.25] Differentiate among various computer networking models.</p> <p>[IT.27] Summarize the flow of data through a computer network scenario.</p> <p>[IT.35] Differentiate among strategies for business continuity provisioning of IT resources at the enterprise level.</p> |
| <b>ITE-PFT Domain: Platform Technologies</b>  |  |
| <p>[PFT-E01] Describe how the historical development of hardware and operating system computing platforms produced the computing systems we have today. (<i>Computing systems</i>)</p> <p>[PFT-E02] Choose the most effective operating system based on a computer's intended use. (<i>Operating systems</i>)</p> <p>[PFT-E03] Diagram the main parts of a computer, including interconnections. (<i>Architecture and organization</i>)</p> <p>[PFT-S01] Perform at least one operating system installation on a computer. (<i>Operating systems</i>)</p> <p>[PFT-S02] Illustrate how to store and retrieve data using a computer. (<i>Architecture and organization</i>)</p> | <p>[IT.2] Differentiate among various operating systems.</p> <p>[IT.5] Identify basic components of an end-user IT system.</p> <p>[IT.18] Differentiate among a variety of technology-based sensory interactions.</p> <p>[IT.37] Identify a variety of enterprise-level digital storage technologies.</p>  |

| <i>IT-Transfer2020 Competencies</i>  | <i>IT2yr2014 Learning Outcomes</i>  |
|--|---|
| <b>ITE-SPA Domain: System Paradigms</b>  |   |
| <p>[SPA-E01] Implement appropriate procedures and technologies to enforce administrative policies within a corporate environment. <i>(Operational activities)</i></p> <p>[SPA-E02] Use appropriate and emerging technologies to improve the performance of computer systems. <i>(Performance analysis)</i></p> <p>[SPA-S01] Implement effective and appropriate system administration policies with sensitivity to the goals and constraints of an organization. <i>(System governance)</i></p>  | <p>[IT.6] Implement a hardware and software configuration responsive to an identified scenario.</p> <p>[IT.24] Diagram the components of an integrated IT system.</p> <p>[IT.50] Summarize the role of IT in supporting the mission and goals of an organization.</p>                                 |
| <b>ITE-SWF Domain: Software Fundamentals</b>   |   |
| <p>[SWF-E01] Produce a program that implements an appropriate style, intended input behavior, correct program components, and includes descriptions of program functionality. <i>(App development practices)</i></p> <p>[SWF-E02] Develop algorithms to solve a computational problem. <i>(Algorithm development)</i></p> <p>[SWF-S01] Explain how programs implement algorithms in terms of instruction processing, program execution, and running processes. <i>(Algorithm development)</i></p> <p>[SWF-S02] Implement appropriate data structures, while using multiple levels of abstraction, to create a new program that requires teamwork and is socially relevant. <i>(Program development)</i></p> <p>[SWF-S03] Implement a mobile or web app with appropriate user experience design, functionality, and security analysis while using standard libraries, unit testing tools, and version control in a team environment. <i>(App development practices)</i></p> | <p>[IT.30] Diagram the phases of the Secure Software Development Lifecycle.</p> <p>[IT.31] Discuss software development methodologies.</p> <p>[IT.32] Summarize the differences among various programming languages.</p> <p>[IT.34] Use a programming or a scripting language to solve a problem.</p> |

| <i><b>IT-Transfer2020 Competencies</b></i>  | <i><b>IT2yr2014 Learning Outcomes</b></i>  |
|---|--|
| <b>ITE-UXD Domain: User Experience Design</b>   |  |
| <p>[UXD-E01] Develop a simple application that maximizes usability by using relevant tools and techniques, such as prototyping. (<i>Design tools and techniques</i>)</p> <p>[UXD-S01] Develop an interactive application that optimizes usability while applying a user-centered design cycle with related tools and techniques. (<i>Design tools and techniques</i>)</p>   | <p>[IT.4] Identify a variety of assistive or adaptive technologies and universal design considerations.</p> <p>[IT.28] Demonstrate best practices for designing end-user computing interfaces.</p> |
| <b>ITE-WMS Domain: Web and Mobile Systems</b>   |  |
| <p>[WMS-E01] Describe the major components of a web system and how they function together, including the web server, database, analytics, and front end. (<i>Web system infrastructure</i>)</p> <p>[WMS-S01] Analyze how a responsive web application utilizes a web framework and presentation technologies in support of a diverse online community. (<i>Web application development</i>)</p> <p>[WMS-S02] Develop a mobile app that is usable, efficient, and secure on more than one device. (<i>Mobile app development</i>)</p> <p>[WMS-S03] Analyze a web or mobile system and correct security vulnerabilities. (<i>Web and mobile security</i>)</p> <p>[WMS-S04] Implement storage, transfer, and retrieval of digital media with appropriate file, database, or streaming formats. (<i>Digital media storage and transfer</i>)</p> | <p>[IT.19] Differentiate among data types, data transfer protocols and file characteristics specific to the targeted use.</p>  |
| <b>ITS-ANE Domain: Applied Networks</b>   |  |
| <p>[ANE-S01] Investigate security and performance issues related to wireless networks. (<i>Security and performance</i>)</p>  | <p>None.</p>   |

| <i>IT-Transfer2020 Competencies</i>   | <i>IT2yr2014 Learning Outcomes</i>   |
|---|--|
| <b>ITS-CCO Domain: Cloud Computing</b>  |  |
| <p>[CCO-E01] Discuss various concepts and technologies related to cloud computing. <i>(Technologies)</i></p> <p>[CCO-S01] Distinguish cloud service categories, including public, private, and hybrid clouds, and be aware of privacy regulation impact on cloud application requirements. <i>(Legal and Design)</i></p> <p>[CCO-S02] Discuss various factors, including basic architecture, that affect the performance of cloud applications. <i>(Technology)</i></p>       | <p>[IT.40] Summarize the implications of various cloud computing models.</p>             |
| <b>ITS-CEC Domain: Cybersecurity Emerging Challenges</b>  |  |
| <p>[CEC-E01] Implement common standards, procedures, and applications used to protect the confidentiality, integrity and availability of information and information systems. <i>(System integrity)</i></p> <p>[CEC-E02] Analyze human facets that enable the exploitation of computing-based systems. <i>(Human dynamics)</i></p> <p>[CEC-S01] Perform common malware analysis procedures on mobile and desktop computer systems. <i>(Malware and forensic analysis)</i></p> | <p>[IT.39] Modify a system to improve data confidentiality or regulatory compliance.</p> |
| <b>ITS-DSA Domain: Data Scalability and Analytics</b>   |  |
| <p>[DSA-S01] Use appropriate data analysis methods to solve real-world problems. <i>(Requirements and development)</i></p>  | <p>None.</p>   |
| <b>ITS-IOT Domain: Internet of Things</b>   |  |
| <p>[IOT-S01] Use wireless sensors within an ad-hoc network architecture to capture data within a multimedia system. <i>(Wireless data acquisition)</i></p>  | <p>None.</p>   |

| <i>IT-Transfer2020 Competencies</i>  | <i>IT2yr2014 Learning Outcomes</i>  |
|--|---|
| <b>ITS-MAP Domain: Mobile Applications</b>   |   |
| <p>[MAP-S01] Discuss various implementation strategies for web applications, including an application programming interface (API) and a platform-independent interpreted code. <i>(Technologies)</i></p> <p>[MAP-S02] Produce a functional server-side application using several techniques for server-side programming. <i>(Design and Development)</i></p>   | None.   |
| <b>ITS-SDM Domain: Software Development and Management</b>   |   |
| <p>[SDM-S01] Use tools and services to develop computing systems that consider platform constraints, support version control, track requirements and bugs, and automate building. <i>(Development)</i></p>   | None.   |
| <b>ITS-SRE Domain: Social Responsibility</b>   |   |
| <p>[SRE-E01] Discuss the roles that teamwork, ethics, and legal considerations play in an IT organization. <i>(Teamwork, legal and ethical considerations)</i></p> <p>[SRE-E02] Summarize how governmental and environmental regulations affect an organization's environment. <i>(Government and environment)</i></p> <p>[SRE-S01] Evaluate various security breaches and their effect on business operations. <i>(Risk management)</i></p> | <p>[IT.7] Summarize life-cycle strategies for replacement, reuse, recycling IT technology and resources.</p> <p>[IT.41] Summarize the security implications and risks for distributed IT systems.</p> |
| <b>ITS-VSS Domain: Virtual Systems and Services</b>  |   |
| <p>[VSS-E01] Contrast virtualized and non-virtualized platforms. <i>(Technologies)</i></p> <p>[VSS-E02] Implement virtualization for desktops and servers. <i>(Install technologies)</i></p> <p>[VSS-S01] Implement a storage environment and use performance measurement tools. <i>(Technologies and performance)</i></p> <p>[VSS-S02] Explain virtualization for applications and network platforms. <i>(Install technologies)</i></p>     | [IT.38] Implement an application of virtualization.   |

| <i>IT-Transfer2020 Competencies</i>                                  | <i>IT2yr2014 Learning Outcomes</i>  |
|--|---|
| <b>Not directly associated with an IT2017/IT-Transfer2020 Domain</b> |   |
| N/A  | <p>[IT.1] Carry out troubleshooting strategies for resolving an identified end-user IT problem.</p> <p>[IT.8] Summarize strategies to support or train users with their IT resources.</p> <p>[IT.20] Illustrate the activities of a digital media design process.</p> <p>[IT.21] Implement communication principles into digital media design.</p> <p>[IT.22] Carry out basic computer network troubleshooting techniques.</p> <p>[IT.43] Describe the attitudes, knowledge and abilities associated with quality customer service.</p> <p>[IT.45] Use documentation or a knowledge base to resolve a technical challenge in an identified computing scenario.</p> <p>[IT.49] Describe IT procurement processes for goods and services.</p> |





## Appendix C. Contributing Reviewers

The IT Transfer Task Group wishes to thank the following individuals for contributing their time and expertise by reviewing this document and making it better because of their feedback:

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## Appendix D. IT Transfer Articulation Worksheet

To assist transfer partner institutions in determining how to best articulate their respective programs, the IT-Transfer2020 Task Group recommends the use of the worksheet below to help with determining which IT domains, or which parts of an IT domain, should be covered by the two-year program or the four-year program. Methodologies include simply marking each applicable cell with an X to indicate coverage, inserting a percentage of the domain coverage into each cell, inserting the number of instructional hours estimated for covering the domain, or inserting the identifiers for the competencies to be covered (e.g., [CSP-E01]).

*Table D.1. IT Transfer Articulation Worksheet*

| IT Domains                                    | Covered by<br>2-year Program | Covered by<br>4-year Program |
|---|------------------------------|------------------------------|
| Cybersecurity Principles [ITE-CSP]            |                              |                              |
| Global Professional Practice [ITE-GPP]        |                              |                              |
| Information Management [ITE-IMA]              |                              |                              |
| Integrated Systems Technology [ITE-IST]       |                              |                              |
| Networking [ITE-NET]                          |                              |                              |
| Platform Technologies [ITE-PFT]               |                              |                              |
| System Paradigms [ITE-SPA]                    |                              |                              |
| Software Fundamentals [ITE-SWF]               |                              |                              |
| User Experience Design [ITE-UXD]              |                              |                              |
| Web and Mobile Systems [ITE-WMS]              |                              |                              |
| Applied Networks [ITS-ANE]                    |                              |                              |
| Cloud Computing [ITS-CCO]                     |                              |                              |
| Cybersecurity Emerging Challenges [ITS-CEC]   |                              |                              |
| Data Scalability and Analytics [ITS-DSA]      |                              |                              |
| Internet of Things [ITS-IOT]                  |                              |                              |
| Mobile Applications [ITS-MAP]                 |                              |                              |
| Software Development and Management [ITS-SDM] |                              |                              |
| Social Responsibility [ITS-SRE]               |                              |                              |
| Virtual Systems and Services [ITS-VSS]        |                              |                              |



## Appendix E. Articulation Agreement Example

The courses below allow students transferring from College of DuPage with an Associate of Science to complete a Bachelor of Information Technology and Management degree at IIT. Thanks to Ray Trygstad, Associate Chair, Department of Information Technology and Management, Illinois Institute of Technology, for providing this example.

Table E.1. Articulation between College of DuPage's A.S. and IIT's B.S. IT and Management

| College of DuPage Course |                                    |            |           | vs.       | Illinois Institute of Technology Equivalent |   |            |
|--------------------------|------------------------------------|------------|-----------|-----------|---|---|------------|
| Class                    | Title                              | Cred. Hrs. | Min. Grd. | =>        | Class                                       | Title                                       | Cred. Hrs. |
| MATH 1635                | Statistics                         | 3          | C         | =>        | BUS 221                                     | Business Statistics                         | 3          |
| MATH 2115                | Discrete Mathematics               | 3          | C         | =>        | MATH 230                                    | Introduction to Discrete Math               | 3          |
|                          |                                    |            |           | <b>Or</b> | MATH 180                                    | Fundamentals of Discrete Math               | 3          |
| CIT 1112                 | Advanced System Maintenance        | 3          | C         | =>        | ITM 301                                     | Intro OS and Hardware I                     | 3          |
| CIT 1123                 | Scaling Networks                   | 3          | C         | =>        | ITMO Elective                               |   | 3          |
| CIT 1124                 | Connecting Networks                | 3          | C         | =>        | ITMO Elective                               |   | 3          |
| CIT 1613                 | Enterprise Desktop PC Support Tech | 3          | C         | =>        | ITMO Elective                               |   | 3          |
| CIT 1640                 | Security+                          | 3          | C         | =>        | ITMS 478                                    | Cyber Security Mgmt (ITMS elective)         | 3          |
| CIT 2251                 | CCNA Security                      | 3          | C         | =>        | ITMS Elective                               |   | 3          |
| CIT 1645                 | Internet Telephony                 | 3          | C         | =>        | ITMO 446                                    | Telecomm Over Data Networks (ITMO elective) | 3          |
| CIT 2410                 | CCNA Voice                         | 3          | C         | =>        | ITMO Elective                               |   | 3          |
| CIT 1650                 | IT Project Plus (elective)         | 3          | C         | =>        | ITMM 471                                    | Project Management for ITM                  | 3          |
| CIT 2652                 | Computer Forensics II (elective)   | 3          | C         | =>        | ITMS 438                                    | Cyber Forensics (ITMS elective)             | 3          |

For more information visit <http://bulletin.iit.edu/undergraduate/colleges/applied-technology/information-technology-management-school-applied-technology/bachelor-information-technology-management/> .

## **Program Examples**

Program examples illustrating how courses in an IT Transfer program align with the competencies presented in this guidance are available on the ACM CCECC web site, and more program example submissions are welcome. If your college is interested in highlighting its IT Transfer program, visit [ccecc.acm.org/correlations](http://ccecc.acm.org/correlations) for instructions, or contact the ACM CCECC with any questions at [ccecc.acm.org/contact](http://ccecc.acm.org/contact) .

## Appendix F. Bloom's Revised Taxonomy

The foundational Taxonomy of Educational Objectives: The Classification of Educational Goals was established in 1956 by Dr. Benjamin Bloom, an educational psychologist, and is often referred to as Bloom's Taxonomy. This classification divided educational objectives into three learning domains: Cognitive (knowledge), Affective (attitude) and Psychomotor (skills). In 2000, Lorin Anderson and David Krathwohl updated Bloom's seminal framework to create Bloom's Revised Taxonomy, focusing on the Cognitive and Affective Domains. The ACM Committee for Computing Education in Community Colleges has adopted Bloom's Revised Taxonomy for the assessment of student learning outcomes in its computing curricula.

It is important to note that in the framework of Bloom's Revised Taxonomy learners need not start at the lowest taxonomic level and work up; rather, the learning process can be initiated at any point, and the lower taxonomic levels will be subsumed within the learning scaffold:

- Before we can understand a concept, we must remember it,
- Before we can apply the concept, we must understand it,
- Before we analyze it, we must be able to apply it,
- Before we can evaluate its impact, we must have analyzed it, and
- Before we can create, we must have remembered, understood, applied, analyzed, and evaluated.

In its computing curricula, the ACM Committee for Computing Education in Community Colleges uses the Cognitive domain to assess student mastery of learning outcomes. There are six levels in the taxonomy for the Cognitive domain, progressing from the lowest order processes to the highest:

1. Remembering - Retrieving, recalling, or recognizing information from memory. Students can recall or remember information. Note: This process is the most basic thinking skill.
2. Understanding - Constructing meaning or explaining material from written, spoken or graphic sources. Students can explain ideas or concepts.
3. Applying - Using learned materials or implementing materials in new situations. Students can use/apply information in a new way.
4. Analyzing - Breaking material or concepts into parts, determining how the parts relate or interrelate to one another or to an overall structure or purpose. Students can distinguish between different parts.
5. Evaluating - Assessing, making judgments and drawing conclusions from ideas, information, or data. Students can justify a stand or decision.
6. Creating - Putting elements together or reorganizing them into a new way, form or product. Students can create a new product. Note: This process is the most difficult mental function.

*Table F.1. Bloom's Revised Taxonomy*

| <b><i>Remembering</i></b> | <b><i>Understanding</i></b> | <b><i>Applying</i></b> | <b><i>Analyzing</i></b> | <b><i>Evaluating</i></b> | <b><i>Creating</i></b> |
|---------------------------|-----------------------------|------------------------|-------------------------|--------------------------|------------------------|
| Define                    | Classify                    | Apply                  | Analyze                 | Appraise                 | Assemble               |
| Duplicate                 | Convert                     | Calculate              | Attribute               | Argue                    | Construct              |
| Find                      | Demonstrate                 | Carry out              | Categorize              | Assess                   | Create                 |
| Identify                  | Describe                    | Edit                   | Compare                 | Choose                   | Design                 |
| Label                     | Differentiate               | Diagram                | Contrast                | Critique                 | Develop                |
| List                      | Discuss                     | Execute                | Decompose               | Debate                   | Devise                 |
| Locate                    | Exemplify                   | Illustrate             | Deconstruct             | Defend                   | Formulate              |
| Memorize                  | Explain                     | Implement              | Deduce                  | Estimate                 | Hypothesize            |
| Name                      | Infer                       | Investigate            | Discriminate            | Evaluate                 | Invent                 |
| Recall                    | Interpret                   | Manipulate             | Distinguish             | Judge                    | Make                   |
| Recognize                 | Paraphrase                  | Modify                 | Examine                 | Justify                  | Plan                   |
| Retrieve                  | Report                      | Operate                | Integrate               | Support                  |                        |
| Select                    | Summarize                   | Perform                | Organize                | Test                     |                        |
| State                     | Translate                   | Produce                | Outline                 | Value                    |                        |
|                           |                             | Solve                  | Structure               | Verify                   |                        |
|                           |                             | Use                    |                         |                          |                        |
|                           |                             | Write                  |                         |                          |                        |







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