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Enterprise Computing Curriculum: A Reference Framework

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Abstract

An expanding number of colleges and universities are offering one form or another of enterprise computing academic programs to meet the market demand for graduate in this field. The programs regularly are developed by team of faculty who are expert in this area and in collaboration with Enterprise Application Solutions Vendors offering platforms in this field. As of presently, there's no enterprise computing reference curriculum recognized by the scholarly community or industry. Industry and the scholarly community frequently vary in the scope and the definition of enterprise computing program. Subsequently, the need for an enterprise computing reference framework has regularly been enunciated in an assortment of of meetings within the enterprise computing community. The goal of this paper is to propose an enterprise computing reference curriculum model at the undergraduate level based on a study of the enterprise computing program at several local, regional, and international universities, the industry needs of enterprise computing competencies, the expertise of the authors, and the best practices available in the scholarly community and industry.

Keywords: Reference curriculum; Reference framework; Enterprise computing; Enterprise application solutions vendors (EASV); Enterprise systems; Enterprise solutions.
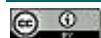
1. Introduction

Enterprises must face the realities of the 21st century knowledge economy as markets become more complex and competitive and knowledge becomes the primary economic resource. An enterprise organization typically employs plan-driven business processes (Waardenburg and Vliet, 2013). For companies to succeed in this economy, they must collaborate with their partners in a collective network to share their complementary strengths and capabilities, have on-demand access to information and resources and improve agility in dealing with operational challenges to achieve some common goals and to compete more effectively on the national, regional and international levels. In such economy, companies need enterprise computing experts to help to improve resource utilization, improve business processes efficiency and effectiveness, maximize flexibility, rapid elasticity, improve accessibility, increase client empowerment, increase collaboration and communication, and to reduce cost and economies of scale.

Universities must respond to these challenges by introducing new enterprise computing programs to develop and produce students and graduates ready to function in the 21st century knowledge economy. These students will gain the knowledge of end-to-end systems solutions found in modern organizations and can be the resource that these companies need. Meanwhile, Enterprise Application Solutions Vendors (EASV) like SAP, Oracle, IBM, HP, Microsoft, and many others have recognized the shortage of enterprise computing expertise over the coming years due to the exponential growth of the development, deployment, integration, maintenance, and management of enterprise applications onsite or in the cloud. They need graduates with a mix of business and IT knowledge in the area of enterprise systems. It will be very costly for these companies and their customers to hire fresh graduates with degrees in business or IT or a combination with no hands-on experience with their – or at least a competitor's – solution packages. By recognizing this gap, most of these EASVs established an academic initiative in the form of partnership programs with universities in which universities access the EASV's latest technologies and solutions, to give students hands-on experience with the technology, and to give the faculty the training to teach students the required knowledge.

To this extent, many universities have established strategic partnership agreements with one or more of the EASV to design and develop an enterprise computing curriculum to meet the enterprise competencies sought by industry and the national needs. It is important to note that partnerships with only one vendor can be somewhat problematic, especially for universities funded by taxpayers' money. However, this topic is beyond the scope of this paper.

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To understand the complexities of managing global enterprises, the term enterprise computing needs to be closely examined. According to Shan and Earle (1998) enterprise computing "*involves the development, deployment and maintenance of the information systems required for survival and success in today's business climate*".

Laudon and Laudon (2016) state that enterprise computing is a method of planning and designing of systems that "*integrates the key business processes within a firm and even integrates business processes across an entire industry*". A business process is a set of interrelated activities/routines across the enterprise functional areas (marketing & sales, accounting & finance, human capital, manufacturing & production etc.) with flow of information, material, and finance in an effective and efficient way to meet the goals and objectives of the enterprise. Gartner (2017), enterprise application software includes – among others – ERP, CRM, and SCM systems as well as office suits.

This paper focuses on proposing an enterprise computing reference curriculum at the undergraduate level based on a study of enterprise computing programs at several local, regional, and international universities, the industry need of EC competencies, the expertise of the authors and best practices.

The remainder of this paper is organized as follows. First, a review of enterprise computing academic programs is presented. Then, the research gap, statement of the problem and the contribution of the study will be discussed. Following, the methodology of the study will be discussed. Next, the enterprise computing programs and curricula will be conferred, followed by the proposed EC reference curriculum. Finally, remarks, recommendations and future directions are presented.

2. Review of Enterprise Computing Academic Programs - The Study
2.1. Name of the Academic Program

In many cases, the terms "*enterprise computing", "enterprise systems", "enterprise applications*", "*business solutions*" and "*business informatics*" are used interchangeably by universities to describe the same major. Because of the different naming conventions, this research focuses more on the course requirements. The requirements of the academic program are composed of core, major, required and elective courses based on the home of the major that lead to a university degree. The truth is, what you name your program does matter, but for consistency and for the sake of this study, we will use the term "*Enterprise Computing*" throughout this paper to refer to the same set of course requirements.

2.2. Home of the Academic Program

The enterprise computing major (concentration) can be found in business administration, Information Technology or computer science degree programs (Jung and Lehrer, 2017), or jointly offered by the business administration and IT. Thus, the most common options for undergraduate degrees are:

- Bachelor of Science in Business Administration with a major in Enterprise Computing
  o Business emphasis first (accounting, finance, sales & marketing, etc.) supported with enterprise technical skills and provide problem solving ability in business decision making.
- Bachelor of Science in Computer Science (Information Technology) with a major in Enterprise Computing:
  o Depth in technical skills complemented by breadth in statistics and business.
- Bachelor of Science in Information Systems & Technology Management with a major in Enterprise Computing
  o The program focuses on integrating business and technical emphasis on the development, management and planning of enterprise systems.

Although a College of Business is usually the home of a Business Administration degree and a College of Information Technology the home of a Computer Science degree, both degree programs include courses of the other field. This mix leads to a variety of degree program with more or less focus on business or information technology. In addition, several universities offered a joint College of Business and College of Information Technology enterprise computing program.

2.3. Theory vs. Practice

Another dimension of EC programs is the affinity to theory and research or – in contrast – to practice and applied sciences. The organizational form of the academic program is generally defined by the university type (research university vs. university of applied sciences), the university profile (business, IT, engineering etc.), and the main research philosophy (behavioral research vs. design science research).

Both dimensions (discipline/focus and research philosophy) can be visualized in the below quadrant model.

Figure-1. The two dimensions of EC program
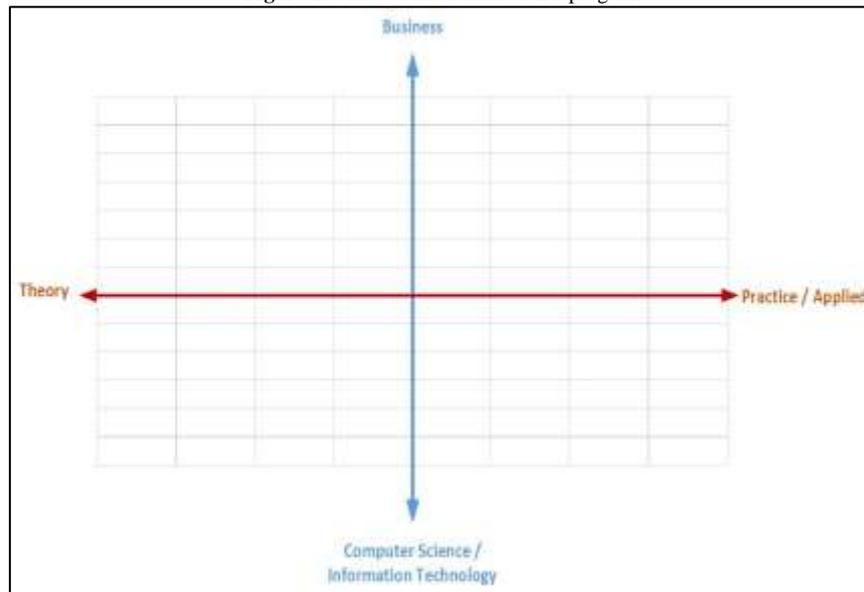
The focus of this paper is to propose a curriculum reference framework for the Bachelor of Science, major (concentration) in enterprise computing in the college of Information Technology (& Systems). We will leave the other options for future research work.

2.4. Research Gap, Statement of The Problem and Contribution of the Study

Several researchers and practitioners have proposed various academic program curriculum structure in information systems and information technology (The Association for Computing Machinery (ACM), 2008 and 2017; the Association for Information Systems (AIS) (German Informatics Society, 2017a; Hansen *et al.*, 2012; Jung and Lehrer, 2017; Lunt *et al.*, 2008; Topi *et al.*, 2010); and the information systems discipline in Australia, 2007). In researching the literature on developing a framework for enterprise computing curriculum and until currently we found no substantial evidence of research in this area at a global scale. The development of such a program will benefit higher education institutions (HEI), the industry, and the community. The development of an enterprise computing program is underway in several institutes, but it lacks a reference framework and structure. ABET (2016) defines an educational program as "*an integrated, organized experience that culminates in the awarding of a degree. The program will have program educational objectives, student outcomes, a curriculum, and facilities.*" The development of an enterprise computing academic program to achieve its objectives and student's outcomes involves more than the adoption of definitions provided by any accreditation body. The curriculum reference should answer important questions such as: What is the main objective of the EC curriculum (acquired qualifications)? What is the content (courses and relevant material) that the students will be taught? How should the content be delivered to the students (teaching methods)? And how will the curriculum evolve (evaluation methods, plans and strategies)?

For the sake of this study, information from websites, catalogues, published paper, and other publicly available documents of 10 different universities were collected. The data collection focused on the EC core courses, EC specialization courses and elective courses including: course name, course number, course description, course outline, and course pre-requisite or co-requisite. Over 100 courses were analyzed, and an initial set of enterprise computing topical areas were identified. Through several iterations (Jain, 2006), each course was reviewed and defined by eliminating overlaps, gaps, redundancies and consolidating multiple course titles for similar topics.

As such, the research question for this study is to "*design and develop an Enterprise Computing Reference Curriculum at the undergraduate level*". Such framework is designed and developed based on the expertise of the authors, a study of the EC program at several local, regional, and international universities, the industry needs of EC competencies and best practices.

3. Methodology

This study used the same research methodology of Jain and Verma (2007) outlined in their study to develop the reference curriculum for the EC program. The methodology consists of several steps as follows:
- Research on current EC-centric curricula
- o Identify EC-centric programs
- o Gather program and curriculum information of all identified EC-centric undergraduate programs
- o Identify topical areas by performing pattern analysis on the consolidated and synthesized curriculum information
- Research on industry needs of EC competencies
- o Research on industry needs for EC competencies
- o Consolidate and synthesize a list of industry-required EC competencies

- Propose a reference EC undergraduate curriculum
  - Map the identified topical areas with the required EC competencies
  - Perform gap analysis on the mapping result
  - Propose an undergraduate curriculum based on the gap and pattern analysis

A number of industry and government surveys and studies (CBI, 2012; European Commission, 2003; Manpower Group, 2015) formed the basis for understanding the required technical competencies, knowledge and skills. Detailed references to a selection of these studies are provided in the paper.

4. Enterprise Computing Programs and Curricula
4.1. Research on Current EC-Centric Curricula

Enterprise computing is a discipline that integrates key business processes within all functional areas and the supply chain of a company and involves the development, deployment, maintenance and operation of the information systems which involve the use of the right IT infrastructure to help an organization succeed in today's complex business environment. To fulfil the need of this discipline, the reference curriculum framework should include components of information systems and information technology.

The Association for Computing Machinery (ACM) and the Association for Information Systems (AIS) (2008) published curriculum guidelines for undergraduate degree programs in Information Systems (IS) (2010), and ACM and IEEE Computer Society published curriculum guidelines for undergraduate degree programs in Information Technology (IT) (2017). Jung and Lehrer (2017) proposed guidelines for education in business and information systems engineering (BISE0 at tertiary institutions. The guideline identified 12 educational areas with several learning contents in each area (see table 1). Hansen *et al.* (2012) compiled a master list of 909 institutions operating in the United States with one form of computing programs. Of those programs, 220 were identified as being close enough to IT programs. In addition, Hansen *et al.* (2012) provides a list of different names the IT programs were known by, and the respective number of each. 62 of the 220 university refer to the program as BS, Information Technology. Topi *et al.* (2010) identified three IS knowledge and skills categories to be considered when designing and developing an IS program: IS-specific knowledge and skills (identifying and designing opportunities for IT-enabled organizational improvement, analyzing trade-offs, designing and implementing information systems solutions, and managing ongoing information technology operations); Foundational knowledge and skills (leadership and collaboration, communication, negotiation, analytical and critical thinking, including creativity and ethical analysis, and mathematical foundations); and domain fundamentals (general models of a domain, key specializations within a domain, and evaluation of performance within a domain). Lunt *et al.* (2008) depict the academic discipline of Information Technology and identify the following pillars of IT: programming, networking, human-computer interaction, databases, and web systems. These pillars are built on a foundation of knowledge of the fundamentals of IT and overarching the entire foundation and pillars are information assurance and security, and professionalism. Information Systems (IS) professionals are interested in the application of information technology to business activities. They are concerned with the design and implementation of information systems to support the information processing needs of an organization. So, we need to design a curriculum to focus on the problem space of computing that students typically do after graduation. ACM (2008) ACM (2017) illustrates by graphical characterizations the commonalities and differences among the computing disciplines (IT, IS, CS) by suggesting how each discipline occupies the problem space of computing. The space of computing can be illustrated by identifying a horizontal range (x-axis) from Theory, Principles, Innovation, to Application, Development, Configuration. The vertical range (y-axis) runs from Computer Hardware and Architecture, to Organizational Issues and Information Systems. We use the same theme to develop the below figure to illustrate the characteristics of EC discipline.

Figure-2. Characteristics of the Enterprise Computing Descipline – IT/CS
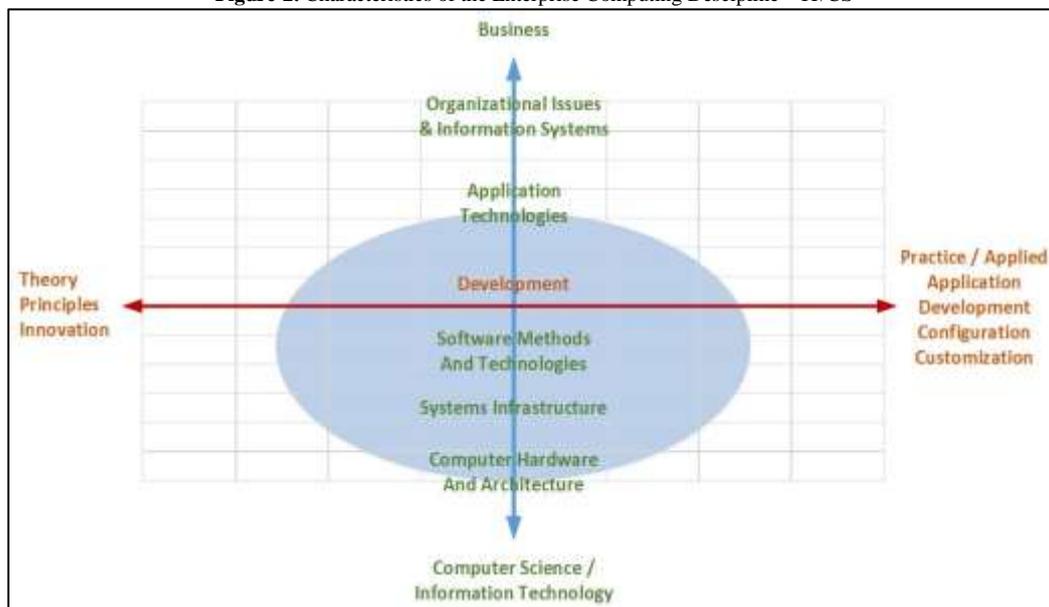
By applying the same problem space of computing to enterprise computing, vertically the focus is on people, information, organizational workplace, application technologies, software methods and technologies and systems infrastructure. Horizontally, the focus is on application implementation, customization, configuration and integration to solve organizational problems. As a result of the survey and the analysis of the above sources, the typical course requirements for an IT degree program are of four types, and together comprise the 120 semester credits: the general education, college core requirements, field of concentration (major) requirements, and free electives. At minimum, 66 of the required 120 credits must be from courses within the college of IT. The general education courses are intended to help students place the specialized study within a broader context. College core courses must be chosen as per the posted guidelines set by the college. Field of concentration courses must be chosen from offerings by the college, and free electives may be chosen from throughout the university.

By conducting further curriculum gap analysis and cross-referencing courses offered by the above specializations (majors), we developed a comprehensive list of course titles and descriptions that can be used for a proposed enterprise computing curriculum framework. Once the baseline course titles and descriptions (2006) were finalized, each course was placed into one of four levels: Level 0: Fundamental Courses, Level 1: Fundamental (introductory) courses, Level 2: Core Courses and Level 3: Specialization Courses. After cross-referencing the courses among the universities listed above, the final grouping of the topical areas into levels (2007) is identified as follows:

- Level 0: Foundation courses
  o Pre-enterprise computing courses. Students must be competent in these areas to enter the enterprise computing program
- Level 1: Fundamental (Introductory) courses
  o Fundamental computing and IT concepts, underlying technologies, business, accounting and management concepts
  o These are the initial courses taken in the enterprise computing program
- Level 2: Core Courses (college-specific)
  o Various aspects of computing skills and knowledge of information systems or information technology
  o Required core courses towards the completion of an undergraduate degree in information systems or information technology. These are recommended as core courses in any information systems or information technology program
- Level 3: Specialization Courses
  o Either advanced courses which focus on enterprise computing niches or special areas related to enterprise information systems.
  o Advanced courses in areas such as Information System Management, IT Audit & Control, Decision Support, Knowledge & Project Management, Business Process Management, Logistics, SCM and Workflow.
  o Students focus on specialization courses once the initial and core courses are complete

In the current EC programs, several courses are included as part of the core courses. We believe that some of these courses should be included as a specialization, and it is categorized as a specialization course in the proposed framework. The grouping of the twenty-one topical areas into four levels are shown in Table 1.

Table-1. Topical Areas Grouping into Curriculum Levels

Level	Jung and Lehrer (2017)	Tropical Area
0: Foundation Courses (6 credits)	5.3a Foundations of Computer Science 5.4a Further Foundations	Mathematics for IS
		Probability and Statistics for IS
1: Fundamental (Introductory) Courses (12 credits)	5.1 Subject and Context 5.2 Economic Foundations	Fundamental of Enterprise Information Systems
		Business administration foundations
		Fundamentals of Accounting & Finance
		IT Innovation & Entrepreneurship
2: Core Courses (24 credits)	5.5 Data Management 5.7 Information Management 5.8a Development and Operation of Information	Management Information Systems
		Introduction to Security basics
		Database Management Systems
		Technical and Professional Communication
		Integrative Programming & Technologies
		Human Computer Interaction
		IT Project Management
		Systems Analysis and Design
3: Specialization (Major) Courses (30 credits)	5.6 Process Management 5.9 Corporate Core Systems 5.10 Knowledge Management and Collaborative 5.11 Model-Based Decision Support, Business 5.12 igital Transformation	Enterprise Resource Planning
		IT in Logistics and Supply Chain
		Enterprise Systems Developments
		Business Process Management
		IT Management, Strategy & Governance
		System Integration and Architecture
		IT Audit, Assurance and Control
		Applied Database Systems
		Knowledge Management and Collaborative technologoies
		Senior Project/Capstone

4.2. Research on Industry needs of EC Competencies

The world of information technology is evolving all the time requiring new talent and forcing universities to be more proactive to review, assess, and update their academic curricula on a regular basis for their graduates to be competitive in today's job market and to keep pace with industry talent needs and demands. The current competitive environment is defined by four main factors (continuous technological developments, shorter product life cycles, increasingly demanding consumers and global competition) (2003) which are evolved around the human capital talent.

Mr. Jonas Prising, Manpower Group (2015) CEO, said that the recent financial crises have "*transformed the employment landscape.*" He added that "*we have seen the emergence of the Human Age, where talent is the new differentiator.*" And "*through all of this uncertainty, the one constant is that talent shortages continue unabated.*" And "*talent shortages are something companies struggle with all over the world.*" He was referring to the results of the survey that his company has conducted in 42 countries and territories in which more than 41,700 hiring managers participated in the survey. (2015). The first step to address talent shortages is to have a talent strategy and it should be aligned with business strategy. Moreover, the intensive competitive environment that we are witnessing in "*knowledge-intensive economies*" has reinforced a growing consensus on the key role that human capital talent plays in sustaining economic growth and enterprises' competitiveness (European Commission, 2003). The knowledge has become one of the most important inputs underpinning economic development and competitive advantage. The skills currently required are a mix of technical nature ("*hard*" skills), organizational and social character ("*soft*" skills) (2003).

European Commission (2003) identified several "*soft*" skills competencies to be required by enterprises in the future including: information processing and management, analytical skills, creative thinking and problem-solving skills, decision making skills, communication skills, language skills, teamwork, management & leadership, strategic thinking, and self-management & self-development.

Talent shortages are most likely to have negative impact on companies. As reported in the Manpower Group (2015) survey, 42% of employers feel that a more limited ability to serve clients and reduced competitiveness/productivity are most likely to be regarded as key business consequences if they cannot hire all the talent they need. Followed by 30% expecting an increase in employee turnover and 26% anticipating lower employee engagement and morale. Around one in four (25%) expects reduced innovation and creativity in their organization and the same proportion say talent shortages can lead to higher compensation costs. In the changing landscape of higher education, strong partnerships between businesses and universities must be a priority to respond to the talent shortages and to help businesses drive their future plans (2012). More than 542 employers collectively employing some 1.6 million peoples in the UK responded to the CBI/Pearson education and skills survey. In this survey, two thirds (63%) of employers indicated that they have developed links with universities in activities ranging from providing sandwich-year and other placements to a role in shaping degree programs. Furthermore, almost half of employers (47%) offer internship opportunities of some type for graduates. Employers want to see universities upping their game by enhancing students' employability skills (65%) and increasing the business relevance of undergraduate courses (61%).

Employers believe universities should be providing more programs to develop employees (a priority for 31% of employers) and increasing number and quality of STEM graduates. Most employers want workers who are able to solve problems using science, technology, engineering, and math (STEM) skills and knowledge.

STEM integrates these fields into one learning experience and develop "*soft*" & "*hard*" skills to prepare students for integrated careers. These "*soft*" skills include: communication and cooperation skills, creative skills to solve problems, innovative skills to develop new ideas, leadership skills, and organization skills.

Thus, a STEM-based enterprise program is designed to improve academic achievement. A well-developed STEM-based curriculum focused on creativity, innovation, and reasoning, blended with strong commitment to STEM disciplinary knowledge. At the core of quality STEM learning are teachings of inquiry, critical thinking, problem solving, and creativity (Marginson *et al.*, 2013). STEM is a multi-faceted and inter-disciplinary approach, not just in the areas of science, technology, engineering or mathematics, but also integrating subject matter that may be relevant to problems such as environmental, social, regulatory, political and economic aspects (Roman, 2012). Enterprise systems deals every day with very complex and 'messy' small and large problems, and for these reasons enterprise systems graduates need to be equipped with skills and knowledge based on a successful STEM-based program (Roman, 2012). STEM-based disciplinary skills and knowledge is an essential component of any modern enterprise systems curriculum.

Nightingale (2009) proposed a framework for enterprise principles and transformation methodologies that consist of a set of interdependent methodologies, tools and enterprise principles which support holistic enterprise transformation with five elements: Enterprise Thinking, Enterprise Transformation Roadmap, Lean Enterprise Self-Assessment Tool (LESAT), Enterprise Strategic Analysis for Transformation (ESAT), and Enterprise Architecting Framework. These elements will be part of the EC competencies.

Every company has organized their employees into key functional areas such as sales, marketing, operations, finance and accounting, customer service, supply chain management and logistics, human resources and technology which work together to achieve the goals of the company. Functional areas are teams of employees who have similar skills and expertise. Companies are organized by functional areas for many reasons including: more efficient to group employees with similar skills and expertise; team up on projects requiring same and complement expertise; backup expertise in case one employee is unable to complete their task; makes training and knowledge sharing easier. Several universities are offering a course in business functional areas to provide students an overview of

the functional areas of a business and to explore how these areas complement each other to contribute to the achievement of the organization's goals. Companies are looking for solution analyst talent to design and develop solutions for the business functional areas. This includes reviewing business requirements, designing system solutions, working with IT and business teams to develop solutions.

Most companies provide universities with Enterprise Application solutions across the value chain in the areas of: Enterprise Resource Planning (ERP), Supply Chain Management (SCM), Logistics Management (LM), Supplier Relationship Management (SRM) and Customer Relationship Management (CRM). For example, SAP has established a "*University Alliances Program*" (UAP) in which member universities gain access to a range of opportunities including: access to full SAP solutions from ERP, SCM, Business Analytics to Mobility, HANA to BPM; access SAP curriculum and integrate parts of it to create entirely new courses; take part in SAP student competitions and contests; get involved with co-innovation projects with customers and partners in the SAP ecosystem; and get directly involved in research and the development of new SAP solutions. As of May 1, 2019, more than 3,100 institutions in over 106 countries already signed up with SAP. Specializing in one or more functional / technical areas is essential to meet the future career needs as it is identified by EASV.

Enterprise computing graduates can take up positions ranging from inventing new technologies or new principles to helping organizations integrate off-the-shelf products to solve companies' business problems to helping companies on assessing how technology can work for them and their impact. As such a range of technical positions are available for EC graduates such as programmers/analysts, system analysts, solution analyst, solutions architect, functional technical analyst, technical consultants, business process effectiveness specialists, software/system developers, software engineers, software specialist, and system/application administrators, and less technical positions including technical sales support, sales engineers, project/product managers, web/database/network administrators and web services designers. The list of EC competencies obtained from the above sources and considered for this study is shown in Table 2.

Table-2. EC competencies

STEM	Enterprise Thinking (Nightingale, 2009)	Holistic Lifecycle view	Enterprise System Design	Systems Management
STEM skills & knowledge	Enterprise concepts and principles	Plan, determine and manage stakeholder requirements	IT Architecture Framework	Business Process Management
Creativity, innovation, and reasoning	Internal and external enterprise interdependencies capability issues	Enterprise system requirements	Functional analysis	Enterprise integration
Inquiry, critical thinking, and problem solving	Strategy, business and technology environment		Data and interface management design	Planning, monitoring and controlling
			Modelling and simulation	Logistics and operations
			Select preferred solution	Enterprise Systems Management: Governance, Risk, and Compliance (GRC)
			Testing, integration & verification	
			Transition to operations	

5. Gap Analysis: Map Curriculum Level Grouping to Industry Needs

Next, we cross-referenced the topical areas and their curriculum level groupings to industry needs through a Six-Sigma Quality Function Deployment (QFD) exercise to identify gaps in the process or gaps in the ability to meet industry needs, as shown in Appendix 1. This process was repeated until industry needs were sufficiently addressed, and the topical areas were refined into a suggested EC curriculum. The correlation entries in Appendix 1 are "*Strong Positive*," "*Medium Positive*," "*Weak Positive*," and "*No Correlation*".

In reviewing existing EC programs and mapping their offerings to industry needs, we identified missing topics and topics that could be strengthened. The gap analysis showed that current EC-centric programs do not address the following industry-required EC competencies:

ƒ Inquiry, Critical Thinking, and Problem Solving
ƒ Modelling and Simulation
ƒ Functional Analysis
ƒ Creativity, Innovation, and Reasoning

To fill these gaps, the research revealed that the following specialization courses had a weak relationship or absence of any relationship with the other topical areas:

▪ Research Design & Data Analytics
▪ Modeling and simulation
▪ Functional Technical Areas
▪ Emerging Technology for the Enterprise (core)

The intent of this correlation is to embed enough correlating themes in these courses to allow the emergence of an appreciation for the cross-cutting implications of the topics when applying an enterprise systems approach. We believe that a mature and evolving curriculum will allow sufficient links across courses to exemplify this enterprise systems perspective.

The topic of emerging technologies is rapidly building momentum in the scholarly and professional communities. Emerging technology is part of the research line on "*Emerging Technologies for Digital Transformation*" (Informs, 2019). Emerging technologies, such as artificial intelligence (AI), data analytics, robotics, Internet of Things (IoT), Big Data, Data Analytics, machine and cognitive learning, digital platforms, social media, digital traces, blockchain, and 3D printing are "*increasingly reshaping human action and interaction in domains as varied as consumer credit-risk assessment, product design, platform work, healthcare diagnosis, hiring, predictive policing, custom manufacturing, automated fraud detection, consumer services, and surveillance*" (Informs, 2019). As the emerging technologies for digital transformation landscape is changing in a rapid speed, the proposed framework needs to be continuously reviewed and revised to ensure up-to-date curriculum content.

6. Proposed Framework

A framework for a reference curriculum in enterprise computing at the undergraduate level is proposed to be used as a guideline for universities. The proposed framework takes into consideration the commonalities and patterns in enterprise information systems content based on the discussion in the previous sections. A combination of Information Technology courses (ITC), where students apply more-than-basic IT-related knowledge/skills to be able to function in knowledge-intensive workplaces; Management Information Systems (MIS) courses, where students apply their IT skills and knowledge to work in teams to design, plan, and develop a solution to contemporary computer information system problem; IT Operations/Business courses (ITB), where students concentrate on business operations related to computing business processes; Application Development courses (ADC), where students train to simplify the tasks of the end user or resolve recurring problems through process automation; and Enterprise Business Systems courses (EBC), where students will be provided with knowledge of business processes, systems, applications development and analysis practices are the foundations of the proposed framework for a reference curriculum in enterprise computing at the undergraduate level. One of the main objectives of proposing a reference curriculum of enterprise computing is to try to bridge the gap between the expected enterprise computing competencies by the potential employers and the graduate enterprise computing program curricula.

The framework should support the development of new undergraduate programs in enterprise computing, and the enhancements to the existing enterprise computing undergraduate programs. The proposed framework has the following three dimensions:

1. Topical areas of interest to academia and industry and needed by students
2. Four levels of Enterprise Computing-related courses
3. Enterprise computing competencies

Figure 3 shows the proposed enterprise computing reference curriculum framework in two dimensions. The proposed framework does not provide guidance on the number and titles of courses that an undergraduate program should have under each topical area. It assumes that the pedagogy of the courses is specific to each undergraduate program. Therefore, the pedagogy and undergraduate-level courses will evolve as the field of enterprise computing grows and matures.

Figure-3. Proposed framework for EC Reference Curriculum
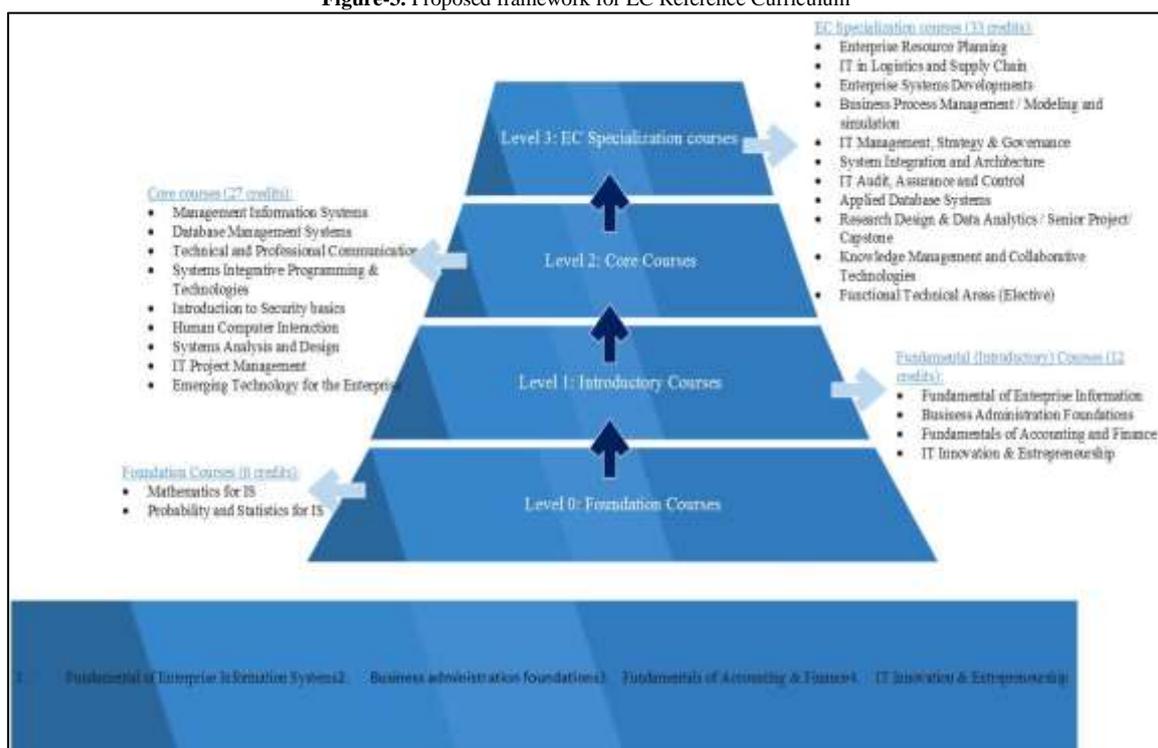
7. Conclusion

This study has been taken to recommend an enterprise computing reference curriculum at the undergraduate level. The enterprise community realizes that there are many perspectives on the scope and content of an enterprise computing reference curriculum, and there is a need for relative convergence in this regard.

This research involves literature review to evaluate various enterprise computing academic programs and the gab in the current enterprise computing programs followed by the proposed reference curriculum. The proposed reference curriculum uses a four-level approach, beginning with a foundation in statistics/mathematics and 9 introductory courses, and transitioning to 21 core courses supplemented with 11 advanced and special courses related to enterprise computing. The recommended framework consists of a baseline of several topical areas in enterprise computing and related subjects for universities to consider when developing an undergraduate-level curriculum in enterprise computing.

By implementing the proposed framework, the EC graduates will be ready to take exciting and demanding jobs in the field or to continue their studies in pursuit of advanced technical or professional degrees. At the same time, the adopting institutes will provide enterprise organizations with graduates with enterprise computing expertise to help them to streamline their business processes to be more efficient, improve customer service, achieve growth and realize cost savings.

As the information systems landscape is changing in a rapid speed, the proposed framework needs to be updated in a regular basis to ensure up-to-date curriculum content.

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Appendix I: Six-Sigma Quality Function Deployment (QFD)

Figure-4. Six-Sigma Quality Function Deployment (QFD)

Row #	Max Relationship Value in Row	Relative Weight	Weight / Importance	Industry Required EC Competencies (a.k.a. "Industry Requirements" or "Whats")	1. Enterprise Resource Planning	2. IT in Logistics and Supply Chain	3. Enterprise Systems Development	4. Business Process Management	5. IT Management, Strategy & Governance	6. System Integration and Architecture	7. IT Audit, Assurance and Control	8. Applied Database Systems	9. Senior Project/Capstone	10. Knowledge Management and Collaborative Technologies
1	9	6.3	9.0	STEM: Skills & Knowledge	○	○	○	⊙	▲	▲		▲	○	▲
2	9	6.3	9.0	STEM: Creativity, Innovation, and Reasoning				▲	▲		▲	○	○	▲
3	9	6.3	9.0	STEM: Inquiry, Critical Thinking, and Problem Solving	▲	▲	▲	▲		▲	▲	▲	○	▲
4	9	6.3	9.0	Enterprise Thinking: Enterprise Concepts and Principles	⊙	⊙	⊙	⊙	○	▲	○	○	○	○
5	9	6.3	9.0	Enterprise Thinking: Internal and External Enterprise Interdependencies Capability Issues	▲	⊙	○	○	○	▲	▲	▲	○	
6	9	6.3	9.0	Enterprise Thinking: Strategy, Business and Technology	▲	▲	▲	○	⊙	▲	▲		○	○
7	9	2.1	3.0	Holistic Lifecycle View: Plan, Determine and Manage Stakeholder Requirements	○	○	⊙	○	○	▲		▲		
8	9	6.3	9.0	Holistic Lifecycle View: Enterprise System Requirements	○	○	⊙		○	▲		▲	▲	○
9	9	6.3	9.0	Enterprise System Design: IT Architecture Framework	▲	▲	○		○	○				
10	9	6.3	9.0	Enterprise System Design: Functional Analysis			▲	▲				○	▲	○
11	9	2.1	3.0	Enterprise System Design: Data and Interface Management Design	▲	▲	▲	▲		⊙		⊙		○
12	9	6.3	9.0	Enterprise System Design: Modeling and Simulation	▲	▲	▲	○	▲			▲		
13	9	2.1	3.0	Enterprise System Design: Select Preferred Solution			⊙		▲					▲
14	9	6.3	9.0	Enterprise System Design: Testing, Integration & Verification			⊙		▲	⊙	▲	⊙	▲	▲
15	9	6.3	9.0	Enterprise System Design: Transition to Operation	▲	▲	⊙	○						
16	9	2.1	3.0	Enterprise Systems Management: Business Process Management	○	○	○	⊙	▲	○	▲		▲	
17	9	2.1	3.0	Enterprise Systems Management: Enterprise Integration			○	○		⊙		▲		▲
18	9	6.3	9.0	Enterprise Systems Management: Planning, Monitoring and Controlling			○	○	○	○	○			○
19	9	2.1	3.0	Enterprise Systems Management: Logistics and Operation		⊙								
20	9	6.3	9.0	Enterprise Systems Management: Governance, Risk, and Compliance (GRC)			▲		○		⊙	▲		
				Difficulty (0=Easy to Accomplish, 10=Extremely Difficult)	5	5	5	5	5	5	5	5	5	3
				Max Relationship Value in Column	9	9	9	9	9	9	9	9	9	9
				Weight / Importance	145.8	214.6	383.3	258.3	204.2	177.1	127.1	172.9	133.3	129.2
				Relative Weight	7.5	11.0	19.7	13.3	10.5	9.1	6.5	8.9	6.9	6.6