

# **AC 2004-1306: INFORMATION SYSTEMS CURRICULUM OPTIMIZATION FOR EFFECTIVE LEARNING OF PROBLEM SOLVING**

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## Information Systems Curriculum Optimization for Effective Learning of Problem Solving

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**Abstract-**The Information Systems (IS) field is witnessing a rapid change due to the continuous advances in technology. Consequently, academic institutions need to frequently update the IS curriculum to remain current. An important yet unpopular part of the curriculum is problem solving and programming. As students encounter difficulties in understanding the concepts of programming, a number of colleges attempt to solve the issue by introducing different programming languages. Currently, Java is the programming language of choice for industry and academic institutions. However, Java is not easy to learn even for non-novice programmers. In this paper, we propose a sequence of IS courses that emphasizes the problem solving component prior to introducing the syntax and semantics of programming languages. The proposed sequence includes courses in problem solving concepts, algorithm design and development, solution modeling, and finally coding. We anticipate that the proposed course sequence will provide insights on the development of a framework to teach not only programming but problem solving in general. The proposed framework will make students appreciate the usefulness of problem solving and will facilitate the use of appropriate programming languages to develop solutions.

### 1. Introduction

The last decade has witnessed an ever increasing demand for IT professionals. In fact, the US Bureau of Labor Statistics forecasts an increasing demand for high level IT professionals. For instance, system analysts will see 110 percent increase for the period 1992-2005 averaging eight percent annually<sup>1,2</sup>. This trend is also being witnessed all over the world as the US is outsourcing a number of entry-level IT positions to countries in Asia and elsewhere. Universities and colleges worldwide are struggling to keep up with the strong demand for IS graduates and to frequently update the IS curriculum to respond to the needs of government and industry. The IS degree major remains attractive to many students looking for better job opportunities. Also, a strong demand for the IS minor by students in other disciplines who need IS expertise in their work is being witnessed.

Academic institutions in the US and elsewhere aspire to generate an IS curriculum that can produce graduates with the skills required by business and government while providing the needed general education. Currently, the IS 2002 recommendations<sup>3</sup> form the blueprint for curriculum development of IS majors. An important part of the IS curriculum is problem solving and programming. In fact, the IS 2002 recommendations acknowledge the importance of problem solving in the curriculum and require an embedded approach to introducing problem solving and critical thinking in all courses. However, many students encounter difficulties in

understanding the concepts of programming. These difficulties become more pronounced when students attempt to use the syntax and semantics of the language to solve the problems.

Colleges and universities worldwide use various approaches to teach problem solving and programming. There is, however, disagreement on how to integrate problem solving and critical thinking in IS courses. In fact, only a few IS courses touch upon the topic of problem solving. Furthermore, there is no standard approach to integrate problem solving as a whole. Most IS courses that claim to introduce problem solving, actually focus on programming. Moreover, those courses seem to be the most challenging to students. As a consequence, after taking these courses many students change their majors. This has created a difficult situation for IS colleges as the number of new entering students drops. Most faculty members believe that the issue lies in choosing the appropriate programming language. This has prompted a number of colleges to focus on programming languages. Currently, the most popular languages include C++ and Java. These are the programming languages of choice for industry and academic institutions. A number of academic institutions have adopted Java because it is platform independent. However, Java is not easy to learn even for non-novice programmers<sup>4</sup>.

An academic institution<sup>5</sup> in the UAE, has recently established a program in IS that satisfies the demands of the country and the ABET accreditation requirements<sup>6</sup>. The IS curriculum is outcome-driven and consists of 129 semester hours including 60 semester hours in General Education. Critical thinking and reasoning is an important learning outcome that has to be implemented in most courses. Another critical outcome is problem solving. The core component of the IS curriculum offers a sequence of courses in programming and problem solving including the coverage of Java as a modern programming language. The IS curriculum has gone through many rounds of updates and changes. The goal of these updates is to provide a curriculum that answers the needs of government and business. Even though the IS field remains attractive to many students, the curriculum remains difficult as it emphasizes too much programming. Without easy introductory courses in problem solving, the understanding of programming is very challenging. In fact, though Java is currently used as a primary language in academic institutions and industry, students find it hard to learn<sup>4,7</sup>.

In this paper, we propose a course sequence that emphasizes problem solving and critical thinking in IS courses prior to introducing the syntax and semantics of programming language. The proposed sequence includes courses in problem solving concepts, algorithm design and development, solution modeling, and finally coding. The rest of the paper is organized as follows: Section 2 introduces the IS curriculum at Zayed University, Section 3 lists the IS2002 recommendations and the ABET criteria, Section 4 presents the proposed IS course sequence that embeds problem solving and critical thinking, and Section 5 is the conclusion.

## **2. IS curriculum at Zayed University**

Zayed University (ZU), an educational institution in the UAE, adopted a hybrid outcome-based and grade-point average academic model that provides students with an education of lasting value and makes them become self-learners<sup>8,9</sup>. This new Academic Program Model (APM) is designed to continuously improve the curriculum and provide students with the knowledge and skills to succeed in a rapidly changing world. The learning outcomes, being the kernel of the

courses, provide focus to the curriculum in the APM. Furthermore, all courses are designed to clearly show the experiences that students draw upon while achieving a Learning Outcome.

The College of Information Systems at ZU seeks to produce graduates who have an understanding of information technology and its uses, and who are capable of identifying and solving problems. The college has established five major learning outcomes which form the basis for curriculum analysis and student assessment:

- Problem identification and analysis
- Problem solving
- Internet technologies and applications
- Systems principles and practices
- Technical communication

The IS curriculum includes courses in the following knowledge domains:

- General Introductory/Literacy/Professional Issues
- Foundations of CIS
- Programming and Problem Solving Foundations
- Database Management
- Web Applications and Management
- Hardware and Software Systems
- Networks and data communication
- Graphics and Multimedia
- IS Practice
- System Analysis and Design
- Other Major Courses

The IS curriculum includes a sequence of IS courses to teach programming and problem solving. The sequence includes the following required courses:

- CIS101 Introduction to Computer Information Systems
- CIS110 Computing Foundations
- CIS210 Computational Methods
- CIS240 Programming and Problem Solving I
- CIS241 Programming and Problem Solving II
- CIS340 Web Programming
- CIS320 IT Hardware and Software
- CIS323 Database Systems I

The Electives are given below:

- CIS342 Object Oriented Programming
- CIS331 Data Structures and Algorithms

Figure 1 shows the sequence of courses in problem solving and programming. In Year One, students learn CIS101. In Year Two, students have five courses; CIS110, CIS240, CIS241, CIS210, and CIS340. In Year Three, students have two required courses, CIS320 and CIS323, and two electives, CIS342 and CIS 331.

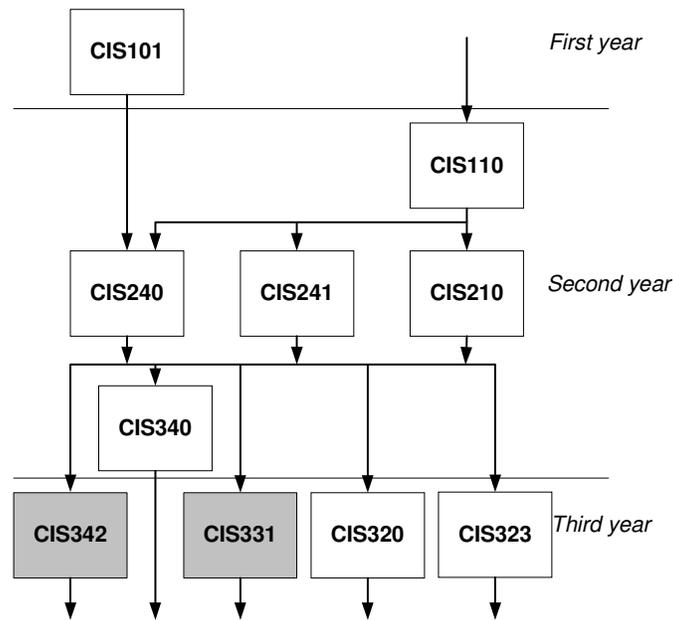


Figure 1. Required and elective courses (gray shaded) in programming and problem solving.

In CIS101, IS students are first introduced to computers and here they learn about the history of programming languages. In CIS110 and CIS210 which are both discrete math courses, students learn algorithm design. In CIS240 and CIS241, students are introduced to the concepts of programming and learn about object-oriented programming languages. In CIS340, students are introduced to the principles and tools of web programming. The CIS320 course provides students with a foundation in IT hardware and software and CIS323 gives students the fundamental concepts of database systems. Both of CIS342, a course on object-oriented programming, and CIS331, a course in data structures and algorithms, are electives.

The IS curriculum is designed to incorporate learning outcomes that address problem solving and critical thinking. However, the implementation of the curriculum to take full advantage of the learning outcomes is still at an early stage. Instructors need to redesign their course contents to effectively include problem solving.

There are a number of issues and challenges in designing and implementing IS curricula. One of these issues is the selection of a modern appropriate programming language that fulfills the requirements of the ABET criteria as well as the IS 2002 recommendations. ABET requires the student to be proficient in a modern programming language, however, the IS 2002 recommendations include only one course in programming. To become proficient in a modern programming language, students must take at least two courses in problem solving and programming.

When it comes to the advantage and disadvantage of conventional programming languages such as C, C++, and Java, programmers usually hold strong opinions<sup>7</sup>. The comparative analysis has to be elaborate for conclusive results. Despite the difficulties in conducting such analysis, we still need to compare different programming languages for further insights. Acquiring such

knowledge will help improve the curriculum design and advance the state of the software development.

### **3. The IS 2002 Recommendations and the ABET Criteria**

For the development of the IS curriculum, we implemented the IS 2002 recommendations. The characteristics of the IS profession have been identified and listed in the recommendations:

- IS professionals must have a broad business and real world perspective.
- IS professionals must have strong analytical and critical thinking skills.
- IS professionals must have interpersonal communication and team skills and have strong ethical principles.
- IS professionals must design and implement information technology solutions that enhance organizational performance.

The curriculum has 30 semester hours of formal IS courses but also assumes use of prerequisite or corequisite courses in communications, mathematics, statistics, and business functions. The IS 2002 curriculum also requires an embedded problem solving and critical thinking framework in all courses. The architecture of the IS curriculum consists of five curriculum presentation areas:

- information systems fundamentals;
- information system theory and practice;
- information technology;
- information systems development; and
- information systems deployment and management processes.

The five presentation areas consist of ten courses and one prerequisite course. These are:

- IS 2002.P0- Personal Productivity with IS Technology
- IS 2002.1- Fundamentals of Information Systems
- IS 2002.2- Electronic Business Strategy, Architecture and Design
- IS 2002.3- Information Systems Theory and Practice
- IS 2002.4- Information Technology Hardware and System Software
- IS 2002.5- Programming, Data, File and Object Structures
- IS 2002.6- Networks and Telecommunication
- IS 2002.7- Analysis and Logical Design
- IS 2002.8- Physical Design and Implementation with DBMS
- IS 2002.9- Physical Design and Implementation in Emerging Environments
- IS 2002.10- Project Management and Practice

The ABET requirement states that at least 30 semester hours of IS must be included in the IS curriculum. Taking the IS 2002 model curriculum and ABET criteria for accreditation<sup>6</sup>, we have developed a course sequence in IS curriculum which integrates problem solving into courses. Moreover, this sequence should allow students to learn concepts of programming and the use of a modern programming language with less difficulty.

### **4. IS course sequence for problem solving and programming**

We propose a sequence of IS courses which includes problem solving and critical thinking at all course levels. The proposed courses satisfy the IS2002 recommendations and the ABET requirements discussed in Section 3. Furthermore, the sequence of courses in programming and problem solving is designed for students to easily understand concepts of programming while staying focused on problem solving.

In the first year of the IS curriculum, three courses are recommended; CIS010, CIS101, and CIS110. CIS010 is a course that introduces students to the fundamentals of computer literacy. Here, students learn how to use productivity tools to solve real-world problems. This is the first exposure students have to the concepts of problem solving. This is equivalent to the IS 2002.P0- Personal Productivity with IS Technology recommended prerequisite to other IS courses. CIS101 provides students with an introduction to information systems. Here, students learn about programming languages, their historical development, and the program development life cycle. This course fulfills the recommendation of the IS 2002.1- Fundamentals of Information System. CIS110 teaches students the basics in discrete mathematics using application such as MathCAD and Maple. This course fulfills the requirement by ABET as part of the nine hours of quantitative analysis beyond pre-calculus.

In the second year of the IS curriculum, four courses are recommended; CIS180, CIS210, CIS240 and CIS340. In CIS180, students learn programming methodology and how to solve a problem without using a particular programming language. Here, students are introduced to tools which are used for problem solving such as flowcharting, hierarchy charts, pseudocode, and Unified Modeling Language (UML). In this course, students learn how to use top-down design methodologies to break problems into modules. This course fits in the learning unit goals of IS 2002.5- Programming, Data, File and Object Structures. In CIS210, students learn advanced concepts in discrete math including recursion. This course fits into the ABET area of quantitative analysis. In CIS240, students learn object-oriented programming and problem solving. Students learn how to create applications using VisualBasic.NET programming language which has become popular among students. This course fits into the learning unit goals of 2002.5- Programming, Data, File and Object Structures, and IS 2002.9- Physical Design and Implementation in Emerging Environments. In CIS340, students learn web programming which includes HTML and XML. This course fits in the learning unit goals of 2002.2- Electronic Business Strategy, Architecture and Design, and IS 2002.9- Physical Design and Implementation in Emerging Environments.

In the third year of the IS curriculum, two required and one elective courses are recommended; CIS241, CIS320 and CIS345. In CIS241, students learn programming and problem solving using Java as an implementation tool. Here, students learn advanced concepts of object-oriented programming such as inheritance and polymorphism. This course fits in the learning goals of IS 2002.5- Programming, Data, File and Object Structures and IS 2002.9- Physical Design and Implementation in Emerging Environments. In CIS320, students learn Information Technology hardware and software while staying focused on problem solving. This course fits in the learning unit goals of IS 2002.4- Information Technology Hardware and System Software. CIS345 is an IS elective which introduces students to object-oriented programming using COBOL. Here,

CIS345 provides students with an alternative programming language. This course fits in learning unit goals of IS 2002.5- Programming, Data, File and Object Structures.

In total, students will spend 30 semester hours between their freshman and junior years learning problem solving and critical thinking. The following list describes courses which embed problem solving and critical thinking.

- CIS010: Introduction to Personal Computer Productivity Tools
- CIS101: Introduction to Computer Information Systems
- CIS110: Discrete Math I
- CIS210: Discrete Math II
- CIS180: Programming Methodology and Modeling
- CIS240: Object-Oriented Programming and Problem Solving I
- CIS241: Object-Oriented Programming and Problem Solving II
- CIS340: Web Programming
- CIS320: IT Hardware and Software
- CIS345: Object-Oriented COBOL (elective course)

Figure 2 shows the proposed sequence of courses from the first to the third year. The levels in problem solving and critical thinking increase with the course content and this is reflected by the change in color in the diagram that lists the sequence.

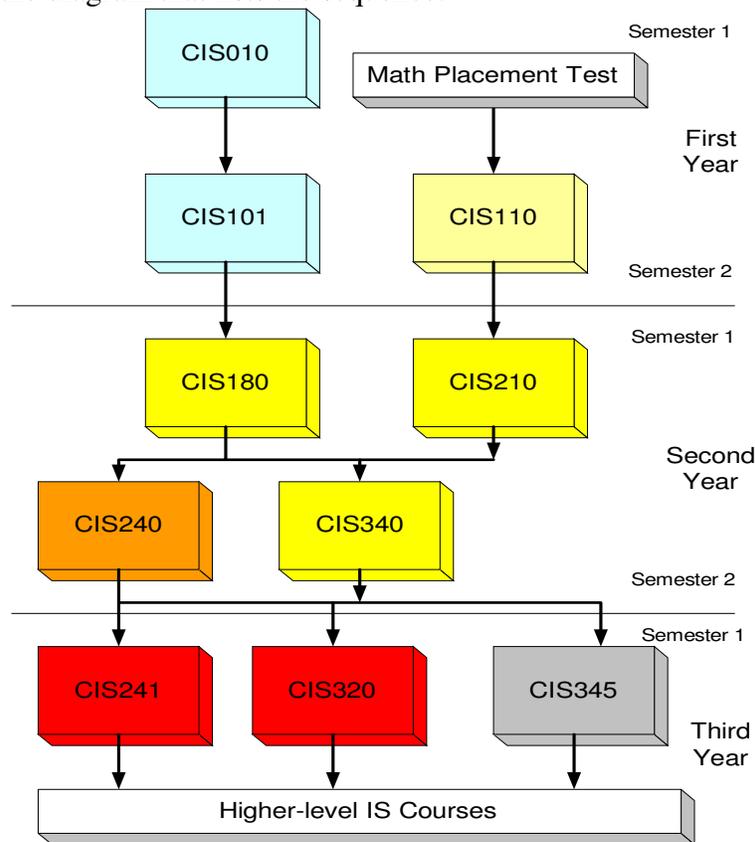


Figure 2. Proposed course sequence for problem solving and programming.

## 5. Conclusions

In this paper, we have proposed a sequence of IS courses that embed problem solving and critical thinking. The sequence satisfies both the ABET requirements and the IS 2002 recommendations. Furthermore, we show how each course maps into the IS 2002 learning unit goals as well as the ABET criteria. The proposed sequence shows the gradual increasing levels of learning in problem solving and critical thinking for each course. We propose to introduce concepts of programming after students have a thorough understanding of problem solving, design and modeling of solutions. We also suggest using VisualBasic.NET as a primary language to introduce object-oriented programming and problem solving. Higher-level concepts in object-oriented programming are introduced using Java. We anticipate that the proposed sequence of IS courses will make students appreciate the usefulness of problem solving and will enable them to know how to use programming languages to develop solutions to real-world problems.

## 6. References

1. The 1999 National Survey of Information Technology in US Higher Education. The Campus Computing Project October 1999. <http://www.campuscomputing.net>
2. Green, K.C., Campus Computing 1998, the Ninth National Survey of Desktop Computing and Information in Higher Education (Encino, Calif. The Campus Computing Project, February 1999).
3. IS 2002: Model Curriculum and Guidelines for Undergraduate Degree Programs in Information Systems, <http://www.acm.org/education/curricula.html#IS2002>
4. A. Benander, B. Benander, and J. Sang, "Factors related to the difficulty to program in Java-an empirical study of non-novice programmers", Journal of Information and Software Technology, Vol. 46, 2004, pp. 99-107.
5. Zayed University Catalogue, <http://www.zu.ac.ae/>
6. Criteria for Accrediting Computers Programs, Computing Accreditation Commission, [http://www.abet.org/criteria\\_cac.html](http://www.abet.org/criteria_cac.html)
7. L. Prechelt, "An empirical comparison of seven programming languages", Journal of Computing Practices, October, 2000, pp. 23-29.
8. F. Bouslama, A. Lansari, A. Al-Rawi, and A. Abonamah, "A novel outcome-based educational model and its effect on student learning: curriculum development and assessment", Journal of Information Technology Education, Special Issue on Information Technology in the Assessment Process of Student Learning, Vol. 2, 2003, pp. 203-214.
9. F. Bouslama, A. Lansari, A. Al-Rawi, and A. Abonamah, "Modeling the performance of an outcome based educational framework" in the Proc. of the 2003 ASEE Annual Conference & Exposition June 22-25, Nashville, Tennessee, USA, 2003.

## **Biography**

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Faouzi received a PhD degree in Electronic Engineering from Shizuoka University in 1992. From 1992-1994, he was a researcher at Toshiba Co., Tokyo. From 1994-2000, he was Associate Professor of Information Systems, Hiroshima City University in Japan. He joined Zayed University in the UAE in August 2000 as an associate professor. His research interests include Neural Networks, Fuzzy Logic and Curriculum Design and Modeling.

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Azzedine received a PhD in Biomedical Engineering from North Carolina State University in 1992. From 1992-1998, he was a senior researcher at MANTECH, NC. He joined Zayed University in August 1998. His research interests include systems modeling, educational technology and curriculum design in Information Systems. His teaching interests include Instructional Technology and statistical modeling.

### **AKRAM ALRAWI**

Akram is a Sun certified Java Programmer and a Professor of CIS at Zayed University, UAE. He has worked at several academic institutions of which the last two were the University of Missouri-Columbia and Columbia College, MO. His teaching interests include programming languages, logic design, and computer architecture. His research interests include computer simulation, web-caching architecture, and curriculum design.