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IS2020 A Competency Model for Undergraduate Programs in Information Systems: The Joint ACM/AIS IS2020 Task Force

Paul Leidig
Grand Valley State University, leidig@gvsu.edu

Hannu Salmela
Turku School of Economics and Business Administration

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The Joint ACM/AIS IS2020 Task Force

Paul Leidig, Grand Valley State University, USA - co-chair, ACM

Hannu Salmela, Turku School of Economics, Finland - co-chair, AIS

Greg Anderson, Brigham Young University, USA – AIS

Jeffry Babb, West Texas A&M University, USA – EDSIG

Carina de Villiers, University of Pretoria, South Africa – AIS

Lesley Gardner, University of Auckland, New Zealand – AIS

Jay F. Nunamaker Jr, University of Arizona, USA – ACM

Brenda Scholtz, Nelson Mandela University, South Africa – ACM

Venky Shankararaman, Singapore Management University, Singapore – AIS

Raja Sooriamurthi, Carnegie Mellon University, USA – ACM

Mark Thouin, University of Texas at Dallas, USA - ACM

Foreword

The IS2020 report is the latest iteration of model curriculum work for the Information Systems (IS) discipline that dates to the early 1970s. The previous IS model curriculum report, IS2010 (Topi et al., 2010), was a major effort that expanded IS curricula guidelines from a primarily business school context to other domains. The IS2010 report articulated guidelines as IS capabilities, knowledge, and skill requirements, and characterized the core of the IS curriculum, electives, and career tracks (Topi et al., 2010). The model curriculum report prior to IS2010, was IS2002 (Gorgone et al., 2003), which was a relatively minor update of IS'97 (Davis et al., 1997). Both the IS2002 and IS'97 projects were a joint effort between the ACM, AIS, and DPMA/AITP (Data Processing Management Association/Association of Information Technology Professionals). The IS'97 project was preceded by DPMA'90 (Longenecker and Feinstein, 1991), the 1983 ACM Curriculum Recommendations (ACM, 1983), and 1973 ACM Curriculum Recommendations (Couger, 1973). The IS2002 guidelines were widely accepted and have been influential as the basis for the accreditation of undergraduate programs in IS. This IS2020 report constitutes the combined effort of numerous individuals and has been designed to reflect the interests of many more faculty and practitioners. IS2020 is grounded in the expected requirements of the industry and the needs and perspectives of organizations that employ IS graduates and is reflective of the input and support of other IS-related organizations.

The IS2020 report is reflective of the IS discipline and is among the undergraduate curriculum volumes that define the computing disciplines. The Computing Curricula 2020 (CC2020) and The Computing Curricula 2005 (CC2005) provide extensive overviews of curricular guidelines for computing disciplines along with prescriptive recommendations for articulating future updates (Clear, Parrish, et al., 2020; Shackelford et al., 2005). Within the computing disciplines, curriculum recommendations also exist for Computer Engineering (CE2016), Computer Science (CS2013), Cybersecurity (CSEC2017), Information Technology (IT2017), and Software Engineering (SE2014) (ACM 2016, ACM 2013, ACM 2017a, ACM 2017b; ACM 2014). In addition, an ACM task force is currently preparing the first set of computing competency guidelines for Data Science (DS2020). Each of these curriculum reports are under the control of separate committees such that updates are published as they are completed. All curriculum reports, including those in IS, can be downloaded from the ACM Curriculum Recommendations website (ACM, 2020). Recognizing the rapid and frequent change that is inherent in computing fields, guidelines are updated on a regular basis. It is our intent that IS2020 become one of the first guidelines that will continue as a living document, with changes regularly propagated to a publicly available website.

An important input to this report is the MSIS2016 report, that provided a global competency model for graduate degree programs in IS (Topi et al., 2017). MSIS2016 was the first IS curriculum guidance document that was developed with a truly global task force and process. It was also the first report of its kind that did not articulate a fully prescriptive curriculum model. Instead, it offered recommendations as competency categories, and suggested levels of mastery students should attain in each competency category upon completing a graduate degree program in IS. The work

for updating the IS undergraduate model curriculum report (IS2020) was preceded by a joint ACM/AIS exploratory committee that reported its findings and recommendations to AIS and ACM in December 2018 (de Vreede et al., 2018). Having been accepted by both AIS and ACM, the detailed recommendations and guidance from the steering committee have proven to be incredibly useful and are used as the foundations of this revision.

As discussed in more detail within this document, IS2020 follows and extends the competency thinking initiated in the IS2010 report, and further refined in IT2017, MSIS2016 and CC2020. The recommendations proffered in this report also articulate competencies that graduates should have upon completion of an IS undergraduate program. The specified competencies are divided into groupings of requisite competencies (that should be delivered in all IS programs) and elective competencies that students may receive depending on the specific profile of each program. By explicating associated pairings of knowledge elements and skill levels for both required and elective competencies, we suggest that the recommendations of this report will be conducive to the design of learning objectives for IS undergraduate programs and course design. However, like the MSIS2016 report, this report does not offer a prescriptive set of core and elective courses. This omission is purposeful and is intended to avoid the various problems that arise with such rigid course specifications when applied to diverse educational contexts and modes of delivery.

Overall, a guiding principle, and challenge, in the preparation of this report is to balance the increasing variety of competency needs for IS graduates and increasing diversity in the profiles and design of IS undergraduate programs with respect to their goals, profiles, and educational contexts. While these two trends make it more difficult to define universal curricular guidelines, it may be the case that generic guidelines are no longer practical, let alone feasible: one-size-fits-all is no longer prudent. Rather, the competency-based approach taken in this report will better support the evaluation of IS programs and their resource needs by academic heads or accrediting bodies, the design of programs and courses by IS faculty and teachers, and the alignment of IS graduate competencies with the needs of employers.

The guidelines presented in this document incorporate comments, suggestions and feedback from senior scholars, numerous panels, presentations, and solicitations, in many forms, to the IS community at large. Details of the development of IS2020, the process used, and timeline of interactions with the IS education are explained in Appendix 4. This report is grounded in the expected requirements of industry, represents the views of organizations employing the graduates, and is supported by other IS-related organizations. It is the intent of the IS2020 task force that the initial work presented in this report, together with an ongoing cooperative curriculum development effort, will continue to serve the needs of all stakeholders. Any further comments and input are welcome, and readers are encouraged to provide feedback on these materials and insight and suggestions on how these guidelines may be improved via www.IS2020.org.

Acknowledgements

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- AIS VP of Education Heikki Topi
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Executive Summary

The IS2020 report is the latest in a series of model curricula recommendations and guidelines for undergraduate degrees in Information Systems (IS). The report builds on the foundations developed in previous model curricula reports to develop a major revision of the model curriculum with the inclusion of significant new characteristics. Specifically, the IS2020 report does not directly prescribe a degree structure that targets a specific context or environment. Rather, the IS2020 report provides guidance regarding the core content of the curriculum that should be present but also provides flexibility to customize curricula according to local institutional needs.

The foundations of curriculum guidelines for the IS discipline emerged in the 1950s. Since then, the discipline evolved to express simultaneous interest in the design of data structures and applications and the deployment of these artifacts within various organizational domains of use. Typical educational contexts for IS undergraduate programs are business schools, computing schools and schools of information management. However, the expansion of digital technologies across the societal spectrum has led also to other disciplinary variations that are tantamount to IS program contexts. With a balanced combination of IS competencies, domain-specific competencies, and individual foundational competencies, this report is intended to facilitate the development of graduates who are well prepared for jobs that require the design and management of technical solutions for users' organizational, societal, and disciplinary needs of computing. Typical job titles for IS graduates are IT Consultant, Data Analyst, Computer Systems Analyst, IT Auditor, Software Applications Developer, and Information Security Analyst (Mandviwalla et al., 2019).

There are several developments that motivate this revision to the IS model curriculum guidelines. First, the previous significant revision to the model curriculum, IS2010, was published ten years ago and the work to develop that report preceded that date by several years. Over the past decade, other curriculum reports have shared important progress in conceptualizing curriculum design that were worth incorporation into this report. Primary among these advances is the move toward competency thinking. Initiated within the IS context in the IS2010 report, MSIS2016, and IT2017, the CC2020 project subsequently contributed significantly to the maturity, refinement, and standardization of competency thinking. IS2020 builds upon these antecedents, supersedes and subsumes the knowledge area – knowledge unit – topic structure, that was expressed in previous IS model curricula reports using a course-based approach (both core and elective/specialized) with associated learning objectives. Curricular guidance in this report is expressed as context specific competency requirements that may be customized to the particular needs of the institution.

Another motivation for this revision arises from ten years of exceptional growth in and proliferation of ubiquitous digital technologies throughout society. The near-simultaneous maturation of many inter-related technologies has progressed to a level that has enabled widespread adoption by companies and other organizations. The entire spectrum of organizational functions, not simply support processes, are increasingly integrated via computing and digital technologies in a manner that has been significantly transformative. In combination with the rapid growth of volumes and

variety of data assets, this digital transformation has led to significant changes, not only in organizations, but also in broader society. Such changes will inevitably lead to an increase in the quantity and variety of competency requirements for IS professionals—both in the design of data and applications, and in analyzing the benefits and inherent ethical concerns that arise when digital technologies are deployed in various use domains.

A major problem for those who design and manage undergraduate IS programs is how to retain and sustain old relevant competency requirements while also embracing new competencies. For this reason, the IS2020 guidelines do not invalidate any core requirements or recommendations from the IS2010 report. Regarding the technical design of IS artifacts, graduates require competencies related to technology infrastructures and architectures, data structures, logical design, and systems analysis and design. Likewise, in managing the deployment of IS artifacts in an organizational domain, graduates require competencies related to IS strategy and management, project management, and related socio-technical realms. However, in a contemporary context, it would be odd to claim that competencies related to computing security, or the analysis of ethical and societal implications as they relate to digital technologies, do not constitute essential core knowledge. Additionally, the IS2010 recommendation that application development should be considered as elective material garnered immediate and sustained criticism from the IS community and industry representatives; developments during the past decade have further justified the call to reintroduce application development and logical design as a core IS competency.

Overall, the IS2020 report identifies nineteen competency areas, defining ten of them as required and nine as elective. To manage the increasing number and variety of IS competencies, IS2020 groups competency areas into six broad IS competency realms: IS foundations; data; technology; development; organizational; and integration competencies. The following figure depicts the competency realms and areas in IS2020.

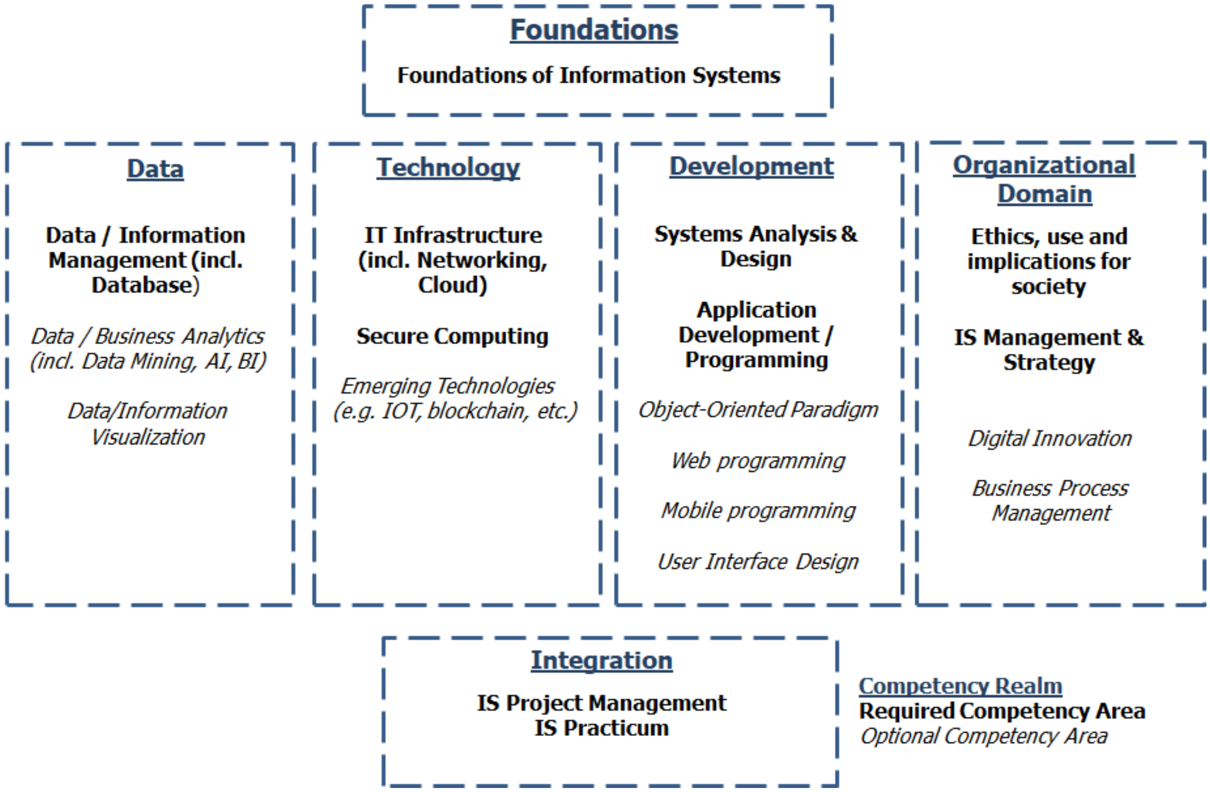

Figure ES-1 Competency Based IS2020 Curriculum Guidelines

The core of these broad competency requirements has remained similar over the decades, as the earliest model curricula defined the three basic knowledge areas that define IS: (1) information systems technology, (2) information systems concepts and processes, and (3) organizational functions and management. They are not radically different from curriculum contents (core and elective courses) proposed in IS2010. These categories are broadly compatible with prerequisite competencies (that is, included in a bachelor's degree) identified in the MSIS2016: (1) Data, Information, and Content Management, (2) IT Infrastructure, and (3) Systems Development and Deployment.

This new competency-based structure, that defines competency expectations, is intended to promote informed decisions in designing and evaluating IS undergraduate programs. For example, programs in computing schools (that typically include numerous IS-specific courses for the major) may be able to dedicate a full course to cover each competency area. Concomitantly, a competency orientation provides the opportunity to accentuate and amplify the number of courses in one competency area to provide the depth of coverage that affords students the opportunity to reach higher skill levels. In contrast, programs in business schools (that typically allocate fewer courses for the major) can make informed decisions so that required IS competencies may be combined in fewer courses. In this reduced environment, skill levels in many IS competency areas inevitably remain lower, however the degree as a whole may include greater coverage of individual foundational competencies and use domain competencies.

We are aware of the tensions that arise when concrete guidelines are proposed when the discipline and industry remain in perpetual flux. Therefore, the need for the curriculum modeling

process to continue as an ongoing discourse, built upon web platforms and digital mediation, has been recognized both by prior task forces (IS2010 and MSIS2016) and the IS2020 exploratory task force. Hence, we have opted for an approach that combines three elements: governance of continuous work as part of existing AIS and ACM structures; use of traditional conference venues for live meetings; and use of on-line platforms and media to support ongoing discussion.

1. Introduction

This introductory chapter presents the foundations for the IS2020 curriculum report: guiding assumptions about the IS discipline, profession, and education contexts. These three areas provide the immediate context for curriculum design. The IS discipline, with its scientific research areas and institutions, defines the concepts and theories that inform and underlie IS curricula. The IS profession represents the demand for education and steers the competencies expected from graduates as they enter the job market and proceed in their professional career. The IS education context identifies the ways in which IS curricula are designed, shaped, and locally influenced by the faculty within institutional contexts.

Thus, the purpose of this report is not to provide an exhaustive account of all possible areas and permutations of IS curricula. Rather, the objective is to make explicit guidelines and characterize a variety of pro-forma contexts. Further, with the progress of time, the IS2020 task force hopes to demonstrate and highlight both stability and change in this overall IS context since the last IS2010 report.

1.1 The IS discipline

True to its namesake, the IS discipline has held the *information system* as the central unit of analysis, for research and teaching, from the very beginning. Broadly speaking, “information systems” are often defined as the synthesis, reconciliation, and harmonization of both the technical system (comprising data and computer programs) and the social system (users who form the basis of input data and output information) (see Table 1-1).

The origins of the IS discipline are often associated with a seminal paper by Leavitt and Whisler (1958) that predicted significant organizational impacts as companies adopted new technologies that they chose to call “Information Technology.” In this early conceptualization users are absent, perhaps reflecting the nature of IT in the 1950s. Interestingly, the description of information technology, as such, has still some bearing to conceptualization of contemporary digital systems today (e.g., a technically rational orientation).

Since those early imaginings, the expansion of technology into daily life and societal function – an ever-expanding sphere of use – has influenced the definitions given for the core concepts of the discipline (Table 1-1). In the 1970s and early 1980s, sometimes labelled as the “mainframe era,” the core conceptualization of the discipline was depicted as *Management Information Systems*, implying that the technical system was a tool and extension of the organizational managerial function (Kennevan, 1970; Keen, 1980; Dickson, 1981). As part of his definition of information systems, Davis (1974), identified a “man/machine” interaction and manual procedures as integral components of an information system. This conceptualization articulates the context for the “information systems” that held consistent for many decades thereafter. Under this guise, the primary user groups of an information system are both employees and management in an organization. As the focus of an information system was often on data processing (collecting, storing, modifying, and reporting day to day information), such systems could also be referred to as transaction processing systems or TPSs.

Table 1-1 Early definitions of the core IS concept within the IS discipline

Source	Definition
Leavitt and Whisler. 1958, p. 41	"IT [Information Technology] is composed of several related parts. One includes techniques for processing large amounts of information rapidly, and it is epitomized by the high-speed computer. A second part centers around the application of statistical and mathematical methods to decision-making problems; it is represented by techniques like mathematical programming, and by methodologies like operations research. A third part is in the offing, though its applications have not yet emerged very clearly; it consists of the simulation of higher order thinking through computer programs."
Kennevan, 1970	"A management information system is an organized method of providing past, present, and projection information relating to internal operations and external intelligence. It supports the planning, control, and operational functions of an organization by furnishing uniform information in the proper time frame to assist the decision-making process."
Davis, 1974	"An integrated, man/machine system for providing information to support decision-making functions in an organization. The system utilizes computer hardware and software, manual procedures, management and decision models, and a database."
Keen, 1980	"Effective Design, Delivery and Usage of Information Systems in Organizations."
Dickson, 1981	"In the simplest, most straightforward terms, MIS deals with all the informational and decision-making activity associated with operating an organization. It is the desire of those working in the MIS area to encourage better organizational efficiency and effectiveness through facilitating information provision and decision support to management."
Davis, 2000	"The information system or management information system of an organization consists of the information technology infrastructure, application systems, and personnel that employ information technology to deliver information and communications services for transaction processing/operations and administration/management of an organization. The system utilizes computer and communications hardware and software, manual procedures, and internal and external repositories of data. The systems apply a combination of automation, human actions, and user-machine interaction."

As the discipline progressed toward the 1990s, coincident with the proliferation and adoption of personal computers, the conceptualization of the discipline also included the empowered user, leading to concepts such as "end-user computing." Still, the primary user groups of IS remained within organizations. However, with the advent of manufacturing planning systems and enterprise resource planning systems in the 1990s, the conceptualization of an "Information System" became more elaborate (Figure 1-1). A hierarchical representation of IS also implied the intended use and users.

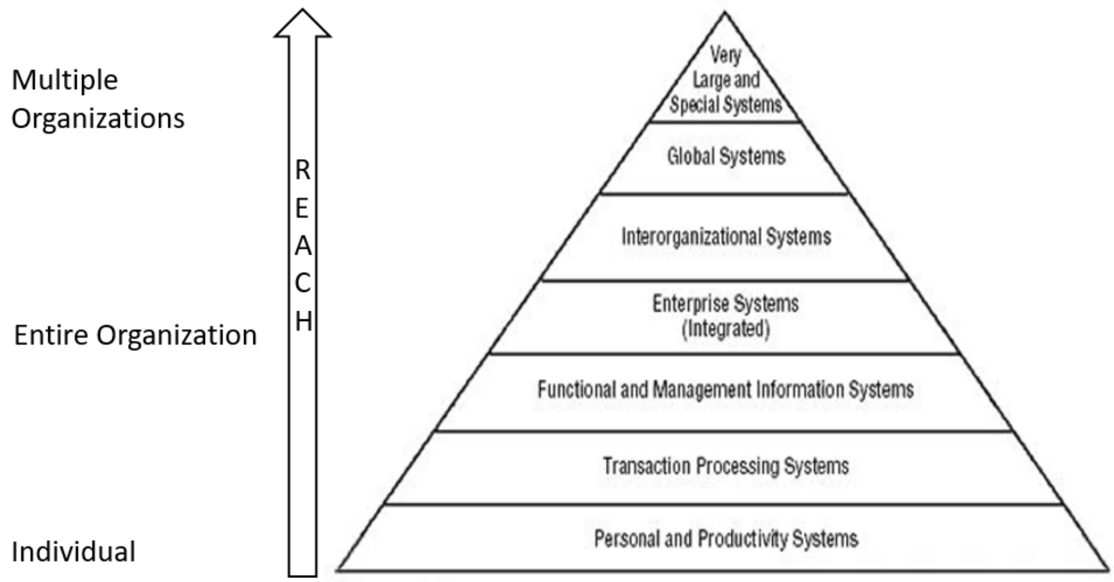

Figure 1-1 Levels of Information Systems (Bélanger, Van Slyke and Crossler, 2019)

Since the late 1990s, the trends toward pervasive and ubiquitous computing – promulgated by the expansion of the Internet, the World Wide Web, and later smartphones – increased the number of inter-connected users dramatically. The expansion of computing and information into the context of everyday life, expanded user groups such that an information system was no longer limited to employees or managers in an organizational context. Rather, new user groups and archetypes are found in roles such as consumers, citizens, drivers, patients, readers, spectators, tourists, game players, bloggers, etc. In other words, individuals outside organizations have become important user groups for IS. Simultaneously, organizations are actively automating many clerical and managerial tasks within the enterprise. What exists today is a compelling confluence of these intra- and extra-organizational configurations that have expanded the reach of the information system.

The expansive context and phenomena surrounding the discipline has presented appreciable changes in how we speak of, theorize on, and teach the core aspects of the discipline. As such, changes in the core concepts are difficult for any discipline, and certainly so for IS. However, forces of stability still pervade the discipline such that some concerns and patterns remain in many established definitions of the IS discipline. For example, citing the Computing Curricula 2020 report, the IS discipline focuses "… on information (i.e., data in a specific context) together with

information capturing, storage, processing and analysis/interpretation in ways that supports decision" and "deals with building information processing into organizational procedures and systems that enable processes as permanent, ongoing capabilities." (Clear, Parrish, et al., 2020).

An additional challenge is that any attempts at a comprehensive conceptualization and image of an IS will inevitably lean toward abstraction. While early definitions of IS articulate five main components – hardware, software, data, users, and process (or procedures) – more recent definitions include a sixth element to account for media/communication (Figure 1- 2). Moreover, a transition to the use of the word "people" also replaces the term "user," indicating the ubiquitous nature of IS in our societies.

Figure 1-2 Elements of an Information System (Bélanger, Van Slyke and Crossler 2019)

While change in official structures may be slow, observed phenomena, and research thereof is always fast in detecting and theorizing on new trends and changes in the discipline. For example, research examining "intention to use" or "perceived usefulness" of systems by corporate employees was transferred to e-commerce customers or game players, often complemented with new variables such as "intention to buy" or "hedonic value."

For the IS discipline, curriculum guidelines constitute an important "discipline structure," aiming to maintain stability through reflective reconciliation of recent trends while also exploring, enabling, and embracing change as a by-product of periodic review. For the purposes of the IS2020 report, it is important to emphasize that, despite the new user groups and contexts, the organizational context surrounding IS use – the need to design, implement, and manage those

systems – has not radically changed and is unlikely to do so. The operations and management of organizations, and the quality of digital products and services they offer, continues to depend on the core IS disciplinary competencies that organizations will continue to both seek and develop. However, the expansion of user groups and use domains throughout all aspects of society will continue to influence requisite competencies expected in IS professionals, and thus also create new expectations for IS curricula.

1.2 The IS profession

The IS profession is typically understood as belonging to a broader Information Communication Technology/Information Technology (ICT or IT) profession and shares many core professional competencies with the broader information technology realm. Concomitantly, the IT profession covers a broad range of job profiles. This makes identifying job profiles as "Information Systems jobs" (requiring an IS degree) difficult. On the supply side a broad range of nomenclature exists (ICT jobs are in IT consulting firms, ICT firms or in software companies). On the demand side, jobs are typically within IT departments, product development units or, recently, also in digital business units.

To discern which job competency profiles can be considered as "IS jobs," several sources provide information as to the relevance and importance of specific IS career paths to the IS discipline. The European e-Competency Framework (eCF) is a framework that describes competencies that apply to 30 commonly held ICT jobs in seven different families (CEN, 2018). ICT families include process improvement, business, technical, design, development, service and operation, and support. The eCF framework also assigns detailed competency levels for different competency areas for each ICT job profile.

For purposes of the IS2020 report, eCF provides an interesting, yet tentative, analysis of job profiles according to technical skills vs. use domain (business) skills, and level of independence requiring higher competency levels (Figure 1-3). The eCF responds to calls from industry for a more holistic perspective of classifying jobs. Naturally, the real-life application of these job titles varies, and the report acknowledges that positioning job titles is hardly "an exact science." Nevertheless, the job titles classified as requiring higher autonomy and business domain of use orientation are also typical job titles for the alumni of IS programs.

The Skills Framework for the Information Age (SFIA) is a framework developed by leading industry firms and the British Computer Society (SFIA, 2020). Version 7 of SFIA identifies skill groupings in 5 focused views for the following five high growth job areas – digital transformation, DevOps, big data, software engineering and agile. Each of the five views details the SFIA skill and skill levels required for each job area. The SFIA Foundation, a global not-for-profit foundation, oversees the continued development of the SFIA Framework, resulting in refreshments and updates every three years.

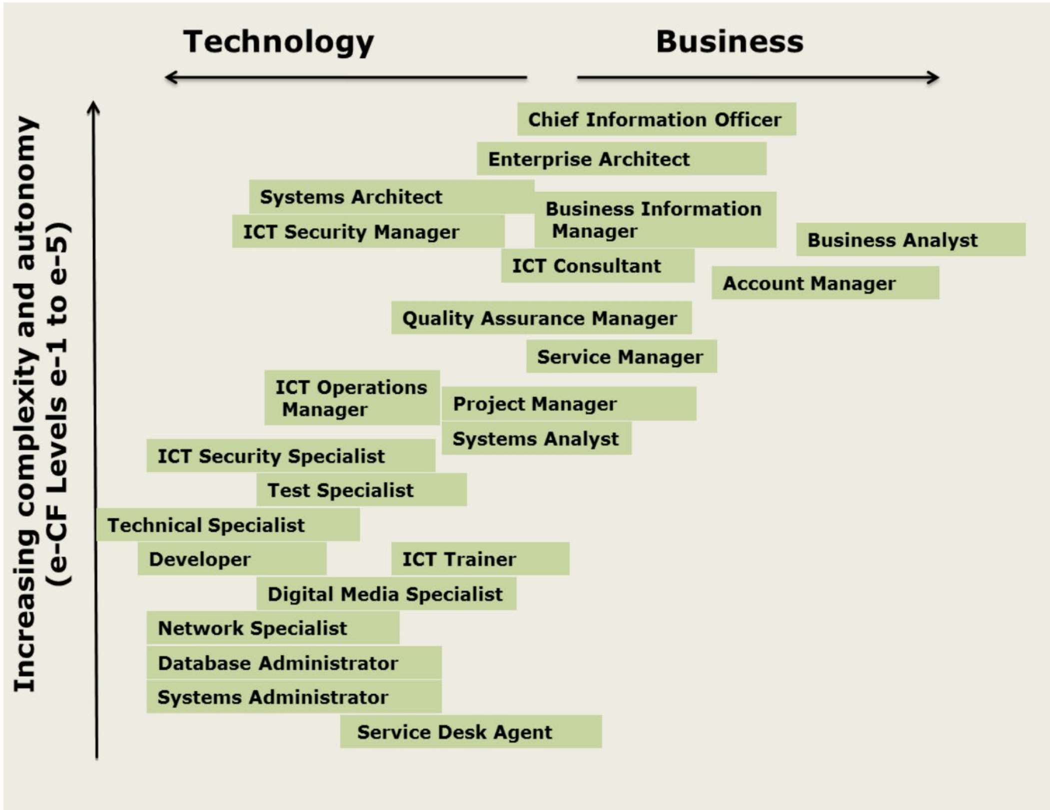

Figure 1-3 The 23 European ICT Profiles positioned against increasing Autonomy and Complexity (eCF levels) and Business – Technology Orientation (CEN, 2012, p. 57)

Both eCF and SFIA are valuable tools for designing a competency based IS curriculum. By identifying professional tasks, competencies, and competency levels, both tools provide a counterpart and referent for competencies developed in IS undergraduate and graduate programs. It is perhaps important to note, however, that they are also different: the competencies developed in the academy result from carefully designed tasks given to students in the safety of the "laboratory," whereas the competencies in the workforce relate to routine tasks that ICT professionals do as part of their work. Thus, while they describe two stages and phases of professional development, they are related.

Prior IS curriculum guidelines also provide some clues for identifying the IS profession. For that purpose, the prior curriculum guideline reports have identified some job titles as representative of the IS profession (Table 1-2). IS2010 provides profiles of many occupations, but chose to emphasize application developer, business analyst, business process analyst, and database administrator as being most representative for the IS profession. Likewise, MSIS2016 provided profiles for graduates of IS programs in the following four areas – IT consultant, project manager, analytics specialist, and start-up entrepreneur. Following this tradition in IS2020, we provide further illustration of competency requirements in typical IS job profiles (IT Consultant, Data Analyst, Software Application Developer, Computer Systems Analyst, IT Auditor) in Appendix 1, with detailed list and description of the competency requirements in each profile.

Table 1-2 Profiles discussed in IS2010 and MSIS2016

IS2010 (Undergraduate)	MSIS 2016 (Graduate)
Application Developer	IT Consultant/Systems Analyst
Business Analyst	Project Manager
Business Process Analyst	Analytics Specialist
Database Administrator	Start-Up Entrepreneur

An additional source available to define the “IS profession” are the IS graduates’ job placements (Table 1-3). The Association for Information Systems (AIS) publishes a biannual Job Index with details of job placements for recent IS graduates. In the 2019 AIS Job Index Survey,t+he recent IS graduates (numbering 1420) responded from 43 different US universities. The results indicate which jobs are most held and obtained by IS graduates. The most recent AIS Job Index indicates that the most common job title of IS graduates was IT consultant; data analyst, computer systems analyst, IT auditor, software application developer, and information security analyst round out the top six.

Table 1-3 Most Common IS Occupations Obtained by Recent Grads (AIS Job Index)

Rank	AIS Job Index 2017	AIS Job Index 2019
1	IT Consultant	IT Consultant
2	Data Analytics	Data Analytics (Data Analyst)
3	Computer Systems Analyst	Computer Systems Analyst
4	Software Application Developer	IT Auditor
5	IT Auditor	Software Applications Developer
6	Project Manager	Information Security Analyst

Job titles lists provide an important input for revising curriculum guidelines as they provide explicit evidence of industry needs and the job market arising from these needs. Job market trends undoubtedly influence IS programs in many ways; for example, when considering elective courses, or specialization, and when communicating an IS program’s profile to students and recruiters. To some degree, job placements and trends also influence the “core” of the discipline. To wit, given the results of the latest AIS Job Index, it can be concluded that computing security should be added or incorporated into the required (core) competencies of the discipline.

It is also important to recognize the hazards of drawing acute conclusions from job placement statistics. Job postings will require a broad spectrum of IS competencies, often beyond the acute competency areas implied in the job title. As such, given the nature of undergraduate education,

we echo the recommendations of prior guidelines that undergraduate IS programs provide students with a broad and solid foundation across many IS competency areas. We also fully agree with prior IS undergraduate and graduate task forces, reflecting the calls from industry, those individual foundational competencies, and domain area competencies, are equally as important as mastering specific IS competency.

Overall, the need for individuals with an IS education continues to grow and IS is again a popular major for students. The AIS 2017 Information Systems Job Index report revealed that the demand for IS professionals remains strong and there has been a steady increase in the starting salaries of IS graduates both at an undergraduate level and a graduate level (Mandviwalla, et al., 2017). The report states that there is a 74% job placement rate for undergraduates upon graduation: however, many programs across the US report 100% or near 100% placement ratios. One reason an IS degree is popular is because it pairs use of domain skills with technical skills. College Factual (College Factual) ranks the Computer Information Systems (CIS) degree as the 16th most popular major out of 384 college majors. They state that in 2020, 20% of Computer Information Systems students are women while men make up 80% of the student body. However, as evidence that the IS discipline is still maturing toward a standardized definition and conceptualization, College Factual ranks the Management Information Systems (MIS) degree as the 56th most popular degree with 70% of the student body males and 30% females.

A major benefit of broadening participation in computing disciplines such as information systems comes in recruiting and retaining women and other underrepresented groups to help fill worker shortages. In addition, the value of ensuring inclusion of women and other underrepresented groups goes beyond having a ready and ample workforce. The National Council for Women & Information Technology (NCWIT)'s "What is the Impact of Gender Diversity on Technology Business Performance: Research Summary" summarizes research studies and identifies key findings of benefits and costs of diverse teams. Diversity is a prudent financial decision. Gender-balanced companies perform better financially, and gender-balanced teams improve team productivity. Teams that are more diverse adhere to project schedules in various technology companies, share knowledge and have lower project costs than homogeneous teams.

1.3 The IS education context

A defining characteristic of IS education is that IS programs co-exist in a wide variety of faculties and institutions. While business schools and computing schools provide the typical academic context for IS programs, particularly in the U.S. and Europe, globally, information (management) schools and engineering schools are also important contexts. Lately, following the expansion of information systems use into new domains, IS programs have been established in medical schools, design schools, and schools within the faculties of humanities and social sciences.

Historically, the emergence of IS programs can be traced to limitations observed in "primary" disciplines. For example, in computing and software engineering schools, the natural science or engineering background of main disciplines was perceived as ill-suited to examine user behavior. As such, Computer Science was a theoretical study of implementing structures and processes to a computer, while Software Engineering focused on the design and construction of computer

hardware and software. IS was introduced to examine the usage of computers within organizations to serve as a bridge to organizational and societal contexts.

Many business schools established their first IS courses in the 1960s to meet the need for professionals capable of developing and using transaction processing and reporting systems. However, many academic institutions developed their IS degree throughout the 1980s, 1990s, and 2000s from a wide range of other departments. Often, this would be a response to a somewhat specific local industry request, for example an Accounting Information Technology degree was established in some schools as response to request that the Institute of Management Accountants (IMA) and the American Institute of Certified Public Accountants (AICPA) indicated that accountants need a technical background. The same pattern has also been followed by information schools and other schools primarily focused on a specific domain – these IS programs are established to educate domain professionals with additional technical competencies. Essentially the same basic argument explains the establishment of programs in areas such as "digital marketing," "digital management," or "health care information systems."

Often the educational context influences an IS program's context and defines closely related disciplines that suggest possibilities and opportunities to share resources and feature minor subject offerings and alternatives. In what follows, a handful of archetypal educational contexts are briefly summarized.

Computing schools provide a context where IS programs co-exist with more technical programs, often in areas such as Computer Science, Information Technology, Software Engineering, Cybersecurity, and Data Science. This context provides excellent opportunities for sharing technical courses. The orientation in these programs may be slightly more technical, and programs may use the more technical moniker "Computer Information Systems." Often, students and faculty in CIS programs are active members of ACM and may seek accreditation of their programs with the Accreditation Board for Engineering and Technology (ABET). An advantage of these programs is in degree structures that provide more credit hours for the major subject where graduates from these programs often excel in technical IS competencies.

Business schools provide a context where IS programs co-exist with a large number of business disciplines, such as accounting, finance, economics, marketing, management, organizational behavior, and supply chain management, to mention only a few. This educational context provides excellent opportunities for sharing of courses that examine the design, delivery and use of technology in organizations. Hence, the profile of these programs is often slightly more use-domain oriented where programs are referred to as "Business Information Systems" or "Management Information Systems." Due to the business school context, the number of major subjects studied is often lower, limiting the possibility to reach higher skill levels in technical IS competency areas. Often, programs in business schools place more emphasis on individual foundational competencies and business domain competencies.

Information schools provide a context focusing on a foundational understanding of information and knowledge. Originally, information management did not assume the use of computers – information as such provided the main unit of analysis. In some countries, the naming of programs

referred to libraries, which indeed have a long tradition in analyzing and classifying knowledge. Other typical names used are Information Management School, Information Science School, or iSchools. IS programs in information schools are often positioned to offer an emphasis on information access, analytics and knowledge management. Program names may refer to information management or information science, rather than IS. If combined with data science, management science, or operations research, these programs can provide strong competencies in data analytics and knowledge management. Information management appears to be a somewhat common educational context for IS programs in China, as seven universities out of 16 sharing their IS program information in EDUglopedia (2020) include “Information Management” in their institution name.

Given the diversity of extant educational contexts and the resulting variety in IS programs, it is particularly challenging to define universal guidelines for IS curricula. The need to incorporate sufficient flexibility to capitalize on advantages of specific educational contexts is evident. However, it is feasible to provide core disciplinary guidelines grounded to the needs of the profession and connected to research traditions of the discipline, regardless of the specific educational context for which an IS program is designed. For the efficacy of the IS discipline itself, it may also be necessary to specify boundaries for IS programs regarding the conditions and core requirements necessary to be recognized as an undergraduate computing program in IS.

2. Motivations

This chapter motivates and explains the changes to IS curriculum recommendations in this report. It provides an overview of the reasons why it was important for the IS community to go through a curriculum revision process accounting for concurrent changes that have taken place in (1) information technologies and infrastructures, (2) organizational uses of data and technology, and (3) the role and implications of technology for individuals and society. With this overview, it is not intended to give a complete and comprehensive overview of changes in all these areas; rather many ways are illustrated in which IS professionals and educators have seen significant changes over the past decade.

Based on these changes, the IS2020 competency recommendations are compared to those provided in the IS2010. We argue the reasons why an additional four competency areas (Application Development, IS Ethics, Computing Security, and Practicum) were added to the IS curriculum core. We will also explicate reasons that led us to group the eighteen competency areas into six broader IS competency realms.

2.1 Motivations for revising IS2010

The IS2010 curriculum was published 10 years ago (ACM, 2010), which is a sufficient reason to revise the guidelines in most disciplines. The IS discipline is, by nature, multi-disciplinary and evolves together with a seemingly continuous stream of technological developments, deployment opportunities, and trends. Such dynamism adds challenges for IS faculty to design a curriculum that adequately addresses the needs of future generations of IS professionals. Since 2010, the technological, organizational, and societal space has evolved radically. Some of the 2010 curriculum elements link closely to certain technologies and may become outdated, but they are still relatively few. Perhaps more importantly, the dynamic increase in new technologies is raising interest in new competency areas requiring additional recognition.

2.1.1 Changes in technology and data

Since 2010, important changes have occurred in the technical systems, as many technologies that were emerging just prior to the release of the 2010 curricula are now commonplace or being actively implemented in organizations. Major developments in the technological environment include the proliferation of smart mobile devices, sensors, cyber-physical systems, the Internet of Things (IoT), and smart networks (Prifti et al., 2017).

New technologies will also have a profound impact on technologies that collect, store, and utilize data. The resulting high-volume data sets collected from, for example, social media enable the use of Artificial Intelligence (AI) technologies such as machine learning. These technologies are now prevalent in most modern systems available today. Automated personal assistants and other forms of AI agents such as AI robots, Virtual Reality (VR), Augmented Reality (AR), AI-enabled Decision Support Systems, Robotic Business Process Automation and ambient computing have emerged as commercially viable technologies.

There have been several advances in technologies that allow for direct observations of an individual's physical behavior, such as ocular metrics (e.g., eye tracking), physiological (e.g., respiration rate), kinesics (e.g., gestures), linguistic (e.g., voice recognition), and vocalics (e.g., articulation or pronunciation). Other technologies that have emerged are the recent advances in distributed ledgers through blockchain technology, which has led to an upsurge in research and development on applications of cryptocurrencies and smart contracts. The cost and availability of cloud computing is now making it a minimum entry requirement for organizations both big and small to be competitive.

2.1.2 Changes in organizations

Developments in digital technologies discussed above are dramatically influencing organizations. They can radically improve all enterprise processes due to their ability for automation and integration. The digitization of work and individuals provides new ways for organizations and individuals to collaborate, to co-create, to perform business transactions and to make data-based decisions. Digitalization enables the creation of new or improved business models and processes with digital technologies.

The abundance of high volumes of data together with the internet as a marketing channel has changed the way in which businesses, governments, and non-profit organizations build their brand and relationships with their customers. Additionally, crowdsourcing, and the more specific application of this in crowdsensing, are also increasingly used by many kinds of organizations. With mobile systems, social media and interactive web-based technologies, organizations can involve individuals to contribute time and effort to a variety of information processing tasks, such as innovation ideation, data collection, and community problem solving.

In manufacturing industries, the transformative nature of new technologies is sometimes referred to as Industry 4.0. Smart Manufacturing is an emerging technological innovation that is a result of the convergence of various technologies that improve manufacturing in terms of productivity, quality, delivery, and flexibility. Adoption of digital technology is also a key driver for improved sustainability and energy efficiency.

For service organizations in public and private sectors, AI is expected to make dramatic advances. Such advances are projected in areas such as medical, education, security, crisis management and sustainability services. In traditional services, concepts such as smart homes, smart offices, smart ways of working and smart cities convey the potential of digital technologies. In mobility services, autonomous vehicles and drones may soon enable organizations to deliver completely new ways for transporting goods and people. New technologies have spurred a myriad of applications in gaming, security informatics, and health informatics.

The adoption of new technologies has also led to completely new types of digital firms, whose value offerings are largely based on software. They successfully compete with traditional firms in media, manufacturing, and finance, with excellent skills in designing software-based services, but no legacy of physical assets. For incumbent firms in those industries, the need to complement their traditional value offering with digital or data-based services can induce deep-structure changes, often referred to as digital transformation. Platform providers like Uber are good

examples of digital firms. Some of the platform organizations rely on business models of the new "sharing" economy, enabling individuals to directly market goods and services more effectively and usually at a lower cost (e.g., Airbnb, Lyft). In general, new digital technologies provide excellent opportunities for establishing small start-ups, also for the IS graduates.

2.1.3 Implications for individuals and society

At the level of society, the combined effect of trends discussed above is sometimes referred to as the Fourth Industrial Revolution (4IR). It has the ability and potential to provide solutions for many of the critical challenges facing the world such as the increasing shortages of resources. For individuals, these trends and technological developments give access to completely new services such as (Surdack, 2014):

- *Mobility* – The proliferation of smartphones and tablets enable us to be connected all the time
- *Virtual living – Increasingly people are interacting with friends and family online through social media rather than face to face*
- *Digital commerce – A wide variety of alternatives are provided for buying goods and services online*
- *Social media has changed the way in which individuals connect and interact*
- *Online entertainment – There are billions of online channels and entertainment sites that can keep us entertained*

It is evident that IS are becoming increasingly ingrained in our everyday business, professional and personal lives (Bélanger, Van Slyke and Crossler, 2019). These systems are becoming even more pervasive, and it is difficult to get through the day without interacting with an information system. The "user" in IS has expanded from just considering industry employees to now considering all types of individuals. Therefore, IS has become more society-centric, not simply organization-centric. Furthermore, the imperative to specify a computing curriculum for the information systems discipline remains relevant (Longenecker et al., 2015).

Some implications and consequences resulting from this revolution will be controversial and even negative, threatening the basic rights of citizens, and creating hazards for societies. To deal with potential adverse consequences of the information explosion, governments and other regulators are developing new legislation and standards. As an example, such regulations can deal with the collection and use of personal data (e.g., the EU General Data Protection Regulation). Societal and regulatory changes relating to privacy and ethical issues also suggest the need for updates to curriculum recommendations for the knowledge of rules, ethics, and regulations affecting IS.

2.2 Summary of revisions in the core IS competencies

The impact of the trends discussed above will have a significant impact on the competency needs of IS professionals. Requirements for individual foundational competencies and domain competencies have remained consistent and continue to be relevant. At the same time, we are

witnessing an increasing variety in the IS competency realm, and many of the prior IS competency areas that previously were considered optional are now becoming mandatory.

Considering how the trends discussed above will affect the requirements for IS undergraduate education was an important aspect for the IS2020 task force. Using the Delphi methodology, the IS2020 task force gathered data from the following sources:

- IS2020 Topic analysis
- Job placement of IS Graduates
- Competency frameworks for the IS profession
- Program contents in leading universities
- MSIS2016 curriculum contents
- ABET requirements for IS programs
- IS in relation to other disciplines
- Themes in the AMCIS 2019 panel feedback
- MSIS2016 competency model
- CC2020 Competency model
- Courses in EDUglopedia (2020)
- IS curriculum related literature in journals and conferences

Perhaps the most significant impact of these trends is that the number and diversity of IS competency areas is increasing. The design of new applications to solve problems in a user domain requires an increasing number of competencies, knowledge, and skills to tackle the multiple methods and perspectives required. It follows then that undergraduate IS programs should cover all these perspectives to provide a broad understanding of the issues involved. To respond to this increasing diversity, we made the following three changes:

1. Added four competency areas to the IS core, in addition to the previous six in IS2010, to ensure that the most essential views and perspectives are addressed.

2. Grouped IS competency areas in six IS competency realms to make it easier to design specializations and elective courses within a program.

3. Defined the IS core through required competencies (rather than compulsory courses) to facilitate flexibility in defining the core of IS programs.

In what follows, the reasons for these changes will be further explained as they vary from the recommendations of the IS2010 report. Chapter 3 provides motivations for and detailed discussion of the second major area of revision, adoption of competency models. Details of the development of IS2020, the process used, and timeline of interactions with the IS education are explained in Appendix 4.

2.2.1 Changes in the IS program core

A challenge for organizations and for IS education is that the new competency requirements do not replace the need to master the old ones and are, in effect, cumulative. As such there is a compression effect such that IS professionals will need to master a wider set of IS competencies.

While IS2010 defined the core of IS undergraduate programs via seven core courses (Table 2-1, column to the left), IS2020 identifies 10 required competency areas (Table 2-1, column to the right). Six out of seven core courses appear as a required competency area in IS2020.

Table 2-1 Core courses in IS2010 and their inclusion in the IS2020 required competency areas

IS2010 core courses	IS2020 required competency areas
1. Foundations of Information Systems	1. Foundations of Information Systems
2. Data and Information Management	2. Data / Info. Management
3. IT Infrastructure	3. IT Infrastructure
4. IS Project Management	4. IS Project Management
5. Systems Analysis and Design	5. Systems Analysis & Design
6. IS Strategy, Management, and Acquisition	6. IS Management & Strategy
7. Enterprise Architecture	*(not included as a competency area)*

In IS2010, detailed descriptions of core courses with learning objectives were used to identify and refine minimum requirements for undergraduate programs. In a similar manner, IS2020 defines the minimum required competency areas – listing key competencies within each area – as well as associated minimum knowledge-skill levels that graduates should have upon completion of a program (see Appendix 3). The definition of the IS undergraduate curriculum core expressed as graduates' competencies and expected skill levels defines the core perhaps in a more precise manner as compared to the approach taken in the IS2010 report.

As Table 2-1 illustrates, IS2020 retains significant continuity in the explicit requirements for the core. All core courses of IS2010, except Enterprise Architecture, continue as required competency areas in the IS2020 recommendations. The removal of Enterprise Architecture from the core is a significant modification which required a lot of consideration from different perspectives. The decision to remove it from core competency areas is based on the following three main arguments.

- Despite the recommendation in IS2010, courses on Enterprise Architecture have not become commonplace in IS undergraduate programs.
- The necessary competencies to apply enterprise architecture methods requires broad knowledge on modelling infrastructure, data, security, applications, and user domain.
- Enterprise Architecture is very centrally placed as a core competency in MSIS2016, and thus will be addressed (perhaps appropriately) in graduate programs.

Because of these considerations, Enterprise Architecture was not included as a separate competency area. It is, however, included as a knowledge-skill area in other required competency

areas, most notably in IT infrastructure, and IS management and strategy. We consider it mandatory for graduates to understand the basic concepts of Enterprise Architecture; however, given the constraints in undergraduate programs, and the expansive compression effect of requisite knowledge for the profession, reaching higher levels of mastery can be deferred to graduate programs in IS.

As another major change, IS2020 proposes four new IS competency areas to be included in core IS undergraduate curriculum requirements (Table 2-2). Two of the changes (Application Development and Secure Computing) move what previously accommodated as material for an elective course to the required competencies for IS graduates. Two of the new competency areas are completely new in the sense that they did not appear as separate courses in the IS2010 report. The following sections briefly explain the arguments for including these competency areas in the IS undergraduate curriculum core.

Table 2-2 Introduction of new IS competency areas in the IS2020

IS2010 (elective) courses	IS2020 required competency areas
(Elective: Application development)	Application development / programming
(Elective: IT security and risk management) *(Elective: IT audit and Controls)*	Secure computing
(none)	Ethics, use and implications for society
(none)	Practicum

Application Development / Programming: The decision in the IS2010 report's recommendations to move Application Development from inclusion in the IS core to an elective course led to a lot of criticism from the IS community. Leidig et al. (2019) state that because of this flexibility in the IS2010 model curriculum, the technical skills of IS graduates no longer meet industry needs. One clear gap between IS2010 and industry needs are reports that requisite technical skills are higher than what many IS graduates appear to possess. The evidence shows that industry expects programming skills and abilities from graduates of all computing related programs. While most existing IS programs include some level of programming in their curriculum, and while others might have multiple courses in programming, the curriculum model (in IS2010) does not highlight this as a required component. The task force therefore recommends an adequate depth of coverage to ensure technical and programming competency. For IS students, application development should be the process of creating a computer program or a set of programs to perform the different tasks that a business requires. Application development can be either through programming using languages such as Python, Java, PHP, C#, etc. or using code generator tools such as ANTLR, Jinja2, etc. It is the providence of predicate logic and problem-solving that constitutes the overall benefits of programming and application development competencies.

Ethics, use and implications for society, has become more and more relevant as the use of IS applications expands to all sectors in society. IS has the potential to significantly contribute to solving global challenges as technologies bring new concerns and hazards for individuals and the society. IS students need to understand the implications of the use of technology on society and the environment and be able to make ethical decisions about sustainable technology use.

Secure computing is an increasingly important field of study as people become more reliant on technology. Two security courses were previously included as electives in IS2010 recommendations; however, the past decade has seen an increased rise in security and privacy violations and technological developments to address them; thus, confirming the increasing importance of this topic for modern organizations and for the IS profession. Recent statistics of graduates' jobs show that IT security and IT auditing are career options also for IS graduates. Hence, all IS students should be able to understand the foundations of software security and the utilization of code and cryptography to adequately secure networks and IS. Competencies within this realm include managing and implementing cybersecurity, protecting IT assets, developing an information assurance strategy, implementing, and managing quality audit processes, and assuring safety through the systems' lifecycle.

An *IS practicum* is required to ensure that students are able to deploy the IS competencies they have acquired in different courses, regarding technology, security, data, development and use of domain perspectives. A practicum also has potential to address weaknesses that are often mentioned in graduates, namely practical experience, individual foundational competencies (including leadership), project management, critical thinking, problem solving and change management. This competency can take the form of internships, integrated IS capstone projects, etc.

2.2.2 Introduction of IS competency realms

A characteristic already in the IS2010 report was the inclusion in the model of industry tracks relative to the needs of the country or area where the program is offered. Yet only few programs offer such tracks with specifically designed courses.

As a change in IS2020, we group the 19 identified IS competency areas to six competency realms. One reason for this is related to an observation that, even if we focus only on the most essential areas, listing all (19) is no longer informative. By grouping competency areas to broader realms, it is intended to promote program-level discussions on profile, specializations, and electives. The *Foundations* and *Integration* realms are required to prepare a more holistic understanding of the discipline, improving the ability of students to first identify required competencies (in *Foundations*), and the ability to combine and deploy acquired knowledge and skills as needed (*Integration*). However, the remaining four competency realms aim at providing depth by allowing sequencing, thus also providing a possibility to profile the program with a specialization.

Table 2-3 describes the six competency realms, by listing the required and elective course in each competency realm. We have also included elective courses from IS2010, to describe continuity in elective studies from previous guidelines.

Table 2-3 IS Competency realms guiding program profiling and specialization

IS competency realm	Required competency areas in IS2020	Elective competency areas in IS2020	Courses mentioned in IS2010 (Figure 6)
Foundations	Foundations of Information Systems		
Data and Information Management	Data / Info. Management	Data / Business Analytics (incl. Data Mining, AI, BI) Data / Info Visualization	Data mining / business intelligence Info. search and retrieval Knowledge management
Technology and Security	IT Infrastructure Secure computing	Emerging technologies (e.g., IOT, blockchain)	IT audit and controls IT security and risk management
Development	Systems analysis & design Application Development & Programming	Object oriented paradigm Web development Mobile development User interface design	Application development Collaborative Computing Human-Computer Interaction
Organizational Domain	Ethics, use and implications for society IS management and strategy	Digital Innovation Business Process Management	Business Process Management Enterprise systems Social Informatics
Integration	IS Project Management IS Practicum		

Overall, increasing diversity of IS competencies adds challenges not only in providing the core, but also in making choices regarding electives in a purposeful manner. The four IS competency realms illustrated in Table 2-3 have a lot of similarity to proposals for specializations or career tracks examined in recent IS curriculum literature (Stefanidis, Fitzgerald, and Counsell, 2013), proposing specializations in Data/Analytics (Jafar, Babb, and Abdullat, 2017; Lawler and Molluzzo, 2015), Security (Wang and Wang, 2019), Mobile Application Development (Babb and Abdullat, 2012) or Enterprise Applications (Saltz, Serva, and Heckman, 2013). It is agreed that as stated in the IS2010 and MSIS2016 propositions, specializations should be designed to meet the specific needs of the local IS job markets.

2.2.3 Move from courses to competencies

The adoption of competency thinking in curriculum design is motivated by many factors that will be discussed in more detail in Chapter 3. One of the factors relates to the changes in the role of IS in society, and the resulting variety in IS competency needs. There are many practical advantages of just “listing courses,” perhaps supported with detailed course descriptions. With a list of courses, it is easy to demonstrate or check compliance to guidelines.

The basic problem in defining a list of core courses is, that in IS education, one size does not fit all. Programs operating in more restricted educational structures (offering a minimal number of courses for a major) will define the maximum limit. Another problem is that a core theme must be such that it can be packaged as a course, for it to be raised as a central required element in the IS curriculum.

In the context of IS2020, a requirement of 10 compulsory study units or courses (one for each required competency area) may be too high for some academic units. However, even in these restrictive educational contexts, an objective to include all required competency areas is a positive target; this encourages curriculum designers to use the credit hours available as effectively as possible. Likewise, programs in less restrictive environments may also use the guidelines to carefully design courses for each competency area to reach higher skills levels within one competency area or promote specialization within competency realms. Some of the recommended competency areas, like “Ethics, use and implications for society” or “IS practicum,” may not require a separate course, but can be addressed as part of another course, or as an integrative theme addressed in many courses.

Hence, competency-based requirements shift attention from course structures to required competencies. The main emphasis is on ensuring that the program curriculum engages students to tasks that promote achievement of required skill levels and competencies. The focus shifts from course structures to student learning. For evaluators, this shift means additional work. To check compliance to IS2020 requirements, examining the list of core and elective courses will not be enough, there is also a need to pay attention to the learning objectives in each course. While this requires some more work, it is believed that this evaluation approach will lead to a more rewarding and mindful exercise for all stakeholders.

3. Competency model

The basis of the IS2020 model curriculum continues recent trends toward expressing IS curricula as expected student competencies achieved upon completion of an undergraduate program in IS. In this regard, IS2020 is both architecturally and philosophically different from its predecessor. The IS2010 report was structured around describing courses using a knowledge area (KA), knowledge unit (KU), and learning outcome (LO) hierarchy (or, KA-KU-LO model). In contrast, a competency-based approach articulates a model curriculum with a different set of components focused on observable tasks and the competencies required to fulfill these tasks in a means that is readily recognizable by relevant stakeholders. A competency-based approach inculcates the graduate's *knowing what, knowing how,* and *knowing why*. Thus, IS2020 continues and builds upon the philosophical shift evident in the MSIS2016, IT2017, and CC2020 curriculum projects in the utilization of a competency model for curriculum specification.

3.1 Motivations

Formal curriculum planning structures and processes in the majority of universities relies on a course-based approach that is reflective of the KA-KU-LO model. Universities expect faculty and program heads to provide a description of their program, comprising a list and sequence of courses, with explicit learning outcomes and course content. This process identifies what graduates will learn and what competencies can be demonstrated and measured. Concomitantly, course containers and credit-hour systems are necessary to convey investment in time, scheduling, and resources. However, as such these measures often do not convey the breadth and depth that an IS program has designed for its students beyond what can be gleaned from course descriptions. Often, the language expressed in course catalogs is vague and generic for the purposes of administrative flexibility.

A competency-based approach does not aim to replace formal university structures, but rather brings important enhancements to the curriculum design process as well as to how content for learning outcomes at the program and course levels are identified and expressed. A competency approach supports a way of IS undergraduate program design where the focus is on what graduates can do, rather than what they know. Thus, while the Body of Knowledge (BoK) associated with a curriculum continues to be foundationally important, a student's outcomes and demonstrable abilities to apply knowledge within the context of specific tasks, extend beyond what they know to what they can do. A competency-based approach provides a means of specifying the content supporting student outcomes by articulating the curriculum at a finer level of granularity with a specificity that leaves less doubt about what can be expected of graduates.

As an expression of learning objectives, and as a composition for learning outcomes, competency models provide a clearer link between the expectations that a program has for its students, the expectations of students, and the expectations of stakeholders. Each of these parties share expectations that certain tasks are within the student's capabilities, *in situ*. The empirical nature of a competency is such that graduates' abilities to perform practical tasks are specified and engrained in the curriculum. Commonly, stakeholders of IS programs often cite individual foundational competencies as being equally essential as the acute computing and technical skills

that students acquire in our curricula. Further, task and skill depth can be matched. If a graduate shows great promise in one set of competencies, and yet is shown to have had only cursory instruction in others, stakeholders are more capable of making informed decisions on whether they will commit to the resources necessary to enhance areas where competency skill levels are lower.

The CC2020 task force has found that key IS competencies across all IT realms reflect three key elements that define a competency: knowledge, skills, and dispositions. The *knowledge* component includes core concepts of the discipline of study, the *skills* component includes the ability to develop and refine skills via “hands-on” practice and activity, while the *disposition* component has to do with attitude, behavior, social skill, and emotional capabilities. Expressing competencies using these components should lead to stronger guiding principles in bettering graduates’ skills for the workplace and make for improved curriculum design.

A competency-based approach can also be a means to promote critical and analytical thinking. Morris (2018) explains that a curriculum should be logically organized in a step-by-step manner to enable learners to target more challenging learning objectives. In doing so, it is fundamental to facilitate the concept of critical thinking to ensure the learning outcomes are attained successfully. By focusing on competencies, students are encouraged to appreciate the fact that knowledge is not secured over either time or context due to the change in social contexts and that the use of knowledge is applied in accordance with the societal surrounding (Morris, 2018).

Topi et al. (2019) list the following benefits of a competency-based approach.

- Competencies focus on what the students need to learn, not what educators need to teach.
- Competencies effectively communicate expectations of graduates to external stakeholders.
- Competencies encourage reflection on student learning.
- Competencies can be used globally in diverse contexts.
- Competencies fit well with most accrediting agencies that use an outcome-focused approach.

These benefits may be of increasing value as education is moving toward new trends and forms; education itself is changing. One example of recent trends in IS undergraduate curricula is the emergence of online learning and Massive Open Online Courses (MOOCs). Some IS curricula have included study abroad segments as a mandatory part of the program to expose students to a variety of (work) cultures. Several universities have successfully included experiential learning components into their curricula, to expose students to real world environments and to better prepare them for the workplace.

Furthermore, some universities have adopted a modular approach to the undergraduate degree in terms of course topics and credits where students can cover a significant part of their degree with transfer credits originating from other recognized programs. These include advanced placement courses, courses from community colleges and polytechnics, industry training modules, or evidence of relevant practical experience also known as Recognition of Prior

Learning (RPL). There has also been an increased flexibility in curricula to cater for students who work full-time and pursue their degree as part-time students. This is evident from initiatives such as EDUglopedia (2020), that allows universities from around the world to showcase and promote their IS program(s) (or other programs) in an open format so that students and other interested stakeholders can get a detailed understanding of the program.

IS education needs to be aligned with the nature and needs of the IS job market and with the dynamic and constantly changing nature of IS education methods. In the IS job market, mobility is increasing and taking different forms, thus creating a need to update competencies in different areas. IS professionals seem to change jobs at an increasing rate, which often leads to increased demand for continuous training. The so-called “free agent” or consultant model has also become popular, whereby IS professionals work independently for different employers, often in the context of start-ups or through crowdsourcing relationships.

Overall, the competency-based philosophy aims at placing the impetus and onus on curriculum design where it should lie – with the principles and faculty designing a given program. The desired outcome is not only a pro forma presentation of required courses in the major, it also provides a philosophy, structure, and basic guidelines to design a curriculum that more specifically outlines the aims and intents of that program. This should increase program comparability, which in turn should better assist students, parents, employers, and other stakeholders, in comprehending the expected benefits and outcomes of a program.

3.2 Defining competencies

Our definition of a competency, as it relates to undergraduate curricula in IS, is consistent with that of MSIS2016 and CC2020: *A competency is the graduate’s ability to apply knowledge, skills, and dispositions (called attitudes in MSIS2016 and dispositions in CC2020) to effectively complete tasks*. This philosophy and definition acknowledge cognitive and metacognitive skills, demonstrated use of knowledge and applied skills, and interpersonal skills that often work in concert. Thus, while not entirely obsolete, many of the classic assessments used to demonstrate student attainment toward fulfillment of outcomes do not capture the broadest range of competency. The objective is not to ignore those elements not easily measured, but to acknowledge them as among the elements of competency and to design curricula to meet needs.

The details of a competency-basis for the recommendations put forth in this IS2020 report are directly informed by a competency model developed for the CC2020 project. The IS2020 report holds that competencies are the traits, behaviors, and abilities that the graduate of an IS baccalaureate program must demonstrate to capably perform in a job, role, function, task, or duty. Job-relevant behaviors, motivations, and technical knowledge-skills are utilized together in the accomplishment of the task. We also adopt the Knowledge, Skills, and Dispositions structuring of a competency from the IT2017 and CC2020 reports. However, the CC2020 report contributes greatly to the further specification of skills and disposition as a component of competency. We adopt the CC2020 formulation to define the elements of a competency:

Competency = [Knowledge + Skills + Dispositions] in Task

In each task situation, a competency is observed in the confluence of the knowledge-skill pairing and mediated/moderated by disposition (See Figure 3-1). The task situation dictates the roles, goals, objectives, and constraints. Thus, the competency can be understood as a propensity to satisfy task requirements, on average and across experience; it is unlikely that any single task presents a consistent set of specific characteristics but presents readily identified general characteristics.

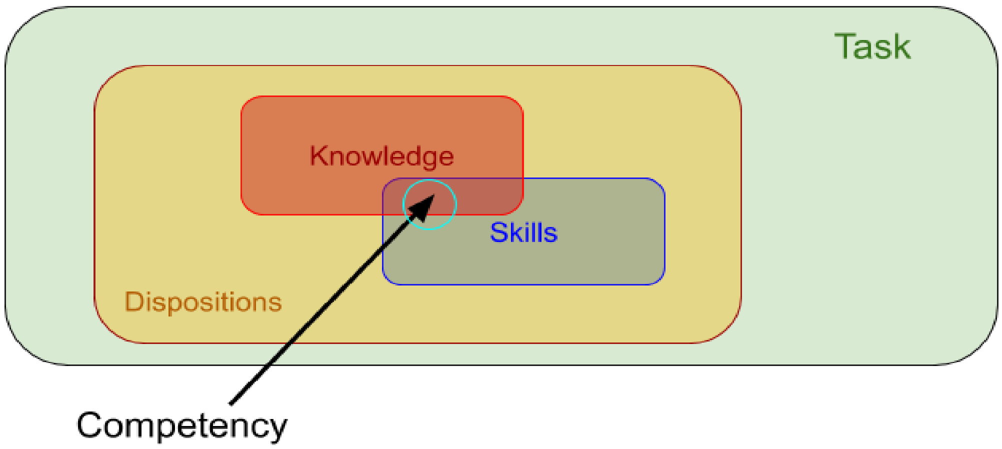

Figure 3-1 Relationship Among Competency Components (CC2020, 2020)

Much as perspectives on learning have become extended to accommodate multiple intelligences, such as Fleming's VARK (1995) model for learning styles, so too does the competency model allow for a multitude of curricula and curricular approaches to instill and cultivate the requisite competencies necessary to fulfill a task. A competency approach makes it possible to both specify what an IS program is (and is not) and accommodate program diversification and specialization. Further, the *computing-of-x* and *x-computing* trend promises to further blur the lines that distinguish disciplines. A competency model makes it possible to define the core of IS as well as express specialization transparently.

3.2.1 Knowledge

Knowledge is the "know-what" component of a competency that is most familiar and commonly associated with any curriculum. These are the factual elements we embed in our catalogs, syllabi, lectures, and associated materials. They are familiar to most learners by virtue of common assessment strategies. Elaborations on knowledge – *Knowledge Areas*, *Knowledge Units*, *Knowledge Elements* – have been the mainstay of most curricular models and guidelines as they constitute the comprehensive aspects of "what" is required to accomplish goals and perform tasks. These are critically important nouns that define the "what" that is taught in an IS curriculum.

Some of the categorization work from prior model curricula projects remains useful in that knowledge in the IS domain is best comprehended under some categorization scheme. This is so, even for the same of discussion, consideration, and comparison. Many computing disciplines, including IS, contain substantial categorizations and classifications of computing knowledge available through the publications and other intellectual contributions from scholars and practitioners. These would be the basis for the standardization of the K-S pairs and, potentially,

the dispositions. A variety of disciplinary model curriculum documents, and past and present Computing Curricula reports will serve as the basis for the categorizations used in this report and are further elaborated in Appendix 3.

3.2.2 Skills

Skills constitute the method and means by which “know-what” is fulfilled by “know-how.” As there is a significant time and practice aspect to skill and skill acquisition, skill development requires a progression through experience and the application of higher orders of cognitive load. As such, the CC2020 approach of adopting a modified Bloom’s taxonomy of learning objectives for clarity on complexity and specificity has been adopted here as well. This acknowledges that the conclusion of a baccalaureate often marks the ability to start on a path of life-long learning where learning-through-doing in a practical and professional context will continue and extend beyond the academy. Skills are the verbs in competency-task statements that suggest the approach to the application of knowledge.

	B-I Remembering	B-II Understanding	B-III Applying	B-IV. Analyzing	B-V Evaluating	B-VI. Creating
Definitions	Exhibit memory of previously learned materials by recalling facts, terms, basic concepts, and answers.	Demonstrate understanding of facts and ideas by organizing, comparing, translating, interpreting, giving descriptions,	Solve problems to new situations by applying acquired knowledge, facts, techniques and rules in a different way.	Examine and break information into parts by identifying motives or causes. Make inferences and find evidence to support	Present and defend opinions by making judgments about information, validity of ideas, or quality of	Compile information together in a different way by combining elements in a new pattern or proposing alternative
Verbs	Choose, Define, Find, How, Label, List, Match, Name, Omit, Recall, Relate, Select, Show, Spell, Tell, What, When, Where, Which, Who, Why	Classify, Compare, Contrast, Demonstrate ,Explain, Extend, Illustrate, Infer, Interpret, Outline, Relate, Rephrase, Show, Summarize, Translate	Apply, Build, Choose, Construct, Develop, Experiment, with, Identify, Interview, Make, use, of, Model, Organize, Plan, Select, Solve, Utilize	Analyze, Assume, Categorize, Classify, Compare, Conclusion, Contrast, Discover, Dissect, Distinguish, Divide, Examine, Function, Inference, Inspect, List, Motive, Relationships, Simplify, Survey, Take part in, Test for, Theme	Agree, Appraise , Assess, Award, Choose, Compare, Conclude, Criteria, Criticize, Decide, Deduct, Defend, Determine, Disprove, Estimate, Evaluate, Explain, Importance, Influence, Interpret, Judge, Justify, Mark, Measure, Opinion, Perceive, Prioritize, Prove, Rate, Recommend, Rule on, Select, Support, Value	Adapt, Build, Change, Choose, Combine, Compile, Compose, Construct, Create, Delete, Design, Develop, Discuss, Elaborate, Estimate, Formulate, Happen, Imagine, Improve, Invent, Make up, Maximize, Minimize, Modify, Original, Originate, Plan, Predict, Propose, Solution, Solve, Suppose, Test, Theory

Figure 3-2 Revised Bloom's Cognitive Skill List (CC2020, 2020)

The inclusion of Bloom's levels illustrates the close linkage between knowledge-based and competency-based approaches. On the lower skill levels, students are expected to "remember" or "understand" knowledge, which refers to more cognitive aspects of learning. However, to reach the level "applying" or higher, assignments where students practice the use of knowledge in specific tasks provided by a teacher are required. In the competency descriptions in the appendix, root verbs are used to indicate the Blooms levels (e.g., Remember instead of Remembering).

3.2.3 Dispositions

Dispositions outline the "know-why" component of the skilled application of knowledge and capture the nuances brought about by the contextual application of knowledge-skill pairs. There is often a character and quality of application inherent in the domain and context of application that suggests the qualifiers inherent to that domain. The *computing-of-x* and *x-computing* phenomena suggest that demand for the contextualized use of knowledge-skill pairing in IS will

continue to rise as the pervasiveness and ubiquity of computing into nearly all aspects of society, organizations, government, and business continues in a process often referred to as digitalization. Dispositions are the adjectives that bring the socio-technical aspects of technology use to bear. "Know-why" imbues sensitivity to context that is value-laden and requires an ability to divine the intention behind the application of knowledge-skill pairs.

3.2.4 Tasks

The task is the catalyst and occasion that calls upon the action and efficacy inherent in a competency. The work in most aspects of daily life necessitates that tasks must be accomplished and require the application of knowledge-skill pairs of the competencies associated with the IS discipline. The nature of a task, and the ongoing need for the completion of a task, completes the cycle between the design and specification of a competency for use in an IS curriculum with the practical needs of application. The pragmatic aspects of the discipline are evident and task descriptions bring about clarity in this regard.

A competency-based approach is sometimes criticized for reducing university education into vocational training. This confusion may result from a too straightforward interpretation of the meaning of a "task." There are two options for defining tasks, one drawn from education and the other from profession. In an *education context*, a task relates to assignments that students do as part of a course. A student is able to apply his/her knowledge to complete a given task and demonstrate this competency in exams or tests. Bloom's levels provide a useful scale for evaluating the level of competency that a student achieves. In a *professional context*, competency refers to tasks that are completed as part of routine work related to a job profile, leading to successful performance. Professional competency frameworks such as SFIA and eCF provide IS task categories and task descriptions, together with responsibilities and expected competency levels required for specific job profiles. Competency levels are typically described using levels such as Awareness, Novice, Supporting, and Independent.

There is no reason why the IS model curriculum could not link directly to professional competencies; as such, the MSIS2016 report explicitly links competencies to professional tasks. In IS2020, we chose a slightly more conservative approach – our focus is on entry-level competencies of graduates, acquired mainly through completing assignments as part of their studies. Naturally, the dialogue between professional competencies, curricular competencies, and tasks is an important one. The possibility of identifying gaps between the two remains an important benefit of the competency-based approach.

3.3 Describing competencies

Adopted from the CC2020 approach, the competency model used in this report arises from a competency template meant to align a prose competency statement with the "know-what, know-how, and know-why" of the Knowledge, Skill, and Disposition (K-S-D) components of the competency that fulfills the task. Using a modified competency template, here are the three principal components of a competency.

1. The Prose Task Statement and Title: this is a natural-language expression of the task that adopts both straight-forward, every-day descriptions along with any domain-appropriate terms and vernacular to make the task comprehensible to those that will derive value from task completion.

2. The K-S-D Structure: To materially substantiate and specify the competency statement, a well-structured expression of the attendant knowledge-skill pairs and dispositions are associated with the task statement.

3. Competency Metadata: The categorical and taxonomic annotations that permit easier organization of a body of competencies associated with domains, disciplines, and other contexts accompany any competency statement and its associated K-S-D structure.

The prose competency statement should be as close as possible to the every-day natural language of the domain and context of the task it supports. The prose statement should be tailored to the audience for whom the task has importance. Further, some degree of natural-language processing is envisioned for the wider management of competency statements.

In contrast, the formal structure of the components – K-S-D – are meant to precisely express requisite components of a competency and benefit from common classification elements and identifiers. Such provisions are intended byproducts of both the IS2020 and CC2020 projects. A quick analysis, paired with a notional human assessment, holds the potential to quickly liken and differentiate two IS programs. Thus, a competency-based model would allow for diversification and specialization while also quickly determining how close or far a program is from the canonical elements of an IS curriculum. Table 3-1 shows the various values that can be applied to Knowledge, Skills and Dispositions.

Table 3 1 Example of Knowledge, Skills, and Dispositions from CC2020 (CC2020, 2020)

Knowledge	Skills	Dispositions
Factual	Remember	Meticulous
Conceptual	Understand	Responsive
Procedural	Apply	Collaborative
Metacognitive	Analyze	Adaptable
	Evaluate	Responsible
	Create	Professional
		Purpose-driven
		Passionate
		Self-directed
		Inventive

Another useful element of the CC2020 project is the proposal to classify K-S pairs along a semiotic spectrum to better understand the level at which a competency is addressing the domain, context, and organizational character of the task described in the competency statement.

The metadata comprises, for example, the multiple connections between individual competencies. Given the provision for categorization in the competency model in this report, it is likely that the K-S pairs, Dispositions, and Competencies themselves will be re-used such that extant items for each of these would be re-applied to development of closely related competencies. A person having competency *A* would already possess some of the knowledge needed in for competency *B*. It is quite likely that competencies identified are linked, leading to them being presented in a form of a map.

CC2020 provides an additional concept that supports a combination of competencies in the form of a map. At a basic level, an *Atomic Competency* is composed of the competency title, description, dispositions list, and K-S pairs. Further, it would be also conceivable that a *Composite Competency* would be developed from existing *Atomic Competencies* where the additional qualification and clarification would come from the prose competency description, and a set of attendant dispositions that characterize the confluence. It is conceivable that, given the hybrid nature of the IS discipline, continued program specialization would necessitate *Composite Competencies*. The description and dispositions for a *Composite Competency* would allow for

context and nuance to accommodate new combinations. The “child” competencies – be they *Atomic Competencies* or other *Composite Competencies* – that constitute a *Composite Competency* are referred to as *Constituent Competencies*.

In this IS2020 report, competency descriptions appear as part of the competency area descriptions in Appendix 3. They explicate the competencies within IS competency areas, and each competency is further defined by identifying key knowledge areas and skill levels. Hence, the competency descriptions provided in the report are not as detailed as those described in the CC2020 report as they exclude competency-specific dispositions and competency maps. The reasons for this reduced detail in describing competencies are purely practical. While inclusion of dispositions, and provision of competency maps, would be useful, the mere number of competency areas and individual competencies limits the richness available to illustrating competencies that can be achieved in a single report. Eventually, however, a curriculum could contain very intricate and complex graphs of these competencies. Such specificity provides clearer definitions of a designed IS curriculum. It is expected that tooling, emerging both from the IS2020 group and the CC2020 group, would assist in developing, cataloging, and comparing competencies.

3.4 Competency realms and competency areas

The competency-based architecture of the IS2020 model curriculum also establishes some of the hierarchical categorization of the MSIS2016 model curriculum to make the aggregate set of competencies easier to navigate. Competency modelling in MSIS2016 followed a top-down approach. The highest level of the model comprises realms: (1) individual foundational competencies, (2) areas of domain competencies, and (3) IS competencies. The IS competencies realm is further divided to competency areas, that in turn are broken down to competency categories and ultimately to competencies. Competency areas and categories were much more stable and depended less on technology, or local variation, than the competencies themselves. Hence, MSIS2016 did not attempt to be comprehensive in listing all competencies and instead presented examples of competencies for each competency category.

The competency model in IS2020 follows the idea of grouping competencies to hierarchical categories. In particular, the concept of IS competency area in IS2020 has approximately the same meaning as in MSIS2016 as does the concept of a competency realm as the highest level of classification. This hierarchical view of competencies grouped into high-level areas and realms attempts to group competencies according to their similarity. It would seem likely that the formulation of competency maps discussed in CC2020 could start within each competency area and realm.

The main reason for hierarchic presentation of competencies is, however, in providing a language for discussing competencies and learning outcomes of an entire program curriculum. A three or four-year undergraduate program (or two-year graduate program) addresses a large number of tasks and competencies. Aggregate constructs, such as areas and realms, enable discussion of program level choices regarding curriculum, its profile and specialization. The logic is somewhat

similar as in traditional curriculum models, that break knowledge areas to units and ultimately topics, thus forming a Body of Knowledge (BoK).

3.5 Architecture of the information systems curriculum in IS2020

Architecturally, IS2020 is quite different from its predecessor. The IS2010 structure included three major elements: *Course*, *Learning Objective*, and the three-level *Knowledge Area – Knowledge Unit – Learning Outcome* hierarchy. Further, this model relied on the concept of *Coverage* to represent the extent to which a specific *Topic* within a *Course* is required to support achievement of a specific *Learning Objective*. Please note that *Topics* themselves can be organized hierarchically into multiple levels. A *Level* is specified for each *Learning Objective*, indicating the type of cognitive processing that the student is required to demonstrate to achieve the learning objective.

The IS2020 exploratory committee task force explicitly recommended developing IS2020 as a hybrid model combining both the competencies and course structure(s). To this end, the IS2020 Architecture combines concepts from a course-based curriculum model, and the competency-based model. In the following, we describe the key curriculum architecture concepts and the way they are applied in this curriculum implementation.

3.5.1 Key concepts

The structural architecture of IS2020 is proposed in Figure 3-3 as a guide for an IS model curriculum. Constructs on the left represent the traditional curriculum design view, (program – program learning outcome, course – course learning outcomes). Constructs to the right represent entities of competency models: Competency realm, area, competency, knowledge-skill pairs, and dispositions. Definitions for terms are presented in Table 3-2.

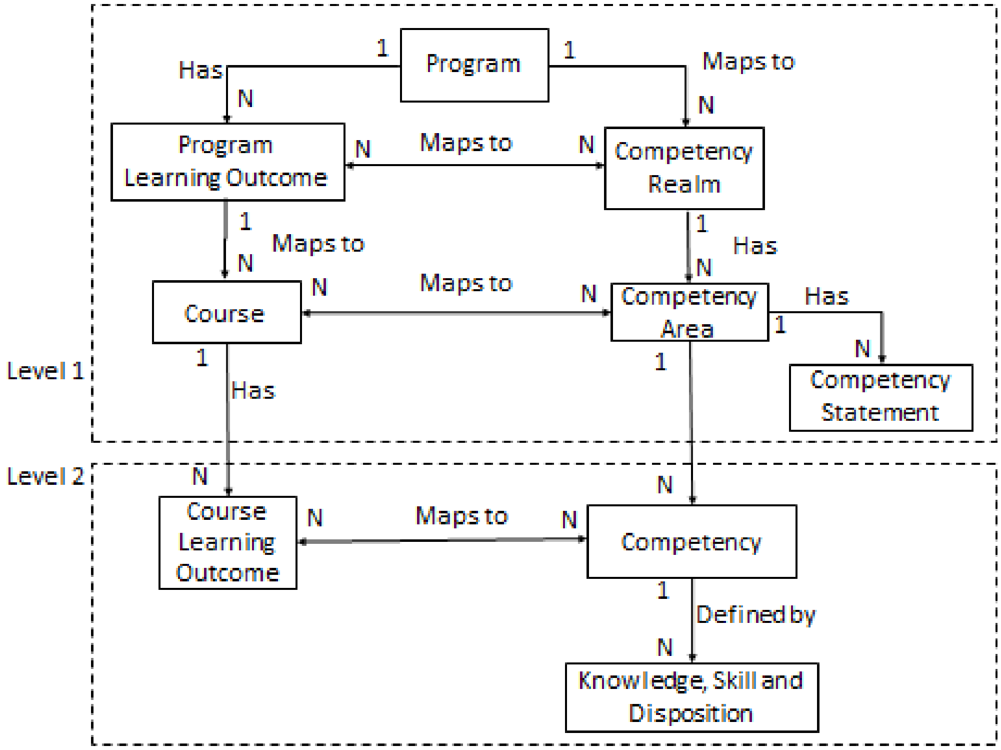

Figure 3-3 Proposed Curriculum Architecture

The structure is divided into two levels. Level 1 includes the six major elements: *Program*, *Program Learning Outcome*, *Competency Realm*, *Competency Area*, *Competency Statement,* and *Course*. These concepts provide the language for comparing program level descriptions, profiling, and learning outcomes, with choices related to competency realms and competency areas. Level 1 aligns with principles of the competency model in MSIS2016.

Level 2 includes *Course Learning Outcome* and *Competency* which is further defined through three elements, namely *Knowledge*, *Skill*, and *Disposition*. Each *Competency Area* (CA) has a set of detailed competencies. These competencies are defined using a combination of *Competency Statement*, *Knowledge*, *Skills* and *Dispositions* that one must have to demonstrate a specific competency under a *Competency Area*. These concepts allow a more detailed comparison of the learning objectives in a course, based on tasks assigned for students, and associated knowledge areas, skill levels, and dispositions. Level 2 aligns with the competency model in CC2020.

Table 3-2 Definition of Terms Used in the Architecture

Term	Definition
Program	A major or a complete undergraduate degree program in IS.
Program Learning Outcome	Defines what students are expected to know and be able to do on completing the program. They are similar to ABET Student Outcomes.

Competency Realm	Broad areas of study relevant to an IS graduate.
Competency Area	A component of the Competency Realm.
Competency Statement	A high-level description of the capability to apply or use a set of knowledge and skills required to successfully perform broad work functions related to a Competency Area.
Course description	A description of what will be covered in the course. They are generally less broad than Program Learning Outcomes and broader than Course Learning Outcomes.
Course Learning Outcome	A detailed description of what a student must be able to do on completion of a course. When writing outcomes, it is helpful to use verbs that are measurable or that describe an observable action.
Competency	A detailed description of the capability to apply or use a set of knowledge, skills, and dispositions to successfully perform specific work tasks related to a Competency Area.

3.5.2 Process for deriving and designing courses from competency specifications

The guidelines presented in the next chapter will define the requirements only in terms of competencies. To illustrate the practical application of the architecture, and the use of the competency guidelines, we provide a procedure for deriving courses from competency specifications. Following the example in MSIS2016, such process can comprise the following steps.

1. Perform needs analysis (covering, for example, program's key markets, university or school requirements, and available resources), to determine general target characteristics of the graduates.
2. Finalize the decision regarding the target job profile(s) for which the program wants to prepare its graduates. IS2020 includes a sample set of specializations for IS students (see Table 2-3), but it is likely that individual programs over time will develop many others.
3. Based on the job profile(s) for which the program desires to prepare its graduates for, identify the required Competency Areas (CA) across the six IS Competency Realms, Individual Foundational Competencies and Domain Area Competencies.
4. Make an initial architectural decision regarding the total number of courses in the program and the approximate percentage of time dedicated to mandatory core Competency Areas and optional Competency Areas.
5. (For existing programs only) Ensure that the current Program Learning Outcomes (PLO) and the Course Learning Outcomes (CLO) have been appropriately identified and documented for all current courses.

6. (For new programs only) Create the Program Learning Outcomes. Accordingly, develop a draft set of the course structure along with courses including course titles, brief descriptions, and Course Learning Outcomes.
7. Create a mapping between current (or draft for new programs) Program Learning Outcomes (PLOs) and the IS2020 Competency Areas (CAs). Additionally, also map the current courses (or draft for new programs) to the IS2020 Competency Areas (CAs). After completing this mapping, analyze the extent to which the PLOs and the courses contribute to the achievement of each of the IS2020 CAs. The PLOs and courses must, at a minimum, map to the mandatory IS2020 Competency Areas and associated minimum skill levels within them.
8. Based on #7 above, identify the Competency Areas that the current course structure (or draft course structure) does not allow the students to attain adequately.
9. Based on #8 above, determine:
    a. how the courses and their learning outcomes and experiences have to be changed;
    b. which new courses must be introduced, and/or;
    c. how the learning experiences must be reconfigured between the courses so that they will collectively enable the students to attain the IS2020 mandatory Competency Areas.
10. Repeat steps #7 to #9 iteratively if necessary.
11. For each course, determine the Course Learning Outcomes, course content, and pedagogies. Map the Course Learning Outcomes to the Competencies (using Knowledge, Skills and Dispositions) for the relevant Competency Areas that are mapped to the course. When defining the competencies, you can adapt and reuse the Competency Statements that were defined earlier.

By following this procedure, the generic competency guidelines offered in the next section can inform curriculum design in a variety of geographic regions and IS job markets, as well as in different educational contexts, providing varying credit hours for studies in the major subject.

4. Curriculum guidelines

This chapter provides the curriculum guidelines, with a focus on competencies that graduates should have upon completion of an undergraduate IS program. By doing so, the guidelines for the IS curriculum are also defined. The key principles that have guided prior guideline task forces .were also leading principles in this work.

- The model curriculum should represent a consensus from the IS community.
- The model curriculum should be designed to help IS programs to produce competent and confident entry-level graduates well suited to workplace responsibilities or further studies of IS.
- The model curriculum should guide but neither prescribe nor proscribe. Using the model curriculum guidelines, faculty can design their own courses and schools can design their own programs.
- The model curriculum should be based on sound educational methodologies and make appropriate recommendations for consideration by IS faculty.
- The model curriculum should be flexible and adaptable to most IS programs.
- The model curriculum should not b not restricted to a specific domain; all IS programs are, however, linked to some domain.
- The model curriculum should have a core of content that is common to all IS programs internationally.
- The model curriculum should have career targets that require both core and elective content.
- The model curriculum should not focus on specific issues related to pedagogy. This is not a reflection of our understanding of the importance of pedagogical decisions – it is simply that these highly significant issues are outside the scope of this document.

The exploratory committee further emphasized the global applicability of IS2020 with different academic structures, and developed IS2020 as a ‘hybrid model’, combining the competencies and course structures.

In what follows, guidelines are defined regarding general competency realms, followed by a more detailed account of the IS competency realm. This includes the definition of 10 required IS competency areas, forming an IS core that will provide a foundation that is useful in all IS professions. Electives are also identified that can be used to complement the core, leading to specializations.

The latter part of the chapter focuses on issues related to guideline implementation in three main educational contexts, those of computing school, business school, and information school. For

each context, the design of major and minor studies, possibilities for collaboration with other subjects, and considerations related to accreditations are discussed. The chapter concludes with some practical considerations related to resources, applicable again in any educational context.

4.1 High level competency realms

Both IS2010 and MSIS2016 emphasize the critical need for IS graduates to possess competencies outside the immediate IS competencies. Figure 4-1 was used in both guidelines as the highest-level competency realm framework. In addition to IS competencies, outcome expectations comprise both individual foundational competencies and domain competencies. While these individual foundational competencies are useful in all disciplines, including all computing disciplines, they are of significant importance in IS programs, given its focus on application of information technologies in different user domains.

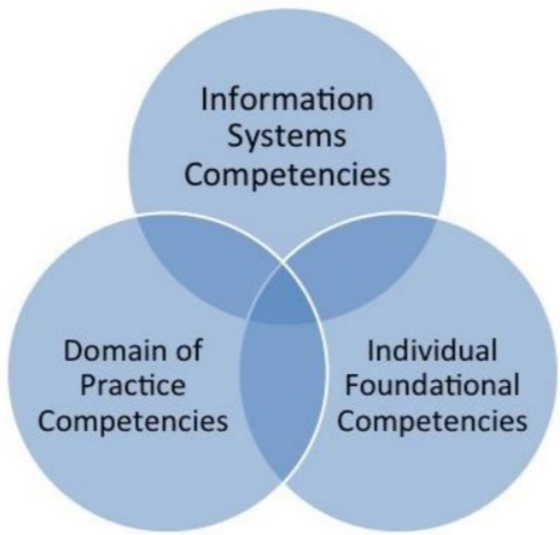

Figure 4-1 IS2020 High level competency realms
(originally presented in IS2010, adapted to competency model for MSIS2016)

The significance of these three competency realms remains profound within the IS profession. Outcome expectations for IS programs cannot be reduced to IS competencies only. In fact, the role of individual foundational competencies may be increasing. The *Future of Jobs* report by the World Economic Forum predicted that complex problem solving, social skills, process skills, and systems skills are expected to be in much higher demand than physical abilities or content skills.

Regarding Individual Foundational Competencies and Domain of Practice competencies, we rely largely on the excellent and meticulous work that was carried out in IS2010 and MSIS2016. Due to the generic nature of these competencies, the expectations for these competencies have not changed considerably. In this respect, IS2020 further strengthens the propositions stated in prior guidelines.

4.1.1 Individual Foundational Competencies

In IS2010, Foundational Knowledge and Skills comprised five areas: *Leadership* and *Collaboration*, *Communication*, *Negotiation*, *Analytical* and *Critical Thinking* (including creativity and ethical analysis), and *Mathematical Foundations*. MSIS2016 (Topi et al., 2016) identified the following eleven individual foundational competencies as being critically important to the IS profession: critical thinking, creativity, collaboration and teamwork, ethical analysis, intercultural competency, leadership, mathematical and statistical competencies, negotiation, oral communication, problem solving, and written communication.

While all of these competencies serve an important role for the success of an IS professional, the state of flux resulting from simultaneous deployment of many emerging technologies over the decade portends that some individual foundational competencies may increase in significance as we transition to the 2020s.

- *Critical Thinking and Problem Solving*: IS professionals must be capable of logical and analytical thinking. Working with and analyzing large complex data to make effective decisions is an essential competency area. Individual foundational competencies associated with logical and analytical thinking and decision-making processes must be learned and developed to become an effective IS professional. In addition, IS professionals must be effective problem solvers.
- *Lifelong Learning and Development*: As technology advances rapidly, IS professionals must adopt a continuous learning orientation and a mindset that embraces change. Competencies associated with learning how to learn and continuous growth and development are required core skills.
- *High Tolerance for Ambiguity*: IS professionals work in a complex profession and it is often not possible to completely understand an IS and the system's relationships with other entities and people. Hence, IS professionals must be adept and working with and adapting to ambiguous situations with incomplete information. Individual foundational competencies associated with managing and adapting to complex environments with incomplete information are required.

IS2020 continues to emphasize written and oral communication that remain relevant and significant. IS professionals must be effective communicators capable of communication at the level appropriate for a given audience particularly given a common disparity in communication that often surrounds the socio-technical boundary. Oral communication, written communication, and presentation competencies remain essential to the profession. Students need to master individual foundational competencies in their traditional meaning (physical world) and in digital media (virtual world).

It is perhaps important to note the close relationship between individual foundational competencies and some of the individual traits or dispositions (e.g., collaborative, responsive, self-directed). An examination of the role of dispositions in the context of specific IS competencies could provide a more nuanced and detailed view on the critical role of individual foundational

competencies. In the IS2020 guidelines, we emphasize this opportunity as a highly significant opportunity to establish and communicate nuance and specialization among graduates' competencies.

4.1.2 Domain of Practice Competencies

Domain of practice refers to knowledge and skills related to specific use contexts for information technology. The IS2010 report defines business in general as the most common domain, but also identifies many others, such as business specialties (for example accounting and finance), government, health care, the legal profession, and non-governmental organizations. MSIS2016 further identified scientific research, education (K-12 and post-secondary) as additional potential domains. While these illustrate typical domains of practice, it is important to recognize digital firms and other realms as a new domain of practice that have arisen from the overall digitalization process.

Domain of practice competencies refer to knowledge, skills, and dispositions that graduates possess relevant to a discipline. IS professionals have a unique role where their attention to understanding and reconciling the role of technology in a domain of practice constitutes a core competency. Throughout their careers, IS professionals are required to learn, develop, and apply competencies in a domain of practice. IS2010 identified domains of knowledge related to general understanding, specialized operations, and performance evaluation, the latter also comprises the philosophical orientations evident within a domain. MSIS2016 provided a closer account of two domains, namely business (relying on MSIS2006) and healthcare (being informed by sources such as the American Medical Informatics Association).

Defining competencies for domains of practice realms falls outside the scope of IS2020, yet we further confirm the critical role of domain competencies that are established in prior guidelines. An IS professional should possess domain competencies that, when combined with IS competencies, enable an IS practitioner to design, deliver and use information systems for the benefit of an entity in a domain of practice. Knowledge of one domain of practice (e.g., understanding of organizational structures, technology and processes, values, ethical questions and concerns, legislation) will assist in learning similar issues in another domain, and in general highlights the critical need to understand the domain of use as an important consideration in designing IS applications, including transfer of such applications from one.

Lacking sufficient coverage related to foundational skills and knowledge, and to domain-specific skills and knowledge, a curriculum would not be compatible with the IS2020 curriculum recommendations, even if this document does not specifically articulate how to meet these requirements. As the implications of this requirement are slightly different, depending on the educational context (computing/engineering school, business school, information school), we elaborate the implications for education in more detail in section 4.4.

4.2 IS competency realms

Recommendations regarding IS competencies provide a key deliverable for the IS2020 task force. Following the adoption of a competency-based model, our focus was to articulate outcome (entry

level) IS competencies of IS graduates upon completion of their bachelor's degree. As these are hierarchically structured, the identified competency realms and areas are discussed here. Within each area, we provide additional depth regarding the required competencies as well as related electives that might define a career track or specialization. Figure 4-2 presents the overall competency architecture of IS2020 recommendations. IS competencies are divided into six competency realms, each comprising required competencies. An affordance has been made for electives to allow for further specialization within an area or realm.

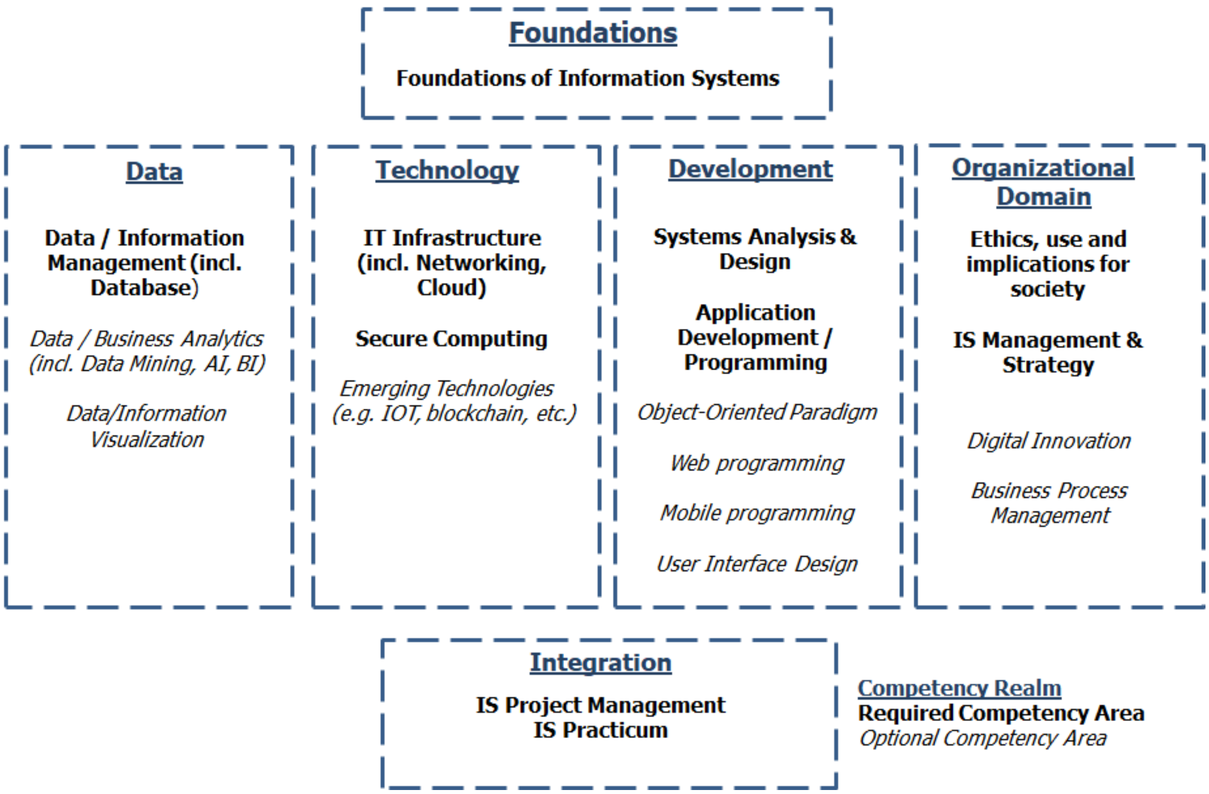

Figure 4-2 Competency Based IS2020 Curriculum Guidelines

Requisite competencies constitute essential foundations required for any IS professional. First, given the unique interdisciplinary stance of IS, an undergraduate program should provide a broad understanding of the field covering all fundamental realms. The ten required competency areas outlined in Figure 4-2 represents this core. While providing a broad understanding, these realms, in and of themselves, do not yet specialize the student into any specific IS profession. In some sense, the elective competencies may appear to be more significant, as they increase students' competencies to align with the expectations of a specific IS career track. The list of elective/recommended IS competencies is not meant to be exhaustive. Rather, they are examples of IS competencies that undergraduate programs can choose to offer when designing specializations.

The remainder of Chapter 4 describes each competency realm and the required and optional competency areas within each competency realm. For a detailed list and description of IS

competencies in each competency area and their associated knowledge skill pairs see Appendices 2 and 3.

4.2.1 Foundations competency realm

Foundational IS competencies are typically first introduced as part of an "Introductory Course," sometimes also referred to as an "MIS Course" or "Foundations Course." Competencies in this area will improve as more courses are taken. As a competency area, it represents the IS discipline as a whole: What are the knowledge areas and how are they being applied? Why is this subject significant? What specializations exist? What is the work like? Do I want to study IS? What kind of career would I like to have? The foundational IS competency realm comprises one required area (IS Foundations).

Information Systems Foundations refer to the ability of students to understand the fundamental concepts of IS (including hardware, software, and information acquisition) and the support that IS provides for transactional, decisional, and collaborative business processes. They will also be able to understand the collection, processing, storage, distribution, and value of information and be able to make recommendations regarding IS that support and enable individuals in their daily lives as well as the management, customers, and suppliers of the enterprise. This competency includes the ability to conduct an organizational business analysis, and assess processes, and systems.

While specific electives are not proposed in this competency realm, it is perhaps important to note that these foundational skills will be important in future IS researcher/teacher careers. At the undergraduate level, it may be premature to elaborate and extend in this area.

4.2.2 Data/Information competency realm

Traditionally, Data Management has focused on data persisting in organizations, usually in relational databases. Such data assets support the core business processes of the organization and form the basis for business applications. Increasingly, organizations also process ever larger volumes of data that emerge from expansive digitalization (web traffic, social media, and sensed sources). Regardless of the source and type of data, the fundamental questions and concerns of this realm remain the same: How to gather, organize, curate, and process data to help run an organization or extract actionable information to increase effectiveness. The Data/Information competency realm comprises one required area (Data and Information Management) and two elective areas (Data and Business Analytics; Data and Information Visualization).

The **Data and Information Management** area comprises competencies related to tools and techniques for managing data with database systems. At the highest level, competencies within this area are related to two questions: (1) how to use a database and (2) how to build a database. Most of this competency area will focus on the classic relational model. In the past several years, driven by evolving functional and non-functional (quality) needs of an organization, alternatives to the classic relational model have emerged. Illustrative samples will be examined of these popular alternatives known as non-relational or NoSQL models.

Electives: Following the trend toward big data and analytics, there is increasing need for professionals in this area and thus opportunities for specialization. While specialized programs exist that produce data scientists, this area has also emerged as an important area for graduates from IS programs. To support the design of this specialization to an undergraduate IS program, two specialization areas, Data and Business Analytics and Data and Information Visualization, are identified.

Data and Business Analytics: Big Data is differentiated from traditional data in terms of the three 'V's: volume, velocity, and variety. When data are processed at the terabyte and petabyte level (volume) what fundamental shift in the approach to solving problems occurs? Given the fast transmission and computational speeds of current systems (velocity), what new capabilities are enabled by the processing of huge amounts of data in real time? Estimates are that more than 90% of the world's data is not structured (variety); what type of new actionable insights are facilitated by the processing of semi-structured (e.g., csv, JSON) and unstructured (e.g., text, images, audio) data? To answer these questions, graduates will need data driven actionable competencies, such as (1) apply the principles of computational thinking (CT) to learning data science, (2) analyze data science problems with a CT framework, (3) express a business problem as a data problem (4) perform exploratory data analysis from inception to the value proposition, (5) explain the core principles behind various analytics tasks such as classification, clustering, optimization, recommendation, (6) articulate the nature and potential of Big Data, and (7) demonstrate the use of big data tools on real world case-studies.

Data and Information Visualization: Turing award recipient Richard Hamming commented that "The purpose of computing is insight, not numbers." The goal of information visualization is the unveiling of the underlying structure of large or abstract data sets using visual representations that utilize the powerful processing capabilities of the human visual perceptual system. The Data and Information Visualization competency area contains competencies pertaining to computational approaches for gaining insight via visualizations. Competencies in this area emphasize the fundamentals of statistical exploration of data, fitting models to produce specialized graphs to support the exploration of data in a detailed and statistics-oriented manner, and the use of data visualization tools such as Excel, Python, R, and Tableau.

Naturally, these three areas should not be considered as providing an exhaustive coverage necessary for acute specialization. Rather, they are provided as illustrative examples, where specialization should be supported and augmented with competencies from other disciplines related to mathematics. Whether a program provides this additional support directly or indirectly would be a localized choice.

4.2.3 Technology competency realm

Traditionally, *Information Technology* has focused on Information Technology assets within an organization, its infrastructure and architecture for data, communications, and applications. Recent trends toward cloud computing, SaaS applications, and deployment of devices/applications for private life to a business context are examples of trends that add complexity to this realm. Simultaneously, hazards related to computing security, and the

associated potential adverse consequences within the use domain, are increasing. Because of the significance of technology infrastructure and information security, these two competency areas are required among core competencies. The realm also comprises a third elective area supporting further specialization: emerging technologies.

The **IT infrastructure** area covers all aspects of information technology infrastructure, as it is used in the organization. IT infrastructure includes the design and development of suitable architectures or servers, physical and cloud services, capacity planning, and networking. The content covers the installation, configuration, maintenance, and management of all aspects of technology from the server through to the organization's network. A basic understanding of Enterprise Architecture in the context of IT Infrastructure is also needed.

The **Secure Computing** area is concerned with practices associated with assuring secure business operations in the context of adversaries. Assuring secure operations involves the creation, operation, defense, analysis, and testing of secure computer systems. Hence secure computing is an interdisciplinary area including aspects of computing, law, policy, human factors, ethics, and risk management. The proposed competencies cover these areas, but with an IS discipline lens. This includes data security, software security, human security, societal security, and organization security.

Following the need for an increased focus on infrastructure and security, the need for dedicated professionals in IT and security consultancy provides a basis for further specialization. While dedicated programs exist to produce cybersecurity specialists, IS auditing and security are important related areas of need and demand for job placement of IS graduates. For building IS competencies in this specialization, we propose one elective, to focus on *Emerging Technologies*.

The **Emerging Technologies** area examines emerging technologies and explores their impact on business and societal issues through a business and theoretical lens. A range of technologies is identified and evaluated based on a range of business requirements based on a variety of ethical, environmental, and sustainability perspectives. Technologies are practically applied to enable suitable business opportunities.

4.2.4 Development competency realm

Traditionally, the focus in the *Development* area has involved aspects of the application/systems development life cycle. Trends in software development, such as agile software development methodologies and SCRUM, are now tantamount to a software industry standard (de Vreede et al., 2018). Building on agile development principles are Design Thinking and Human-Centered design approaches, that have become much more commonplace to firmly ground development practices in user preferences and habits. These are often encompassed as being user experience concerns. For many reasons, it is evident that the professional and personal context in which our graduates do their work has changed considerably, and therefore the curriculum needs to reflect this change. This is particularly so within this competency realm as it has been construed as being deprecated in the 2010 report. The systems development competency realm comprises two required areas (Systems Analysis and Design; Application Development and Programming) and

four elective areas (Object Orientation, Web Programming, Mobile Programming, and User Interface Design).

The **Systems Analysis and Design** area examines various systems development methodologies and modeling tools with an emphasis on object-oriented systems development methods, software development life cycle (SDLC), and agile software development while emphasizing analytical techniques to develop the correct definition of business problems and user requirements. Topics should also include design, project management standards, information gathering, effective communication and interpersonal skill development.

The **Application Development and Programming** area comprises two facets: Programming and Application Development:

Application Development is the purposeful application of programming fundamentals to craft usable and useful software artifacts and systems to solve actionable business and organizational problems where the power and automation of computing and data processing is warranted. Elements of design, to include reconciliation between human social systems and data and IS, support a software/systems development life cycle where the industry and craft software realization extend capabilities of software and programming code elements and our understanding of fit and resonance with the human end-users of these systems. In this regard, an IS perspective on application development, although akin to software engineering, includes the necessary elements of human-computer interaction, user experience, and other sociological and psychological components that constitute user and organizational acceptance and satisfaction.

Programming is the language of computation and logic that sequences and orders instructions to computing hardware in a manner that realizes both correct results and discernable results. Logical structures, algorithms, arithmetic facilities, and the ability to input, store, transform, and output data that can be purposefully used to inform decisions and automated intentional processes are at the heart of learning to program. To program a computer is to meet the computer "in the middle" such that the growing capabilities of data and computing can be purposefully guided. Programming is meant to shape the mind and reasoning such that human requirements for data and computing outcomes can be expressed and perfected.

Following the increased deployment of digital technologies and data in all firms, the need for systems developers and programmers is increasing. In some areas, for example offshoring destination countries, systems developers have always been a significant career track. However, systems development and programming remain a vital and essential focus area for IS programs. While undergraduate programs focusing entirely on software development exist (e.g., software engineering), involvement in systems development continues to be important for the job placement of IS graduates. It is software and systems applications that often generate vital information and data resources making for a symbiotic relationship. For building competencies in systems analysis and design specialization, we propose four electives focusing on different contemporary aspects of systems design: Object-Orientation, Mobile programming, Web Programming, and User Interface Design.

The **Object-Orientation** area focuses on software implementations that extend beyond simple utilization of programming constructs and move toward the utilization of modular components often built against paradigmatic best practices for extensible and manageable construction. Programming paradigms are often idiomatic and construe epistemological values about the structuring of applications, reusable code libraries and patterns that lead to architectural decisions. Object-Orientation is a paradigmatic perspective on how to organize data and routines into libraries of reusable code centered on organization of data and routines into containers called classes (for specification) and objects (for instantiation). The set of behavioral provisions inherent in these structures that specify how groups and hierarchies of these entities interact forms the basis of Object-Orientation that pervades most accepted architectural patterns for software and systems development. Thus, Object-Orientation, although intrinsic to contemporary programming languages, also serves as a foundation for problem domain modeling that extends beyond applications in programming. Thus, much of this material will also be contained in most systems analysis and design courses. As such, the focus here is on manifested applications that extend from design to implementation whereas systems analysis and design stops short, in most cases, of implementation. Object-oriented programming requires baseline competencies related to (1) Fundamental elements of objects and classes, (2) Instantiation modalities, (3) Intra-entity communication and messaging, (4) Encapsulation, (5) Inheritance and dependency management, (6) Abstraction, (7) Polymorphism, (8) Design Patterns, and (9) Modeling.

The **Web development** area requires students to understand the concepts of web application design and programming by learning the tools used to create client-side and server-side programs. To design and implement a web site using current standards and best practices requires students to (1) Understand how the Internet works, (2) Create and analyze an algorithm for effectiveness and efficiency, (3) Implement good documentation practices in programming, (4) Demonstrate teamwork, interpersonal group skills, and team software development, (5) Develop skills in client-side (Front-end) web application development technologies including HTML, CSS, JavaScript, and JavaScript libraries, (6) Develop skills in server-side (back-end) web application development technologies using a back-end programming language (i.e., Node/Express, Python/Django, etc.), (7) Create a functioning web application suitable for portfolio presentation including but not limited to skills shown using front-end, back-end, SQL, and current web development tools, (8) Gain knowledge of different internet design patterns (i.e. MVC, MVVM, etc.) and ability to know advantages and disadvantages of each, (9) Understand different design layouts and pros and cons of each, (10) Understand the how to implement security measures for a website, (11) Learn how to debug syntactical and logical errors, (12) Understand Internet copyright laws, and (13) Learn how to deploy a website to a host server.

The **Mobile development** area focuses on the features and upcoming trends of the common mobile platforms to develop a mobile application that uses a web services backend to synchronize and centrally store user data. Topics include but not limited to human interface guidelines for mobile development, tools required for mobile application development in different mobile platforms. For mobile development, graduates need to (1) Understand the Internet of Things (IoT) enabled devices and the mobile industry, (2) Create and analyze an algorithm for effectiveness and efficiency, (3) Implement good documentation practices in programming, (4) Demonstrate

teamwork, interpersonal group skills, and team software development, (5) Develop skills in commonly used mobile development languages like Kotlin, Java, JavaScript, C#, Objective-C, HTML5, Swift, (6) Create a functioning mobile application suitable for portfolio presentation including but not limited to skills shown using database management, hardware interaction, APIs, cross platform development and current mobile development tools, (7) Gain knowledge of different mobile development platforms, (8) Understand mobile user interface design and the user experience, (9) Understand the how to implement cyber security measures for a mobile application, (10) Implement an understanding of memory allocation, (11) Learn how to debug syntactical and logical errors, (12) Understand Copyright laws, and (13) Learn how to market and publish a mobile application.

The **User Interface Design** competency area emphasizes concepts and principles of user interface design, design, and evaluation of user experiences (UX), and usability. Competencies include psychological and interaction principles, requirements analysis, designing for different screens, typography, symbols, color, graphics, and other visual language components. Competencies in this area also include needs identification, system capabilities, and an understanding of physical and mental limitations.

4.2.5 Organizational Domain competency realm

Traditionally, the focus of the Organizational Domain area has been in the strategic management of IT in organizations. This focus has simultaneously been in the frameworks and practices that assist organizations in the management of the IT function and its services, and on the strategies that seek to improve the value of IT for the organization. As IT is being deployed increasingly outside the traditional business organization context, and also incorporated closely to products and services for consumers, there are new ethical challenges to comprehend and address. Hence, for this competency realm, we include two required competency areas: IS Management and Strategy/Ethics, and the Use and Implications for Society. The Organizational Domain competency realm comprises two required areas (IS Ethics, Sustainability, Use and Implications for Society; IS Management and Strategy) and two elective areas (Business Process Management, Digital Innovation).

The **IS Ethics, Sustainability, Use and Implications for Society** area is concerned with practices associated with the ethical use of information systems and the ethical use of the information and data captured by such systems; designing, implementing, and using computing resources in a sustainable environmentally conscious manner; and competencies associated with how information systems may be used and created for the benefit of society. The area comprises two facets: *Ethics* and *IS sustainability.*

Ethics, within the information systems ecosystem, reflects agreed moral codes of practices and control associated with the use of information systems through the: collection of data, the creation and storage, and its sharing of information. As such ethical codes that govern both the use or dissemination of data must apply to both the information systems and the society in which it exists. The information system practitioner must be cognizant of these ethical codes and its implications for society.

IS sustainability, through its design, implementation, and use of computing resources, reflects an imperative that such systems and their data sources must be adaptable, relevant to all stakeholders, and support the maintenance of data captured by such systems. Such data is constantly transformed through sustainable processes, actions, and performance to support the organization, individual, and society at large. Students need to be able to explore and understand the societal implications of disseminating information.

The **IS Management and Strategy** area includes the capability to develop, maintain, and consistently improve the systems to deliver the information necessary for an organization. The capability focuses on creating value for an organization and on the IS staff motivation, performance, and accountability. IS Strategy emphasizes the competency to create long-term plans for implementing and using organizational information systems to achieve strategic organizational goals and objectives. This area also covers monitoring and controlling organizational IS resources to ensure alignment with and achievement of strategies, goals, and objectives.

Following the increased deployment of digital technologies and data in private and public organizations, the need for consultants with a capability to promote the use of technology in developing organizational processes and innovate new products/services is increasing and presents an opportunity for program specialization. While many business disciplines focus entirely on business development and innovation, career opportunities as a business analyst related to aligning business with IT opportunities continues to be an important option for the job placement of IS graduates. For building competencies in IS Management and Strategy, two elective IS competency areas are proposed: (1) Digital Innovation and (2) Business Process Management.

The **Digital Innovation** area focuses on competencies needed in the deployment of information technologies to innovate and transform organizational processes and value offerings (products and services). To participate in such innovation processes, graduates need competencies related to how digital innovations are being created, distributed, and commercialized. This requires understanding of both theoretical and practical aspects of emerging and existing digital innovation, their potential impact, disruption, and transformation on business and society. It is advised that for building such competencies, practical hands-on application and theoretical business modeling be used. In order to participate in digital innovation creation, distribution, and commercialization, graduates will need to be able to (1) Articulate and critically reflect on the unique features that an application of emerging technology may offer, (2) Demonstrate knowledge of the role of digital business technologies in social and mobile domains, (3) Identify and critique characteristics necessary for digital innovation, (4) Identify and validate an opportunity to develop a new digital business model, (5) Identify and evaluate key issues related to implementation and infrastructure issues, (6) Identify and assemble the required resources, processes, and partners to bring a digital business model to fruition, and (7) Practically demonstrate the investigation and application of a new innovation.

Process modelling is a foundational skill required to be able to implement a complete Business Process Management capability in an organization. The **Business Process Management** competencies include being able to establish a sound theoretical basis of state-of-the-art theories

in the field of Business Process Modelling (BPM) and to discover and practice the techniques and best practices in the field of BPM.

4.2.6 IS Integration competency realm

IS Integration competencies are typically introduced toward the end of the undergraduate program. The purpose is to engage students in learning experiences where they integrate and apply knowledge and skills learned across the curriculum. Given the applied nature of the IS discipline and profession, an opportunity to work through a comprehensive project experience, to change perspectives and methods as needed, to address and deploy different perspectives, and to experience unanticipated and unscripted problems as a team, is of critical importance. For this area, two required interchangeable competency areas (Project Management; IS Practicum) are provided. These areas are described as interchangeable as they accommodate ends of the spectrum of IS programs that run a gamut from closer proximity to organizational concerns (e.g., an MIS program) and those with closer proximity to technical concerns (e.g., a CIS program). The first competency area in this realm is IS Project Management and it would typically appear in a program whose context is more geared toward organizational concerns. IS Practicum would typically appear in a program whose context is more geared toward technical and implementation concerns. This need not be an exclusive designation.

The **Project Management** area provides an understanding of the concepts of project management and appropriate project management techniques in dealing with IS management. Topics include principles of project management, project management functions, project management processes, selecting an appropriate project management methodology, agile software development principles, and scrum. Emphasis is placed on understanding and gaining practical knowledge of key project management skills: integration management, scope management, time management, cost management, quality management, human resource management, communications management, and risk management. Emphasis is also placed on understanding iterative development processes and decision criteria for choosing between planned and agile project management approaches. To contribute to project management, students need to learn the tools, techniques, and processes to manage project performance along with moving from one phase to another until the closure of the project.

The second competency area in this realm is the IS Practicum and would typically appear in a program whose context is more geared toward technical and implementation concerns. This need not be an exclusive designation.

The **IS Practicum** area is an applied synthesis of foundational courses related to exercising design and applying one or more media of construction to effect and implement an IS artifact to suit client or organizational needs. Emphasis on the application of data management, application development, IT infrastructure, and IT Project Management. Students work in teams and apply a software/systems development paradigm toward the development of a system prototype to satisfy the intentions and needs of an organizational client. Client interaction, often best facilitated via the use of Agile software methods, must be sustained and ongoing such that emergence in design and development can be experienced.

We are not proposing any specialization or electives in this competency realm, although it is perhaps important to note that *IS Integration* competencies form a significant area in graduate IS programs, with concepts such as “enterprise architecture” or “IT service management” very central in that curriculum.

4.3 Guidelines for different educational contexts

To illustrate the adaptability and flexibility of the curriculum structure and demonstrate how different types of academic contexts can use it, we provide examples of three different educational contexts in which undergraduate degree programs in IS exist.

1. Computing and Engineering Schools: The educational context is characterized by good coverage of technical competencies. Degree structures offer relatively greater affordance for courses dedicated to the major.
2. Business Schools: The educational context is characterized by good coverage of one domain of practice context (business) and explicit attention to individual foundational skills. Degree structures offer relatively lesser affordance for courses dedicated to the major.
3. Information Schools: The educational context is characterized by primary interest in information and the relationship among information, people, and technology. Degree structures typically offer relatively greater affordance for courses dedicated to the major.

These are by no means exclusive cases and are provided as illustrations of how to use this model curriculum in different academic environments. Within these contexts, typical choices related to major, minor, and collaboration with other disciplines will be discussed.

When comparing the educational contexts in Tables 4-1, 4-2, and 4-3, we have used an approximation that an undergraduate IS program comprises 40 courses. A typical undergraduate IS program in the U.S. comprises a minimum of 15 three-credit courses in information systems, plus additional required courses that support the IS program, the overall bachelor’s degree requiring about 120 semester credit hours in total. In the European system, a typical undergraduate IS program comprises a total of 180 ECTS credits and courses are typically 5-6 ECTS credits, totaling about 30–35 courses. The total number of courses required for an undergraduate degree is likely to differ considerably, between individual universities, within and between geographic regions, and educational contexts. Hence, the assumption of 40 courses overall is merely an approximation, to allow some comparison between the three educational contexts.

4.3.1 Computing or Engineering School

In Computing or Engineering Schools, IS programs exist in a context with many disciplines having a more technical approach to information technology and systems, such as computer science, information technology, cybersecurity software engineering, and/or data science. The IS undergraduate program differs from other programs as being less technical, and with a more applied focus, and emphasis on interaction with users.

Table 4-1 presents an example of a realistic degree structure in this type of a school. A typical average IS major consists of 15 courses or 37.5% of the degree. This is sufficient for covering all required IS competency areas. The size of IS electives (five courses) is sufficient for a somewhat in-depth specialization. In many schools, degree structure also comprises a "domain core" module, to ensure that a student learns technology application in at least one domain of practice.

Table 4-1 Positioning the IS2020 Competency Areas to a typical degree structure in Computing Schools

Degree Structure	IS Competency Areas
General Education Core (15 courses)	As part of Computing Core - Foundations of IS
Domain Core (5 Courses)	Competencies in the - Domain of Practice Competency Realm
IS Core (10 Courses)	Required IS competency areas: - Data / Info. Management - IT Infrastructure - Secure computing - Systems Analysis & Design - Application development / programming - IS Management & Strategy - Ethics, use and implications for society - IS Project Management - Practicum
IS Electives (5 Courses)	Specialization in Systems Development (example): - Object oriented paradigm - Web programming - Mobile programming - User interface design
Minor or Free Electives (5 Courses)	- (electives/minor chosen by the student)

<u>The IS major</u> in computing and engineering schools enables graduates to excel in technical competency areas, related to areas such as data, IT infrastructure, computing security, and development (addressed both in the General Education Core, IS Core, and IS electives). The Domain Core with five courses also offers students the possibility to focus on one domain of practice. It is perhaps important to note that the Individual Foundational competency realm is not easily associated to any module as such. Rather, to ensure alignment with the IS2020 recommendations, students need to learn individual foundational competencies as part of their Major Subject courses with the IS Practicum playing an important role here.

<u>Collaboration with other disciplines</u>: While this degree structure is conducive to the production of IS degrees, the availability of IS faculty resources (and the number of students in the major) may be limiting factors. Where resources are limited, an exchange of courses with other computing disciplines may be required. Such opportunities probably exist for both the IS core and electives.

Naturally, competition over students and resources may flavor such collaboration. Further, some collaboration is also required in arranging the domain core, as students would typically study this domain core outside of the computing/engineering school.

An IS minor for other subjects: In computing/engineering schools an IS minor is primarily offered to students who are majoring in one of the more technical areas. For these students, an IS minor could offer a possibility to broaden their competencies outside their immediate area of specialization. For example, for a student majoring in cybersecurity, an IS minor could provide an opportunity to learn about infrastructure, data, and systems development, and analysis of the use domain. Courses offered as part of the IS core (focusing on required IS competencies) would offer a natural starting point for the minor. It is also possible to rely on an IS concentration structure where the subject focus of the major is recommended and approved at the departmental or IS studies program level.

Accreditation: IS programs in computing and engineering schools often seek accreditation from ABET. The structure described above is well-suited to such an accreditation.

4.3.2 Business School

In Business Schools, IS programs exist in a context with many disciplines having a specific view on business operations, such as Accounting and Finance, Management and Organization, Marketing, Economics, Supply Chain Management, Entrepreneurship, International Business, and Business Statistics. The IS undergraduate program differs from other majors as being more technical, with a focus on the technical design of information systems in addition to their practical application in different business functions.

Table 4-2 presents an example of a realistic degree structure in a business school. On average, a typical average IS major in a business school consists of 6+2 courses or 20% of the degree. With only six courses, the size of the core is sparse in terms of meeting all required core IS competency areas. The allowance for IS electives (set for two courses) is sufficient for select additional in-depth specialization in one area. In some universities, students may be able to choose a minor from a computing school, but most students will do a business minor.

Table 4-2 Positioning the IS2020 Competency Areas to a typical degree structure in Business Schools

Degree Structure	IS Competency Areas
General Education Core (15 courses)	North America: General Education Core Europe: Language and Communication Studies - IS Foundations
Domain/Business Core (12 courses)	Competencies in the - Domain of Practice Competency Realm
IS Core (6 Courses)	Required IS competency areas: - Data / Info. Management - IT Infrastructure

	- Secure computing - Systems Analysis & Design - Application development / programming - IS Management & Strategy - Ethics, use and implications for society - IS Project Management - Practicum
IS Electives (2 Courses)	Specialization in Use Domain (example): - Business Process Management - Digital Innovation
Minor or Free Electives (5 Courses)	(electives/minor chosen by the student)

The IS major in business schools enables graduates to excel in one domain of practice (business) as a central theme in the general educational core. In addition, individual foundational competencies, including language and communication studies, receive high priority in the general business educational core. The challenge for IS programs in business schools is to address all required IS competency areas within only six compulsory courses available. This may, for example, require a combination of two IS competency areas in a single course, or for an IS competency area to be addressed as part of a compulsory course in the general business educational core. However, the IS2020 guidelines do bring forth the need for a meticulous approach in designing undergraduate IS curriculum in business school contexts. The IS2020 guidelines specify minimum skill levels for knowledge-skill pairings to avoid compromises to essential preparedness for graduates of IS programs.

Collaboration with other disciplines: An additional challenge and concern for the IS discipline is evident in increasing digitalization of organizations and functions and professions within them. The deployment of digital technologies, discussed in Chapter 2, are not only affecting the IS discipline but also impact specific business functions and disciplines in a manner that may be even more profound. The Management Curriculum for Digital Era (MaCuDE) project (supported by groups such as AACSB) was launched in the beginning of 2020 to investigate how digital technologies are affecting the business school curriculum. In a new situation, students and faculty of other disciplines make well-justified calls for including courses such as “Digital Marketing” or “Digital Governance and Strategy,” in addition to “must have” courses on Enterprise Systems, or Excel.

An IS minor for other subjects in business schools is offered to students majoring in any of the business disciplines. For those students, an IS minor offers a possibility to broaden their professional competency with technical competencies. The needs of the students vary depending on their major. A Finance and Accounting major, with specialization on auditing, may find databases, technology infrastructures, and computing security useful. A marketing major is more likely to be interested in big data analytics, IS use and ethics, or application development. In addition to courses that are defined in the core for the IS major, electives such as Digital

Innovation or Business Process Management could also be useful. Defining a fixed set of courses to be defined as an IS minor may therefore not serve the interests of the students.

Accreditation: The most common accreditations for business schools are AACSB and EQUIS. AACSB accreditation leads business schools to place a lot of emphasis on individual foundational competencies. Responsibility, Critical Thinking, Teamwork and Presentation skills are typical school-level learning goals and AACSB requires schools to monitor their achievement as part of an Assurance of Learning process. In this sense, recommendations related to individual foundational competencies in IS2010, MSIS2016 and now in IS2020 align well with the AACSB requirements. An individual program can seek AMBA accreditation, but that is not discipline specific and hence does not have specific requirements for IS (or any other discipline).

4.3.3 Information School

Individuals interested in combining technical knowledge and business skills should consider a degree in information management, that may also be referred to as management information systems, computer information systems or electronic business design. Some programs focus more heavily on either the technical or business aspects of the field; prospective students can choose between them based on their academic interests.

Information schools, colleges, and departments have been newly created or are evolving from programs formerly focused on specific tracks such as information technology, library science, informatics, and information science. While each individual School has its own strengths and specializations, together they share a fundamental interest in the relationships between information, people, and technology. An interdisciplinary approach is followed to understand the opportunities and challenges of Information Management. It is concerned with questions of design and preservation across information spaces from digital and virtual spaces to physical spaces that include libraries and museums. Course offerings often include information architecture, design, policy, knowledge management, user experience design and usability, human-computer interaction, and computer science. The IS undergraduate program differs from other majors as being a mixture of interests in both the technical and the application of IS in practice. It must be noted that there are a wide variety of different undergraduate degree structures. A number of information schools offer only master’s degrees and no undergraduate degrees.

Table 4-3 presents an example of a realistic degree structure in this type of a school where IS will be a major. A typical average IS major (or any other major) consists of 15 courses or 37.5% of the degree. The size of the core is extensive, for covering all required IS competency areas.

Table 4-3 Positioning the IS2020 Competency Areas to a typical degree structure in Information Schools

Degree Structure	**IS Competency Areas**
General Education Core (15 courses)	General educational core: Foundations of IS, Writing and communication, Health related subjects.
Domain Core (12 courses)	Competencies in the - Domain of Practice Competency Realm
IS Core (6 Courses)	Required IS competency areas: - Object-oriented programming - Database concepts - Web programming - IT Infrastructure - Human-computer interaction - IT integration - Ethics - Security
IS Electives (2 Courses)	Specialization on analytics (example): - Data Visualization - Data / Business Analytics - User Interface Design
Minor or Free Electives (5 Courses)	(electives/minor chosen by the student) Mostly Statistics or Mathematics or Computer Science

The IS major in information schools allows students to excel in data and knowledge management, as this area forms a key substance of the general education core of the degree. With 40 to 50% of the degree allocated to an IS core, and about 20% to IS specialization, programs can easily address all required IS competency areas. A challenge for IS programs in information schools is to how to balance required IS technical and management-oriented competencies. In China, following the guidelines from the Chinese Education Guide Committee, the IS curriculum should be updated every 4 years in order to catch up with the competencies required from the job market in China.

Collaboration with other disciplines: A wide variety of other disciplines are combined with IS to make up the undergraduate degree. The most popular disciplines are Library Science, Curation, Computer Science, Communication Science, Data Science, Cyber Security, eCommerce, and Health Care Informatics, to mention only a few.

An IS minor for other disciplines in information schools is offered to students majoring in a wide range of disciplines. Examples of these disciplines are Library Science, Communication Science, Computer Science, and Digital Media and Society. While IS competency areas in data and analytics and in systems development can provide a useful addition to the major, it might also be useful to consider competencies in the areas of secure computing, or IS ethics.

Accreditation: The most common accreditations for information schools seek accreditation from ABET. The structure described above meets well the required competencies in ABET, as an example. Although not a form of accreditation, information schools also seek recognition from the iSchool organization, representing over 100 information schools globally (https://ischools.org).

4.4 Linking IS2020 with MSIS2016

This section shows how IS2020 prepares the student for the recommendations of MSIS2016. Table 4-4 shows the Information Systems competencies required by MSIS2016 and the competencies specified in IS2020 that will prepare the student for the master studies.

Table 4-4 Comparing competencies in MSIS2016 and IS2020

IS Competency Areas in MSIS2016	Corresponding Competency Areas in IS2020
Business Continuity and Information Assurance	Secure computing
Data, Information and Content Management	Data / Information Management
Enterprise Architecture	Included in Systems Analysis and Design, IT Infrastructure, IS Management and Strategy
Ethics, Impacts and Sustainability	Ethics, use and implications for Society
Innovation, Organizational Change and Entrepreneurship	Digital innovation
IS Management and Operations	IS Management and Strategy, IS Project Management
IS Strategy and Governance	IS Management and Strategy
IT Infrastructure	IT Infrastructure
Systems Development and Deployment	Systems Analysis and Design, IS Practicum

MSIS 2016 identifies four competency areas as prerequisites for the master’s program: (1) foundational understanding of IS and its role in organizations, (2) Data, Information and Content management, (3) IT infrastructure, and (4) Systems development and Deployment. The IS2020 competency realms and required competency areas align well with these prerequisites. The competency area of Application Development and Programming distinguishes IS2020 from MSIS2016.

4.5 Resource requirements

Overall, the adoption of digital technologies in all sectors of society has increased the need for IS professionals with competencies in the design of digital systems to include the analysis of domain-specific requirements and sensitivities. In the IS2020 model curriculum, the entry-level competency requirements of IS graduates are clarified in order to guide the design of an IS curriculum. While curriculum design is highly significant, accounting for the required resources for implementation is equally significant. Three main themes are identified.

- Diversity: the variety of competency areas that IS faculty should master is becoming increasingly diverse.
- Number of faculty: student volumes both in IS majors and IS minors is increasing. This requires, among other measures, more resources.
- Teaching methods: IS faculty and students are well equipped to deploy learning technologies. This requires sufficient computing resources, together with a possibility to experiment with new kinds of software.

In current educational structures, IS is rarely the “core” subject of the school. Rather, IS combines perspectives from different schools and is cross-disciplinary in nature. While such combinations are valued in practice, they are not as easily realized in the academy, where disciplinary silos remain. In this regard, the role of deans and other academic heads remains highly significant for securing sufficient resources for IS programs.

5. Use of the model curriculum

This chapter addresses the use of the IS2020 model curriculum. Benefits to IS stakeholders are outlined along with the proposal of ways in which this model can be utilized. In doing so, the inherent tensions that arise in any attempt to provide comprehensive guidelines regarding detail and granularity are acknowledged – too generic, making them too broad but easy to implement versus becoming too prescriptively specific in details and advice. The IS2020 attempt addresses the deployment of the model curriculum from the perspectives of a range of stakeholders: from academic executives to teaching faculty of various disciplines. Also, there was a concern with the nature of the discipline regarding such model curricula reports. Traditionally, these reports represent a snapshot in time in the form of a stable "pdf" report that is hopefully well-groomed and edited. However, given the rapid proliferation and elaboration of the discipline, it has been considered that the report may also manifest as a living document, an adaptive repository facilitating ongoing discussion and changing requirements. In the deliberation regarding these tensions, an attempt has been made to accommodate both the granular and the broader conceptualizations using competencies and attendant realms that are described in section 5.1 below. Regarding the ongoing and emergent nature of curricula specification, the initiatives and efforts on this subject are described along with a call to make the IS curriculum process more sustainable through the deployment of a living document protocol; these initiatives and efforts are described in section 5.2.

5.1 Use of the model curriculum report

This document contains high-level guidelines that are designed to be sustainable over time. It defines the boundaries of the IS discipline and identifies its competency realms and areas and introduces the idea of competencies as the underlying foundation for curriculum design. Although it is expected that the technology and systems vehicles that underpin the current IS2020 curriculum will change progressively, it is expected that these high-level guidelines will remain relevant over time. As such, they provide a valuable framework for all stakeholders who have an interest in IS Curriculum, namely: academic executives; academic heads; faculty (both IS and Non-IS); accrediting bodies; representatives from industry; and students.

5.1.1 Requirements definition

A fundamental purpose of this report is to provide a language for discussing the educational role and requirements of the IS discipline in computing schools, business schools, and information schools. The provision of stable high-level guidelines in Chapter 4, suitable for decision making at different levels, are valuable, and often sufficient, for many stakeholder groups (such as executives and resource managers). Chapters 1 and 2 additionally describe the foundations: history and current view of IS discipline, as well as the IS professions that are closely related to the discipline. In computing schools, foundations and guidelines define the relationship with other computing disciplines, including data science and cybersecurity. In business schools, digitalization of the economy is increasing student interest in IS education, and these guidelines define its fit into the business world.

It is essential to understand at this point that the required resources (physical and faculty), credit-hour requirements, and implications of educating core and elective competencies require careful thought and balance. As such, increasing interest in IS as a major or minor subject, together with the diversity of technologies and competencies to be addressed, make resource considerations critical for IS subjects. Therefore, the curriculum guidelines shared in this report constitute important considerations for resource planning at multiple levels, from executives through to faculty planning. Correctly planning for these requirements will be important evaluation criteria for accreditation bodies.

5.1.2 Program design

For IS faculty, these guidelines will assist in curriculum and course design and are of interest to academic leaders and administrators responsible for IS programs. As IS competency needs are becoming more diverse, the need to make conscious choices in curriculum design is evident. This model facilitates evaluative dimensions that program decision makers and leaders can use to confirm their program profile and design appropriate curriculum units that promote competencies. The competency realms and areas prescribed in section 5.1.3 provide concepts that may assist in making the high-level profiling choices and selections in curriculum design.

These guidelines make deliberate and effective recommendations for designing the IS program core. For example, as noted in section 4.2, whereas the previous IS2010 curriculum model did not specify sufficient technical skills to satisfy the needs of industry and academic investigation, this document has attempted to do so here. However, this will not be without important consideration for resources and curriculum design and constitute, for some, a significant challenge. Moreover, as this curriculum model indicates the selection of core competencies across four different pillars, program designers must select the appropriate competencies to weave together as content to be presented in learning units, that, when amalgamated, lead to elective specializations and courses. Careful consideration is required to balance the capabilities of faculty, the need for continuous improvement, and upskilling. This should place the burden, appropriately, on the program, but it is believed the competency-based model provides the acuity and flexibility of articulation to accommodate this challenge.

IS faculty responsible for individual course design may use the framework outlined in these recommendations to incorporate competency-based thinking in individual courses. For this purpose, more detailed accounts have been included of each competency area, detailing more specific competencies, and further breaking them down to required knowledge areas, skills, and dispositions (see section 4.2 and Appendix 3). It is believed that these materials will assist educators to define learning goals and course content descriptions that explicitly address knowledge-skill levels. Doing so will assist to better define the role of a given course in the overall curriculum of a module or program.

5.1.3 Competency identification

There is a necessary relationship between the design of undergraduate IS programs, expected to lay a foundation for often-evolving career opportunities, and the expectations that industry has

for graduates of such programs. IS undergraduate programs exist as a mutual predicate for both parties and, to remain relevant, should continue to do so. For IS professionals and students, these guidelines should assist in student decision making and career planning, in fostering industry engagement, and in IS professional continuous improvement processes. Section 1.2 of this report describes a contemporary view of the IS profession, so that students may make informed choices regarding their undergraduate IS studies and the implications these choices have for their career. Similarly, we anticipate benefits for IS recruitment agents such that clear competency expectations from IS graduates are available and known. Although the competency model herein refers to competencies that students build by doing tasks in courses, it is believed they are comparable to and consistent with industry-based competency frameworks, such as e-CF and SFIA. By doing so, this report supports a continuous process of competency identification with attention to the explicit identification of the underlying knowledge elements, skills, level, and dispositions that constitute these competencies.

5.2 Living document and sustaining the process

The provision of permanent guidelines that continue to be relevant to an industry in perpetual flux is challenging, if not impossible. The need for dynamic online platforms to facilitate ongoing discussion has been recognized in prior guidelines (IS2010 and MSIS2016) and was one of the recommendations of the exploratory task force for IS2020.

An ongoing (and thus timely) discussion would be particularly relevant for academic program heads and faculty members who design curriculum and courses. Such discussion would support IS faculty to address new competency requirements and share implementation experiences with competency-based guidelines in different educational contexts. As the process of defining a curriculum that sufficiently addresses all selected competencies, in the presence of restrictions related to a specific educational context, is a complex task, the need for an online and digital community is evident.

The IS2020 task force has paid special attention to promoting an ongoing discussion which will continue after this report has been finalized. The recommended approach utilizes a combination of process governance already part of existing AIS and ACM committees, and use of traditional and on-line forums as venues for discussion. Hence, a continuous discussion will proceed as follows.

- The ongoing discussion should be governed and facilitated through the AIS SIGEd and the ACM Education Board working in close collaboration.
- There should be an annual panel in a dedicated AIS and/or ACM conference, that focuses on IS curriculum issues.
- The IS2020.org site should continue to serve as a platform for discussion, and knowledge sharing surrounding IS curriculum design and related research.

To sustain an ongoing effort involving dedicated and competent participants, a proper incentive structure will be essential. Articulating benefits of this living community to sponsoring organizations and contributing individuals is critical to engaging members. Institutional members

(e.g., ACM and AIS) would have their organization logo, details, and description on a page on the site as well as a Living Document Community membership badge for use on the institutional websites. Each institutional member would receive voting rights at meetings as well as an annual impact report from the Board, featuring highlights from that year's activities. Individual members may gain several benefits, including participation in academic service and scholarly research in improving IS competencies. Participants would be able to contribute to and borrow from best practices. Further, as a focus for IS curricula, it is hoped the community would serve as a nexus and clearinghouse to share academic conferences and journal publishing opportunities for curriculum-focused research and output.

What is feasible in the era of rapid digitalization is to develop a repository and a community to support and maintain it. The extension of input to a broader community provides an opportunity for the body of a model curriculum report to be sustained and thrive as a "living document."

A subset of the IS2020 task force along with a subset of members of the CC2020 task force have begun to produce the beginnings of an open living community. This concept is presented as a first draft for engaging in a competency basis for curriculum design and articulation. Thus, the aims of a living document and curriculum community are the following.

- The provision of a repository, clearinghouse and database for competencies and competency elements as a web-based tool
- Peer and community support for the development and utilization of competencies
- The facilitation of discourse on existing and proposed curricular elements
- A participatory process whereby input and modification to a candidate model curriculum may occur on an ongoing basis
- A structured open community, designed as a foundation, based on best practices from the open-source software community.

This section outlines potential processes and procedures that might be used to augment and supplement the IS2020 model curriculum report in hopes of developing the tools, support, and community that allows for the iterative and emergent development of this model. The intent is to shorten the period between formal reports and foster a more direct and open capture of community input. Proposed details are provided in a document titled *A Process for a Living Document and Curriculum Community* available at *IS2020.org*. These details include suggested operating procedures, architectural elements, an outline of expected phases and codes of conduct for such a community.

5.2.1 Proposed Community Management and Governance Structures

While it may seem presumptuous for this task force to recommend an additional endeavor, a well-governed community of those who engage with information systems education requires some clear outlines of norms of behavior and discourse. In this regard, we borrow from both the literature on volunteer groups and from the experiences of the open-source software community. A broad sketch of leadership and roles follows.

Board of Directors. As an example of a Living Document Community governance structure, the task force suggests the need for a board of directors. The board should be responsible for resources, and formal reporting and communication with founding and collaborating organizations. Membership of the board would include representatives of the ACM and AIS education boards or SIGs, a steering group chair, and technical developers. A structure should include persons serving in traditional roles of President/Chair, Vice President/Chair, Secretary/Treasurer, and appointed representative liaisons from the ACM Education Board and AIS Education. The board should be responsible for accountability to the membership for progress on the core mission and updates on the health and well-being of the project.

Steering Group. A Steering Group should be responsible for and have oversight of operations and the value of development work for the community: Members representing participating institutions should have responsibility for strategies for continued relevance and value, setting priorities for development work, recruiting people to document groups, and promoting broader user engagement. The steering group should hold regular meetings.

Technology and Development Group. A longer-serving group should remain dedicated to the development and maintenance of the web applications that constitute the community and tooling described in this appendix. This group should have responsibility for the design, development, maintenance, and deployment of all infrastructure, data, and software systems of the open community.

Document Group. A document project group should be responsible for the adoption and change of particular documents, aiming to create value for curriculum design activities of the participating universities. This group should be composed of scholars from participating institutions or registered users of the community, selected based on expertise, experience, and commitment to the document group.

Membership. In order to engage in the community, it is necessary to become a member of a Living Document Community (LDC). This is necessary to encourage the accountability, attribution, authentication, and authorization necessary for healthy participation in the community. Membership categories might include institutional representative members or individual membership. The Living Document Community would best operate with input and support from institutional members: academic, municipal, and corporate. It is important to encourage institutional membership in order to acknowledge their support and give voice to organizations and institutions interested in supporting and sponsoring the Living Document Community and a Competency-Based Computing Curricula Tool (C3T). Each institution would have their organization logo, details, and description on a page on the site as well as a Living Document Community membership badge for use on the institutional websites.

5.2.2 Living Document Community Foundation Goals

A Living Document Community would support several goals that it endeavors to address and support. Its focus would support both individuals and institutions who wish to browse, develop, or discuss computing curricula from a competency perspective. The Living Document Community aspires to advance state of the art in curriculum development, through an open-source model.

Through this platform, the Living Document Community will promote the use of the Competency-Based Computing Curricula Tool (C3T) and Living Document Community features among the world-wide computing education community. Continued community engagement will be the promotion of the Living Document Community by sponsoring panels, workshops, research, conference sessions, social media, and community events.

An internet-mediated platform will be used to provide the infrastructure to house and service the community who choose to engage with the managed content. Through a governed platform, a number of different stakeholders will be supported. In order to provide stability to the organization, decisions on membership and levels of access to the system must be defined as well as any membership fees or contribution expectations.

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APPENDIX 1 – Program Level Career Tracks and Competency Areas

Appendix 1 shows the association between various competency areas discussed in this report and possible career tracks (see page 79). The amount of emphasis of a particular concentration for a career track is shown by shading. We have three levels: beginner, intermediate, and proficient. The brown color depicts competencies that this report views as required by all IS programs. The blue color depicts optional (or recommended) competencies.

In the curriculum design process, Appendix 1 is intended to be used in selecting high level goals and specializations for the program (Figure A1-1). The curriculum manager can use the table (p. 79) to discuss the broad design options, and career tracks, with employers and recruiters, with department heads and faculty, and with students. Table A1-1 assists in translating career opportunities of the local job markets into considerations related to program goals and specializations, and ultimately to the role of different competency areas within the program. By doing so, it provides one central input for defining more specific targets for competency levels in selected competency areas.

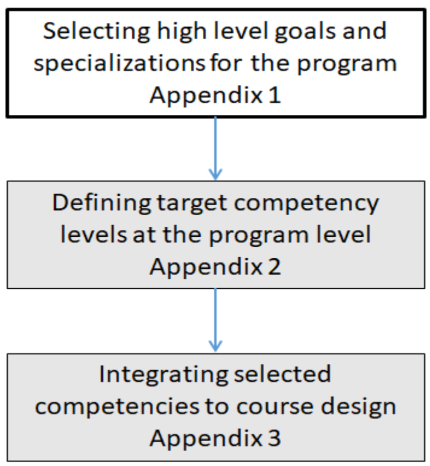

Figure A1-1: Intended use of Appendix 1 in a competency-based curriculum design process

In addition to its use in the curriculum design process, the table (p. 79) can be used in a few ways. A person who would like to specialize in a specific track can identify which competencies are needed for that career. For example, a data scientist would need to be proficient in information management, analytics, and information visualization whereas the proficient competencies for a security executive would be IT infrastructure and Secure Computing. A student could also start from the competencies and identify job tracks they could pursue. For example, a student who is passionate about information visualization could identify with a career in UI/UX design.

To be able to use this table to build a curriculum with a specific career path in mind, we have used the first three levels of the Skills Framework for the Information Age (SFIA framework) (https://sfia-online.org/en).

The SFIA framework describes the skills and competencies required by professionals involved in information and communication technologies, digital transformation, and software engineering. There are seven levels of responsibility in the SFIA framework (Figure A1-2).

Figure A1-2 SFIA levels of responsibility (https://sfia-online.org/en/about-sfia/how-sfia-works)

Each level of responsibility is characterized by five generic attributes:

- Autonomy
- Influence
- Complexity
- Knowledge
- Business skills

Figure A1-3 Five generic attributes associated with SFIA 7 (Brown, 2020)

The current version of SFIA is SFIA 7 that focuses on the following themes:

- software engineering
- cybersecurity
- digital transformation
- Agile and DevOps
- big data and informatics
- knowledge (https://sfia-online.org/en/sfia-7)

Beginner Demonstrates application of basic knowledge and skills appropriate to the competency area. Expected to work under supervision and has very little discretion. Is expected to seek guidance in resolving issues. (SFIA Level 1)

Intermediate Demonstrates application of essential knowledge and skills appropriate to the competency area. Expected to work with little supervision for routine tasks. Uses limited discretion in resolving issues. (SFIA Level 2)

Proficient Demonstrates effective application of essential knowledge and skills appropriate to the competency area. Expected to work on complex and non-routine tasks with periodic supervision. Uses discretion in resolving issues. (SFIA Level 3)

Table A1-1 Competencies and Careers

Table A1-1 shows the association between various competencies discussed in this report and possible career tracks. The amount of emphasis of a particular concentration for a career track is shown by shading. We have three levels: beginner, intermediate and proficient. The brown color depicts competencies that this report views as required by all IS programs. The blue color depicts optional (or recommended) competencies. Table A1-1 can be used in a few ways. A person who would like to specialize in a specific track can identify which competencies are needed for that career. For example, a data scientist would need to be proficient in information management, analytics, and information visualization whereas the proficient competencies for a security executive would be IT infrastructure and Secure Computing. A student could also start from the competencies and identify job tracks they could pursue. For example, a student who is passionate about information visualization could identify with a career in UI/UX design.

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APPENDIX 2 – Competencies and Skill Levels by Competency Areas

Appendix 2 presents a table of a consolidated view of all the competency realms, competency areas, along with the description of each competency and the corresponding skill level (Bloom cognitive level). The skill levels shown in this table are consistent with Appendix 3. The table that begins on p. 82 reflects the highest skill level associated with a particular competency. The skill level will provide input to the type of assessment that needs to be included in the course. For example, MCQs may be suited for "Remember," "Understand," and "Apply," and Project may be suitable for "Create."

In the curriculum design process, Appendix 2 is intended to be used in program level discussions related to setting target levels for competencies (Figure A2-1). The curriculum manager can use the table to translate high-level considerations related to program goals and specializations into specific competency goals, thus providing input to the design of individual courses. Hence, depending on the goals and specializations of the program, some elective competency areas may be left out, and for included elective areas, the lists of competences, and associated competency levels, can be adjusted to reflect the broader goals and specializations defined for the program.

For required competency areas, the competency lists and associated Bloom's skill levels do provide additional definition on the required competency areas. We consider such clarification necessary, as a brief competency area description alone is not sufficient to define required competencies. However, the purpose of the list of specific competencies with required areas is to guide, not to prescribe. While it would be ideal to reach the target skill levels in all competencies within the 10 required competency areas, curriculum managers can also exercise their own judgement in defining the detailed objectives.

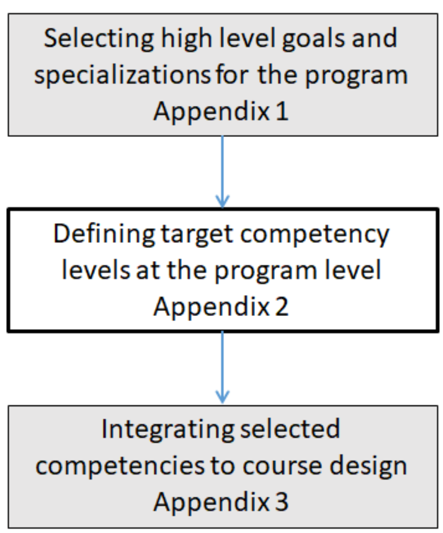

Figure A2-1: Intended use of Appendix 2 in a competency-based curriculum design process

In combination with Appendix 3, the table provided below can be additionally used in the following ways.

- A curriculum manager can review the overall curriculum and examine how well the courses in the curriculum map to the recommended or target skill level.
- An instructor teaching a specific course can adapt their course to include the competencies and the levels provided in this table.
- A school wishing to launch a new course offering in “Data Visualization,” can examine the competencies DATA.INVIS.1 to DATA.INVIS.7 to help design the course.

A curriculum manager can review the overall curriculum and examine how well the courses in the curriculum map to the recommended skill level.

Realm	Area	Abbreviation	Competency	Dispositions	L1 Remember	L2 Understand	L3 Apply	L4 Analyze	L5 Evaluate	L6 Create
FOUNDATIONS		FOUN	**Competency Realm: FOUNDATIONS**							
	Foundations of IS	FOIS	**Competency Area: Foundations of Information Systems (Required)**							
		FOUN.FOIS.1	Classify the components, elements, operations and impact of IS	Self-directed Inventive Purpose-driven						
		FOUN.FOIS.2	Interpret the dimensions, characteristics and value of quality information	Purpose-driven Self-directed Responsive						
		FOUN.FOIS.3	Explain the roles, responsibilities, and characteristics of the IS professional	Self-directed Inventive Purpose-driven						
		FOUN.FOIS.4	Recommend techniques for using information and knowledge for business decision making and strategic value	Self-directed Purpose-driven Professional						
		FOUN.FOIS.5	Analyze a business case and critique appropriate IS solutions to common business problems, based on the different components, elements, types, and levels of IS	Self-directed Purpose-driven Professional						
		FOUN.FOIS.6	Critique and recommend Enterprise Systems for a given business problem and processes.	Purpose-driven Professional Self-directed						
		FOUN.FOIS.7	Identify techniques for transmitting and securing information in an organization.	Purpose-driven Self-directed Professional						
		FOUN.FOIS.8	Demonstrate an ability to solve basic computational and design problems using IS development with appropriate methodologies, software tools and innovative methods for improving processes and organizational change	Self-directed Purpose-driven Professional						

DATA		DATA	**Competency Realm: DATA**	
	Data / Info Management	MGMT	**Competency Area: Data/Info Management (incl. Database) (Required)**	
		DATA.MGMT.1	Query the relational model	Meticulous Self-directed Purpose-driven
		DATA.MGMT.2	Design relational databases	Self-directed Purpose-driven Meticulous
		DATA.MGMT.3	Programming database systems using functions and triggers	Meticulous Self-directed Purpose-driven
		DATA.MGMT.4	Secure a database	Meticulous Self-directed Purpose-driven
		DATA.MGMT.5	Compare trade offs of different concurrency modes	Self-directed Meticulous Inventive
		DATA.MGMT.6	Develop non-relational models	Meticulous Self-directed Purpose-driven
	Analytics	ANLY	**Competency area: Data / Business Analytics (incl. Data Mining, AI, BI) (Optional)**	
		DATA.ANLY.1	Apply the principles of computational thinking (CT) to learning data science	Self-directed Purpose-driven Meticulous
		DATA.ANLY.2	Analyze data science problems with a CT framework	Self-directed Purpose-driven Meticulous
		DATA.ANLY.3	Express a business problem as a data problem	Self-directed Purpose-driven Meticulous
		DATA.ANLY.4	Perform exploratory data analysis from inception to the value proposition	Self-directed Meticulous Inventive
		DATA.ANLY.5	Explain the core principles behind various analytics tasks such as classification, clustering, optimization, recommendation	Purpose-driven Meticulous Self-directed
		DATA.ANLY.6	Articulate the nature and potential of Big Data	Self-directed Purpose-driven Meticulous
		DATA.ANLY.7	Demonstrate the use of big data tools on real world case-studies	Self-directed Purpose-driven Adaptable
	Visualiza	INVS	**Competency area: Data / Information Visualization (Optional)**	
		DATA.VIS.1	Explain the fundamentals of human perception and vision	Purpose-driven Self-directed Responsible
		DATA.VIS.2	Demonstrate effective ways of displaying numeric data, counts, and proportions	Meticulous Inventive Self-directed
		DATA.VIS.3	Present information in an understandable, efficient, effective, and aesthetic manner, for the purposes of explaining ideas and analyzing data.	Purpose-driven Self-directed Responsible
		DATA.VIS.4	Use a tool such as R (or Python) to perform basic data manip-ulation such as filtering, aggregating, and organizing data sets	Meticulous Purpose-driven Inventive

ation	DATA.VIS.5	Produce graphics using a visualization tool	Meticulous Purpose-driven Inventive
	DATA.VIS.6	Develop transformations and model to fit, explore, check assumptions about data	Meticulous Inventive Self-directed
	DATA.VIS.7	Express the story of the data in a compelling narrative	Inventive Self-directed Purpose-driven

	TECH	**Competency Realm: TECHNOLOGY**	
	INFR	**Competency area: IT Infrastructure (incl. Networking, Cloud) (Required)**	
IT Infrastructure	TECH.INFR.1	Explain key infrastructure concepts, including how it functions, how to define critical functions, and how to plan and manage infrastructure	Self-directed Purpose-driven Professional
	TECH.INFR.2	Explain the principles of layered network architectures	Self-directed Meticulous Responsible
	TECH.INFR.3	Explain the components of IT infrastructure solutions from client/server, network hardware, (including wireless and wired)	Self-directed Meticulous Responsible
	TECH.INFR.4	Explain the principles of network software and configuration	Self-directed Responsible Proactive
	TECH.INFR.5	Explain network protocols and their configuration	Self-directed Responsible Proactive
	TECH.INFR.6	Illustrate a clear understanding of security principles as they pertain to networks	Self-directed Professional Responsible
	TECH.INFR.7	Examine and critique IT infrastructure for organizations	Self-directed Responsible Purpose-driven
	TECH.INFR.8	Examine and critique IT server architecture (physical or cloud)	Self-directed Responsible Purpose-driven
	TECH.INFR.9	Explain concepts of Enterprise Architecture	Self-directed Responsible Purpose-driven

TECHNOLOGY	Secure Computing	**SECU**	**Competency area: Secure Computing (Required)**	
		TECH.SECU.1	Explain the purpose of cryptography and how it can be used in data communications	Responsible Purpose-driven Self-directed
		TECH.SECU.2	Describe the concepts of authentication, authorization, access control, data integrity and how it helps to enhance data security	Self-directed Responsible Purpose-driven
		TECH.SECU.3	Explain the security requirements that are important during software design	Self-directed Responsible Professional
		TECH.SECU.4	Analyze the concepts of identification, authentication, and access authorization in the context of protecting people and devices	Self-directed Responsible Professional
		TECH.SECU.5	Analyze the importance of social media privacy and security	Self-directed Responsible Professional
		TECH.SECU.6	Illustrate how cyberattacks work, how to avoid them and how to counteract their malicious consequences	Purpose-driven Inventive. Self-directed
		TECH.SECU.7	Describe risk management techniques to identify and prioritize risk factors for information assets and how risk is assessed	Professional Self-directed Responsible
		TECH.SECU.8	Illustrate the types of security laws, regulations, and standards within which an organization operates	Professional Self-directed Responsible
	Emerging Technologies	**EMER**	**Competency area: Emerging Technologies (e.g. IOT, blockchain, etc.) (Optional)**	
		TECH.EMER.1	Research and identify a selection of current and emerging technologies	Self-directed Purpose-driven Inventive
		TECH.EMER.2	Evaluate technologies based on a range of business requirements	Self-directed Purpose-driven Inventive
		TECH.EMER.3	Make recommendations about the usage of technologies	Self-directed Purpose-driven Inventive
		TECH.EMER.4	Investigate technologies through a theoretical lens	Self-directed Purpose-driven Inventive
		TECH.EMER.5	Evaluate technologies from an ethical and sustainability perspective	Self-directed Purpose-driven Inventive
		TECH.EMER.6	Identify the impact of technologies on society and business	Self-directed Purpose-driven Inventive
		TECH.EMER.7	Practically design and apply technologies to a business problem	Self-directed Purpose-driven Inventive
		TECH.EMER.8	Apply emerging technologies in a teamwork scenario	Self-directed Purpose-driven Inventive

	DEVP	**Competency Realm: Development**	
Systems Analysis & Design	SADN	**Competency area: Systems Analysis and Design (Required)**	
	DEVP.SADN.1	Explain what systems are and how they are developed	Self-directed Responsible Proactive
	DEVP.SADN.2	Demonstrate the SDLC phases and activities	Self-directed Responsible Meticulous
	DEVP.SADN.3	Identify SDLC Models (Agile, Waterfall, V-shaped, iterative, spiral)	Self-directed Purpose-driven Responsible
	DEVP.SADN.4	Work effectively in a team environment	Collaborative Adaptable Responsible
	DEVP.SADN.5	Describe data modeling techniques	Self-directed Responsible Purpose-driven
	DEVP.SADN.6	Describe the role and responsibilities of the participants in SDLC	Self-directed Responsible Purpose-driven
	DEVP.SADN.7	Explain the common ways projects fail and how to avoid these failures	Self-directed Responsible Purpose-driven
	DEVP.SADN.8	Identify Enterprise Architecture concepts related to SDLC phases	Self-directed Responsible Purpose-driven
Application Dev and	ADEP	**Competency area: Application Development and Programming (Required)**	
	DEVP.ADEP.1	Develop data storage strategies using primitive data types in a computer's volatile memory	Purpose-driven Meticulous Inventive
	DEVP.ADEP.2	Apply data transformations using arithmetic, assignment, and transpositional operators	Purpose-driven Meticulous Inventive
	DEVP.ADEP.3	Develop predicate expressions using relational & logical operators	Purpose-driven Meticulous Self-directed
	DEVP.ADEP.4	Express algorithmic problem-solving using sequence, selection, and repetition structures	Purpose-driven Meticulous Inventive
	DEVP.ADEP.5	Modularize the algorithmic and operating capabilities of a program using functions, methods, subroutines or similar organizing structures.	Purpose-driven Meticulous Inventive
	DEVP.ADEP.6	Select and utilize appropriate linear and non-linear data structures to maintain and manage sets of related data in non-volatile memory	Purpose-driven Meticulous Inventive
	DEVP.ADEP.7	Utilize Object-Oriented concepts in the organization and structuring of programs for behavior and concept management	Purpose-driven Meticulous Inventive
	DEVP.ADEP.8	Conduct a systematic requirements analysis to determine the basic facts used to organize the application of programming effort to solve a problem or reach a goal	Purpose-driven Meticulous Inventive
	DEVP.ADEP.9	Formalize and communicate requirements in a manner that is comprehensible for all stakeholders that will determine the success of the software system	Purpose-driven Meticulous Inventive

Development	Programming	DEVP.ADEP.10	Specify the software system architecture such that the principal components and dependencies of the system are visible and comprehensible for all involved in shaping the materials of design and construction	Purpose-driven Meticulous Inventive
		DEVP.ADEP.11	Identify the lateral components and libraries that the designed and developed system will depend on	Purpose-driven Meticulous Inventive
		DEVP.ADEP.12	Develop the programming code implementation that realizes the system architecture and design.	Purpose-driven Meticulous Inventive
		DEVP.ADEP.13	Test all developed programming code components to ensure fidelity, consistency, and fit.	Purpose-driven Meticulous Inventive
		DEVP.ADEP.14	Maintain software throughout deployment and utilization such that extant or new intentions and requirements are accommodated such that the intended purpose will function.	Purpose-driven Meticulous Inventive
		DEVP.ADEP.15	Adopt, or adapt, an appropriate software systems process methodology such that people, resources, design requirements and other dynamic considerations allow for correctness and utility.	Purpose-driven Meticulous Inventive
		DEVP.ADEP.16	Establish and maintain the appropriate dialog among stakeholders that ensure a degree of communication and information transparency to maintain the viability of the software system	Purpose-driven Meticulous Inventive
	Object-Oriented Paradigm	**OORP**	**Competency area: Object-Oriented Paradigm (Optional)**	
		DEVP.OORP.1	Apply fundamental elements of objects and classes	Self-directed Purpose-driven Meticulous
		DEVP.OORP.2	Utilize instantiation modalities	Self-directed Purpose-driven Meticulous
		DEVP.OORP.3	Utilize intra-entity communication and messaging	Self-directed Purpose-driven Meticulous
		DEVP.OORP.4	Design for encapsulation	Purpose-driven Meticulous Inventive
		DEVP.OORP.5	Design for inheritance and dependency management	Purpose-driven Meticulous Inventive
		DEVP.OORP.6	Design for abstraction	Purpose-driven Meticulous Inventive
		DEVP.OORP.7	Apply polymorphism	Purpose-driven Meticulous Inventive
		DEVP.OORP.8	Utilize design patterns	Purpose-driven Meticulous Inventive
		DEVP.OORP.9	Utilize objects and classes for entity modeling	Purpose-driven Meticulous Inventive
		WEBD	**Competency area: Web Development (Optional)**	
		DEVP.WEBD.1	Demonstrate an operational understanding of the protocols that enable the Internet	Self-directed Purpose-driven

Web Development	DEVP.WEBD.2	Create and analyze an algorithm for effectiveness and efficiency.	Self-directed Purpose-driven Meticulous
	DEVP.WEBD.3	Implement good documentation practices in programming	Inventive Self-directed Responsible
	DEVP.WEBD.4	Demonstrate teamwork, interpersonal group skills, and team software development	Collaborative Adaptable Responsible
	DEVP.WEBD.5	Demonstrate skills in client-side (Front-end) web application development technologies including HTML, CSS, JavaScript, and JavaScript libraries	Purpose-driven Meticulous Inventive
	DEVP.WEBD.6	Demonstrate skills in server-side (back-end) web application development technologies using a back-end programming language (i.e. Node/Express, Python/Django, etc.)	Purpose-driven Meticulous Inventive
	DEVP.WEBD.7	Create a functioning web application suitable for portfolio presentation including but not limited to skills shown using front-end, back-end, SQL, and current web development tools	Purpose-driven Meticulous Inventive
	DEVP.WEBD.8	Explain the different internet design patterns (i.e. MVC, MVVM, etc.) and ability to know advantages and disadvantages of each	Purpose-driven Responsible Inventive
	DEVP.WEBD.9	Analyze and explain the different design layouts and pros and cons of each	Purpose-driven Meticulous Inventive
	DEVP.WEBD.10	Implement security measures for a website	Inventive Self-directed Responsible
	DEVP.WEBD.11	Debug syntactical and logical errors	Meticulous. Self-directed Inventive
	DEVP.WEBD.12	Explain the Internet Copyright laws	Self-directed Responsible Professional
	DEVP.WEBD.13	Deploy a website to a host server	Collaborative Adaptable Responsible
Mobile De	**MOBD**	**Competency area: Mobile Development (Optional)**	
	DEVP.MOBD.1	Describe the Internet of Things (IoT) enabled devices and the mobile industry	Purpose-driven Self-directed Inventive
	DEVP.MOBD.2	Create and analyze an algorithm for effectiveness and efficiency	Purpose-driven Meticulous Inventive
	DEVP.MOBD.3	Implement good documentation practices in programming	Meticulous Purpose-driven Self-directed
	DEVP.MOBD.4	Demonstrate teamwork, interpersonal group skills, and team software development	Collaborative Self-directed Responsible
	DEVP.MOBD.5	Utilize a contemporary mobile application development framework	Purpose-driven Meticulous Inventive
	DEVP.MOBD.6	Create a functioning mobile application suitable for portfolio presentation including but not limited to skills shown using database management, hardware interaction, APIs, cross platform development and current mobile development tools	Purpose-driven Meticulous Inventive

	velopment	DEVP.MOBD.7	Describe and distinguish different mobile development platforms	Purpose-driven Meticulous Inventive
		DEVP.MOBD.8	Demonstrate mobile user interface design and the user experience	Purpose-driven Self-directed Professional
		DEVP.MOBD.9	Implement cyber security measures for a mobile application	Meticulous Self-directed Responsible
		DEVP.MOBD.10	Explain memory allocation and management	Purpose-driven Meticulous Inventive
		DEVP.MOBD.11	Debug syntactical and logical errors	Meticulous Self-directed Purpose-driven
		DEVP.MOBD.12	Explain the importance of Copyright laws	Self-directed Responsible Purpose-driven
		DEVP.MOBD.13	Market and publish a mobile application	Purpose-driven Self-directed Meticulous
	User Interface	**USID**	**Competency area: User Interface Design (Optional)**	
		DEVP.USID.1	Apply principles of user-Centered design (UCD)	Purpose-driven Professional Collaborative
		DEVP.USID.2	Apply user-system interaction principles	Purpose-driven Professional Collaborative
		DEVP.USID.3	Design and create effective user-centered user interaction with an application	Purpose-driven Inventive Self-directed
		DEVP.USID.4	Identify and evaluate attributes of effective UX	Purpose-driven Inventive Self-directed
		DEVP.USID.5	Evaluate the influence user centered design has on user experience (UX)	Purpose-driven Professional Inventive

Organization	ORGD		**Competency Realm: Organizational Domain**	
	Ethics	ETHS	**Competency area: Ethics, use and implications for society (Required)**	
		ORGD.ETHS.1	Demonstrate ethical behavior during data collection	Professional Responsible Proactive
		ORGD.ETHS.2	Identify the moral issues that surround the storage and usage of data	Professional Responsible Proactive
		ORGD.ETHS.3	Examine ethical philosophies and their practical application	Professional Responsible Proactive
		ORGD.ETHS.4	Evaluate ethical codes of practice and their implications for society	Professional Responsible Proactive
		ORGD.ETHS.5	Identify aspects of sustainability and adaptive systems and data	Responsible Purpose-driven Professional
		ORGD.ETHS.6	Categorize ethical stakeholders and their importance to Information Systems	Professional Responsible Passionate
		ORGD.ETHS.7	Investigate sustainable processes, actions, and performance to support organizations	Responsible Professional Proactive
		ORGD.ETHS.8	Investigate sustainable processes, actions, and performance to support the individual	Responsible Professional Proactive
		ORGD.ETHS.9	Investigate sustainable processes, actions, and performance to support society at large	Responsible Professional Proactive
	IS Management & Strat	ISMS	**Competency area: IS Management & Strategy (Required)**	
		ORGD.ISMS.1	Apply professional managerial skills to design and manage an effective IS organization	Collaborative Professional Self-directed
		ORGD.ISMS.2	Ensure operational efficiency and effectiveness in service delivery of organizational information	Professional Collaborative Responsible
		ORGD.ISMS.3	Manage the information resources in coordination with line management	Collaborative Adaptable Responsible
		ORGD.ISMS.4	Create and manage the oversight mechanisms by which an organization evaluates, directs, and monitors organizational information technology - managing decision rights and organizational information technology decision making practices	Professional Proactive Collaborative
		ORGD.ISMS.5	Implement strategic plans that have been created for the delivery and use of organizational information systems	Professional Collaborative Self-directed
		ORGD.ISMS.6	Ensure organizational information systems comply with policies, applicable laws and regulations	Professional Collaborative Responsible
		ORGD.ISMS.7	Manage organizational risk and develop risk mitigation plans	Professional Purpose-driven Proactive
		ORGD.ISMS.8	Create IT procurement policies and understand and negotiate IT contracts	Professional Collaborative Responsible

al Domain	egy	ORGD.ISMS.9	Develop plans for workforce development, training, talent acquisition, and employee retention	Professional Collaborative Responsible						
		ORGD.ISMS.10	Apply leading service management frameworks, such as ITIL and CMMI	Professional Inventive. Self-directed						
		ORGD.ISMS.11	Identify commonly used governance frameworks, such as COBIT and TOGAF, to align information systems with organizational requirements	Professional Collaborative Responsible						
	Digital Innovation	**DIGI**	**Competency area: Digital Innovation (Optional)**							
		ORGD.DIGI.1	Articulate and critically reflect on the unique features that an application of emerging technology may offer	Inventive Self-directed Purpose-driven						
		ORGD.DIGI.2	Demonstrate knowledge of the role of digital business technologies in social and mobile domains	Self-directed Purpose-driven Inventive						
		ORGD.DIGI.3	Identify and critique characteristics necessary for digital innovation	Inventive Self-directed Purpose-driven						
		ORGD.DIGI.4	Identify and validate an opportunity to develop a new digital business model	Inventive Self-directed Purpose-driven						
		ORGD.DIGI.5	Identify and evaluate key issues related to implementation and infrastructure issues	Inventive Self-directed Purpose-driven						
		ORGD.DIGI.6	Identify and assemble the required resources, processes, and partners to bring a digital business model to fruition	Inventive. Self-directed Purpose-driven						
		ORGD.DIGI.7	Practically demonstrate the investigation and application of a new innovation	Inventive Self-directed Purpose-driven						
	Business Process Mgmt	**BPMG**	**Competency area: Business Process Management (Optional)**							
		ORGD.BPMG.1	Explain the characteristics of a process and the different perspectives of a process model	Self-directed Purpose-driven Meticulous						
		ORGD.BPMG.2	Use a BPM tool to design and implement business process models	Self-directed Purpose-driven Meticulous						
		ORGD.BPMG.3	Choose appropriate process discovery techniques for different business scenarios	Self-directed Purpose-driven Meticulous						
		ORGD.BPMG.4	Design a Process Architecture	Self-directed Purpose-driven Meticulous						
		ORGD.BPMG.5	Analyze an AS-IS business process using appropriate techniques	Self-directed Purpose-driven Meticulous						
		ORGD.BPMG.6	Use process improvement methods and implement TO-BE processes by eliminating the bottlenecks, enhancing, and innovating the AS-IS process	Self-directed Purpose-driven Meticulous						
		ORGD.BPMG.7	Evaluate techniques and tools that support the planning, design, analysis, operation, and monitoring of business processes	Self-directed Meticulous Inventive						

Integration	INTG	**Competency Realm: Integration**								
	ISPM	**Competency area: IS Project Management (Required)**								
IS Project Management	INTG.ISPM.1	Explain basic project management concepts and terms	Purpose-driven Professional Proactive							
	INTG.ISPM.2	Use integration management tools, techniques, and processes	Proactive Inventive Self-directed							
	INTG.ISPM.3	Use scope management tools, techniques, and processes	Proactive Purpose-driven Professional							
	INTG.ISPM.4	Develop estimates and time tracking using appropriate tools, techniques, and processes	Proactive Inventive Self-directed							
	INTG.ISPM.5	Develop estimates and cost tracking using appropriate tools, techniques, and processes	Proactive Inventive Self-directed							
	INTG.ISPM.6	Utilize the change control process to maintain and control quality	Professional Proactive Meticulous							
	INTG.ISPM.7	Implement human resource management tools, techniques, and processes	Proactive Inventive Self-directed							
	INTG.ISPM.8	Define and implement a communication management plan	Professional Collaborative Proactive							
	INTG.ISPM.9	Predict and manage project risk through the use of tools, techniques, and processes	Proactive Purpose-driven Professional							
	INTG.ISPM.10	Define and explain procurement management	Proactive Purpose-driven Professional							
	INTG.ISPM.11	Identify and manage stakeholders within the phases of a project	Professional Proactive Collaborative							
	INTG.ISPM.12	Utilize tools, techniques, and processes to manage project performance	Proactive Purpose-driven Professional							
	INTG.ISPM.13	Apply agile project management principles and methods in practice	Purpose-driven Professional Proactive							
	INTG.ISPM.14	Apply the Scrum development process	Purpose-driven Professional Proactive							
	INTG.ISPM.15	Select an appropriate project management methodology based on project characteristics	Proactive Inventive Self-directed							

	ISPT	Competency area: IS Practicum (Required)	
IS Practicum	INTG.ISPT.1	Apply the SDLC	Professional Collaborative Responsible
	INTG.ISPT.2	Utilize a systems/software development methodology	Professional Collaborative Responsible
	INTG.ISPT.3	Utilize tools for software process management	Meticulous Self-directed Purpose-driven
	INTG.ISPT.4	Utilize tools for code and resource version control	Meticulous Self-directed Purpose-driven
	INTG.ISPT.5	Utilize tools for team collaboration and communication	Meticulous Collaborative Self-directed
	INTG.ISPT.6	Utilize tools for client collaboration and communication	Self-directed Professional Proactive
	INTG.ISPT.7	Utilize tools for testing (unit, integration, acceptance)	Meticulous Self-directed Purpose-driven
	INTG.ISPT.8	Align and utilize UML, ERD, and Class/Object Design	Meticulous Self-directed Purpose-driven
	INTG.ISPT.9	Apply Object-Oriented principles in system/software design and implementation	Meticulous Self-directed Purpose-driven
	INTG.ISPT.10	Utilize Object-Relational Mapping tools	Meticulous. Self-directed Purpose-driven
	INTG.ISPT.11	Apply principles of systems delivery and maintenance	Meticulous Self-directed Purpose-driven
	INTG.ISPT.12	Utilize upfront design for system security	Purpose-driven Professional Proactive

APPENDIX 3 – Competencies, Knowledge-Skill Pairs and Dispositions by Competency Area

Appendix 3 provides a detailed illustration of the 19 competency areas identified in Chapter 4. Each competency area is further defined by providing a brief description of the area, along with a listing of competencies associated with the area. As discussed in Chapter 3, a competency is an *ability to apply knowledge, skills, and dispositions to effectively complete tasks.* Hence, competency definitions include specifications regarding the underlying knowledge, skills, and dispositions required for effectively completing tasks.

In the curriculum design process, detailed materials of Appendix 3 are intended to be used in discussing how to transfer and integrate program level targets for competency levels to the specific design of individual courses and their learning objectives (see figure A3-1). In particular, the list of competencies can support defining and formulating the learning objectives for a particular course. Specifications regarding underlying knowledge skills and dispositions can support choices regarding course contents, exercises, and teaching methods. The purpose is to support the design of a course with an aim to build students' competencies.

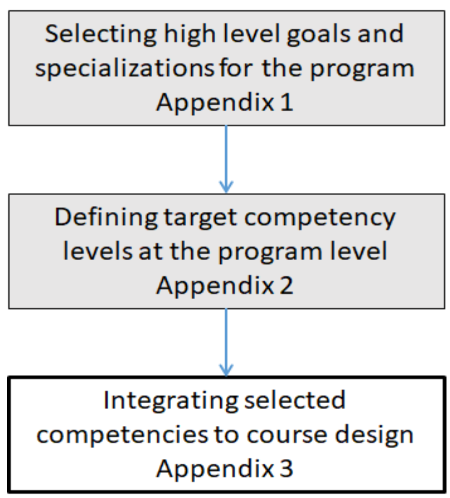

Figure A3-1: Intended use of Appendix 3 in a competency-based curriculum design process

Each competency listed in this appendix includes a competency number, one or more relevant knowledge-skill pairs, and one or more emphasized dispositions. The competency number helps uniquely identify the competency within IS2020. The knowledge-skill pairs are the pairs of attributes that are necessary in order to perform the associated competency. Each knowledge-skill pair includes a definition of the knowledge component and the corresponding skill level required. Knowledge and skill requirements are drawn from established knowledge in the area

of interest and Bloom's Cognitive Taxonomy. The six levels of Bloom's Cognitive Taxonomy are provided in Table A3-1.

Skill Levels (Bloom Cognitive Level)
6 - Create
5 - Evaluate
4 - Analyze
3 - Apply
2 - Understand
1 - Remember

Table A3-1 Skill Levels (Bloom Cognitive Level)

The final component of a competency definition are the competency dispositions, that provide additional context for the competency and help establish foundational characteristics important for each competency. The following table lists each disposition identified in CC2020 and provides a brief definition of the disposition.

Disposition	Disposition ID	Description of Disposition
Proactive	D1	With initiative, self-starter, independent
Self-directed	D2	Self-motivated, determination, independent
Passionate	D3	Conviction, strong commitment, compelling
Purpose-driven	D4	Goal driven, achieve goals, business acumen
Professional	D5	Professionalism, discretion, ethical, astute
Responsible	D6	Use judgment, discretion, act appropriately
Adaptable	D7	Flexible, agile, adjust in response to change
Collaborative	D8	Team player, willing to work with others
Responsive	D9	Respectful, react quickly and positively
Meticulous	D10	Attentive to detail; thoroughness, accurate
Inventive	D11	Exploratory. Look Beyond simple solutions

Table A3-2 Dispositions (CC2020, 2020)

All of the dispositions in the above table may apply to each and every competency in IS2020; however, the importance of dispositions to a competency varies from competency to competency.

Competency definitions focus on only the dispositions that should be emphasized for a given competency and are therefore labeled as Key Dispositions. Additional details regarding competencies, knowledge-skill pairs, and dispositions may be found in Chapter 3.

A3.1 Foundations Competency Realm

A3.1.1 Competency Area – Foundations of Information Systems

Competency Area Statement:

Students who meet the competencies of IS Foundations can understand the fundamental concepts of IS (including hardware, software, and information acquisition) and the support that IS provides for transactional, decisional, and collaborative business processes. They will also be able to understand the collection, processing, storage, distribution, and value of information and be able to make recommendations regarding IS that support and enable individuals in their daily lives as well as the management, customers, and suppliers of the enterprise. This competency includes the abilities to conduct an organizational business analysis and to assess processes and systems.

Competencies: Graduates will be able to:

1. Classify the components, elements, operations, and impact of IS
2. Interpret the dimensions, characteristics, and value of quality information.
3. Explain the roles, responsibilities, and characteristics of the IS professional
4. Recommend techniques for using information and knowledge for business decision making and strategic value
5. Analyze a business case and critique appropriate IS solutions to common business problems, based on the different components, elements, types, and levels of IS
6. Critique and recommend Enterprise Systems for a given business problem and processes
7. Identify techniques for transmitting and securing information in an organization
8. Demonstrate an ability to solve basic computational and design problems using IS development with appropriate methodologies, software tools and innovative methods for improving processes and organizational change

Competency 1: Classify the components, elements, operations, and impact of IS

Key Dispositions: Self-Directed, Inventive, Purpose-driven

Knowledge-Skill Pairs:

Knowledge Element	**Skill Level (Bloom cognitive level)**
Components of IS **-** technology (hardware, software, communication media), data, people, and procedures/processes.	2 - Understand
Operations of IS (the processing cycle of input, processing, storage, output, control)	3 - Apply
The ways in which IS helps us deal with information	3 - Apply
Functions (and operations) of IS and their impact on facilitating organizational change	3 - Apply
Common types of IS (e.g., Transaction Processing Systems, Enterprise Systems)	2 - Understand

Competency 2: Interpret the dimensions, characteristics, and value of quality information

Key Dispositions: Purpose-driven, Self-Directed, Responsive

Knowledge-Skill Pairs:

Knowledge Element	**Skill Level (Bloom cognitive level)**
Dimensions of information quality and information evaluation methods	3 - Apply
The virtual value chain	2 - Understand

Competency 3: Explain the roles, responsibilities, and characteristics of the IS professional

Key Dispositions: Self-Directed, Inventive, Purpose-Driven

Knowledge-Skill Pairs:

Knowledge Element	**Skill Level (Bloom cognitive level)**
Roles and responsibilities of the IS professional	3 - Apply
Characteristics of the IS professional	3 - Apply

Ethical standards for the IS professional	3 - Apply

Competency 4: Recommend techniques for using information and knowledge for business decision making and strategic value

Key Dispositions: Self-Directed, Purpose-driven, Professional

Knowledge-Skill Pairs:

Knowledge Element	**Skill Level (Bloom cognitive level)**
IS and the value of information	2 - Understand
Methods for storing and organizing information	3 - Apply
Role of information in decision making	2 - Understand
Types of decisions and techniques for decision making	3 - Apply
Stages of decision making and appropriate information system tools	3 - Apply
Key IT issues, trends, and alignment of IT with business	2 - Understand
IS strategic planning process	2 - Understand
Information and knowledge for business decision making and strategic value	2 - Understand
Decision support systems	2 - Understand

Competency 5: Analyze a business case and critique appropriate IS solutions to common business problems, based on the different components, elements, types, and levels of IS

Key Dispositions: Self-Directed, Purpose-driven, Professional

Knowledge-Skill Pairs:

Knowledge Element	**Skill Level (Bloom cognitive level)**
Components of IS	3 - Apply
Operations of an IS or information processing cycle (input, processing, storage, output, control)	3 - Apply
Elements of IS (data, hardware, software, communication, and processes)	3 - Apply

Types and utility of IS	3 - Apply
IS solutions and tools for different business contexts and processes	3 - Apply

Competency 6: Critique and recommend Enterprise Systems for a given business problem and processes

Key Dispositions: Purpose-driven, Professional, Self-Directed

Knowledge-Skill Pairs:

Knowledge Element	Skill Level (Bloom cognitive level)
Business processes modelling and optimization	3 - Apply
Components of an enterprise system	3 - Apply
Types and functions of Enterprise systems (including ERP and BI)	3 - Apply

Competency 7: Identify techniques for transmitting and securing information in an organization

Key Dispositions: Purpose-driven, Self-Directed, Professional

Knowledge-Skill Pairs:

Knowledge Element	Skill Level (Bloom cognitive level)
Methods for transmitting information using networks (including communication, Web 2.0 and Web 3.0 applications, IoT, crowdsourcing)	2 - Understand
Methods for transmitting information using networks (including communication, Web 2.0 and Web 3.0 applications, IoT, crowdsourcing)	2 - Understand
Key components of networks	2 - Understand
Types of information security threats	2 - Understand
Security technologies and solutions	2 - Understand
Types of information privacy threats	2 - Understand
Consequences of information privacy violations	2 - Understand

Technologies and solutions for information privacy	2 - Understand
Fair information practices and privacy policies	2 - Understand
Government information privacy regulations	2 - Understand

Competency 8: Demonstrate an ability to solve basic computational and design problems using IS development with appropriate methodologies, software tools and innovative methods for improving processes and organizational change

Key Dispositions: Self-Directed, Purpose-driven, Professional

Knowledge-Skill Pairs:

Knowledge Element	Skill Level (Bloom cognitive level)
Methods and tools for using information	3 - Apply
Buy versus build decision	2 - Understand
Outsourcing possibilities and models for IS	2- Understand
Computational methods	2- Understand
Software tools and computational methods	3 - Apply
Software development methodologies	2 - Understand
Systems development lifecycle	2 - Understand
Innovation and design techniques	3 - Apply

A3.2 Data / Information Competency Realm

A3.2.1 Competency Area – Data / Information Management

Competency Area Statement:

We currently live in a data driven age. Data has emerged as the new oil that drives an organization: The successful operation of modern organizations relies on the effective use of their operational data. Database management systems (DBMS) are the engines of this data driven world.

Data collected and used by an organization is broadly divided into two types (1) line of business data and (2) customer behavior data. Traditionally data management has focused on online business data. For example, when a ride request is made to a ride sourcing company (Uber, Lyft, etc.), what data is needed to meet that request? When a purchase is made in a grocery store

what is the flow of data during that transaction? Line of business data is used to support core business processes of the organization. Alternatively, based on the purchase patterns of a shopper or the volume or location of ride requests, how can a grocery store or a ride sourcing company make their operation more effective? The answer to this question is based on customer behavior data (who bought what, when etc.). Whatever type of data it may be, many fundamental questions are the same: how do you gather, organize, curate, and process data to help run an organization or extract actionable information to increase effectiveness?

The use of data involves three aspects: (1) management (2) security and (3) analytics.

We will study tools and techniques for managing data with database systems. At the highest level we will study two questions (1) how to use a database and (2) how to build a database. For more than three decades, the relational model has been the predominant model of data management. Most of this module will focus on the classic relational model. In the past several years, driven by evolving functional and non-functional (quality) needs of an organization, alternatives to the classic relational model have emerged. We will examine illustrative samples of these popular alternatives known as non-relational or NoSQL models.

Competencies: Graduates will be able to:

1. Query the relational model
2. Design relational databases
3. Programming database systems using functions and triggers
4. Secure a database
5. Compare tradeoffs of different concurrency modes
6. Develop non-relational models

Competency 1: Query the relational model

Key Dispositions: Meticulous, Self-Directed, Purpose-driven

Knowledge-Skill Pairs:

Knowledge Element	Skill Level (Bloom cognitive level)
Relations, tuples, and fields Model data using tables, rows, columns, keys	3- Apply
User stories and business requirements Translate user stories to SQL statements using (SELECT, FROM, WHERE, ORDER BY, DISTINCT, LIKE, BETWEEN, IN, JOIN, GROUP BY, HAVING, sub-queries, ANY, ALL, UNION)	6 - Create

Competency 2: Design relational databases

Key Dispositions: Self-Directed, Purpose-driven, Meticulous

Knowledge-Skill Pairs:

Knowledge Element	Skill Level (Bloom cognitive level)
Integrity, entity, referential and check constraints	3 - Apply
Anomalies, functional dependencies, normalization, normal forms, and conversion to BCNF	5 - Evaluate
Conceptual, logical models, and physical models; Transform a conceptual model to a logical model and a logical model to a physical model	6 - Create

Competency 3: Program database systems using functions and triggers

Key Dispositions: Meticulous, Self-Directed, Purpose-driven

Knowledge-Skill Pairs:

Knowledge Element	Skill Level (Bloom cognitive level)
SQL procedural language	6 - Create
Functions and triggers	6 - Create

Competency 4: Secure a database

Key Dispositions: Meticulous, Self-Directed, Purpose-driven

Knowledge-Skill Pairs:

Knowledge Element	Skill Level (Bloom cognitive level)
Views and authorization	4 - Analysis
Identify potential for and prevent SQL injections	2 - Understand
Access control: DAC, MAC, RBAC, ABAC	3 - Apply

Competency 5: Compare tradeoffs of different concurrency modes

Key Dispositions: Self-Directed, Meticulous, Inventive

Knowledge-Skill Pairs:

Knowledge Element	**Skill Level (Bloom cognitive level)**
Concurrency and Recovery	3 - Apply
ACID database transaction properties (atomicity, consistency, isolation, and durability)	3 - Apply
Transaction levels	3 - Apply

Competency 6: Develop non-relational models

Key Dispositions: Meticulous, Self-Directed, Purpose-driven

Knowledge-Skill Pairs:

Knowledge Element	**Skill Level (Bloom cognitive level)**
Explain the need for non-relational models	2 - Understand
Design and build Key-value stores	6 - Create
Design and build document stores	6 - Create

A3.2.2 Competency Area – Data / Business Analytics

Competency Area Statement:

Currently we are in the midst of the next disruptive age of Information Technology. In 1945 electronic computers appeared ushering in what one could call the first disruptive age of hardware. Starting with the mainframes of the 60s to current cloud computing we have seen various hardware instances such as minicomputers, supercomputers, personal computers, handheld computers, and wearable computers. Paralleling advances in hardware, there have been many advances in software: programming paradigms (imperative, object-oriented, functional, concurrent), development methodologies (CMM, agile), and algorithms for solving a range of problems (e.g., systems, networking, AI, machine learning, analytics). Starting around the late 1960s to the explosion of the Web in the early 90s the third disruptive age was in communication – the ability for computer systems around the world to transmit and share data. The combined advances in hardware, software, and communication form the basis of our current disruptive age of Data. Massive amounts of data (Terabytes and beyond) are available in a range of domains: science, commerce, finance, healthcare, social media, real-time sensors, etc. At historically unprecedented levels we are able to collect, transmit, curate, and process huge amounts of data at enormous speeds resulting in our ability to do ongoing tasks better and to do tasks we could not do before.

Since early 2000 the nature of data has morphed. Big Data is differentiated from traditional data in terms of the three 'V's: volume, velocity, and variety, each of which raise interesting questions.

- Volume: When we process data at the Tera and Peta byte level, what fundamental shift in our approach to solving problems occurs?
- Velocity: Given the fast transmission and computational speeds of current systems, what new capabilities are enabled by the processing of huge amounts of data in real time?
- Variety: Estimates are that more than 90% of the world's data is not structured (i.e., not in classical relational databases amenable to SQL queries). What type of new actionable insights are facilitated by the processing of semi-structured (e.g., csv, JSON) and unstructured (e.g., text, images, audio) data?

Data Science and Machine Learning: Organizations and businesses need data driven actionable insights. For example, a casino may want to identify whether there is a certain group of customers from which more business occurs – a task known as customer segmentation. A cell phone company may want to know if there is a risk of customers leaving for another carrier – a business situation known as customer churn. Analytic tasks that facilitate such actionable insights include prediction, optimization, recommendation, classification, clustering, etc.

Competencies: Graduates will be able to:

1. Apply the principles of computational thinking (CT) to learning data science
2. Analyze data science problems with a CT framework
3. Express a business problem as a data problem
4. Perform exploratory data analysis from inception to the value proposition
5. Explain the core principles behind various analytics tasks such as classification, clustering, optimization, recommendation
6. Articulate the nature and potential of Big Data
7. Demonstrate the use of big data tools on real world case-studies

Competency 1: Apply the principles of computational thinking (CT) to learning data science

Key Dispositions: Self-directed, Purpose-driven, Adaptable

Knowledge-Skill Pairs:

Knowledge Element	**Skill Level (Bloom cognitive level)**
Principles of computational thinking	2 - Understand
Decomposition, Abstraction, Pattern Recognition, Generalization/abstraction, and Automation	4 - Analyze

Competency 2: Analyze data science problems with a CT framework

Key Dispositions: Self-Directed, Purpose-driven, Meticulous

Knowledge-Skill Pairs:

Knowledge Element	**Skill Level (Bloom cognitive level)**
Data Science problems	2 - Understand
Framework for thinking about CT	3 - Apply

Competency 3: Express a business problem as a data problem

Key Dispositions: Self-Directed, Purpose-driven, Meticulous

Knowledge-Skill Pairs:

Knowledge Element	**Skill Level (Bloom cognitive level)**

Business problem	2 - Understand
Problem, Data characteristics, Analysis, and Policy	5 - Evaluate

Competency 4: Perform exploratory data analysis from inception to the value proposition

Knowledge-skill Pairs:

Key Dispositions: Self-Directed, Purpose-driven, Meticulous

Knowledge Element	**Skill Level (Bloom cognitive level)**
Descriptive statistics	3 - Apply
Data visualization	6 - Create

Competency 5: Explain the core principles behind various analytics tasks such as classification, clustering, optimization, recommendation

Key Dispositions: Purpose-driven, Meticulous, Self-Directed

knowledge-skill Pairs:

Knowledge Element	**Skill Level (Bloom cognitive level)**
Classification	4 - Analyze
Clustering	4 - Analyze
Optimization	4 - Analyze
Recommendation	4 - Analyze

Competency 6: Articulate the nature and potential of Big Data

Key Dispositions: Self-Directed, Purpose-driven, Meticulous

knowledge-skill Pairs:

Knowledge Element	**Skill Level (Bloom cognitive level)**

Volume	2 - Understand
Velocity	2 - Understand
Variety	2 - Understand

Competency 7: Demonstrate the use of big data tools on real world case-studies

Key Dispositions: Self-Directed, Purpose-driven, Adaptable

knowledge-skill Pairs:

Knowledge Element	Skill Level (Bloom cognitive level)
Hadoop	5 - Evaluate
Map reduce	5 - Evaluate
Spark	5 - Evaluate

A3.2.3 Competency Area - Data / Information Visualization

Competency Area Statement:

Turing award recipient Richard Hamming commented "The purpose of computing is insight, not numbers" (1962). The goal of information visualization is the unveiling of the underlying structure of large or abstract data sets using visual representations that utilize the powerful processing capabilities of the human visual perceptual system. The Data and Information Visualization competency area contains competencies pertaining to computational approaches for gaining insight via visualizations. Competencies in this area emphasize the fundamentals of statistical exploration of data, fitting models to produce specialized graphs to support the exploration of data in a detailed and statistics-oriented manner, and the use of data visualization tools such as Excel, Python, R, and Tableau.

Competencies: Graduates will be able to:

1. Explain the fundamentals of human perception and vision
2. Demonstrate effective ways of displaying numeric data, counts, and proportions
3. Present information in an understandable, efficient, effective, and aesthetic manner, for the purposes of explaining ideas and analyzing data
4. Use a tool such as R (or Python) to perform basic data manipulation such as filtering, aggregating, and organizing data sets
5. Produce graphics using a visualization tool
6. Develop transformations and model to fit, explore, check assumptions about data
7. Express the story of the data in a compelling narrative

Competency 1: Explain the fundamentals of human perception and vision

Key Dispositions: Purpose-driven, Self-Directed, Responsible

Knowledge-Skill Pairs:

Knowledge Element	Skill Level (Bloom cognitive level)
Human vision	2 - Understand
Human perception	2 - Understand

Competency 2: Demonstrate effective ways of displaying numeric data, counts, and proportions

Key Dispositions: Meticulous, Inventive, Self-Directed

Knowledge-Skill Pairs:

Knowledge Element	Skill Level (Bloom cognitive level)
Types of data	4 - Analyze
Numerical vs. Categorical	4 - Analyze

Competency 3: Present information in an understandable, efficient, effective, and aesthetic manner, for the purposes of explaining ideas and analyzing data

Key Dispositions: Purpose-driven, Self-Directed, Responsible

Knowledge-Skill Pairs:

Knowledge Element	Skill Level (Bloom cognitive level)
Different types of plots	4 - Analyze
Mapping data to plot aesthetics	6 - Create

Competency 4: Use a tool such as R (or Python) to perform basic data manipulation such as filtering, aggregating, and organizing data sets

Key Dispositions: Meticulous, Purpose-driven, Inventive

Knowledge-Skill Pairs:

Knowledge Element	Skill Level (Bloom cognitive level)
Algorithmic processing of data	6 - Create
Relational operations on data sets	6 - Create

Competency 5: Produce graphics using a visualization tool

Key Dispositions: Meticulous, Purpose-driven, Inventive

Knowledge-Skill Pairs:

Knowledge Element	Skill Level (Bloom cognitive level)
Using plotting libraries (ggplot or plotnine)	6 - Create
Basics of scales, geoms, coordinates	2 - Understand

Competency 6: Develop transformations and model to fit, explore and check assumptions about data

Key Dispositions: Meticulous, Inventive, Self-Directed

Knowledge-Skill Pairs:

Knowledge Element	Skill Level (Bloom cognitive level)
Hypothesis generation	3 - Apply
Interactive visualizations	6 - Create

Competency 7: Express the story of the data in a compelling narrative

Key Dispositions: Inventive, Self-Directed, Purpose-driven

Knowledge-Skill Pairs:

Knowledge Element	Skill Level (Bloom cognitive level)
The art of the narrative	5 - Analyze
Exploratory vs. Explanatory expositions	6 - Create

A3.3 Technology Competency Realm

A3.3.1 Competency Area – IT infrastructure

Competency Area Statement:

This area covers all aspects of information technology infrastructure, as it is used in the organization. IT infrastructure includes the design and development of suitable architectures or servers, physical and cloud services, capacity planning, and networking. The content covers the installation, configuration, maintenance, and management of all aspects of technology from the server through to the organization's network.

Competencies: Graduates will be able to:

1. Explain key infrastructure concepts, including how it functions, how to define critical functions, and how to plan and manage infrastructure
2. Explain the principles of layered network architectures
3. Explain the components of IT infrastructure solutions from client/server, network hardware, (including wireless and wired)
4. Explain the principles of network software and configuration
5. Explain network protocols and their configuration
6. Illustrate a clear understanding of security principles as they pertain to networks
7. Examine and critique IT infrastructure for organizations
8. Examine and critique IT server architecture (both physical or cloud-based)
9. Explain concepts of Enterprise Architecture

Competency 1: Explain key infrastructure concepts, including how it functions, how to define critical functions, and how to plan and manage infrastructure

Key Dispositions: Self-Directed, Purpose-driven, Professional

Knowledge-Skill Pairs:

Knowledge Element	**Skill Level (Bloom cognitive level)**
Individual components of IT infrastructure	2 - Understand
Functions of IT infrastructure	3 - Apply
Plan and manage IT infrastructure	3 - Apply
Organizing structures and processes	2 - Understand
Role of IT infrastructure in business	2 - Understand

Competency 2: Explain the principles of layered network architectures

Key Dispositions: Self-Directed, Meticulous, Responsible

Knowledge-Skill Pairs:

Knowledge Element	Skill Level (Bloom cognitive level)
Layers of the TCP/IP protocol suite	2 - Understand
Layers of the OSI model	2 - Understand
Duties of each layer of TCP/IP protocol suite	2 - Understand
Duties of each layer of OSI model	2 - Understand
Network security	4 - Analyze

Competency 3: Explain the components of IT infrastructure solutions from client/server, network hardware, (including wireless and wired)

Key Dispositions: Self-Directed, Meticulous, Responsible

Knowledge-Skill Pairs:

Knowledge Element	Skill Level (Bloom cognitive level)
Components of a network	4 - Analyze
Components of Client/server	2 - Understand
Wired networks	2 - Understand
Wireless protocols	3 - Apply

Competency 4: Explain the principles of network software and configuration

Key Dispositions: Self-Directed, Responsible, Proactive

Knowledge-Skill Pairs:

Knowledge Element	Skill Level (Bloom cognitive level)
Configuration and setup processes on network hardware, software and other supporting devices and components	3 - Apply
Four types of computer networks, LAN, WAN, PAN, MAN	2 - Understand
Network topologies: Mesh, Star, Bus, Ring, Hybrid	2 - Understand

Competency 5: Explain network protocols and their configuration

Key Dispositions: Self-Directed, Responsible, Proactive

Knowledge-Skill Pairs:

Knowledge Element	Skill Level (Bloom cognitive level)
Types of protocols: Transmission Control Protocol (TCP), Internet Protocol (IP), User Datagram Protocol (UDP), Post office Protocol (POP), Simple mail transport Protocol (SMTP), File Transfer Protocol (FTP), HyperText Transfer Protocol (HTTP), HyperText Transfer Protocol Secure (HTTPS)	2 - Understand

Competency 6: Explain security principles as they pertain to networks

Key Dispositions: Self-Directed, Professional, Responsible

Knowledge-Skill Pairs:

Knowledge Element	Skill Level (Bloom cognitive level)
Basic forms of system attacks	2 - Understand
Access control to computers and networks	2 - Understand
Techniques to make data secure	2 - Understand
Strengths and weaknesses of passwords	2 - Understand
Basic features of cryptography	2 - Understand
Firewalls and types of firewall protection	2 - Understand
Techniques to secure wireless communication	2 - Understand
Advantages of a security policy	2 - Understand

Competency 7: Examine and critique IT infrastructure for organizations

Key Dispositions: Self-Directed, Responsible, Purpose-driven

Knowledge-Skill Pairs:

Knowledge Element	Skill Level (Bloom cognitive level)
Infrastructure components	4 - Analyze

Infrastructure planning	4 - Analyze
Continuity planning	5 - Evaluate

Competency 8: Examine and critique IT server architecture (both physical or cloud-based)

Key Dispositions: Self-Directed, Responsible, Purpose-driven

Knowledge-skill Pairs:

Knowledge Element	Skill Level (Bloom cognitive level)
Server Components	4 - Analyze
Cloud configuration	4 - Analyze

Competency 9: Explain concepts of Enterprise Architecture

Key Dispositions: Self-Directed, Responsible, Purpose-driven

Knowledge-Skill Pairs:

Knowledge Element	Skill Level (Bloom cognitive level)
Foundations of TOGAF	2 - Understand
Foundations of ITIL	2 - Understand

A3.3.2 Competency Area – Secure Computing

Competency Area Statement:

This competency area is concerned with practices associated with assuring secure business operations in the context of adversaries. Assuring secure operations involves the creation, operation, defense, analysis, and testing of secure computer systems. Hence secure computing is an interdisciplinary area including aspects of computing, law, policy, human factors, ethics, and risk management. The proposed competencies cover these areas, but with an IS discipline lens. This includes data security, software security, human security, societal security, and organization security.

Competencies: Graduates will be able to:

1. Explain the purpose of cryptography and how it can be used in data communications
2. Describe the concepts of authentication, authorization, access control, and data integrity and how it helps to enhance data security
3. Explain the security requirements that are important during software design
4. Analyze the concepts of identification, authentication, and access authorization in the context of protecting people and devices
5. Analyze the importance of social media privacy and security
6. Illustrate how cyberattacks work, how to avoid them and how to counteract their malicious consequences
7. Describe risk management techniques to identify and prioritize risk factors for information assets and how risk is assessed
8. Illustrate the types of security laws, regulations, and standards within which an organization operates

Reference: Cybersecurity Curriculum 2017

Competency 1: Explain the purpose of cryptography and how it can be used in data communications

Key Dispositions: Responsible, Purpose-driven, Self-Directed

Knowledge-Skill Pairs:

Knowledge Element	Skill Level (Bloom cognitive level)
Data communications	2 - Understand
Cryptography	2 - Understand

Competency 2: Describe the concepts of authentication, authorization, access control, and data integrity in the context of data communication

Key Dispositions: Self-Directed, Responsible, Purpose-driven

Knowledge-Skill Pairs:

Knowledge Element	Skill Level (Bloom cognitive level)
Authentication	2 - Understand
Authorization	2 - Understand
Access control	2 - Understand
Data integrity	2 - Understand

Competency 3: Explain the security requirements that are important during software design

Key Dispositions: Self-Directed, Responsible, Professional

Knowledge-Skill Pairs:

Knowledge Element	Skill Level (Bloom cognitive level)
Security-by-design	2 - Understand
Data sanitization	2 - Understand
Input validation and data sanitization	2 - Understand
Security vulnerability	2 - Understand

Competency 4: Analyze the concepts of identification, authentication, and access authorization in the context of protecting people and devices

Key Dispositions: Self-Directed, Responsible, Professional

Knowledge-Skill Pairs:

Knowledge Element	Skill Level (Bloom cognitive level)
Identification	4 - Analyze
Authentication	4 - Analyze
Access Authorization	4 - Analyze
Audit trails and Logs	2 - Understand

Competency 5: Analyze the importance of social media privacy and security

Key Dispositions: Self-Directed, Responsible, Professional

Knowledge-Skill Pairs:

Knowledge Element	**Skill Level (Bloom cognitive level)**
Privacy trade-offs and risks in the social context	4 - Analyze
Organizational context	4 - Analyze

Competency 6: Illustrate how cyberattacks work, how to avoid them and how to counteract their malicious consequences

Key Dispositions: Purpose-driven, Inventive, Self-Directed

Knowledge-Skill Pairs:

Knowledge Element	**Skill Level (Bloom cognitive level)**
Types of cyberattacks	3 - Apply
Anatomy of cyberattacks	3 - Apply
Cyberattacks mitigation mechanisms	3 - Apply

Competency 7: Describe risk management techniques to identify and prioritize risk factors for information assets and how risk is assessed

Key Dispositions: Professional, Self-Directed, Responsible

Knowledge-Skill Pairs:

Knowledge Element	**Skill Level (Bloom cognitive level)**
Identify and Prioritize risk factors	2 - Understand
Risk management techniques	2 - Understand

Competency 8: Illustrate the types of security laws, regulations, and standards within which an organization operates

Key Dispositions: Professional, Self-Directed, Responsible

Knowledge-Skill Pairs:

Knowledge Element	**Skill Level (Bloom cognitive level)**
Security laws, regulations, and standards	2 - Understand

A3.3.3 Emerging Technologies

Competency Area Statement: Examines emerging technologies and explores their impact on business and societal issues through both a business and theoretical lens. Identifies and evaluates a range of technologies based on a range of business requirements that have a variety of ethical, environmental, and sustainability perspectives. Practically applies these technologies to enable suitable business opportunities.

Competencies: Graduates will be able to:

1. Research and identify a selection of current and emerging technologies
2. Evaluate technologies based on a range of business requirements
3. Make recommendations about the usage of technologies
4. Investigate technologies through a theoretical lens
5. Evaluate technologies from an ethical and sustainability perspective
6. Identify the impact of technologies on society and business
7. Practically design and apply technologies to a business problem
8. Apply emerging technologies in a teamwork scenario

Competency 1: Research and identify a selection of current and emerging technologies.

Key Dispositions: Self-Directed, Purpose-driven, Inventive

Knowledge-Skill Pairs:

Knowledge Element	**Skill Level (Bloom cognitive level)**
Research methods and theories	4 - Analyze
Emerging technology types, features, and impact	5 - Evaluate

Competency 2: Evaluate technologies based on a range of business requirements

Key Dispositions: Self-Directed, Purpose-driven, Inventive

Knowledge-Skill Pairs:

Knowledge Element	**Skill Level (Bloom cognitive level)**
Business requirements analysis	4 - Analyze
Emerging technology types	5 - Evaluate
Evaluate methods	5 - Evaluate

Business needs classification	4 - Analyze

Competency 3: Make recommendations about the usage of technologies

Knowledge-Skill Pairs:

Knowledge Element	Skill Level (Bloom cognitive level)
Recommender frameworks	5 - Evaluate
Decision making	5 - Evaluate
Simulations	4 - Analyze

Competency 4: Investigate technologies through a theoretical lens

Key Dispositions: Self-Directed, Purpose-driven, Inventive

Knowledge-Skill Pairs:

Knowledge Element	Skill Level (Bloom cognitive level)
Appropriate theories related to technology implementation and use	5 - Evaluate
Evaluation frameworks	5 - Evaluate

Competency 5: Evaluate technologies from an ethical and sustainability perspective

Key Dispositions: Self-Directed, Purpose-driven, Inventive

Knowledge-Skill Pairs:

Knowledge Element	Skill Level (Bloom cognitive level)
Ethics fundamentals	4 - Analyze
Sustainability fundamentals	4 - Analyze

Competency 6: Identify the impact of technologies on society and business

Key Dispositions: Self-Directed, Purpose-driven, Inventive

Knowledge-Skill Pairs:

Knowledge Element	Skill Level (Bloom cognitive level)
Organizational behavior	2 - Understand
Business impact of technology	5 - Evaluate
Impact identification	4 - Analyze

Competency 7: Practically design and apply technologies to a business problem

Key Dispositions: Self-Directed, Purpose-driven, Inventive

Knowledge-Skill Pairs:

Knowledge Element	Skill Level (Bloom cognitive level)
Design methods	3 - Apply
Prototyping	5 - Evaluate
Analysis methods	4 - Analyze
Business problem analysis	4 - Analyze
Solution creation	6 - Create

Competency 8: Apply emerging technologies in a teamwork scenario

Key Dispositions: Self-Directed, Purpose-driven, Inventive

Knowledge-Skill Pairs:

Knowledge Element	Skill Level (Bloom cognitive level)
Communication	5 - Evaluate
Team working	5 - Evaluate
Timekeeping	5 - Evaluate
Note-taking	3 - Apply
Project management	3 - Apply

A3.4 Systems Development Competency Realm

A3.4.1 Competency Area – Systems Analysis and Design

Competency Area Statement:

Examines various systems development methodologies and modeling tools with an emphasis on object-oriented systems development methods, software development life cycle (SDLC), and agile software development while emphasizing analytical techniques to develop the correct definition of business problems and user requirements. Topics should also include design, project management standards, information gathering, effective communication and interpersonal skill development.

Competencies: Graduates will be able to:

1. Explain what systems are and how they are developed
2. Demonstrate the SDLC phases and activities
3. Identify SDLC Models (Agile, Waterfall, V-shaped, iterative, spiral, etc.)
4. Work effectively in a team environment
5. Describe data modeling techniques
6. Describe the role and responsibilities of the participants in the SDLC
7. Explain the common ways projects fail and how to avoid these failures
8. Identify Enterprise Architecture concepts related to SDLC phases

Competency 1: Explain what systems are and how they are developed.

Key Dispositions: Self-Directed, Responsible, Proactive

Knowledge-Skill Pairs:

Knowledge Element	Skill Level (Bloom cognitive level)
Purpose of systems analysis (what the system should do)	2 - Understand
Purpose of design (how to accomplish the objective of the system)	2 - Understand
What is a system	2 - Understand
Need for and value of a formalized step-by-step approach to the analysis, design, and implementation of computer information systems	2 - Understand

Competency 2: Demonstrate the SDLC phases and activities

Key Dispositions: Self-directed, Responsible, Meticulous

Knowledge-Skill Pairs:

Knowledge Element	Skill Level (Bloom cognitive level)
Project definition and attributes	2 - Understand
Systems request	3 - Apply
Technical and Software Requirement Specifications	5 - Evaluate
Technical Feasibility	5 - Evaluate
Cost-benefit analysis	2 - Understand
Economic Feasibility	2 - Understand
Business Requirement Documentation	2 - Understand
Organizational Feasibility	2 - Understand
Project Management plan	3 - Apply
Responsibility Assignment Matrix	3 - Apply
Functional and non-functional requirements	3 - Apply
Requirement elicitation techniques	3 - Apply
Root cause analysis	3 - Apply
Use Cases	6 - Create
Work Breakdown Structure	5 - Evaluate
Work schedule and Critical Path	3 - Apply
Risk management and its role in the project management	2 - Understand
Systems migration plan	2 - Understand
Systems maintenance program	2 - Understand
IT infrastructure design	2 - Understand
User Interfaces	6 - Create
Data models and entity relationship diagrams (ERDs)	6 - Create
Process modeling diagrams	6 - Create
Data Flow diagrams	6 - Create

Database creation	6 - Create
Testing plan for performance and security	3 - Apply
Deployment plan	3 - Apply
Terminating a project	2 - Understand
System maintenance plan	3 - Apply
Change request document	3 - Apply

Competency 3: Identify SDLC Models (Agile, Waterfall, V-shaped, iterative, spiral, etc.)

Key Dispositions: Self-Directed, Purpose-driven, Responsible

Knowledge-Skill Pairs:

Knowledge Element	Skill Level (Bloom cognitive level)
System Development Life cycle (SDLC) model: Agile	2 - Understand
System Development Life cycle (SDLC) model: Waterfall	2 - Understand
System Development Life cycle (SDLC) model: other relevant models	2 - Understand

Competency 4: Work effectively in a team environment

Key Dispositions: Collaborative, Adaptable, Responsible

Knowledge-Skill Pairs:

Knowledge Element	Skill Level (Bloom cognitive level)
Team environment tools and skills	3 - Apply
Team communication	3 - Apply

Competency 5: Describe data modeling techniques

Key Dispositions: Self-Directed, Responsible, Purpose-driven

Knowledge-Skill Pairs:

Knowledge Element	Skill Level (Bloom cognitive level)

Different types of data diagraming models and when used	2 - Understand
Different types of entity relationship diagrams (Bachman, Chen, ORM, etc.)	2 - Understand
Data entity models	6 - Create

Competency 6: Describe the role and responsibilities of the participants in the SDLC

Key Dispositions: Self-Directed, Responsible, Purpose-driven

Knowledge-Skill Pairs:

Knowledge Element	Skill Level (Bloom cognitive level)
Roles and responsibilities	2 - Understand
Stakeholder management plan	2 - Understand

Competency 7: Explain the common ways projects fail and how to avoid these failures

Key Dispositions: Self-Directed, Responsible, Purpose-driven

Knowledge-Skill Pairs:

Knowledge Element	Skill Level (Bloom cognitive level)
Historical failed projects	2 - Understand
Project risks	2 - Understand
Risk Management plan	3 - Apply

Competency 8: Identify Enterprise Architecture concepts related to SDLC phases

Key Dispositions: Self-Directed, Professional, Purpose-driven

Knowledge-Skill Pairs:

Knowledge Element	Skill Level (Bloom cognitive level)
Foundations of TOGAF	2 - Understand
Foundations of ITIL	2 - Understand

A3.4.2 Competency Area – Application Development and Programming

Competency Area Statement:

A key function of any information system is an ability to transform data into information in support of organizational or personal goals. The software that developed in parallel to operate computer hardware has evolved to extend the utility of computation has evolved into myriad applications that are both pervasive and ubiquitous in everyday life. Thus, the principal importance of this facet of the IS curriculum is twofold.

1. **Programming** is the language of computation and logic that sequences and orders instructions to computing hardware in a manner that realizes both correct results and discernable results. Logical structures, algorithms, arithmetic facilities, and the ability to input, store, transform, and output data that can be purposefully used to inform decisions and automated intentional processes are at the heart of learning to program. To program a computer is to meet the computer "in the middle" such that the growing capabilities of data and computing can be purposefully guided. Programming is meant to shape the mind and reasoning such that human requirements for data and computing outcomes can be expressed and perfected.
2. **Application Development** is the purposeful application of programming fundamentals to craft usable and useful software artifacts and systems to solve actionable business and organizational problems where the power and automation of computing and data processing is warranted. Elements of design, to include reconciliation between human social systems and data and information systems, support a software/systems development life cycle where the industry and craft software realization extend capabilities of software and programming code elements and our understanding of fit and resonance with the human end-users of these systems. In this regard, an information systems perspective on application development, although akin to software engineering, includes the necessary elements of human-computer interaction, user experience, and other sociological and psychological components that constitute user and organizational acceptance and satisfaction.

Competencies: Graduates will be able to:

<u>Programming-Related Competencies</u>

1. Develop data storage strategies using primitive data types in a computer's volatile memory
2. Apply data transformations using arithmetic, assignment, and transpositional operators
3. Develop predicate expressions using relational and logical operators
4. Express algorithmic problem-solving using sequence, selection, and repetition structures
5. Modularize the algorithmic and operating capabilities of a program using functions, methods, subroutines, or similar organizing structures.

6. Select and utilize appropriate linear and non-linear data structures to maintain and manage sets of related data in non-volatile memory.
7. Utilize Object-Oriented concepts in the organization and structuring of programs for behavior and concept management

Application Development Related Competencies

8. Conduct a systematic requirements analysis to determine the basic facts used to organize the application of programming effort to solve a problem or reach a goal
9. Formalize and communicate requirements in a manner that is comprehensible for all stakeholders that will determine the success of the software system
10. Specify the software system architecture such that the principal components and dependencies of the system are visible and comprehensible for all involved in shaping the materials of design and construction
11. Identify the lateral components and libraries that the designed and developed system will depend on
12. Develop the programming code implementation that realizes the system architecture and design.
13. Test all developed programming code components to ensure fidelity, consistency, and fit.
14. Maintain software throughout deployment and utilization such that extant or new intentions and requirements are accommodated such that the intended purpose will function.
15. Adopt, or adapt, an appropriate software systems process methodology such that people, resources, design requirements and other dynamic considerations allow for correctness and utility.
16. Establish and maintain the appropriate dialog among stakeholders that ensure a degree of communication and information transparency to maintain the viability of the software system

Competency 1: Develop data storage strategies using elemental data types in a computer's volatile memory.

Key Dispositions: Purpose-driven, Meticulous, Inventive

Knowledge-Skill Pairs:

Knowledge Element	Skill Level (Bloom cognitive level)
Select appropriate primitive data types to store and recall numeric, string/character, and Boolean data	3 - Apply
Define new derivative data types used to compose complex types from primitive types	3 - Apply

Select from primitive data types according to the precision in the storage of fractional numeric information	3 - Apply
Select from primitive data types according to the magnitude of the integral value relative to available volatile memory	3 - Apply
Define the relationship between binary, octal, decimal, and hexagonal expressions of numeric values	3 - Apply
Explain the importance of the binary nature of computer storage	3 - Apply

Competency 2: Apply data transformations using arithmetic, assignment, and transpositional operators.

Key Dispositions: Purpose-driven, Meticulous, Inventive

Knowledge-Skill Pairs:

Knowledge Element	Skill Level (Bloom cognitive level)
Apply arithmetic operators for data transformation	3 - Apply
Utilize assignment operators to set the values to be stored in variables associated with volatile memory	3 - Apply
Use operator precedence and its impact on the specification and validation of operations	3 - Apply
Apply unary and transpositional operators that modify values stored in volatile memory	3 - Apply
Apply any language-specific keywords that modify the availability or use of values stored in volatile memory	3 - Apply

Competency 3: Develop predicate expressions using relational and logical operators.

Key Dispositions: Purpose-driven, Meticulous, Self-Directed

Knowledge-Skill Pairs:

Knowledge Element	Skill Level (Bloom cognitive level)
Mathematical expressions resolve multiple operations to a single value	2 - Understand
Develop Boolean predicates utilize relational operators	3 - Apply

Develop compound predicate expressions using logical operators	3 - Apply
The relationship between logical operations and computer processor architectures	2 - Understand

Competency 4: Express algorithmic problem-solving using sequence, selection, and repetition structures.

Key Dispositions: Purpose-driven, Meticulous, Inventive

knowledge-skill Pairs:

Knowledge Element	Skill Level (Bloom cognitive level)
Statement as a unit of computing work	2 - Understand
Structure program progression using sequence structures	3 - Apply
Structure iterative program evaluation using repetition structures	3 - Apply
Structure decisive program evaluation using selection structures	3 - Apply

Competency 5: Modularize the algorithmic and operating capabilities of a program using functions, methods, subroutines or similar organizing structures.

Key Dispositions: Purpose-driven, Meticulous, Inventive

Knowledge-Skill Pairs:

Knowledge Element	Skill Level (Bloom cognitive level)
Basic algebraic concept of a mathematical function	2 - Understand
Modularity as a strategy for organization and complexity management	2 - Understand
Define a subroutine/method/function	3 - Apply
Define a subroutine/method/function that defines parameters to be passed as arguments	3 - Apply
Define a functional return value for a subroutine/method/function	3 - Apply
Utilize (call) a subroutine/method/function from elsewhere in code	3 - Apply

Apply the benefits of well-named subroutines/methods/functions that express processes or outcomes as actions or behaviors (verb)	3 - Apply
Utilize any language-specific keywords that modify the availability, persistence, or visibility of a subroutine/method/function	3 - Apply

Competency 6: Select and utilize appropriate linear and non-linear data structures to maintain and manage sets of related data in non-volatile memory.

Key Dispositions: Purpose-driven, Meticulous, Inventive

Knowledge-Skill Pairs:

Knowledge Element	Skill Level (Bloom cognitive level)
Understand the necessity of storing and accessing a set of related values from a single logical or physical memory structure	3 - Apply
Contiguous linear data structures	3 - Apply
Appropriate use of dynamically sized and non-contiguous linear data structures	3 - Apply
Understand the necessity of non-linear data structures	2 - Understand
Understand basic elements of graphs	2 - Understand
Understand the mathematical principles behind hashing algorithms for data storage and retrieval from volatile memory	2 - Understand
Identify and utilize language-specific collections libraries as tested implementations of linear and non-linear data structures	3 - Apply

Competency 7: Utilize Object-Oriented concepts in the organization and structuring of programs for behavior and concept management

Key Dispositions: Purpose-driven, Meticulous, Inventive

Knowledge-Skill Pairs:

Knowledge Element	Skill Level (Bloom cognitive level)
Design objects and classes from domain descriptions	6 - Create

Identify opportunities for abstraction and specialization	5 - Evaluate
Design for dependency management using inheritance and composition	6 - Create

Competency 8: Conduct a systematic requirements analysis to determine the basic facts used to organize the application of programming effort to solve a problem or reach a goal

Key Dispositions: Purpose-driven, Meticulous, Inventive

Knowledge-Skill Pairs:

Knowledge Element	**Skill Level (Bloom cognitive level)**
Apply principles of elicitation and process documentation	3 - Apply
Utilize tools to structural aspects of the problem	3 - Apply
Utilize tools to behavior aspects of the problem	3 - Apply

Competency 9: Formalize and communicate requirements in a manner that is comprehensible for all stakeholders that will determine the success of the software system

Key Dispositions: Purpose-driven, Meticulous, Inventive

Knowledge-Skill Pairs:

Knowledge Element	**Skill Level (Bloom cognitive level)**
Work within a known design paradigm to express requirements	4 - Analyze
Iteratively maintain a specification	5 - Evaluate
Develop increment goals for development and validation	6 - Create

Competency 10: Specify the software system architecture such that the principal components and dependencies of the system are visible and comprehensible for all involved in shaping the materials of design and construction

Key Dispositions: Purpose-driven, Meticulous, Inventive

Knowledge-Skill Pairs:

Knowledge Element	**Skill Level (Bloom cognitive level)**

Select and apply basic design patterns	4 - Analyze
Select and apply architectural patterns	4 - Analyze
Apply SOLID Principles for complexity management	3 - Apply

Competency 11: Identify the lateral components and libraries that the designed and developed system will depend on

Key Dispositions: Purpose-driven, Meticulous, Inventive

Knowledge-Skill Pairs:

Knowledge Element	Skill Level (Bloom cognitive level)
Identify and implement relevant aspects of libraries that are endogenous to the programming language or development platform	5 - Evaluate
Identify and implement relevant aspects of libraries that are exogenous to the programming language or development platform	5 - Evaluate
Utilize semantic versioning for dependency specification	3 - Apply

Competency 12: Develop the programming code implementation that realizes the system architecture and design

Key Dispositions: Purpose-driven, Meticulous, Inventive

Knowledge-Skill Pairs:

Knowledge Element	Skill Level (Bloom cognitive level)
Select, develop, and utilize appropriate application programming interfaces	4 - Analyze
Maintain code integrity using source code management	5 - Evaluate

Competency 13: Test all developed programming code components to ensure fidelity, consistency, and fit

Key Dispositions: Purpose-driven, Meticulous, Inventive

Knowledge-Skill Pairs:

Knowledge Element	Skill Level (Bloom cognitive level)
Select from appropriate unit, acceptance, and integration testing strategies	4 - Analyze
Explain how technical debt is accrued and paid	2 - Understand

Competency 14: Maintain software throughout deployment and utilization such that extant or new intentions and requirements are accommodated such that the intended purpose will function

Key Dispositions: Purpose-driven, Meticulous, Inventive

Knowledge-Skill Pairs:

Knowledge Element	Skill Level (Bloom cognitive level)
Utilize continuous integration and deployment strategies	5 - Evaluate
Utilize a software process paradigm that is adaptive and iterative	5 - Evaluate

Competency 15: Adopt, or adapt, an appropriate software systems process methodology such that people, resources, design requirements and other dynamic considerations allow for correctness and utility

Key Dispositions: Purpose-driven, Meticulous, Inventive

Knowledge-Skill Pairs:

Knowledge Element	Skill Level (Bloom cognitive level)
Select from available software process methodologies as is appropriate to the problem domain and context	4 - Analyze
Regularly review and adjust software process models in response to changing conditions	4 - Analyze

Competency 16: Establish and maintain the appropriate dialog among stakeholders that ensure a degree of communication and information transparency to maintain the viability of the software system

Key Dispositions: Purpose-driven, Meticulous, Inventive

Knowledge-Skill Pairs:

Knowledge Element	**Skill Level (Bloom cognitive level)**
Utilize structures for stakeholder interaction specified with a selected software process model	5 - Evaluate
Establish goals and acceptance criteria for each product increment	4 - Analyze

A3.4.3 Competency Area – *Object-Oriented Paradigm*

Competency Area Statement:

Most software implementations extend beyond simple utilization of programming constructs and move toward the utilization of modular components often built against paradigmatic best practices for extensible and manageable construction. Programming paradigms are often idiomatic and construe epistemological values about the structuring of applications, reusable code libraries and patterns that lead to architectural decisions. Object-Orientation is a paradigmatic perspective on how to organize data and routines into libraries of reusable code centered on organization of data and routines into containers called classes (for specification) and objects (for instantiation). The set of behavioral provisions inherent in these structures that specify how groups and hierarchies of these entities interact forms the basis of Object-Orientation that pervades most accepted architectural patterns for software and systems development. Thus, Object-Orientation, although intrinsic to contemporary programming languages, also serves as a foundation for problem domain modeling that extends beyond applications in programming. Thus, much of this material will also be contained in most systems analysis and design courses. As such, the focus here is on manifested applications that extend from design to implementation whereas systems analysis and design stops short, in most cases, of implementation.

Competencies: Graduates will be able to:

1. Apply fundamental elements of objects and classes
2. Utilize instantiation modalities
3. Utilize intra-entity communication and messaging
4. Design for encapsulation
5. Design for inheritance and dependency management
6. Design for abstraction
7. Apply polymorphism
8. Utilize design patterns
9. Utilize objects and classes for entity modeling

Competency 1: Apply fundamental elements of objects and classes

Key Dispositions: Self-directed, Purpose-driven, Meticulous

Knowledge-Skill Pairs:

Knowledge Element	Skill Level (Bloom cognitive level)
Model the properties of an entity using data types and variables within a class definition	6 - Create
Model the behaviors of an entity using procedures within a class definition	6 - Create
Distinction between instance and class members	6 - Create

Model the properties of an entity using data types and variables within a class definition	3 - Apply

Competency 2: Utilize instantiation modalities

Key Dispositions: Self-directed, Purpose-driven, Meticulous

Knowledge-Skill Pairs:

Knowledge Element	**Skill Level (Bloom cognitive level)**
Object instantiation operations	3 - Apply
Class basis for object instantiation	3 - Apply
Prototype basis for object instantiation	3 - Apply
Object instantiation using constructors and related operators	3 - Apply
Implementing language features related to memory management (unmanaged vs. managed)	3 - Apply

Competency 3: Utilize intra-entity communication and messaging

Key Dispositions: Self-directed, Purpose-driven, Meticulous

Knowledge-Skill Pairs:

Knowledge Element	**Skill Level (Bloom cognitive level)**
Method declaration and use	3 - Apply
Calls by reference and value	3 - Apply
Member visibility and language-specific access modification	3 - Apply
Class packaging for reuse (namespaces, packages, libraries)	3 - Apply
Accessing packaged classes	3 - Apply

Competency 4: Design for encapsulation

Key Dispositions: Purpose-driven, Meticulous, Inventive

Knowledge-Skill Pairs:

Knowledge Element	Skill Level (Bloom cognitive level)
Language features to stratify and organize member visibility and accessibility within a class	3 - Apply
Design for object autonomy and integrity using encapsulation techniques	6 - Create
Refactoring for encapsulation	3 - Apply
Decoupling using encapsulation	3 - Apply

Competency 5: Design for inheritance and dependency management

Key Dispositions: Purpose-driven, Meticulous, Inventive

Knowledge-Skill Pairs:

Knowledge Element	Skill Level (Bloom cognitive level)
Object extensibility and reuse through inheritance (“is a kind of”)	6 - Create
Single and multiple inheritance	3 - Apply
Object extensibility and reuse through composition (“has a”)	3 - Apply
Dependencies and constructors	3 - Apply
Dependency injection and inversion of control	3 - Apply
Interfaces and mixins as an alternative to multiple inheritance	3 - Apply
Object extensibility and reuse through delegation (“knows a”)	3 - Apply

Competency 6: Design for abstraction

Key Dispositions: Purpose-driven, Meticulous, Inventive

Knowledge-Skill Pairs:

Knowledge Element	Skill Level (Bloom cognitive level)
Language features that identify a class as abstract - the source of inheritance without instantiability	3 - Apply
Refactoring or design of abstract inheritance hierarchies	6 - Create
abstraction vs. interfaces (virtual members)	3 - Apply

Data structuring of related data types through abstract references	3 - Apply

Competency 7: Apply polymorphism

Key Dispositions: Purpose-driven, Meticulous, Inventive

Knowledge-Skill Pairs:

Knowledge Element	**Skill Level (Bloom cognitive level)**
Relationship between base/parent class references and derived/child class instances	3 - Apply
Override base/parent class behaviors and attributes in derived/child classes	3 - Apply
Behaviors that respond uniquely to commonly inherited method calls	3 - Apply
Separation of concerns	3 - Apply

Competency 8: Utilize design patterns

Key Dispositions: Purpose-driven, Meticulous, Inventive

Knowledge-Skill Pairs:

Knowledge Element	**Skill Level (Bloom cognitive level)**
Creational, Structural, and Behavioral patterns	3 - Apply
Relationship to modeling notations	3 - Apply
SOLID principles	3 - Apply

Competency 9: Utilize objects and classes for entity modeling

Key Dispositions: Purpose-driven, Meticulous, Inventive

Knowledge-Skill Pairs:

Knowledge Element	**Skill Level (Bloom cognitive level)**
Relationship between OOP implementation and UML	3 - Apply
Limitations in language implementation	3 - Apply

Object-Relational Mapping and data persistence	3 - Apply
Reuse and Libraries	3 - Apply

A3.4.4 Competency Area – *Web Development*

Competency Area Statement:

Students will understand the concepts of web application design and programming by learning the tools used to create client-side and server-side programs. A web site will be designed and implemented using current standards and best practices.

Competencies: Graduates will be able to:

1. Demonstrate an operational understanding of the protocols that enable the Internet
2. Create and analyze an algorithm for effectiveness and efficiency.
3. Implement good documentation practices in programming
4. Demonstrate teamwork, interpersonal group skills, and team software development
5. Demonstrate skills in client-side (Front-end) web application development technologies including HTML, CSS, JavaScript, and JavaScript libraries
6. Demonstrate skills in server-side (back-end) web application development technologies using a back-end programming language (i.e., Node/Express, Python/Django, etc.)
7. Create a functioning web application suitable for portfolio presentation including but not limited to skills shown using front-end, back-end, SQL, and current web development tools
8. Explain the different internet design patterns (i.e., MVC, MVVM, etc.) and ability to know advantages and disadvantages of each
9. Analyze and explain the different design layouts and pros and cons of each
10. Implement security measures for a website
11. Debug syntactical and logical errors
12. Explain the Internet Copyright laws
13. Deploy a website to a host server

Competency 1: Demonstrate an operational understanding of the protocols that enable the Internet

Key Dispositions: Self-Directed, Purpose-driven

Knowledge-Skill Pairs:

Knowledge Element	Skill Level (Bloom cognitive level)
Purpose of the client (front-end)	2 - Understand
Purpose of the server (backend)	2 - Understand
An Internet server interacting with a client	2 - Understand

Competency 2: Create and analyze an algorithm for effectiveness and efficiency.

Key Dispositions: Self-directed, Purpose-driven, Meticulous

Knowledge-Skill Pairs:

Knowledge Element	**Skill Level (Bloom cognitive level)**
Algorithms and the logic that drives them	6 - Create
Solving a problem using an algorithm	3 - Apply
Efficiency of an algorithm	2 - Understand

Competency 3: Implement good documentation practices in programming

Key Dispositions: Inventive, Self-Directed, Responsible

Knowledge-Skill Pairs:

Knowledge Element	**Skill Level (Bloom cognitive level)**
Documentation of an application	6 - Create
Advantages and disadvantages of documenting an application	2 - Understand
Purpose of readable source code	2- Understand
Best practices in writing source code	3 - Apply
Structured program	6 - Create

Competency 4: Demonstrate teamwork, interpersonal group skills, and team software development

Key Dispositions: Collaborative, Adaptable, Responsible

Knowledge-Skill Pairs:

Knowledge Element	**Skill Level (Bloom cognitive level)**
Team personalities	2 - Understand
Team responsibilities	2 - Understand
Use of team communication tools	3 - Apply
Proper communication with team members	3 - Apply
Version control software in stand-alone environment	3 - Apply
Version control software in a team development project	3 - Apply

Competency 5: Demonstrate skills in client-side (Front-end) web application development technologies including HTML, CSS, JavaScript, and JavaScript libraries.

Key Dispositions: Purpose-driven, Meticulous, Inventive

Knowledge-Skill Pairs:

Knowledge Element	**Skill Level (Bloom cognitive level)**
Client-side (Front-end)	2 - Understand
Client-side skills (HTML, CSS, JavaScript)	6 - Create
Document Object Model (DOM)	2 - Understand
DOM being used in Front-end	6 - Create

Competency 6: Demonstrate skills in server-side (back-end) web application development technologies using a back-end programming language (i.e., Node/Express, Python/Django, etc.)

Key Dispositions: Purpose-driven, Meticulous, Inventive

Knowledge-Skill Pairs:

Knowledge Element	**Skill Level (Bloom cognitive level)**
Server-side (back-end)	2 - Understand
Server-side language (i.e., Node/Express, Python/Django, etc.)	6 - Create

Competency 7: Create a functioning web application suitable for portfolio presentation including but not limited to skills shown using front-end, back-end, SQL, and current web development tools

Key Dispositions: Purpose-driven, Meticulous, Inventive

Knowledge-Skill Pairs:

Knowledge Element	**Skill Level (Bloom cognitive level)**
Full stack development	2 - Understand
Mean stack development	2 - Understand
Skills to create a web application using front- and back-end development along with incorporating database functionality (CRUD)	6 - Create

JavaScript Object Notation (JSON)	2 - Understand
Website that uses JSON or a database as both input and output	6 - Create
View engine and how it is used	2 - Understand
Different web view engines	2 - Understand
Use of view engine in web development	6 - Create
RESTful API, what is it and when to use	2 - Understand
RESTful API	6 - Create

Competency 8: Explain the different internet design patterns (i.e., MVC, MVVM, etc.) and ability to know advantages and disadvantages of each

Key Dispositions: Purpose-driven, Responsible, Inventive

Knowledge-Skill Pairs:

Knowledge Element	Skill Level (Bloom cognitive level)
Design pattern	2 - Understand
Advantages of disadvantages of the different design patterns	2 - Understand

Competency 9: Analyze and explain the different design layouts and pros and cons of each

Key Dispositions: Purpose-driven, Meticulous, Inventive

Knowledge-Skill Pairs:

Knowledge Element	Skill Level (Bloom cognitive level)
Current design layout (i.e., cards, grids, magazine, etc.)	2 - Understand
Advantages of disadvantages of the different design patterns	2 - Understand
Website layout	6 - Create

Competency 10: Implement security measures for a website

Key Dispositions: Inventive, Self-Directed, Responsible

Knowledge-Skill Pairs:

Knowledge Element	Skill Level (Bloom cognitive level)
Authorization vs Authentication	2 - Understand
When to use security and why	2 - Understand
Website authorization	6 - Create
Website authentication	6 - Create
Encryption	2 - Understand
Decryption	2 - Understand
Website database encryption and decryption	6 - Create
Cipher Text	2 - Understand
Plain Text	2 - Understand
Symmetric Key, Asymmetric Key, Public Key, Private Key	2 - Understand

Competency 11: Debug syntactical and logical errors

Key Dispositions: Meticulous, Self-Directed, Inventive

Knowledge-Skill Pairs:

Knowledge Element	Skill Level (Bloom cognitive level)
Process of debugging a website application	2 - Understand
Difference between syntax and logic error	2 - Understand
Website debugging	3 - Apply

Competency 12: Explain the Internet Copyright laws

Key Dispositions: Self-Directed, Responsible, Professional

Knowledge-Skill Pairs:

Knowledge Element	Skill Level (Bloom cognitive level)
Permission to publish	2 - Understand
Freedom of speech	2 - Understand
Intellectual property and ownership	2 - Understand

The @ sign	2 - Understand
Automatic copyright	2 - Understand
Registering a copyright	2 - Understand
Alternative copyright registration	2 - Understand
Types of work	2 - Understand
Other types of protection	2 - Understand

Competency 13: Deploy a website to a host server

Key Dispositions: Collaborative, Adaptable, Responsible

Knowledge-Skill Pairs:

Knowledge Element	Skill Level (Bloom cognitive level)
Server hosts files	2 - Understand
Deployment of website and files	3 - Apply
Configuration of host	3 - Apply

A3.4.5 Competency Area – *Mobile Development*

Competency Area Statement:

Understand the features and upcoming trends of the common mobile platforms to develop a mobile application that uses a web services backend to synchronize and centrally store user data. Topics include but not limited to human interface guidelines for mobile development, tools required for mobile application development, different mobile platforms,

Competencies: Graduates will be able to:

1. Describe the Internet of Things (IoT) enabled devices and the mobile industry
2. Create and analyze an algorithm for effectiveness and efficiency
3. Implement good documentation practices in programming
4. Demonstrate teamwork, interpersonal group skills, and team software development
5. Utilize a contemporary mobile application development framework
6. Create a functioning mobile application suitable for portfolio presentation including but not limited to skills shown using database management, hardware interaction, APIs, cross platform development and current mobile development tools
7. Describe and distinguish different mobile development platforms
8. Demonstrate mobile user interface design and the user experience
9. Implement cyber security measures for a mobile application
10. Explain memory allocation and management
11. Debug syntactical and logical errors
12. Explain the importance of Copyright laws
13. Market and publish a mobile application

Competency 1: Describe the Internet of Things (IoT) enabled devices and the mobile industry

Key Dispositions: Purpose-driven, Self-Directed, Inventive

Knowledge-Skill Pairs:

Knowledge Element	**Skill Level (Bloom cognitive level)**
IoT is changing mobile development (i.e., Smart Home devices)	2 - Understand
Design of mobile application for the IoT experience	2 - Understand
IoT components and challenges	2 - Understand

Competency 2: Create and analyze an algorithm for effectiveness and efficiency

Key Dispositions: Purpose-driven, Meticulous, Inventive

Knowledge-Skill Pairs:

Knowledge Element	Skill Level (Bloom cognitive level)
Algorithms and the logic that drives them	6 - Create
Solving a problem using an algorithm	3 - Apply
Efficiency of an algorithm	2 - Understand

Competency 3: Implement good documentation practices in programming

Key Dispositions: Meticulous, Purpose-driven, Self-Directed

Knowledge-Skill Pairs:

Knowledge Element	Skill Level (Bloom cognitive level)
Documentation of an application	6 - Create
Advantages and disadvantages of documenting an application	2 - Understand
Purpose of readable source code	2 - Understand
Best practices in writing source code	3 - Apply
Structured program	6 - Create

Competency 4: Demonstrate teamwork, interpersonal group skills, and team software development

Key Dispositions: Collaborative, Self-Directed, Responsible

Knowledge-Skill Pairs:

Knowledge Element	Skill Level (Bloom cognitive level)
Team personalities	2 - Understand
Team responsibilities	2 - Understand
Use of team communication tools	3 - Apply
Proper communication with team members	3 - Apply
Version control software in standalone environment	3 - Apply
Version control software in a team development project	3 - Apply

Competency 5: Utilize a contemporary mobile application development framework

Key Dispositions: Purpose-driven, Meticulous, Inventive

Knowledge-Skill Pairs:

Knowledge Element	Skill Level (Bloom cognitive level)
Mobile development programming language	3 - Apply

Competency 6: Create a functioning mobile application suitable for portfolio presentation including but not limited to skills shown using database management, hardware interaction, APIs, cross platform development and current mobile development tools

Key Dispositions: Purpose-driven, Meticulous, Inventive

Knowledge-Skill Pairs:

Knowledge Element	Skill Level (Bloom cognitive level)
JSON and/or database used as both input and output	6 - Create
Cross-platform mobile application	6 - Create
Cloud-based data driving mobile application	6 - Create
Benefits of mobile development APIs (i.e., Google Maps, YouTube, etc.)	2 - Understand
APIs used within mobile application	3 - Apply
Different mobile development tools	3 - Apply
Hardware issues (i.e., resolutions, different devices, etc.)	2 - Understand

Competency 7: Describe and distinguish different mobile development platforms

Key Dispositions: Purpose-driven, Meticulous, Inventive

Knowledge-Skill Pairs:

Knowledge Element	Skill Level (Bloom cognitive level)
Different mobile platforms	2 - Understand
Tools that allow cross-platform development	3 - Apply

Competency 8: Demonstrate mobile user interface design and the user experience

Key Dispositions: Purpose-driven, Self-Directed, Professional

Knowledge-Skill Pairs:

Knowledge Element	Skill Level (Bloom cognitive level)
Seamless experience across multiple devices	3 - Apply
End user personalization of app	3 - Apply
Mobile application layout	6 - Create
Best practices	3 - Apply

Competency 9: Implement cyber security measures for a mobile application

Key Dispositions: Meticulous, Self-Directed, Responsible

Knowledge-Skill Pairs:

Knowledge Element	Skill Level (Bloom cognitive level)
Security issues (i.e., app store security, malware, IoT hardware, etc.)	2 - Understand
Authentication	3 - Apply
Encryption	2 - Understand
Decryption	2 - Understand
Mobile application data encryption and decryption	6 - Create

Competency 10: Explain memory allocation and management

Key Dispositions: Purpose-driven, Meticulous, Inventive

Knowledge-Skill Pairs:

Knowledge Element	Skill Level (Bloom cognitive level)
Memory management (i.e., garbage collection, allocate and reclaim app memory, share memory, etc.)	3 - Apply

Competency 11: Debug syntactical and logical errors

Key Dispositions: Meticulous, Self-Directed, Purpose-driven

Knowledge-Skill Pairs:

Knowledge Element	Skill Level (Bloom cognitive level)
Process of debugging a mobile application	2 - Understand
Difference between syntax and logic error	2 - Understand
Mobile application debugging	3 - Apply

Competency 12: Explain the importance of Copyright laws

Key Dispositions: Self-Directed, Responsible, Purpose-driven

Knowledge-Skill Pairs:

Knowledge Element	Skill Level (Bloom cognitive level)
Permission to publish	2 - Understand
Freedom of speech	2 - Understand
Intellectual property and ownership	2 - Understand
The @ sign	2 - Understand
Automatic copyright	2 - Understand
Registering a copyright	2 - Understand
Alternative copyright registration	2 - Understand
Types of work	2 - Understand
Other types of protection	2 - Understand

Competency 13: Market and publish a mobile application

Key Dispositions: Purpose-driven, Self-Directed, Meticulous

Knowledge-Skill Pairs:

Knowledge Element	Skill Level (Bloom cognitive level)
Marketing plan (i.e., release date, competitive analysis, website or landing page for downloading app, social media, etc.)	2 - Understand
Mobile app stores	2 - Understand
Publishing the app	3 - Apply

A3.4.6 Competency Area – User Interface Design

Competency Area Statement

Students will understand the concepts of user interface design principles by examining user experience (UX) and usability. Topics include design considerations such as: psychological and interaction principles, requirements analysis, designing for different screens, typography, symbols, color, graphics, and other visual language components. Students will learn to identify needs, experience, and capabilities of the system users along with understanding physical and mental limitations.

Competencies: Graduates will be able to:

1. Apply principles of user-Centered design (UCD)
2. Apply user-system interaction principles
3. Design and create effective user-centered user interaction with an application
4. Identify and evaluate attributes of effective UX
5. Evaluate the influence user centered design has on user experience (UX)

Competency 1: Apply principles of user-Centered design (UCD)

Key Dispositions: Purpose-driven, Professional, Collaborative

Knowledge-Skill Pairs:

Knowledge Element	Skill Level (Bloom cognitive level)
Understanding of users, tasks, and environments	2 - Understand
Gathering user feedback to define requirements and design.	2 - Understand
Involve user in the design process	2 - Understand
Implement an iterative user design process	2 - Understand
Essential elements of user centered design	2 - Understand
Human capabilities that motivate them, including motor skills, attention, and human error	2 - Understand

Competency 2: Apply user-system interaction principles

Key Dispositions: Purpose-driven, Professional, Collaborative

Knowledge-Skill Pairs:

Knowledge Element	**Skill Level (Bloom cognitive level)**
Direct manipulation objects of interest in the UI are visible and can be acted upon	2 - Understand
Menu based systems where users work their way through a series of screens or menus	2 - Understand
Form fill-in where a user needs to enter the necessary information in order to complete a specific task for requirement	2 - Understand
Command line interaction with operating systems	2 - Understand
Natural language allowing a user to interact with the computer using a human language	2 - Understand

Competency 3: Design and create effective user-centered user interaction with an application

Key Dispositions: Purpose-driven, Inventive, Self-Directed

Knowledge-Skill Pairs:

Knowledge Element	**Skill Level (Bloom cognitive level)**
Construct navigation enabling users to easily accomplish tasks	6 - Create
Create intuitive forms used for gathering required data	6 - Create
Create a working application or web page template appropriate for various devices using mobile-first design principles.	6 - Create
Identify an application's target audience and create an audience-appropriate design	6 - Create
Use critical thinking skills to revise application based on feedback	5 - Evaluate

Competency 4: Identify and evaluate attributes of effective UX

Key Dispositions: Purpose-driven, Inventive, Self-Directed

Knowledge-Skill Pairs:

Knowledge Element	**Skill Level (Bloom cognitive level)**

Study perception, simplicity, clarity, consistency, hierarchy (visual and temporal)	5 - Evaluate
Achieve a personalized experience	6 - Create
Design and align the information architecture of the application environment to support usability, comprehensibility, and search	6 - Create
Familiarity with human-computer interface principles and issues	3 - Apply
Design and implement user testing strategies to include usability testing, A/B testing, and user flow validation	6 - Create

Competency 5: Evaluate the influence user centered design has on user experience (UX)

Key Dispositions: Purpose-driven, Professional, Inventive

Knowledge-Skill Pairs:

Knowledge Element	**Skill Level (Bloom cognitive level)**
Cooperative and Participatory design to align designer and users in a partnership	3 - Apply
Establish UX purpose, audience, context, and history	2 - Understand
Analysis tools and techniques such as Personas, Scenarios, Use Cases, User Stories, Storyboards, and Wireframes	3 - Apply
Awareness of underlying philosophies such as action-orientation, design thinking, human-centrism, information architecture, and socio-technical perspectives	2 – Understand

A3.5 Organizational Domain Competency Realm

A3.5.1 Competency Area - IS Ethics, Sustainability, Use and Implications for Society

Competency Area Statement:

The IS ethics, sustainability, use, and implications for society competency area is concerned with practices associated with the ethical use of information systems and the ethical use of the information and data captured by such systems; designing, implementing, and using computing resources in a sustainable environmentally conscious manner; and competencies associated with how information systems may be used and created for the benefit of society.

1. Ethics, within the IS ecosystem, reflects agreed moral codes of practices and control associated with the use of information systems through the: collection of data, the creation and storage of data, and the sharing of data's information. As such ethical codes that govern both the use or dissemination of data must apply to both the information systems and the society in which it exists. The information system practitioner must be cognizant of these ethical codes and its implications for society.

Students will explore and understand the societal implications of disseminating information.

2. IS sustainability reflects an imperative that such systems and their data sources must be adaptable, relevant to all stakeholders, and support the maintenance of data captured by such systems – through its design, implementation, and use of computing resources. Such data is constantly transformed through sustainable process, actions, and performance to support the organization, individual, and society at large.

Competencies: Graduates will be able to:

1. Demonstrate ethical behavior during data collection
2. Identify the moral issues that surround the storage and usage of data
3. Examine ethical philosophies and their practical application
4. Evaluate ethical codes of practice and their implications for society
5. Identify aspects of sustainability and adaptive systems and data
6. Categorize ethical stakeholders and their importance to Information Systems
7. Investigate sustainable processes, actions, and performance to support organizations
8. Investigate sustainable processes, actions, and performance to support the individual
9. Investigate sustainable processes, actions, and performance to support society at large

Competency 1: Demonstrate ethical behavior during data collection

Key Dispositions: Professional, Responsible, Proactive

Knowledge-Skill Pairs:

Knowledge Element	Skill Level (Bloom cognitive level)

International laws and regulations governing the collection of data	2 - Understand
Country specific laws and regulations governing the collection of data	2 - Understand
State and local laws governing the collection of data	2 - Understand
How data is collected via mobile devices	2 - Understand
How data is collected via websites	2 - Understand
How data is collected via social media	2 - Understand
How data is collected via email	2 - Understand
How data is collected via wearable devices	2 - Understand
Common ethical philosophical frameworks	2 - Understand
Basic principles governing ethical decision making	2 - Understand

Competency 2: Identify the moral issues that surround the storage and usage of data

Key Dispositions: Professional, Responsible, Proactive

Knowledge-Skill Pairs:

Knowledge Element	Skill Level (Bloom cognitive level)
Data Storage and codes of ethics	3 - Apply
Decision making for sharing and using data	5 - Evaluate
Moral codes for data sharing	2 - Understand

Competency 3: Examine ethical philosophies and their practical application

Key Dispositions: Professional, Responsible, Proactive

Knowledge-Skill Pairs:

Knowledge Element	Skill Level (Bloom cognitive level)
Ethical philosophies	4 - Analyze
Computing practices surrounding data sharing and security	3 - Apply
Vocabulary	3 - Apply

Best practices	4 - Analyze

Competency 4: Investigate ethical codes of practice and their implications for society

Key Dispositions: Professional, Responsible, Proactive

Knowledge-Skill Pairs:

Knowledge Element	Skill Level (Bloom cognitive level)
IS ethical code of conduct	3 - Apply
Importance of an ethical code of conduct	2 - Understand
Critical elements of an ethical code of conduct	3 - Apply
Applying and adhering to ethical code of conduct	3 - Apply
Breaches of ethical codes of conduct	5 - Evaluate
Legal aspects of ethical conduct	4 - Analyze

Competency 5: Identify aspects of sustainability and adaptive systems and data

Key Dispositions: Responsible, Purpose-driven, Professional

Knowledge-Skill Pairs:

Knowledge Element	Skill Level (Bloom cognitive level)
Sustainability of systems	2 - Understand
Adaptability of systems	2 - Understand
Legal issues surround reusing data collected for another purpose	4 - Analyze

Competency 6: Categorize ethical stakeholders and their importance to Information Systems

Key Dispositions: Professional, Responsible, Passionate

Knowledge-Skill Pairs:

Knowledge Element	Skill Level (Bloom cognitive level)
Core IS stakeholders	3 - Apply

IS Stakeholder roles	3 - Apply
Implications for IS	5 - Evaluate

Competency 7: Investigate sustainable processes, actions, and performance to support organizations

Key Dispositions: Responsible, Professional, Proactive

Knowledge-Skill Pairs:

Knowledge Element	**Skill Level (Bloom cognitive level)**
Processes to support ethical behavior in organizations	3 - Apply
Activities to support ethical behavior in organizations	3 - Apply
Performance criteria to support ethical behavior in organizations	3 - Apply

Competency 8: Investigate sustainable processes, actions, and performance to support the individual

Key Dispositions: Responsible, Professional, Proactive

Knowledge-Skill Pairs:

Knowledge Element	**Skill Level (Bloom cognitive level)**
Processes to support ethical behavior for the individual	3 - Apply
Activities to support ethical behavior for the individual	3 - Apply
Performance criteria to support ethical behavior by the individual	3 - Apply

Competency 9: Investigate sustainable processes, actions, and performance to support society at large

Key Dispositions: Responsible, Professional, Proactive

Knowledge-Skill Pairs:

Knowledge Element	**Skill Level (Bloom cognitive level)**
Processes to support ethical behavior by society	3 - Apply
Activities to support ethical behavior by society	3 - Apply

Performance Criteria to support ethical behavior by society	3 - Apply

A3.5.2 Competency Area – IS Management and Strategy

Competency Area Statement:

IS Management competencies cover the capability to develop, maintain, and consistently improve the systems necessary to deliver the information necessary for an organization. The capability focuses on creating value for an organization and on the IS staff motivation, performance, and accountability. IS Strategy emphasizes the competency to create long-term plans for implementing and using organizational information systems to achieve strategic organizational goals and objectives. This area also covers monitoring and controlling organizational IS resources to ensure alignment with and achievement of strategies, goals, and objectives. [MSIS2016]

Competencies: Graduates will be able to:

1. Apply professional managerial skills to design and manage an effective IS organization
2. Ensure operational efficiency and effectiveness in service delivery of organizational information
3. Manage the information resources in coordination with line management
4. Create and manage the oversight mechanisms by which an organization evaluates, directs, and monitors organizational information technology - managing decision rights and organizational information technology decision-making practices
5. Implement strategic plans that have been created for the delivery and use of organizational information systems
6. Ensure organizational information systems comply with policies, applicable laws and regulations
7. Manage organizational risk and develop risk mitigation plans
8. Create IT procurement policies and understand and negotiate IT contracts
9. Develop plans for workforce development, training, talent acquisition, and employee retention
10. Apply leading service management frameworks, such as ITIL and CMMI
11. Identify commonly used governance frameworks, such as COBIT and TOGAF, to align information systems with organizational requirements

Competency 1: Apply professional managerial skills to design and manage an effective IS organization

Key Dispositions: Collaborative, Professional, Self-Directed

Knowledge-Skill Pairs:

Knowledge Element	Skill Level (Bloom cognitive level)
Conceptual skills in the ability for abstract thinking and turning an entire concept into a creative solution	2 - Understand
Interpersonal skills in leading teams and workgroups	2 - Understand

Management skills including planning, communicating, problem-solving, delegating, and making decisions	3 - Apply

Competency 2: Ensure operational efficiency and effectiveness in service delivery of organizational information

Key Dispositions: Professional, Collaborative, Responsible

Knowledge-Skill Pairs:

Knowledge Element	Skill Level (Bloom cognitive level)
Efficiency: an enterprise's capability to deliver IT services to its customers using the most cost-efficient methods with the highest quality of service	5 - Evaluate
Effectiveness: best operating practices for resource optimization in delivering organization IT strategic goals	5 - Evaluate

Competency 3: Manage the information resources in coordination with line management

Key Dispositions: Collaborative, Adaptable, Responsible

Knowledge-Skill Pairs:

Knowledge Element	Skill Level (Bloom cognitive level)
Information management techniques used to add value to products and services utilizing appropriate organizational data	3 - Apply
Policies and practices for the use of information resources	6 - Create
Appropriate technological solutions for increasing competitive advantages in alignment with enterprise strategic goals	6 - Create

Competency 4: Create and manage the oversight mechanisms by which an organization evaluates, directs, and monitors organizational information technology - managing decision rights and organizational information technology decision-making practices

Key Dispositions: Professional, Proactive, Collaborative

Knowledge-Skill Pairs:

Knowledge Element	Skill Level (Bloom cognitive level)
Administrative oversight and accountability best practices	3 - Apply

Decision rights and decision-making practices	3 - Apply
Evaluation and monitoring techniques for IT operations	4 - Evaluate

Competency 5: Implement strategic plans that have been created for the delivery and use of organizational information systems

Key Dispositions: Professional, Collaborative, Self-Directed

Knowledge-Skill Pairs:

Knowledge Element	Skill Level (Bloom cognitive level)
Systematic process for creating long-range plans for IS to meet the organization's overall strategic plan	2 - Understand
Sequence of steps in planning, designing, and communicating the IS strategic plans	2 - Understand
Methodologies, techniques, and tools used in applying strategic planning	3 - Apply

Competency 6: Ensure organizational information systems comply with policies, applicable laws, and regulations

Key Dispositions: Professional, Collaborative, Responsible

Knowledge-Skill Pairs:

Knowledge Element	Skill Level (Bloom cognitive level)
Regulatory standards and regulations. For example, ISO (International Organization for Standardization), Sarbanes-Oxley Act (SOX), Control Objectives for Information and Related Technologies (COBIT), HIPAA (Health Insurance Portability and Accountability Act), PCI-DSS (The Payment Card Industry Data Security Standard), GDPR (General Data Protection Regulation)	5 - Evaluate

Competency 7: Manage organizational risk and develop risk mitigation plans

Key Dispositions: Professional, Purpose-driven, Proactive

Knowledge-Skill Pairs:

Knowledge Element	Skill Level (Bloom cognitive level)
Potential threats, vulnerabilities, and risks associated with an information technology system	2 - Understand
Controls for reducing or eliminating risk	2 - Understand
Risk Management: identifying and assessing risk	5 - Evaluate
Risk Mitigation: steps to reduce risk to an acceptable level	5 - Evaluate

Competency 8: Create IT procurement policies and understand and negotiate IT contracts

Key Dispositions: Professional, Collaborative, Responsible

Knowledge-Skill Pairs:

Knowledge Element	Skill Level (Bloom cognitive level)
Procurement processes and confidentiality	1 - Remember
Delegation of purchasing authority levels	3 - Apply
Bids, proposals and RFP forms and processes	3 - Apply
Non-disclosure agreements (NDA)	4 - Analyze
Specifications and requirements.	6 - Create
Maintenance and support contracts.	6 - Create

Competency 9: Develop plans for workforce development, training, talent acquisition, and employee retention

Key Dispositions: Professional, Collaborative, Responsible

Knowledge-Skill Pairs:

Knowledge Element	Skill Level (Bloom cognitive level)
Talent acquisition: defining, identifying, and attracting appropriate IT skills and dispositions to hire the right person from the start	3 - Apply
Workforce development and training (e.g., in-house workshops, external bootcamps and employee education)	3 - Apply

IT talent retention; creating policies for salaries and benefits, providing appropriate career path development, matching employee skills with organizational needs	3 - Apply

Competency 10: Apply leading service management frameworks, such as ITIL and CMMI

Key Dispositions: Professional, Inventive, Self-Directed

Knowledge-Skill Pairs:

Knowledge Element	**Skill Level (Bloom cognitive level)**
IT Infrastructure Library (ITIL)	3 - Apply
Capability Maturity Model Integration (CMMI)	3 - Apply

Competency 11: Identify commonly used governance frameworks, such as COBIT and TOGAF, to align IS with organizational requirements.

Key Dispositions: Professional, Collaborative, Responsible

Knowledge-Skill Pairs:

Knowledge Element	**Skill Level (Bloom cognitive level)**
Control Objectives for Information and Related Technologies (COBIT)	3 - Apply
Open Group Architecture Framework (TOGAF)	3 - Apply

A3.5.3 Competency Area – Digital Innovation

Digital Innovation area focuses on competences needed in the deployment of information technologies to innovate and transform organizational processes and value offerings (products and services). To participate in such innovation processes, graduates need competences related to how digital innovations are being created, distributed, and commercialized. This requires understanding of both theoretical and practical aspects of emerging and existing digital innovation, their potential impact, disruption, and transformation on business and society. It is advised that for building such competences, practical hands-on application and theoretical business modeling is used. The practical implications of digital innovation and entrepreneurship focus on the practices for digital innovation creation, distribution, and commercialization as well as the necessary digital strategies for management.

Competencies: Graduates will be able to:

1. Articulate and critically reflect on the unique features that an application of emerging technology may offer
2. Demonstrate knowledge of the role of digital business technologies in social and mobile domains
3. Identify and critique characteristics necessary for digital innovation
4. Identify and validate an opportunity to develop a new digital business model
5. Identify and evaluate key issues related to implementation and infrastructure issues
6. Identify and assemble the required resources, processes, and partners to bring a digital business model to fruition
7. Practically demonstrate the investigation and application of a new innovation

Competency 1: Articulate and critically reflect on the unique features that an application of emerging technology may offer

Key Dispositions: Inventive, Self-Directed, Purpose-driven

Knowledge-Skill Pairs:

Knowledge Element	**Skill Level (Bloom cognitive level)**
Emerging digital technology areas	1 - Remember
Methods to learn about emerging technology areas	3 - Apply
Methods to articulate and critically reflect offerings of a particular new digital technology	3 - Apply

Competency 2: Demonstrate knowledge of the role of digital business technologies in social and mobile domains

Key Dispositions: Self-Directed, Purpose-driven, Inventive

Knowledge-Skill Pairs:

Knowledge Element	Skill Level (Bloom cognitive level)
Social applications of technology	5 - Evaluate
Mobile applications of technology	5 - Evaluate
Business Applications of Technology	5 - Evaluate

Competency 3: Identify and critique characteristics necessary for digital innovation

Key Dispositions: Inventive, Self-Directed, Purpose-driven

Knowledge-Skill Pairs:

Knowledge Element	Skill Level (Bloom cognitive level)
Conditions for digital innovation	5 - Evaluate
Domains of digital innovation	5 - Evaluate
Applications of digital innovations	5 - Evaluate

Competency 4: Identify and validate an opportunity to develop a new digital business model

Key Dispositions: Inventive, Self-Directed, Purpose-driven

Knowledge-Skill Pairs:

Knowledge Element	Skill Level (Bloom cognitive level)
Digital business models	5 - Evaluate
Digital business innovation elements	5 - Evaluate
Criteria necessary for new digital business models	5 - Evaluate
Validation criteria for a new digital business model	5 - Evaluate

Competency 5: Identify and evaluate key issues related to implementation and infrastructure issues.

Key Dispositions: Inventive, Self-Directed, Purpose-driven

Knowledge-Skill Pairs:

Knowledge Element	Skill Level (Bloom cognitive level)
Implementation criteria (Scrum or SDLC)	5 - Evaluate
Infrastructure elements for implementation	6 - Create
Key criteria for continuing or stopping implementation	5 - Evaluate

Competency 6: Identify and assemble the required resources, processes, and partners to bring a digital business model to fruition.

Key Dispositions: Inventive, Self-Directed, Purpose-driven

Knowledge-Skill Pairs:

Knowledge Element	Skill Level (Bloom cognitive level)
Ideation for a new business model	6 - Create
Resource identification	5 - Evaluate
Project planning	5 - Evaluate
Collaboration	6 - Create
Negotiation	6 - Create

Competency 7: Practically demonstrate the investigation and application of a new innovation.

Key Dispositions: Inventive, Self-Directed, Purpose-driven

Knowledge-Skill Pairs:

Knowledge Element	Skill Level (Bloom cognitive level)
Project implementation	6 - Create
Evaluation criteria for a successful application	5 - Evaluate
Pitch presentation	6 - Create

A3.5.4 Competency Area – *Business Process Management*

Competency Area Statement:

Process modelling is a foundational skill required to be able to implement a complete Business Process Management capability in an organization. The competencies include being able to establish a sound theoretical basis of state-of-the-art theories in the field of Business Process Modelling (BPM) and to discover and practice the techniques and best practices in the field of BPM.

Competencies: Graduates will be able to:

1. Explain the characteristics of a process and the different perspectives of a process model
2. Use a BPM tool to design and implement business process models
3. Choose appropriate process discovery techniques for different business scenarios
4. Design a Process Architecture
5. Analyze an AS-IS business process using appropriate techniques
6. Use process improvement methods and implement TO-BE processes by eliminating the bottlenecks, enhancing, and innovating the AS-IS process
7. Evaluate techniques and tools that support the planning, design, analysis, operation, and monitoring of business processes

Competency 1: Explain the characteristics of a process and the different perspectives of a process model

Key Dispositions: Self-Directed, Purpose-driven, Meticulous

Knowledge-Skill Pairs:

Knowledge Element	Skill Level (Bloom cognitive level)
Characteristics of process (e.g., actions, events/tasks, decision points, outcomes, and value)	2 - Understand
Perspectives of modelling (control flow, functional, data, organization perspective)	2 - Understand

Competency 2: Use a BPM tool to design and implement business process models

Key Dispositions: Self-Directed, Purpose-driven, Meticulous

Knowledge-Skill Pairs:

Knowledge Element	Skill Level (Bloom cognitive level)

Elements of a BPMN model (Branching and merging (exclusive decisions, parallel execution, inclusive decisions; rework and repetition; Information artifacts and resources)	3 - Apply
Organizational (or resource) elements in BPMN (Pools and Lanes)	3 - Apply
Types of resources (process participant, software system, equipment)	3 - Apply
Example BPM tools- ARIS, Visio or System Architect	3 - Apply

Competency 3: Choose appropriate process discovery techniques for different business scenarios

Key Dispositions: Self-Directed, Purpose-driven, Meticulous

Knowledge-Skill Pairs:

Knowledge Element	**Skill Level (Bloom cognitive level)**
Business Scenarios	3 - Apply
Process Discovery techniques (evidence-based – document analysis, observation, process mining; interview-based; workshop based)	5 - Evaluate

Competency 4: Design a Process Architecture

Key Dispositions: Self-Directed, Purpose-driven, Meticulous

Knowledge-Skill Pairs:

Knowledge Element	**Skill Level (Bloom cognitive level)**
Process Architecture and process portfolios	6 - Create
Types of processes (management, core and supporting)	6 - Create
Relationships between processes: sequence, decomposition, and specialization.	6 - Create

Competency 5: Analyze an AS-IS business process using appropriate techniques

Key Dispositions: Self-Directed, Purpose-driven, Meticulous

Knowledge-Skill Pairs:

Knowledge Element	Skill Level (Bloom cognitive level)
Techniques for collecting and analyzing issues in a process	2 - Understand
Issue root cause analysis (e.g., Pareto chart) and documentation	4 - Analyze

Competency 6: Use process improvement methods and implement TO-BE processes by eliminating the bottlenecks, enhancing, and innovating the AS-IS process

Key Dispositions: Self-Directed, Purpose-driven, Meticulous

Knowledge-Skill Pairs:

Knowledge Element	Skill Level (Bloom cognitive level)
Methods for process improvement redesign and reengineering	2 - Understand
Technology solutions (AI, IOT, Blockchain, etc.)	2 - Understand
Cost-benefits analysis and Return on investment	3 – Apply
Change management and implementation	3 – Apply

Competency 7: Evaluate techniques and tools that support the planning, design, analysis, operation, and monitoring of business processes

Key Dispositions: Self-Directed, Meticulous, Inventive

Knowledge-Skill Pairs:

Knowledge Element	Skill Level (Bloom cognitive level)
Techniques and tools that support the planning, design, analysis, operation, and monitoring of business processes such as business process management systems; BPM suites; BPEL, XML, and XPDL standards; SOA and Web services.	2 - Understand
Robotic Process Automation and tools available (e.g., UIPath Developer)	2 - Understand
Performance measures	2 - Understand

A3.6 Integration Competency Realm

A3.6.1 Competency Area – IS Project Management

Competency Area Statement: Provide an understanding of the concepts of project management and appropriate project management techniques in dealing with IS management. Topics include principles of project management; project management functions, project management processes, selecting an appropriate project management methodology, agile software development principles, and scrum. Emphasis is placed on understanding and gaining practical knowledge of key project management skills: integration management, scope management, time management, cost management, quality management, human resource management, communications management, and risk management. Emphasis is also placed on understanding the scrum process and decision criteria for choosing between planned and agile project management approaches.

Students should also learn the tools, techniques, and processes to manage project performance along with moving from one phase to another until the closure of the project.

Competencies: Graduates will be able to:

1. Explain basic project management concepts and terms
2. Use integration management tools, techniques, and processes
3. Use scope management tools, techniques, and processes
4. Develop estimates and time tracking using appropriate tools, techniques, and processes
5. Develop estimates and cost tracking using appropriate tools, techniques, and processes
6. Utilize the change control process to maintain and control quality
7. Implement human resource management tools, techniques, and processes
8. Define and implement a communication management plan
9. Predict and manage project risk through the use of tools, techniques, and processes
10. Define and explain procurement management
11. Identify and manage stakeholders within the phases of a project
12. Utilize tools, techniques, and processes to manage project performance
13. Apply agile project management principles and methods in practice
14. Apply the Scrum development process
15. Select an appropriate project management methodology based on project characteristics

Competency 1: Explain basic project management concepts and terms

Key Dispositions: Purpose-driven, Professional, Proactive

Knowledge-Skill Pairs:

Knowledge Element	Skill Level (Bloom cognitive level)

Project management terms	2 - Understand
Project life cycle	2 - Understand
Organizational Structure	2 - Understand
Project management processes	2 - Understand
Project management framework	2 - Understand

Competency 2: Use integration management tools, techniques, and processes

Key Dispositions: Proactive, Inventive, Self-Directed

Knowledge-Skill Pairs:

Knowledge Element	Skill Level (Bloom cognitive level)
Project charter	3 - Apply
Project management plan	3 - Apply
Statement of work (SOW)	3 - Apply
Process of making changes	3 - Apply

Competency 3: Use scope management tools, techniques, and processes

Key Dispositions: Proactive, Purpose-driven, Professional

Knowledge-Skill Pairs:

Knowledge Element	Skill Level (Bloom cognitive level)
Scope management plan	3 - Apply
Requirements management plan	3 - Apply
Work breakdown structure	3 - Apply

Competency 4: Develop estimates and time tracking using appropriate tools, techniques, and processes

Key Dispositions: Proactive, Inventive, Self-Directed

Knowledge-Skill Pairs:

Knowledge Element	Skill Level (Bloom cognitive level)
Schedule management plan	3 - Apply
Sequence activities	3 - Apply
Network diagrams	3 - Apply
Critical path	3 - Apply
Schedule compression	3 - Apply
Critical chain method	3 - Apply
Different modeling techniques (i.e. Monte Carlo, etc.)	3 - Apply

Competency 5: Develop estimates and cost tracking using appropriate tools, techniques, and processes

Key Dispositions: Proactive, Inventive, Self-Directed

Knowledge-Skill Pairs:

Knowledge Element	Skill Level (Bloom cognitive level)
Different types of estimation techniques (i.e. three point, analogous, bottom-up, etc.)	3 - Apply
Earned value management	3 - Apply
Plan cost management	3 - Apply

Competency 6: Utilize the change control process to maintain and control quality

Key Dispositions: Professional, Proactive, Meticulous

Knowledge-Skill Pairs:

Knowledge Element	Skill Level (Bloom cognitive level)
Quality tools	2 - Understand
Continuous improvement	2 - Understand
Quality management plan	3 - Apply
Quality assurance	2 - Understand

Controlling quality	2 - Understand
Quality management terms	2 - Understand
Cause and effect diagram	3 - Apply

Competency 7: Implement human resource management tools, techniques, and processes

Key Dispositions: Proactive, Inventive, Self-Directed

Knowledge-Skill Pairs:

Knowledge Element	Skill Level (Bloom cognitive level)
Human resource plan	2 - Understand
Roles and responsibilities of team members	2 - Understand
Acquiring the team	2 - Understand

Competency 8: Define and implement a communication management plan

Key Dispositions: Professional, Collaborative, Proactive

Knowledge-Skill Pairs:

Knowledge Element	Skill Level (Bloom cognitive level)
Communications plan	3 - Apply
Different types of communication	2 - Understand
Performance reporting	2 - Understand
Communication models	2 - Understand
Types of communication	2 - Understand

Competency 9: Predict and manage project risk through the use of tools, techniques, and processes

Key Dispositions: Proactive, Purpose-driven, Professional

Knowledge-Skill Pairs:

Knowledge Element	Skill Level (Bloom cognitive level)
Risk management plan	3 - Apply
Types of risks	2 - Understand
Risk response strategies	2 - Understand
SWOT analysis	2 - Understand

Competency 10: Define and explain procurement management

Key Dispositions: Proactive, Purpose-driven, Professional

Knowledge-Skill Pairs:

Knowledge Element	Skill Level (Bloom cognitive level)
Different types of contracts	2 - Understand
Procurement management plan	3 - Apply
Contract change control systems	2 - Understand
Procurement performance review	2 - Understand
Procurement negotiation	2 - Understand
Procurement documents	2 - Understand

Competency 11: Identify and manage stakeholders within the phases of a project

Key Dispositions: Professional, Proactive, Collaborative

Knowledge-Skill Pairs:

Knowledge Element	Skill Level (Bloom cognitive level)
Stakeholder management plan	3 - Apply
Stakeholder analysis	3 - Apply
Stakeholder engagement and assessment matrix	2 - Understand

Competency 12: Utilize tools, techniques, and processes to manage project performance

Key Dispositions: Proactive, Purpose-driven, Professional

Knowledge-Skill Pairs:

Knowledge Element	Skill Level (Bloom cognitive level)
Project management tools (i.e., MS Project, Hive, Wrike, etc.)	3 - Apply

Competency 13: Apply agile project management principles and methods in practice

Key Dispositions: Purpose-driven, Professional, Proactive

Knowledge-Skill Pairs:

Knowledge Element	Skill Level (Bloom cognitive level)
Agile development principles	2 - Understand

Competency 14: Apply the Scrum development process

Key Dispositions: Purpose-driven, Professional, Proactive

Knowledge-Skill Pairs:

Knowledge Element	Skill Level (Bloom cognitive level)
Sprint execution	2 - Understand
Daily standup	2 - Understand
Sprint planning	2 - Understand
Product backlog grooming	2 - Understand
Writing user stories	2 - Understand
User story estimation	2 - Understand
Role and responsibilities of the product owner	2 - Understand
Role and responsibilities of the scrum Master	2 - Understand
Role and responsibilities of developers	2 - Understand
Sprint review	2 - Understand
Sprint retrospective	2 - Understand
Product release planning	2 - Understand

Competency 15: Select an appropriate project management methodology based on project characteristics

Key Dispositions: Proactive, Inventive, Self-Directed

Knowledge-Skill Pairs:

Knowledge Element	**Skill Level (Bloom cognitive level)**
Software development project characteristics	2 - Understand
Project Management Methodologies	2 - Understand

A3.6.2 Competency Area – IS Practicum

Competency Area Statement: An applied synthesis of foundational courses related to exercising design and applying one or more media of construction to effect and implement an Information Systems artifact to suit client or organizational needs. Emphasis on the application of data management, application development, IT infrastructure, and IT Project Management. Students work in teams and apply a software/systems development paradigm toward the development of a system prototype to satisfy the intentions and needs of an organizational client. Client interaction, often best facilitated via the use of Agile software methods, must be sustained and ongoing such that emergence in design and development can be experienced.

Competencies: Graduates will be able to:

1. Apply the SDLC
2. Utilize a systems/software development methodology
3. Utilize tools for software process management
4. Utilize tools for code and resource version control
5. Utilize tools for team collaboration and communication
6. Utilize tools for client collaboration and communication
7. Utilize tools for testing (unit, integration, acceptance)
8. Align and utilize UML, ERD, and Class/Object Design
9. Apply Object-Oriented principles in system/software design and implementation
10. Utilize Object-Relational Mapping tools
11. Apply principles of systems delivery and maintenance
12. Utilize upfront design for system security

Competency 1: Apply the SDLC

Key Dispositions: Professional, Collaborative, Responsible

Knowledge-Skill Pairs:

Knowledge Element	Skill Level (Bloom cognitive level)
Phases of the SDLC abstract the principal concerns of software systems development	2 - Understand
Appreciation for the implicit sequential nature of the cycle in terms of predicates and flow	2 - Understand
Appreciation for the variety of models that describe the flow and evolution of the SDLC in practice	2 - Understand

Competency 2: Utilize a systems/software development methodology

Key Dispositions: Professional, Collaborative, Responsible

Knowledge-Skill Pairs:

Knowledge Element	**Skill Level (Bloom cognitive level)**
Articulate and implement a **Waterfall** model understanding the assumptions, advantages, and disadvantages of utilizing this model methodologically	3 - Apply
Articulate and implement an **Iterative Waterfall** model as a set of sequential waterfall processes. Be familiar with the assumptions, advantages, and disadvantages of utilizing this model methodologically.	3 - Apply
Articulate and implement a **Spiral** model as a phased abstraction of both the Iterative and Waterfall models. Be familiar with the assumptions, advantages, and disadvantages of utilizing this model methodologically.	3 - Apply
Articulate and implement a **Rapid Application Development/Prototyping** model as an iterative approach that utilizes frequent empirical validation. Be familiar with the assumptions, advantages, and disadvantages of utilizing this model methodologically.	3 - Apply
Articulate and implement an **Agile** model as an iterative and incremental approach that utilizes frequent empirical validation and customer collaboration. Be familiar with the assumptions, advantages, and disadvantages of utilizing this model methodologically.	3 - Apply

Competency 3: Utilize tools for software process management

Key Dispositions: Meticulous, Self-Directed, Purpose-driven

Knowledge-Skill Pairs:

Knowledge Element	**Skill Level (Bloom cognitive level)**
Knowledge of tools that track and manage software projects with respect to resources, features, deadlines, conflicts, and impediments.	3 - Apply

Estimation, validation, and velocity as they pertain to productivity.	3 - Appy
Exposure to at least one tool, such as Jira, Azure DevOps for Teams, TeamCity, etc.	3 - Appy

Competency 4: Utilize tools for code and resource version control

Key Dispositions: Meticulous, Self-Directed, Purpose-driven

Knowledge-Skill Pairs:

Knowledge Element	Skill Level (Bloom cognitive level)
Version Control Systems (VCS) represent a graph structure of the changes, permutations, and state of the software codebase that constitutes the necessary instructions for system realization.	2 - Understand
Atomic operations enable precise change tracking and responsibility	2 - Understand
Branching and merging for feature evolution, defect management, and team coordination	2 - Understand
Tagging and labeling to align code changes with features	2 - Understand
Version control acts as a transaction system with ACID properties	2 - Understand
Use and familiarity with at least one VCS such as Git, SVN, Mercurial, CVS, etc.	3 - Apply

Competency 5: Utilize tools for team collaboration and communication

Key Dispositions: Meticulous, Collaborative, Self-Directed

Knowledge-Skill Pairs:

Knowledge Element	Skill Level (Bloom cognitive level)
Real-time communication that is also linked to features management, code management, and defect tracking	2 - Understand

Links to version control commits and collaborative code development	2 - Understand
Exposure to at least one tool, such as Jira, Trello, TeamCity, BandCamp, etc.	3 - Apply

Competency 6: Utilize tools for client collaboration and communication

Key Dispositions: Self-Directed, Professional, Proactive

Knowledge-Skill Pairs:

Knowledge Element	Skill Level (Bloom cognitive level)
Define and track user-interactive acceptance testing	2 - Understand
Manage features, personas, use cases, or user stories as they related to system modules, information flows, and user experience flows	2 - Understand
Provisions for test and validation deployments	2 - Understand

Competency 7: Utilize tools for testing (unit, integration, acceptance)

Key Dispositions: Meticulous, Self-Directed, Purpose-driven

Knowledge-Skill Pairs:

Knowledge Element	Skill Level (Bloom cognitive level)
A system for developers and end users to identify software defects	2 - Understand
A system for developers and end users to track the status of defects	2 - Understand
Integration with version control systems and features management	2 - Understand
A linked and integrative "pyramid" of testing that cascades from manual testing to integration testing, to unit testing	2 - Understand
Regression testing to safeguard against feature and function regression	2 - Understand

Use and familiarity with at least one unit testing library or harness.	3 - Apply

Competency 8: Align and utilize UML, ERD, and Class/Object Design

Key Dispositions: Meticulous, Self-Directed, Purpose-driven

Knowledge-Skill Pairs:

Knowledge Element	Skill Level (Bloom cognitive level)
Use UML structural diagrams to realize and validate object-oriented module and library design	3 - Apply
Use UML behavioral diagrams to realize and validate logical design	3 - Apply

Competency 9: Apply Object-Oriented principles in system/software design and implementation

Key Dispositions: Meticulous, Self-Directed, Purpose-driven

Knowledge-Skill Pairs:

Knowledge Element	Skill Level (Bloom cognitive level)
Design for modularity for reuse	3 - Apply
Application of SOLID principles	3 - Apply

Competency 10: Utilize Object-Relational Mapping tools

Key Dispositions: Meticulous, Self-Directed, Purpose-driven

Knowledge-Skill Pairs:

Knowledge Element	Skill Level (Bloom cognitive level)
Persistence strategies, such as RDBMS and their role in system execution	2 - Understand
Data and object structures house in runtime-execution and resident in volatile memory	2 - Understand

O/RM tools as a bridge from volatile execution contexts to persistence contexts	2 - Understand
Use and familiarity with at least one O/RM implementation	3 - Apply

Competency 11: Apply principles of systems delivery and maintenance

Key Dispositions: Meticulous, Self-Directed, Purpose-driven

Knowledge-Skill Pairs:

Knowledge Element	Skill Level (Bloom cognitive level)
Continuous Integration and Continuous Delivery strategies	2 - Understand
Test-Driven Development	2 - Understand
Staged development environments	2 - Understand
Platform and Infrastructure as a Service	2 - Understand

Competency 12: Utilize upfront design for system security

Key Dispositions: Purpose-driven, Professional, Proactive

Knowledge-Skill Pairs:

Knowledge Element	Skill Level (Bloom cognitive level)
Assume edge cases and vulnerabilities will expose the system	2 - Understand
Code techniques for security	2 - Understand
Deployment techniques for security	2 - Understand
Procedures for keeping the deployment environment up to date	2 - Understand
Procedures for keeping software dependencies up to date	2 - Understand
Relationship between technical debt and security design	2 – Understand

Appendix 4 — Details of the Development of IS2020

The joint AIS/ACM task force was launched in January 2019 and submitted the final version of the competency model recommendation for approval in February 2021. The co-chairs are Paul Leidig (Grand Valley State University) and Hannu Salmela (University of Turku). Other members of the committee include Brenda Scholtz (Nelson Mandela University), Greg Anderson (Brigham Young University), Raja Sooriamurthi (Carnegie Mellon University), Lesley Gardner (University of Auckland), Mark Thouin (University of Texas at Dallas), Venky Shankararaman (Singapore Management University), Jay F. Nunamaker Jr (University of Arizona), Carina de Villiers (University of Pretoria) and Jeffry Babb (West Texas A&M University, EDSIG representative in the taskforce). During the year, 2019, the work focused on collecting background information and soliciting views on revision needs related to IS 2010. The work was coordinated using monthly meetings, the two face-to-face meetings in August (AMCIS) and December (ICIS) providing a possibility for more in-depth discussions. During Spring and Summer 2020, work focused on designing the competency model and guidelines, and writing the report chapters. Fall 2020 was dedicated to soliciting feedback and making improvements, together with detailed work with Appendices. As face-to-face meetings were no longer possible during the 2020, the taskforce moved to weekly virtual meetings from February to December.

Following the example of the IS 2010 taskforce, the IS2020 taskforce made efforts toward an open and transparent process to the IS community. The IS2020 taskforce benefited from the initial work of the Exploratory Taskforce, whose report was accepted by ACM and AIS during 2018. This report provided detailed and useful guidelines for the revision work. In the background information gathering, Information regarding existing curricula was collected from different universities using an excel sheet in Google Docs, leading to a record of IS curriculum contents of over 50 universities. This view was supported with a classification of over 3000 courses described in the EduGlobedia. The taskforce also reviewed existing materials regarding competency frameworks developed within industry (SFIA, e-CF), and latest Job Index Reports (2017; 2019) published in the U.S. A systematic literature mapping study was conducted to identify over 200 IS curriculum related papers published between 2010 and 2020, many of which suggested enhancements to the IS2010 guidelines. For soliciting feedback, the IS2020.org site was developed for publishing panel materials and draft versions of the guideline report, providing community members a possibility to register and provide feedback. The taskforce itself was larger and more global than the previous ones, with representatives from all three regions (Americas, Africa/Europe, Asia/Pacific), providing a possibility for its members to solicit feedback from their own institutions and regions. The taskforce had close connections to CC2020 and DS2020 taskforces and followed closely the progress made in the MaCuDE project. Developing plans for establishing an open curriculum community to enable ongoing refinement of the competency model and related materials during the coming decade was an important target deliverable for the taskforce.

As with previous curriculum projects, the IS2020 task force presented the development process at several conferences. Panels were organized with a principle of 30 minutes for presentations, 30 minutes for open discussion. Due to the Covid-19 pandemic, the conferences during 2020 were held as virtual panels, providing a possibility to record discussions and copy feedback comments from conference chats. Table 4-1 provides details and the timeline for this effort.

Table A4-1: Details of the IS 2020 Task Force interactions with the community

Date	Committee Interactions	Means
August 2019	Proposal for the IS 2020 process, open discussion based on IS2010 guidelines	AMCIS 2019 Panel – Cancun, 8/2019
November 2019	Proposal for the IS 2020 process, open discussion based on IS2010 guidelines	EDSIGCon – Cleveland, 11/2019
December 2019	Proposal for the IS 2020 process, open discussion based on IS2010 guidelines	AIS SIGEd Panel, Munich 12/2019
March 2020	Presentation of preliminary IS2020 competency guidelines	ACM SIGCSE – 3/2020 virtual format
June 2020	Presentation of preliminary IS2020 competency guidelines	ACM-SIGMIS – 6/2020 virtual format

August 2020	Release of the first full draft of IS2020 report, an invitation to review and comment	IS2020.org, AIS mailing list, personal contacts
August 2020	Presentation of the initial IS2020 competency model and guidelines	AIS-AMCIS – 8/2020 virtual format
October 2020	Release of the October version, an invitation to review and comment	IS2020.org
November 2020	Presentation of the competency model and guidelines based on October version	EDSIGCon – 11/2020 virtual format
December 2020	Release of the December version, invitation to review and comment	IS2020.org
December 2020	Presentation of the competency model and related guidelines based on December version	AIS SIGEd, India 12/2020 virtual format
December 2020	Presentation of the competency model and guidelines based on December version	AIS ICIS, India 12/2020 virtual format
January 2021	Preparation of final draft, in collaboration with ACM and AIS representatives	
January 2021	Submission of the final version for approval to ACM	
February 2021	Submission of the final draft version for approval to AIS	