Ministry of Education

Identified Competency Focus Areas and Core Courses for National Exit Examination

Program: Bachelor of Science in Computer Science/Computer Engineering

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1. Introduction

We live in the digital age, where computers pervade every aspect of our daily lives. It is believed that the potential of computers and the benefits they can bring to society are only just beginning to be realized. Computer scientists are at the forefront of figuring this out, with the goal of improving existing solutions as well as developing entirely new ones. The development of theories, as well as the design and implementation of software and hardware solutions, all necessitate the involvement of computer scientists.As a result, universities both locally and globally teach computer science in an effort to produce the scientists and engineers of tomorrow.

Most Ethiopian higher education institutions offer computer science as a four-year degree program, with the goal of contributing to the country's overall growth by producing needed manpower. In line with this, to avoid irregularities on the graduation profile a harmonized curriculum is in practice which is implemented across all universities. The curriculum states that the minimum requirement for graduation is a CGPA of 2.0, which does not measure the overall learning output of the program but rather individual courses. As a result, a framework that guarantees the fulfillment of the curriculum's graduate profile, as well as the production of qualified labor for the local, national and international markets is needed. To this end, the Ministry of Education (MoE) devised an exit exam as a framework to achieve the aforementioned and other goals, such as creating a conducive environment for stakeholders' proper engagement and assessing students' achievement in their major area.

There are various settings in which an exit exam may be defined. In our case, it is described as a form of assessment that higher education institutions utilize to examine the basic level of competency obtained by its students. It is an assessment that is given to students towards the end of their higher education tenure. Exit exams, according to studies [1], improve student performance, have a positive impact on the job market, and result in faster economic growth.As a result, computer scientists who have completed their higher education can use the exit exam to demonstrate that they have the skills, knowledge, attitudes, and general competencies required by stakeholders worldwide.

1.1. Objectives of the Exit Examination

Computer science curriculums are designed to offer high-quality basic and advanced courses to help students obtain broad knowledge and expertise in computer science. The major objective of the exit exam is to evaluate graduates competency as per the computer science curriculum objectives and demand that are expected by local and international industries.The national computer science exit exam shall have the following specific objectives:

- To produce skilled and competent manpower to national and international market
- Assessing students' educational achievement in major areas of computer science
- Ensuring whether the graduation profile of computer science curriculum have achieved at least common standards of knowledge and practical skills
- Improving public trust and confidence in computer science activities of professionals
- Facilitating the efforts of students to revise the core learning outcomes of the courses covered by the exit examination
- Ensuring all graduates from HEIs satisfy the requirements of the labor market and employability through the national wide implementation of competency-based exit exam
- Creating competitive spirit among computer science departments in Ethiopia with the aim of encouraging them to give due attention to the national standards
- Providing inputs and suggest further ways forward for the policy makers based on the exit exam outcomes

1.2. Significance of the Document

It is important to set competency areas of the subject matter (program) in order to measure the how much graduates are acquired with skills, knowledge and attitudes. The following shows us the significance or setting competencies and identifying core courses of the program;

- To set competencies that helps to assess the basic skills, knowledge and attitude of graduating students;
- To systematically identify the core courses which will be included the exit exam;
- To evaluate and certify the competency of computer science graduates in line with the identified computer science program focus areas;

First and foremost, this competency and exit exam guideline for the BSc degree in computer science program at higher education institutions in Ethiopia outlines the expected profiles of graduates, such as knowledge, skills, and attitudes. The core competencies are then identified and their course mapping is presented. The courses to be included in the exam are then listed and organized into themes. Finally, concluding remarks are communicated.

2. Expected profiles of graduates

The three profiles of knowledge, skills, and attitudes are universally acknowledged as being necessary for graduates [2].

- Knowledge ("know-what") is the mastery of fundamental ideas and concepts as well as the application of learning to new situations
- Skills ("know-how") is the ability to complete tasks with predictable outcomes
- Attitudes ("know-why") are intellectual, social, or moral tendencies

3. Competencies and learning outcomes

3.1. Core competencies

The term competency refers to workplace performance, or what a graduate should bring to a job. The concept glues together the above mentioned expected graduate profiles, i.e., Competency=Knowledge + Skills +Attitudes. The core competencies for computer science graduates are listed as follows:

- Design a computer system application, process, or protocol to meet the requirements of users or stakeholders.
- Use a variety of operating systems, programming languages, and software tools effectively.
- Use formal reasoning to justify the correctness of computer science results
- Manage and administer computing systems and resources
- Identify any risks or safety issues that may be involved in the operation of computing equipment in a given context.

- Evaluate systems in terms of general quality attributes and potential tradeoffs presented within the context of the given problem.
- Create a substantial technical document that describes work and plan of a project.

The expected competency of computer science graduates is outlined below in terms of the three basic metrics mentioned above.

3.1.1 Knowledge

Graduates of computer science are expected to understand both the theoretical and practical aspects of field, as well as the role of computing systems in general. To this end, the ability to apply or justify concepts, methods, and computational proficiency in the field is required. It is, therefore, critical to have comprehensive knowledge and understanding of the following topics:

- The fundamental concepts, principles and theories of computation and the application of computers.
- Software Fundamentals and programming languages
- Systems architecture and infrastructure
- Systems modeling
- Structuring of data and information
- Hardware
- Trends and developments in computer science

3.1.2 Skills

The following skills are also expected from computer science graduates:

- Remembering emerging technologies
- Understanding computer architecture and operating systems
- Applying programming languages and software tools to address issues in the real world
- Analyzing existing computing infrastructures and architectures
- Evaluating systems in terms of general quality attributes and potential tradeoffs
- Creating computer artifacts to solve societal problems by applying system modeling, development, and implementation principles

3.1.3 Attitudes

Graduates of computer science are expected to have a wide range of transferable skills (attitudes), including

- Teamwork: Capable of making a valuable contribution to a development team.
- Communication: Briefly explain technical problems and how to solve them to a range of audiences.
- Handling Ethical Issues in Computer Technology: Recognize and follow the social, professional, and ethical issues that arise from the use of computer technology.

3.2. Mapping between core Competencies and Selected Courses

The mapping of core competencies to core courses is shown in Table 3-1. Competency, as previously stated, is expressed in terms of knowledge, skills, and attitudes. The skills are described using Bloom's levels of skill [3], which are composed of six cumulative degrees of skills including remembering, understanding, applying, analyzing, evaluating, and creating.

Table 3-1 Mapping of core competencies to courses

Competency Vs Courses		Computer Programming	Object Oriented Programming	Web Programming	Data Communication and Computer Networking	Computer Security	Network and System Administration	Automata and Complexity Theory	Database Systems	Software Engineering	Compiler Design	Introduction to Artificial Intelligence	Design and Analysis of Algorithms	Data Structures and Algorithms	Operating System	Computer organization and architecture
Knowledge Element	**Skills**															
Programming Languages	Understanding, Applying	X	X	X												
Structuring of data and information	Analyzing								X					X		
Systems Modeling	Evaluating, Creating								X	X						

Systems architecture & infrastructure	Analyzing, Evaluating				X	X	X								X	X
Software development	Applying, Creating			X					X	X			X			
Software Fundamentals	Understanding, Applying	X	X	X					X	X						
Hardware	Understanding, Remembering														X	X
Concepts, principles and theories of computation and the application of computers	Understanding, Remembering	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Trends and developments in computer science												X				

3.3. Learning outcomes

- Apply computer science theory and software development fundamentals to produce computing-based solutions;
- Use appropriate programming techniques to implement a solution to a problem;
- Develop a software system using the appropriate design principles and patterns;
- Analyze a complex computing problem and apply computing principles to solve it;
- Use analytical and empirical methods to assess the solutions to technological issues;
- Analyze current issues in the evolving field of computer science;
- Articulate the social, professional, ethical, and legal facets of a computing environment.

4. Courses to be included in the exam

A computer science graduate should take 52 courses to graduate, according to the current curriculum. However, including all courses in the competency and exit examination is unrealistic. To that end, the following courses were chosen from among all available options for the competency and exit examination.

Table 4-1: List of selected Courses

No	Course Name	ECTS
1	Computer Programming	5
2	Database Systems[1]	10
3	Object Oriented Programming	5
4	Computer organization and Architecture	5
5	Data Communication and Computer Networking	5
6	Data Structures and Algorithms	5
7	Web programming	7
8	Operating System	5
9	Software Engineering	5
10	Design and Analysis of Algorithms	5
11	Introduction to Artificial Intelligence	5
12	Computer Security	5
13	Network and System Administration	5
14	Automata and Complexity Theory	5
15	Compiler Design	5
Total		**82**

5. Categorizing courses into themes

Table 5-1: Courses organized into themes

Theme	Courses
System Development	Software Engineering
	Web Programming
	Database Systems
Programming and Algorithms	Computer Programming
	Object Oriented Programming
	Design and Analysis of Algorithms
	Data Structure and Algorithms
Computer Networking and Security	Data Communication and Computer Networking
	Computer Security
	Network and System Administration
Intelligent Systems	Introduction to Artificial Intelligence

[1]Fundamentals of Database Systems and Advanced Database Systems

Computer Architecture and Operating Systems	Operating System
	Computer organization and architecture
Compiler and Complexity	Automata and Complexity Theory
	Compiler Design

Computer Science and Engineering (CSE)		
No	Course Name	CrHr
1	Computer Architecture & Organization	3
2	Database Systems	4
3	Object Oriented Programming	3
4	Project Management	3
5	Data Communication and Computer Networking	4
6	Data Structures and Algorithms	3
7	Digital Logic Design	3
8	Operating System	3
9	Fundamentals of Software Engineering	3
10	Algorithms	3
11	Introduction to Artificial Intelligence	3
12	Fundamentals of Programming	3
13	Formal Language and Automata Theory	3
Total		**44**

Computer Science and Engineering (CSE) Courses organized in Themes

1. System Development
   i. Fundamentals of Software Engineering
   ii. Database Systems
   iii. Project Management
2. Programming and Algorithms
   i. Fundamentals of Programming
   ii. Object Oriented Programming
   iii. Algorithms
   iv. Data Structure and Algorithms
3. Computer Networking and Security
   i. Data Communication and Computer Networking
4. Computer Architecture and OS
   i. Computer organization and architecture
   ii. Operating System
   iii. Digital Logic Design
5. Compiler and Complexity
   i. Formal Language & Automata Theory

6. Miscellaneous
    i. Introduction to Artificial Intelligence

6. Conclusion

Core competency and exit examination courses for the computer science BSc degree program were presented in this guideline. Thirteen courses were chosen from a pool of more than 52 courses to assess students' competencies. The courses are further categorized into six themes for comprehension purpose. The courses on the list are fundamental courses that prepare students to compete in the global marketplace.

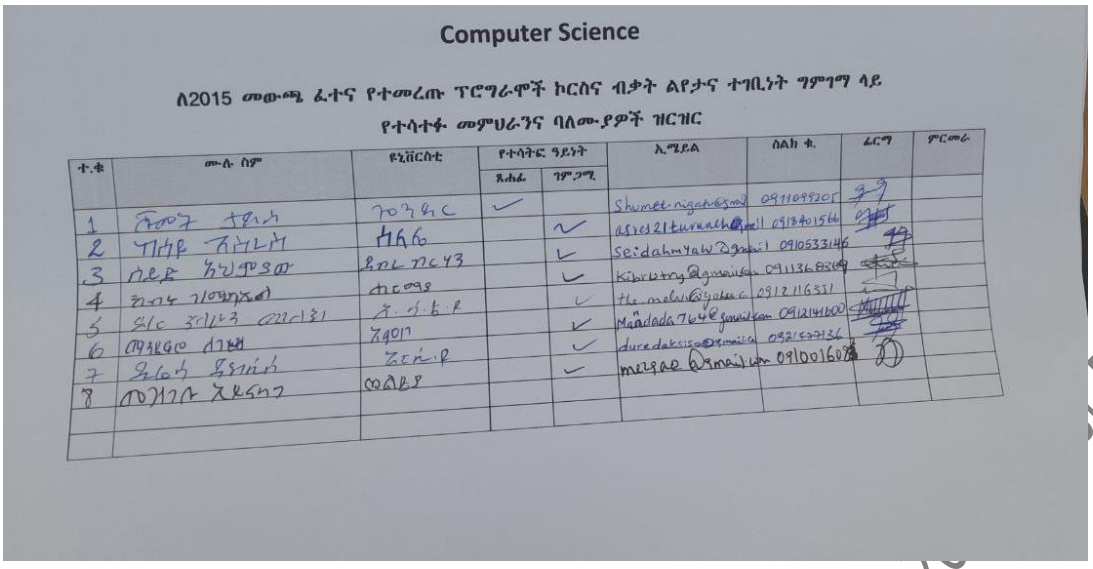
The exam that is going to be prepared from these courses should focus on concepts that guide for long term knowledge and transfer skills instead of detailed assessment. Furthermore, the courses are subject to change in the event of a curriculum update.

References

[1] Woessmann, Ludger. "Central exit exams improve student outcomes." IZA World of Labor (2018).
[2] Clear, A., A. Parrish, J. Impagliazzo, P. Wang, P. Ciancarini, E. Cuadros-Vargas, S. Frezza et al. "Computing curricula 2020 (CC2020) paradigms for global computing education." ACM: New York, NY, USA (2020).
[3] Anderson, L.W. et al., A taxonomy for learning, teaching, and assessing: A revision of Bloom’s taxonomy of educational objectives, abridged edition, (White Plains, NY Longman, 2001).

Appendix

Theme	Courses
System Development	Software Engineering
	Web Programming
	Fundamentals of Database Systems
	Advanced Database Systems
	Human Computer Interaction
	Computer Graphics
	Multimedia
Programming and Algorithms	Computer Programming
	Object Oriented Programming
	Design and Analysis of Algorithms
	Data Structure and Algorithms
	Java Programming
	Mobile Application Development
	Event Driven Programming
Computer Networking and Security	Data Communication and Computer Networking
	Computer Security
	Network and System Administration
	Wirless Communication and Mobile Computing
	Introduction to Distributed Systems
Intelligent Systems	Introduction to Artificial Intelligence
	Introduction to Data Mining and Data Warehousing
	Introduction to Machine Learning
	Introduction to Natural Language Processing
	Computer Vision and Image Processing
	Simulation and Modeling
Computer Architecture and Operating Systems	Operating System
	Computer organization and architecture
	Microprocessor and Assembly Language Programming
	Real time and embedded system
Compiler and Complexity	Automata and Complexity Theory
	Compiler Design



Computer Science

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