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# Student Outcomes Assessment Methodology for ABET Accreditation: A Case Study of Computer Science and Computer Information Systems Programs

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**ABSTRACT** Acquiring academic accreditation for degree programs is a top priority for universities across the world. This is understandable because accreditation not only leads to better content and delivery of these programs but also allows these institutes to acquire good quality students and faculty members. One respectable body that has the mandate to accredit computing programs is the Accreditation Board for Engineering and Technology (ABET). In this paper, we provide the details of our assessment and evaluation strategies for ABET-defined student outcomes (SOs) of computer science and computer information systems programs. The assessment is mainly carried out through a range of direct and indirect assessment methods, including summative data analysis, formative data analysis, exit exam, faculty survey, and alumni survey. Then, data gathered from these sources is aggregated and analyzed to quantify the attainment of SOs. This also forms the basis of the continuous improvement process activities that are the cornerstone of any accreditation-related activity. While presenting this, this paper provides details on the challenges that were faced during the process. The most important contribution includes strategies that were adopted to tackle these issues. A unique aspect of our institute is the academic environment that consists of segregated male and female students and faculty members in order to respect the cultural norms of the society. Another contribution of this paper is that it acts as a guide for institutes and their management that plan to embark upon the journey of accrediting their computing programs.

**INDEX TERMS** Student outcomes, attainment, evaluation, assessment, educational strategies.

## I. INTRODUCTION

Due to enhanced interest of external constituencies, quality assurance has recently emerged as a vital functional area of modern day academic management. Governments and regulatory bodies highlight need of quality assurance activities for benchmarking institutions, whereas students are interested in these processes to priories their selection of potential alma mater [1]. Selection of an academic institution/program has lifelong implications for an individual, so there is an increased demand for more awareness for students and their parents so that they can make an informed judgment [2]. This has led to evolution of different accreditation mechanisms and academic rankings. Some of these accreditation agencies focus at institutional level, whereas some focus on specific academic program. Each of these ranking and accreditation approaches have their own set of criteria, and an independent audit of these bodies is aimed to instill more confidence in standing of different institutions/programs [3].

Although there is skepticism among academia about the effectiveness and fairness of these criteria, still academic institutions strive hard to gain accreditation to give confidence to their stakeholders. These accreditation bodies define their requirements and give flexibility to institutions in devising their own processes to ensure that they are meeting the set forth criteria. On the one hand this flexibility helps mature institutions to satisfy accreditation requirements without modifying their existing processes, but new institutions often confront with the challenges of defining optimal processes to meet accreditation requirements. Management of these institutions face the dilemma whether they are heading in the right direction or not. Keeping in view the variations of environmental variables in different institutions it may not be possible to present a generalized framework but there is a need to enrich this body of knowledge by extensive case studies documenting challenges and counter strategies.

Accreditation Board of Engineering and Technology (ABET) is one such accreditation body, which itself is nonprofit and ISO 9001:2008 accredited. Currently, they have more than 3,800 accredited programs in 31 countries in four areas namely, Applied & Natural science, Computing, Engineering and Engineering Technology [4]. ABET has a well-defined comprehensive requirement for prospective programs and they offer some training to disseminate best practices, but they do not dictate a methodology to achieve these requirements. The crux of ABET accreditation is defining a suitable assessment mechanism, measuring attainment for the program and performing continuous improvement based on attainment results. However, defining an effective assessment mechanism is daunting task and in this paper, we share the experience of defining an assessment mechanism for ABET accreditation of two computing programs offered by same college.

Rest of the paper is organized as follows. Section II presents the literature review. Section III defines the problem statement that we attempt to address in this paper. This is followed by a detailed discussion of the case setting in Section IV. Section V details our evaluation methodology for SOs attainment in the context of ABET. Later, we analyze and present implications of our approach in Section VI that also provides guidelines that might be adopted or considered by other institutes. We conclude the paper in Section VII.

## II. LITERATURE REVIEW

Recently, there has been a significant interest in improving the learning processes in technical professions such as cyber security [5], electrical engineering [6], telecommunication engineering [7], mechatronics [8]. Keeping this in place some researchers have explored that how ABET accreditation processes can help in improving the program quality and learning experience. Koehn [9] has conducted a research study about the relevance of Student Outcomes (SOs) proposed by ABET for engineering programs and found that practicing engineer found that the proposed criteria does not reflect all the required skill set which is required by engineers while practicing their profession. Felder and Brent [10] discuss different pedagogical approaches to enable students with ABET outcomes for engineering programs. Cook *et al.* [11] have discussed the difficulties in developing self-study report for the accreditation program and has proposed a generic model based on ABET criteria to highlight deficiencies in the academic programs intending to apply for ABET accreditation. Collofello [12] has related the ABET accreditation process with acquiring Capability Maturity Model (CMM) certification by Software Engineering Institute. They used lessons learned from CMM assessment in Arizona State University accreditation efforts. Essa *et al.* [13] have developed a web based application which can facilitate assessment data collection and reporting processes. Dawood *et al.* [14] have shared the rubric based assessment mechanisms for ABET student outcome attainment for a computer science program. Abou-Zeid and Taha [15] have highlighted that faculty workload, staff shortage, lack of training and faculty commitment as major obstacles faced by engineering departments in the accreditation process in Saudi Arabia. Pears *et al.* [16] discuss the details of a collaborative project between AlBaha school of computing and Uppsala University Sweden for developing quality assurance processes in line with ABET accreditation requirements. Cabezas [17] propose a continuous improvement cycle by combining ABET criteria and gamification theory which resulted in a positive impact on students learning behavior. Faiz and Al-Mutairi [18] have analyzed the Cooperative Training Program (COOP) of an engineering program and its role in achieving relevant ABET SOs and they further compare the COOP experiences handled by different participating organizations. McKenzie *et al.* [19] shared their experience of development and implementation of the program enhancement plan to satisfy the continuous improvement process for ABET accreditation of an undergraduate modeling and simulation engineering program. Schoepp *et al.* [20] propose to use a discussion based performance task to evaluate six non-technical skills concerning ethical, legal, security and social issues rather than traditional evaluation mechanisms in course based assessments. Calderón *et al.* [21] discuss lack of available literature on designing assessment strategies and shared their successful accreditation experience at a Caribbean University. Rabaa'i *et al.* [22] share their experience of acquiring ABET accreditation and highlighted three student Outcomes as an example based on their accreditation efforts at American University of Kuwait. Harmanani [23] advocates for adopting outcome-based assessment process in computing programs.

Majority of these contributions discuss the ABET accreditation experience at an abstract level without going in more depth or only highlighting one aspect of the ABET criteria such as assessment mechanism or continuous improvement. As a result, there is a gap in literature on how to instantiate assessment methodologies to satisfy the ABET guidelines for a specific setting. With this in view, it is evident that a detailed design and execution of assessment process is required and that forms the main contribution of this paper. Unlike previous efforts, this paper takes a holistic approach to provide guidance on all key issues of the assessment process including design, evaluation, and continuous improvement as implemented by the College of Computer Science and Information Technology (CCSIT) at the Imam Abdulrahman Bin Faisal University (IAU) located in Dammam, Kingdom of Saudi Arabia.

## III. PROBLEM STATEMENT

This section outlines the challenges for designing an assessment methodology for computing programs at higher education institutes. The overall goal for such assessment is to eventually enhance the quality of programs and related processes. However, in this paper we address the issue of fleshing out details for the assessment process. It is pertinent to note that while doing so, certain academic and non-academic challenges need to be handled on the path towards achieving accreditation.

The challenges for designing and establishing assessment mechanisms at any higher education institute—to enhance overall quality of programs and achieve accreditation—include:

### A. EXHAUSTIVE VS. LIGHTWEIGHT

It is important to select balanced and appropriate assessment methodology and this requires careful consideration. On the one hand, having exhaustive assessment mechanisms can increase the confidence in assessment results but on the other hand overburden the institution resources. Whereas, the lightweight approach is desirable in terms of resources but can produce biased/influenced results.

### B. ASSESSMENT APPROACH

The process adopted for conducting assessments is of utmost importance. The structure of assessment can be devised using Top Down or Bottom Up approach for all involved stakeholders. The Top Down approach refers to designing the assessment mechanism by higher management and selected experts and later shared with other stakeholders including faculty members. including key stakeholder representatives involved in designing process. The Bottom Up approach refers to involving all stakeholders of variable expertise from the very start of the design process. Assessment process must also define various artifacts—including appropriate Program Educational Objectives (PEOs), SOs, Performance Indicators (PIs)—and design suitable direct and indirect assessment methods, corresponding rubrics, and their frequency.

### C. FAIR/UNBIASED

The assessment methodology must be fair and unbiased in order to provide accurate assessment results to decision makers. It must be ensured to involve all stakeholders and might be customized in order to suit their socioeconomic, geographical, and industry requirements.

### D. FACULTY MEMBER INVOLVEMENT

An important consideration while designing the assessment methodology is to ascertain the degree to which faculty members are involved in the process. It is important to have faculty members on-board since this process is likely to increase load at least in the initial stages. Also, adopting rubrics-based evaluation has certain advantages as it provides a standard tool for quantifying performance of students. But rubrics-based assessments are hard to design and hence might lead to resistance from stakeholders.

### E. MANAGEMENT SUPPORT

It is vital to have management support at all levels in order to design and implement an effective assessment methodology. There are various aspects of the support but the most important one include providing appropriate resources and to some degree freedom to assessment methodology designers in the initial stages. Designing and implementing an assessment process likely leads to curriculum update and revision of artifacts including PEOs, SOs, PIs, and corresponding rubrics. Also, higher management typically needs to get involved to gather and address feedback from all involved stakeholders.

### F. EASY TO VERIFY

The assessment methodology must be designed to quantify performance of students against a set target value agreed upon through reasoning and rationale. This is challenging because assessment data is originating from various direct and indirect methods and is often collected based on different—and at times conflicting—rubrics/scales.

### G. CONTINUOUS IMPROVEMENT

Perhaps the most important outcome of the assessment mechanism is to provide data, feedback, and recommendations to continuously improve the program over recurring evaluation cycles. This means that the assessment process must be designed in a way to produce and later incorporate continuous improvement recommendations.

## IV. CASE SETTING

This section of the paper provides background information about academic programs that are used as a case-study to showcase assessment and evaluation of SOs.

The College of Computer Science and Information Technology (CCSIT) [24] at the Imam Abdulrahman Bin Faisal University (IAU) [25] has two academic departments namely the Department of Computer Science and the Department of Computer Information Systems. The Department of Computer Science currently offers three degree programs namely Masters of Science in Computer Science, Bachelor of Science in Computer Science (hereafter referred to as the CS program) and Bachelor of Science in Cyber Security and Digital Forensics. On the other hand, the Department of Computer Information System currently has only one program named as Bachelor of Science in Computer Information Systems (hereafter referred to as the CIS program). The scope of this paper is limited to CS and CIS programs. The Bachelor of Science in Cyber Security and Digital Forensics is a new program that was initiated in the 2016-2017 academic year.

Table 1 provides a higher-level overview of CS and CIS program at CCSIT. The Mission Statement of both programs is supported by four PEOs, while each PEO is linked with at least one SO. For the CS program, there are 11 SOs covered

**TABLE 1. CS and CIS program facts.**

| | CS Program | CIS Program |
|---|---|---|
| Program Educational Objectives | 4 | 4 |
| Student Outcomes | 11 (A to K) | 10 (A to J) |
| Performance Indicators | 27 | 25 |
| Years | 4 | 4 |
| Semesters | 8 | 8 |
| Credit Hours | 121 | 121 |

by a curriculum comprising of 121 credit hours. On the other hand, the CIS program has 10 SOs that are evaluated through a curriculum comprising 121 credit hours. Note that the two programs have full-fledged processes to assess and evaluate PEOs and SOs. However, the scope of this paper spans the assessment and evaluation of SOs for CS and CIS programs.

It may be noted that currently the CS and CIS program have adopted Student Outcomes as suggested by ABET. However the assessment methodology presented in this paper is applicable to ABET-defined or customized Student Outcomes that a program might adopt.

Some of the peculiar difficulties and challenges of our College are summarized below. These include:

#### 1) NEW SETUP

The current College came into existence in the year 2010. Before that, the College was sub-campus for another regional University. At the time of the setup, the curriculum, as well as processes and policies—were inherited from the old setup. And operations were initiated with new leadership and young faculty members. As can be imagined, the initial few years after 2010 were spent in re-aligning of adopted processes/policies in the context of new organization layout and stakeholders. It is important to note here that until the year 2014, the two programs did not have some important artifacts including PEOs, SOs, and PIs.

#### 2) YOUNG FACULTY MEMBERS

The College consists of mainly junior faculty members and hence there was lack of assessment design and execution experience. Around 94% and 100% of the faculty members—respectively in CS and CIS departments—are Lecturers and Assistant Professors.

#### 3) TWO GENERAL YEARS

One the major constraint related to flexibility in the curriculum is that the first two years for CS and CIS programs are shared and are considered general years. The execution of shared courses is owned by respective departments. This removes the flexibility to design independent assessment mechanism separately for CS and CIS programs.

#### 4) GENDER-BASED SEGREGATION

Due to the cultural sensitivities of the region, the College maintains separate arrangements in different buildings for male and female faculty members and students. The challenge here is that the curriculum is designed to be uniform but is delivered through different instructors at both sides. It is preferred that male and female students are taught by male and female faculty members respectively. However, there may be rare exceptions to this arrangement if resources are not available. The communication between male and female faculty members is only through electronic means through telephones, emails, or video conferencing tools.

The SOs for CS and CIS programs have been borrowed from the ABET-defined "Criteria for Accrediting Computing Programs, 2016-2017" guidelines available at [26]. Note that the two programs have nine general SOs that are labeled from A to I. As recommended by the ABET guidelines, the CIS program has one specific SO labeled J and the CS program has two specific SOs labeled J and K. The criteria document also defines various accreditation-related terms including PEOs and SOs.

For the two programs, each SO is assessed and evaluated through a set of PIs. Table 2 presents SOs and PIs for CS and CIS programs. Note that SOs are identified through capital alphabets A to K and A to J for CS and CIS programs respectively. PIs are identified with a combination of capital alphabet and a numeric number—for example the SO A has four PIs including A1, A2, A3, and A4. There are some SOs and PIs that are specific to either CS or CIS programs and have been highlighted using [CS only] or [CIS only] labels in Table 2 for convenience. These include SOs J and K (for CS), SO J for (CIS), PIs4and2(for CS), and PIs2and B4 (for CIS). Each PI relies on corresponding rubrics that segregate the students into four categories: 1) Poor, 2) Developing, 3) Developed, and 4) Exemplary. A rubric is an explicit set of performance expectations for each indicator. Ranges for the four categories are as follows:

1) Poor: 0-24%
2) Developing: 25-49%
3) Developed: 50-74%
4) Exemplary: 75-100%

We now shift our attention to PIs assessment and evaluation in the CS and CIS curriculum. All courses in the two programs have several Course Learning Outcomes (CLOs). CLOs are statements that describe what a student must be able to do at the conclusion of a course. Some of these CLOs in turn might map to PIs belonging to SOs. Figure 1 explains the mapping and, offers a hypothetical example. Each course relies on quizzes, home assignments, mid-term exams, final exams, projects, and/or labs to evaluate the performance of students in each CLO. As shown in Figure 1, there are three courses (A, B, and C). Each course has its own list of CLOs: courses A, B, and C have two, three, and two CLOs respectively. Each CLO in turn maps to a single PI. In this hypothetical example, SO A has three PIs: A1, A2, and A3. For course A, CLO 1 maps to3and CLO 2 maps to B1. For course B, CLOs 1, 2, and 3 map to PIs D1, B1, and J2. For course C, CLO 1 maps to PI F1 while CLO 2 does not map

**TABLE 2.** CS and CIS program student outcomes and corresponding performance indicators.

| |
|---|
| **A: An ability to apply knowledge of computing and mathematics appropriate to the program's Student Outcomes and to the discipline.** |
| A1: Students demonstrate the knowledge of the foundations of mathematics, logic, and statistics. |
| A2: Students demonstrate the knowledge of digital logic to understand the fundamentals of computer organization. |
| A3: Students demonstrate an understanding of basic data structures and their representation. |
| A4: Students demonstrate the ability to relate concepts of mathematics with computability. **[CS only]** |
| **B: An ability to analyze a problem, and identify and define the computing requirements appropriate to its solution.** |
| B1: Students demonstrate the abilities to formulate and decompose a problem into appropriate components. |
| B2: Students demonstrate the abilities to write requirements specifications. **[CIS only]** |
| B2: Students demonstrate the abilities to solicit and formulate requirements specifications. **[CS only]** |
| B3: Students demonstrate the abilities to estimate resources required for the proposed solution. |
| B4: Students can demonstrate the abilities to use common modeling techniques to analyze the given problem. **[CIS only]** |
| **C: An ability to design, implement, and evaluate a computer-based system, process, component, or program to meet desired needs.** |
| C1: Students demonstrate the abilities to design computer-based system, process, component, or program to meet desired needs. |
| C2: Students demonstrate the abilities to develop a computer-based solution. |
| C3: Students demonstrate the competency in creating and executing test cases. |
| **D: An ability to function effectively on teams to accomplish a common goal.** |
| D1: Students demonstrate the abilities to participate in team activities. |
| D2: Students demonstrate the abilities to organize themselves and complete assignment to meet deadlines. |
| **E: An understanding of professional, ethical, legal, security and social issues and responsibilities.** |
| E1: Students demonstrate the abilities to understand the security issues in computer systems. |
| E2: Students demonstrate knowledge of professional, ethical, legal, social issues and responsibilities. |
| **F: An ability to communicate effectively with a range of audiences.** |
| F1: Students demonstrate the ability to write technical reports. |
| F2: Students demonstrate the ability to deliver oral presentations. |
| **G: An ability to analyze the local and global impact of computing on individuals, organizations, and society.** |
| G1: Students demonstrate understanding of various ways the computing technology impacts individuals, organizations, and society. |
| G2: Students demonstrate the abilities to analyze and reason about the impact of advances in computer technology. |
| **H: Recognition of the need for and an ability to engage in continuing professional development.** |
| H1: Students demonstrate the abilities to read and summarize research, and technical knowledge. |
| H2: Students demonstrate the abilities to learn new skills and apply them to solve the given problem. |
| **I: An ability to use current techniques, skills, and tools necessary for computing practice.** |
| I1: Students demonstrate competence with current tools/platforms for computing and software development. |
| I2: Students exhibit the abilities to use different systems development methodologies, techniques, and skills for computing practice. |
| **J: An understanding of processes that support the delivery and management of information systems within a specific application environment. [CIS only]** |
| J1: Students demonstrate the abilities of understanding information system management issues, tools and technology. |
| J2: Students demonstrate the abilities of evaluating applicability of a technology for a specific application environment. |
| **J: An ability to apply mathematical foundations, algorithmic principles, and Computer Science theory in the modeling and design of computer-based systems in a way that demonstrates comprehension of the tradeoffs involved in design choices. [CS only]** |
| J1: Students demonstrate the abilities to use mathematical foundations to evaluate and compare the performance of algorithms. |
| J2: Students demonstrate the abilities to apply appropriate algorithmic techniques to solve the given problem that demonstrates comprehension of the tradeoffs involved in design choices. |
| J3: Students demonstrate the abilities to apply Computer Science theory in the modeling and design of computer-based systems. |
| **K: An ability to apply design and development principles in the construction of software systems of varying complexity. [CS only]** |
| K1: Students demonstrate the abilities to write reusable software components. |
| K2: Students are able to understand and apply common software design methodologies. |

to any PI. The mapping information—in the generic form of (SO: X, PI: Y)—is available against each CLO of the course in the syllabus.

In order to evaluate the performance of a particular SO in an academic year, the performance of all corresponding PIs is averaged. As mentioned earlier, SO A has three PIs A1, A2,

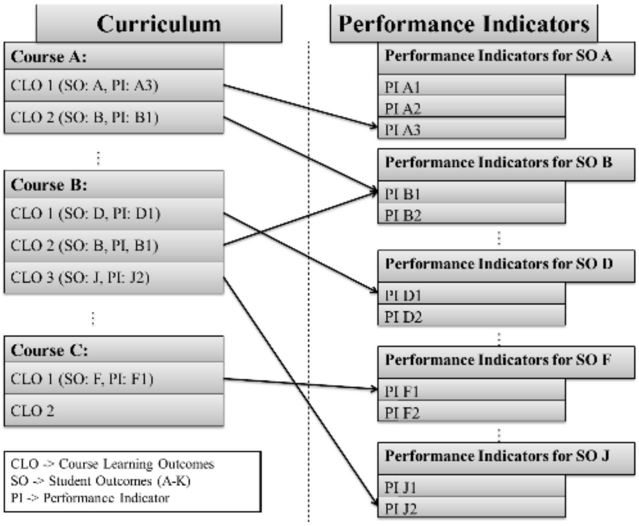


**FIGURE 1.** **Mapping of CLOs to PIs and SOs.**

and A3. To calculate the performance of students in SO A, we average the performance in A1, A2, and A3. The data for each of this PI is fed from the corresponding CLOs from all the courses in the program curriculum.

Table 3 and Table 4 show mapping of PIs against the CS and the CIS curriculum respectively. Each term, a set of SOs for the CS and the CIS curriculum are assessed and evaluated through a set of PIs. There are three levels of mapping: Introductory (I), Reinforcement (R), and Emphasis (E). The Introductory assessment is formative assessment; the Reinforcement and Emphasis assessments are summative. "Summative" data is taken directly from mid-term exams, finals, quizzes, assignments, home works, or labs. "Formative" data is generated by the instructor and explains the extent to which students in his or her courses have met certain PIs. Formative data is collected through a form that allows instructors to write their opinion on student's attainment of PIs. It may be noted that the first two years of the program are shared between the CS and CIS curriculum and are considered general years. This is primarily due to the reason that students decide their degree programs towards the completion of their second year. This also makes designing the curriculum more challenging because any updates must be considered from the point of view of both degree programs. Some third-year courses including—CS 322 "Operating Systems", CIS 422 "Human Computer Interaction", CIS 423 "Web-Based Systems", CIS 425 "Computer Data Security and Privacy".

Both programs have "Practical (Co-op) Training" course that is based on a COOP in the summer after finishing the third year and spans 12 weeks. This course is taken by students after completing 90 credit units out of a total of 121 credit units. As part of COOP, students are typically placed at an external professional organization/College and carefully supervised. Also, both programs mandate students to complete Senior Design Project that comprises of "Project Proposal" (2 credit hours, year 4, and term 1 course) and "Project Implementation" (3 credit hours, year 4, term 2). Note that the word "term" implies "semester" and vice versa throughout the paper.

## V. SO EVALUATION METHODOLOGY AND ATTAINMENT

This section begins by presenting the SO evaluation methodology that spans direct and indirect assessment methods including summative analysis, Exit Exam, formative analysis, alumni survey, and faculty survey. Later the section presents SOs attainment results followed by concrete steps for continuous improvement for CS and CIS programs.

*Methodology:* The attainment of SOs is typically assessed in a cycle. The central idea is to assess and collect data from all curriculum courses that are part of the evaluation process. The duration of the SO assessment cycle varies—typically it is two or three years long. Note that ABET requires at least two evaluation cycles within six years. The SO attainment presented in this paper consisted of a year-long evaluation cycle comprising of two terms namely 2016-2016 Term 2 and 2016-2017 Term 1. This can be considered aggressive but in our case we had to collect, analyze, and present data for the upcoming ABET team accreditation visit to the campus. However, our current plan—presented in Table 5—is to increase the cycle duration to two years from the 2018-2019 academic year. The duration of the attainment cycle is the main factor for selecting SOs to be evaluated in a particular term. This essentially has direct relevance on load for department management and faculty members.

The attainment target for all SOs for two programs is set to 70%. It is important to note that the attainment target is not dictated by ABET and is typically customized by programs as per local needs and requirements and varies across programs and Universities. In our case, the attainment target of 70% is reasonable since this corresponds well with our grading system that is absolute and students fail the course if they get lesser than 60% marks. This section will give more details on how SO attainment is quantified for various direct and indirect assessment methods. SO attainment is typically conducted through a combination of direct and indirect assessments that involve all important stakeholders. Direct assessment can be defined as the approach where student work—contributing to a particular PI and hence SO—is directly assessed by an evaluator. Indirect assessment can be defined as the approach where stakeholders infer student performance for SOs. Some examples of direct assessment are course assessments—including quizzes, assignments, mid-term exams, comprehensive final exams, projects, presentations, lab work—, Exit Exam, and certification exams. Indirect assessments include stakeholder's (faculty, students, employers, alumni, community) survey [27]. While designing the SO evaluation strategies, the College agreed on various direct and indirect assessment methodologies—presented in Figure 2—that are discussed in detail in this section. The direct assessment techniques that are used for SO attainment are summative analysis and Exit Exam. The indirect

**TABLE 3. Mapping of the CS program curriculum to performance indicators (I = Introductory, R = Reinforced, E = Emphasized, I is used for formative assessment while R and E are used for summative assessment).**

| Course Title | A | | | | B | | | C | | | D | | E | | F | | G | | H | | I | | J | | | K | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 1 | 2 | 3 | 1 | 2 | 1 | 2 | 1 | 2 | 1 | 2 | 1 | 2 | 1 | 2 | 1 | 2 | 3 | 1 | 2 |
| CS 211: Introduction to Computing | | I | | | | | | I | | | | | | | | | | | | | | I | | | | | |
| CIS 211: Fund. of Info. Systems | | | | | | | | | | | | | | I | | | I | I | | | | | | | | | |
| MATH 211: Calculus | I | | | | | | | | | | | | | | | | | | | | | | | | | | |
| PHYS 212: Physics | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| ISLM 271: Faith Morals | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| CS 221: Fund. of Programming | | | I | | | | | I | | | | | | | | | | | | | | I | | | | | |
| CS 222: Electronics | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| STAT 207: Intro to Stat. and Prob. | R | | | | | | | | | | | | | | | | | | | | I | | | | | | |
| BIOL 222: Biology | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| ISLM 272: Social System in Islam | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| CIS 313: Technical Reports | | | | | | | | | | | | | | | I | I | | | I | | | | | | | | |
| CIS 315: Comm. and Network Fund | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| CS 311: OO Programming 1 | | | | | I | | | | I | | | | | | | | | | | | | I | | | | I | I |
| CS 314: Digital Hardware | | R | | | | | | I | | | | | | | | | | | | | | R | | | | | |
| ISLM 273: The Eco. System in Islam | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| MATH 301: Discrete Mathematics | R | | | | | | | | | | | | | | | | | | | | | | I | I | | | |
| CIS 321: Database Concepts & Design | | | | | | | | I | | | | | | | | | | | | | | | | | | | |
| CIS 325: Net. Prot. and E-Commerce | | | | | | | | I | | | | | | | | | | | | | | I | | | | | |
| CIS 413: Professional Responsibility | | | | | | | | | | | | | | R | I | I | | R | | | | | | | | | |
| MGMT 290: Business (1) | | | | | | | | | | | | I | | | | | | | | | | | | | | | |
| CS 310: Data Structure | | | R | | | | | | | | | | | | | | | | | | | | | I | | | |
| CS 321: OO Programming 2 | | | | | | | | | R | | | | | | | | | | | | I | R | | | | I | |
| MATH 401: Logic & Proof Techniques | R | | | I | | | | | | | | | | | | | | | | | | | | | I | | |
| CS 322: Operating Systems | | | | | | | | | | | | | | | | | | | | | I | R | | | | | |
| CS 411: Software Engineering | | | | | R | I | I | | | I | | | | | | | | | | | | | | | | R | R |
| CS 412: Algorithm Analysis & Design | | | | | | | | | | | | | | | | | | | | | | | R | R | | | |
| CS 414: Computer Organization | | E | | | | | | R | | | | | | | | | | | | | | | | | | | |
| MATH 411: Numerical Analysis | E | | | | | | | | | | | | | | | | | | | | R | | | | | | |
| CIS 422: Human Computer Interaction | | | | | | | | I | | | | | | | | | I | | | | I | | | | | | |
| CIS 423: Web-Based Systems | | | | | | | | | | | | | | | | | | | | | R | | | | | | |
| CIS 425: Comp. Data Sec & Privacy | | | | | | | | R | | | I | | R | | | | R | | | | | | | | | | |
| CS 422: Lang. The. & Finite Automata | | | | R | | | | | | | R | | | | | | | | | | | | | | R | | |
| CS 444: Practical (Co-op) Training | | | | | | | | | | | | | | | R | R | | R | I | I | | | | | | | |
| CS 511: Project Proposal | | | | | | R | R | | | | E | R | | E | R | R | E | | | | | | | | | | E |
| CS 512: Artificial Intelligence | E | | | | | | | | E | | | | | | | | | | | | | | | E | | | |
| CS 513: Mobile Computing | | | | | | | | | | | | | | | | | | | | | E | | | | | | |
| Elective Course | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Elective Course | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| CS 522: Selected Topics in CS | | | | | | | | | | | | | | | R | R | | | R | | | | | | | | |
| Elective Course | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| ISLM 274: Political System in Islam | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| CS 521: Project Implementation | | | | | | | | | | R | E | R | | E | E | R | | | | R | | E | | | | E | |

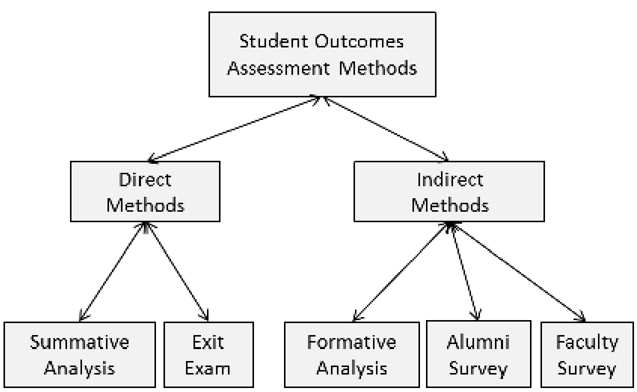


**FIGURE 2. Direct and indirect assessment methods for assessment of student outcomes.**

assessment techniques include formative analysis, alumni survey, and faculty survey.

We begin our discussion with summative analysis that is considered a direct method. Summative Analysis is a type of assessment that is done on the basis of summative data collected at the end of each semester. This data is taken directly from assessments carried out as part of courses in the form of mid-term exams, finals, quizzes, assignments, home works, and/or labs. Typically, this data is collected by aggregating all assessments for a specific CLO mapping to a particular PI. As mentioned earlier, the summative analysis was designed using the Top Bottom approach. As part of this, senior faculty members were involved in the design of SOs, PIs and corresponding rubrics. During this discussion in Section 3, Table 3 and Table 4 presented mapping of PIs against the CS and the CIS curriculum respectively. These tables have three levels of mapping: Introductory (I), Reinforcement (R), and Emphasis (E). The Reinforcement and Emphasis assessments are indicative of summative analysis. In such cases, there is always a CLO mapped to a particular PI (and hence SO) that is used for collecting summative data. In our course syllabi, this mapping is indicated in particular

**TABLE 4. Mapping of the CIS program curriculum to performance indicators (I = Introductory, R = Reinforced, E = Emphasized, I is used for formative assessment while R and E are used for summative assessment).**

| Course Title | A | | | B | | | | C | | | D | | E | | F | | G | | H | | I | | J | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 1 | 2 | 1 | 2 | 1 | 2 | 1 | 2 | 1 | 2 | 1 | 2 | 1 | 2 |
| CS 211: Introduction to Computing | | I | | | | | | I | | | | | | | | | | | | | | I | | |
| CIS 211: Fund. of Info. Systems | | | | | | | | | | | | | I | I | | | I | I | | | | | | |
| MATH 211: Calculus | I | | | | | | | | | | | | | | | | | | | | | | | |
| PHYS 212: Physics | | | | | | | | | | | | | | | | | | | | | | | | |
| ISLM 271: Faith Morals | | | | | | | | | | | | | | | | | | | | | | | | |
| CS 221: Fund. of Programming | | | I | | | | | I | | | | | | | | | | | | | | I | | |
| CS 222: Electronics | | | | | | | | | | | | | | | | | | | | | | | | |
| STAT 207: Intro to Stat. and Prob. | R | | | | | | | | | | | | | | | | | | | | I | | | |
| BIOL 222: Biology | | | | | | | | | | | | | | | | | | | | | | | | |
| ISLM 272: Social System in Islam | | | | | | | | | | | | | | | | | | | | | | | | |
| CIS 313: Technical Reports | | | | | | | | | | | | | | | I | I | | | I | | | | | |
| CIS 315: Comm. and Network Fund | | | | | | | | | | | | | | | | | | | | | | I | | |
| CS 311: OO Programming 1 | | | | I | | | | | I | | | | | | | | | | | | | R | | |
| CS 314: Digital Hardware | | R | | | | | | I | | | | | | | | | | | | | | | | |
| ISLM 273: The Eco. System in Islam | | | | | | | | | | | | | | | | | | | | | | | | |
| MATH 301: Discrete Mathematics | R | | | | | | | | | | | | | | | | | | | | | | | |
| CIS 321: Database Concepts & Design | | | | | | | I | I | | | | | | | | | | | | | | | | |
| CIS 325: Net. Prot. and E-Commerce | | | | | | | | I | | | | | | | | | | | | | | I | | |
| CIS 413: Professional Responsibility | | | | | | | | | | | | | | R | I | I | | R | | | | | | |
| MGMT 290: Business (1) | | | | | | | | | | | | I | | | | | | | | | | | | |
| CS 310: Data Structure | | | R | | | | | | | | | | | | | | | | | | | | | |
| CS 321: OO Programming 2 | | | | | | | | | R | | | | | | | | | | | I | R | | | |
| CS 322: Operating Systems | | | | | | | | | | | | | | | | | | | | | I | R | | |
| CIS 411: Database Management Systems | | | | | | | | R | | | | | | | | | | | | | | | | |
| CIS 412: System Analysis & Design (1) | | | | | I | I | I | I | | | | | | | | | | | | | | I | | |
| CIS 414: IT Project Management | | | | I | | I | | | | | | R | | | | | | | | | | | I | |
| MGMT 415: Business (2) | | | | | | | | | | | | | | | | | | R | | | | | | |
| CIS 421: System Analysis & Design (2) | | | | | R | I | R | R | | I | I | | | | | | | | | | | R | I | |
| CIS 422: Human Computer Interaction | | | | | | | | I | | | | | | | | | I | | | | I | | | I |
| CIS 423: Web-Based Systems | | | | | | | | | | | I | | | | | | | | | | R | | | |
| CIS 425: Comp. Data Security & Privacy | | | | | | | | R | | | R | | R | | | | R | | | | | | I | |
| CIS 424: Information Sys. Management | | | | | | | | | | | | | | | | | R | | | | | | R | |
| CIS 444: Practical (Co-op) Training | | | | | | | | | | | | | | | R | R | | R | I | I | | | | I |
| CIS 511: Project Proposal | | | | R | R | R | R | R | | | R | R | | R | R | R | R | | | R | | | | R |
| CIS 512: Software Quality Assurance | | | | | | | | | | R | | | | | | | | | | | | | | |
| CIS 513: Electronic Business Strategy | | | | | | | | | | | | | | | | | E | | | | | | R | |
| Elective Course | | | | | | | | | | | | | | | | | | | | | | | | |
| Elective Course | | | | | | | | | | | | | | | | | | | | | | | | |
| CS 522: Selected Topics in CIS | | | | | | | | | | | | | | | R | R | E | | R | | | | | |
| Elective Course | | | | | | | | | | | | | | | | | | | | | | | | |
| ISLM 274: Political System in Islam | | | | | | | | | | | | | | | | | | | | | | | | |
| CIS 521: Project Implementation | | | | | | | | | | E | E | E | | E | E | E | | | | R | | E | | R |

format against each CLO in the form of SO: A, PI: A2—this mapping signifies that the CLO is mapping to SO A and PI A2. At the end of each term, all course teaching teams report summative data in Summative Forms that become part of course portfolios. It is stressed at the departmental level that all summative assessments attempt and follow PIs and corresponding rubrics. Summative analysis typically segregates students into four categories—as mentioned earlier in Section 3—namely Poor, Developing, Developed, and Exemplary for each CLO mapping to a PI. Attainment level for summative analysis is defined as the percentage of students in Developed and Exemplary categories. The target for attainment level for summative analysis is set to 70%.

One particular challenge related to summative analysis comes to fore given that several male and female sections are concurrently executing and are typically handled by different instructors. There are mainly two possibilities to handle this issue. The first option is to mandate all faculty members teaching a course to use the exact same assessment questions. This raises several logistic issues since this requires holding all course related assessment at exactly the same time. This puts extra burden on faculty members since they need to agree and communicate on all assessments, which can be a time-consuming proposition. The second option is to allow different faculty members to conduct independent assessments. With this option, the challenge is ensuring that assessments for same topics have weightage and same level of difficulty. At our College we take a hybrid approach. For the final and mid-term exam that are typically around 50%-60% of the overall assessment, the same question paper is used by male and female sections and the exams are held concurrently. For other assessments including

**TABLE 5.** Plan for SO attainment cycle.

| Academic Year | Duration of Evaluation of SOs (# of Years) |
|---|---|
| 2016-2017 | One Year |
| 2017-2018 | One Year |
| 2018-2019 | Two Years |
| 2019-2020 | |
| 2020-2021 | Two Years |
| 2021-2022 | |
| 2022-2023 | Two Years |
| 2023-2024 | |
| 2024-2025 | Two Years |
| 2025-2026 | |

quizzes, assignments, projects, and lab work the individual instructors have the flexibility to have their own versions but they must agree on the difficulty level and the assigned weightage. This is ensured by preparing a document called "Course Evaluation Breakdown" at the beginning of each term for all courses that is followed by all co-instructors during the semester. A sample "Course Evaluation Breakdown" for CS 221 "Fundamentals of Programming" is presented in Table 6.

Another type of direct assessment is the Exit Exam. This is an evaluation done towards the end of the final semester for graduating students. An Exit Exam is used to assess students' performance that covers all important courses and spans all SOs. The practice of conducting Exit Exam was initiated in the academic year 2015-2016 in order to conduct another direct assessment. Some of the Exit Exam facts are highlighted in Table 7 that depicts that it was an MCQ-based exam and was three hours long. All the students in the final semester took this exam. The exam paper was prepared by the department faculty members and an attempt was made to cover all SOs. Results of the Exit Exam were interpreted as follows. Depending on the total scored marks, students were segregated into four categories namely 1) Poor (0-24%), 2) Developing (25-49%), 3) Developed (50-74%), and 4) Exemplary (75-100%). The attainment level was defined as the sum of percentage of students in the Developed and Exemplary categories—the target attainment level was set to 70%.

Rest of the sub-section introduce indirect assessment methods used to evaluate SOs. We begin our discussion with Formative Analysis. This is a type of assessment that is done on the basis of formative data collected at the end of each semester. The Introductory (I) mapping entries in Table 3 (for CS curriculum) and Table CISmap (CIS curriculum) indicate formative analysis of a particular course. Contrary to summative analysis, it is not necessary to have a CLO mapped to a particular PI (and hence SO). This assessment is based on instructors' feedback or inference on the performance of students against various indicators. This inference or feedback might be based on instructor's understanding/opinion or a set of assessments.

The second indirect assessment was the Alumni Survey. It is a survey for alumni of the College to provide feedback on PEOs and also comment on attainment of SOs. This survey is conducted annually. Likert scale of 1-5 is used that include the following options: 1) Strongly Agreed, 2) Agreed, 3) True Sometimes, 4) Disagree, and 5) Strongly Disagreed. The Alumni Survey included sections on feedback for Mission Statement, PEOs, facilities, academic programs, and career/counseling support. However only the feedback related to SOs is used to calculate attainment of SOs. The attainment level for the Alumni Survey is calculated by adding the following respondents 1) "Strongly Agreed", 2) "Agreed" and 3) 50% of "True Sometimes". The reason for adding 50% of "True Sometimes" respondents in the attainment level is the mismatch between the number of categories used in Alumni Survey and the number of categories used in Summative/Formative Analysis and Exit Exam. In the Alumni survey, there are 5 categories whereas Summative/Formative Analysis and Exit Exam rely on 4 categories.

The third indirect assessment was the Faculty Survey. It is a survey for faculty members to provide feedback on PEOs and also comment on the attainment of SOs in the context of graduating students. This survey is conducted annually. Likert scale of 1-5 is used that include the following options: 1) Strongly Agreed, 2) Agreed, 3) True Sometimes, 4) Disagree, and 5) Strongly Disagreed. Like the Alumni Survey, the attainment level for the Faculty Survey is calculated by adding the following respondents 1) "Strongly Agreed", 2) "Agreed" and 3) 50% of "True Sometimes".

### *A. RESULTS*

This sub-section presents SO attainment results. We begin our discussion with presenting the average attainment result for all SOs for two programs. Later we dive deep into details by discussing attainment levels for all direct and indirect assessments—this is done to understand achievement of SOs in a better way.

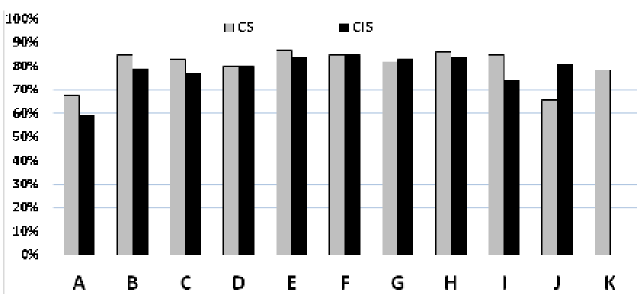


**FIGURE 3.** Average student outcomes attainment for CS and CIS programs.

Figure 3 presents the average attainment level for all SOs for the CS and CIS programs respectively. The overall average attainment levels plotted in Figure 3 are encouraging except outcomes "A" (both for CS and CIS) and "J" (only for CS). These SOs are mainly affected by corresponding low scores in the Exit Exam. Another area of concern is that SOs were evaluated in summative/formative assessments and

**TABLE 6.** Sample course evaluation breakdown for CS 221 fundamentals of programming.

| SO | CLO | PI | Topics | Quizzes | | | Mid | Lab Quizzes | | | | Final | Percentage Evaluation |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | 1 | 2 | 3 | | 1 | 2 | 3 | 4 | | |
| | | | | 5 | 5 | 5 | 25 | 5 | 5 | 5 | 5 | 40 | |
| C | 1. Design and implement computer programs involving decision structures, loops, functions, or parameter passing by value/references | C1 | Selection Structures | 3 | | | 2 | 2 | | | | 3 | 62% |
| | | | Repetition Structures | 2 | | | 6 | 3 | | | | 5 | |
| | | | Built-in Functions | | 1 | | 2 | | 2 | | | 5 | |
| | | | User-defined Functions | | 1 | | 8 | | 3 | | | 5 | |
| | | | By Value/References | | 3 | | 4 | | | | | 2 | |
| A | 2. Design and implement programs using arrays and pointers/references. | A3 | Arrays | | | 3 | 3 | | | 5 | | 7 | 29% |
| | | | Pointers | | | 2 | | | | | 3 | 6 | |
| I | 3. Write programs to perform I/O on sequential access files. | I2 | File I/O | | | | | | | | 2 | 7 | 9% |

**TABLE 7.** Exit exam facts.

| | CS Program | CIS Program |
|---|---|---|
| Exam Format | MCQs | |
| Duration | Three hours | |
| Total Questions | 97 | |
| Total Students | 76 | 56 |
| Student Level | Level 8 (final semester) | |
| Prepared by | Department Faculty Members | |
| Coverage of SOs | All | |
| Performance Target | 70% attainment level | |

Exit Exam using rubrics with four levels. However, faculty and alumni surveys allowed participants to evaluate outcomes over a scale of 1 to 5. This mismatch will be addressed in the future surveys. However, in order to address shortcomings in SOs A (both for CS and CIS programs) and J (only for CS program), the College developed an action plan that is presented in Table 8. Note that the action plan items presented in Table 8 is only for the CS program—a similar plan also exists for the CIS program. Also, Table 8 only contains the item text and do not have other details including description, responsible person, status, and estimated completion date. are only for SOs A and J.

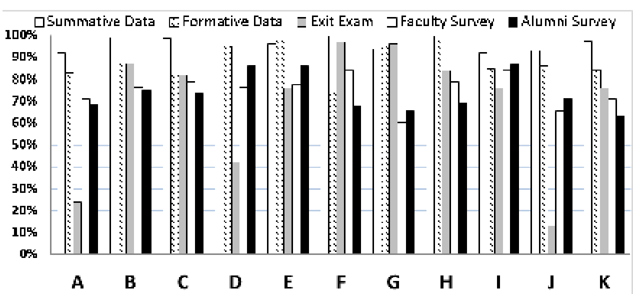


**FIGURE 4.** CS average attainment levels from all direct and indirect assessments.

Figure 4 present attainment levels for all SOs through various direct and indirect assessment methods—including Summative Data, Formative Data, Exit Exam, Faculty Survey, and Alumni Survey—for the CS program. Attainment levels for Summative and Formative Data for two programs is satisfactory since the corresponding bars are well above the target attainment level of 70%. Low attainment levels can be seen in the Exit Exam for SOs A, D, and J. We define attainment in terms of the percentage of Developed and Exemplary students for the Exit Exam. The evaluation of results and exam questions revealed that a potential reason for the low score for SO A is that mathematics and science courses are offered in the first two years of the program and hence it was hard for students to answer questions related to

**TABLE 8.** Action plan items for SOs.

| SO | Action Plan Items |
|---|---|
| All | Action 1: Redesigning Exit Exam Preparation Process |
| | Action 2: Formation of Students Graduation Project Committee |
| | Action 3: Preparing Departmental Exit Survey |
| | Action 4: Forming Knowledge Groups to Manage Continuous Syllabus Improvement |
| | Action 5: Improving the Survey Responses |
| | Action 6: Revision of Curriculum |
| | Action 7: Modification of Assessment Mechanism |
| | Action 8: Revision of PEOs. |
| A | Action 1: Establishment of Mathematics Helpdesk |
| | Action 2: Modification of Rubrics for PI A4 "Students demonstrate the ability to relate concepts of mathematics with computability" on the request of MATH 401 instructor |
| | Action 3: Improvement in Mathematics Courses |
| | Action 4: Modification of Rubrics for PI A2(i) "Students demonstrate an understanding of number systems and digital logic" on the request of CS 314 instructor |
| | Action 5: Hiring Faculty Members with background in Applied Mathematics |
| B | Action 1: Adoption of Project based Learning |
| C | Action 1: Establishing Programming Helpdesk |
| D | Action 1: Enforcing Group Behavior |
| E | Action 1: Absence of Formative Course for PI E1 "Students demonstrate the abilities to understand the security issues in computer systems." |
| | Action 2: Adoption of Case Study based Pedagogy |
| | Action 3: Adding a (sub-)Section in COOP and Final Year Project Report |
| F | Action 1: Improvement in the Students Written Communication |
| G | Action 1: Adoption of Case Study based Pedagogy |
| | Action 2: Adding a (sub-)Section in COOP and Final Year Project Report |
| H | Action 1: Frequent Student Professional Development Activities |
| | Action 2: Exposure to Emerging Concepts in the Profession |
| I | Action 1: Adoption of Modern Tools to Provide Hands-on Skills |
| J | Action 1: Streamlining Data Structures and Algorithms Related Courses |
| | Action 2: Programming Helpdesk to assist with Algorithm Skills |
| | Action 3: Provide Assistance with Practicing Algorithm Development Skills |
| K | Action 1: Improve Software Designing Skills |

defining terms or recalling basic mathematical theorems. The low score against SO D is also understandable as this outcome is mainly based on assessing communication skills, which are typically hard to evaluate in a MCQ-style technical examination. Lastly, the low score for SO J might have been caused due to lower number of questions for this outcome in the Exit Exam—there were only 8 questions out of 97 for this important outcome. As can be seen this particular shortcoming has been communicated to both departments in the form of action plan item "All SO Action 1" in Table 8. As mentioned earlier, the attainment level for faculty and alumni surveys is calculated by adding the following respondents 1) "Strongly Agreed", 2) "Agreed" and 3) 50% of "True Sometimes". The response of faculty members is satisfactory except SOs G and J. Also, the response of alumni is satisfactory except SOs A, F, G, and K. As mentioned earlier, a comprehensive action plan presented in Table 8 has been developed to improve attainment in all SOs.

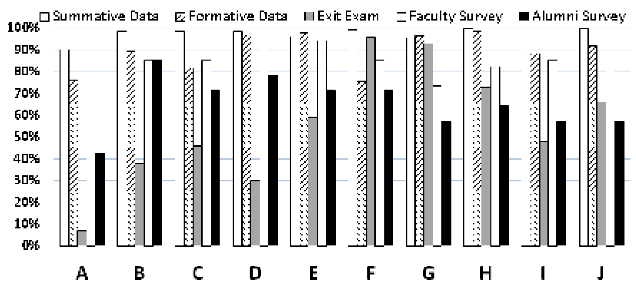


**FIGURE 5.** **CIS average attainment levels from all direct and indirect assessments.**

Figure 5 present attainment levels for all SOs through various direct and indirect assessment methods—including Summative Data, Formative Data, Exit Exam, Faculty Survey, and Alumni Survey—for the CIS program. Attainment levels for Summative and Formative Data for two programs is satisfactory since the corresponding bars are well above the target attainment level of 70%. Low attainment levels can be seen in the Exit Exam for SOs A, B, C, D, E, I, and J. The attainment level for faculty and alumni surveys is calculated by adding the following respondents 1) "Strongly Agreed", 2) "Agreed" and 3) 50% of "True Sometimes". The response of faculty members is satisfactory for all SOs. Also, the response of alumni is satisfactory except SOs A, F, G, and K. As mentioned earlier, a comprehensive action plan, like the one presented in Table 8, has been developed to improve attainment in all SOs for the CIS program too—it is not presented for brevity purposes.

Figure 6 split CS and CIS students into four categories including Poor, Developing, Developed, and Exemplary. These categories are determined based on the Student Outcomes attainment values. As mentioned earlier, the percentage of students in Developed and Exemplary are considered to have "attained" a particular Student Outcome.

In order to determine the internal consistency of the Student Outcomes attainment data—presented in Figures 3, 4, 5,

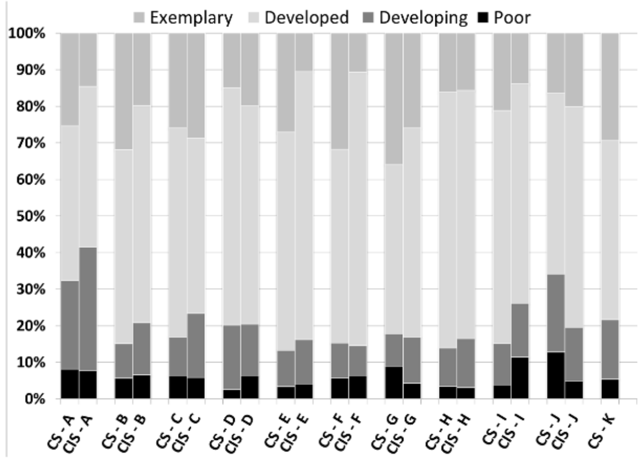


**FIGURE 6.** **CS and CIS students split into four categories–Poor, Developing, Developed, and Exemplary–based on the student outcome attainment values.**

and 6—this sub-section measured Cronbach's $\alpha$, which determines how closely related a set of items are a group. The value of $\alpha$ varies between 0 and 1. Values below 0.5 are considered unacceptable. For the CS and CIS attainment data, the Cronbach's $\alpha$ values are 0.87 and 0.91 respectively that are considered excellent and depict high internal consistency of the data.

## VI. IMPLICATIONS AND ANALYSIS

This section discusses challenges faced during the SO attainment cycles and the way these were managed for CS and CIS programs. The discussion presented here is in the context of the criterion being laid out in Section 2.

### A. EXHAUSTIVE VS. LIGHTWEIGHT

The approach taken at our College can be considered exhaustive. The main reason for this is that the College administration wanted an approach where the attainment results can be fully trusted and acted upon. Also this is reasonable because it is the first time that the SO attainment and evaluation cycle has been executed at the College for CS and CIS programs. Also there were some external factors that came up. Perhaps the most important is lack of knowledge and hence clear direction on the implementation details of the SO attainment cycles. A clear side-effect of this was that the team designed and partially implemented three different implementation methods before agreeing upon one final approach. This was understandably very stressful and proved to be time consuming—and hence exhaustive—in our context. A takeaway message here is that the details of the SO attainment cycles must be planned in advanced and agreed upon by all stakeholders before being implemented.

### B. ASSESSMENT APPROACH

The assessment approach taken at our College was Top Down. In this context, a special committee of senior faculty members from CS and CIS departments was formed that was named Academic Accreditation Committee (AAC). The initial task of this committee was to become familiar with processes and requirements related to ABET. After this, the committee prepared various artifacts of both programs including PEOs, SOs, PIs, and corresponding rubrics. After getting the required approval from authorities, PEOs and SOs of the program were published on the College website and shared with all stakeholders. PIs, corresponding rubrics, and assessment strategies—that required collecting summative and formative data—was also prepared as part of this activity. Initially we witnessed reluctance in the adoption of new educational practices in the College. The main reason was that these activities were resulting in an increased burden on faculty members as they needed to update course specifications including preparing CLOs with mapping to SOs/PIs and designing new assessments to gather evidence for summative and formative analysis. Another reason was that most of the faculty members were junior-level and had no prior experience of accreditation related activities or assessments. In order to tackle these issues, several training sessions were arranged for faculty members and a helpdesk was setup for two departments. As a result, the reluctance diminished with the passage of time as faculty members experienced benefits of the accreditation activities that included improved curriculum, better quality delivery, and more streamlined assessments. Perhaps another important task carried out by AAC was to prepare faculty members for delivering course portfolios that documented summative and formative data, which had to be later used by AAC for quantifying SOs attainment.

### C. FAIR/UNBIASED

In order to have fair and unbiased assessment methodology, a number of direct and indirect assessments were carried out. Direct assessments include summative analysis and the exit exam. Indirect assessments included formative analysis, faculty survey, and alumni survey. Please note that these were the stakeholders involved in quantifying attainment of SOs. For assessment of PEOs, surveys from faculty, alumni, and employers were being carried. Since employers are being involved in the processing of assessing PEOs, this allowed us to cater for regional industry requirements.

### D. FACULTY MEMBER INVOLVEMENT

At the College, we involved faculty members after the initial plan for assessment had been drafted. The Department and College Board were then involved to get this plan approved. This was followed by arranging initial training sessions for faculty members since almost all courses had to be updated in order to adopt the newly drafted and approved assessment plan. This was followed by a complete overhaul of the curriculum that was obviously carried out by the department faculty members. As part of this exercise, several sections of the course specification were updated including CLOs, Course Objectives, course description, grading methods and their weightage. One of the most important activity was to establish mapping between CLOs and PIs/SOs based on the curriculum mapping table, PIs and their corresponding rubrics provided to the faculty members by AAC. Also, a document titled Course Evaluation Breakdown was developed so that assessments for all male and female sections—taught by different faculty members—have unified assessment approach. This obviously required periodic training sessions and frequent interaction of faculty members with senior faculty members from AAC to get response to their queries.

### E. MANAGEMENT SUPPORT

During the process of adopting a new assessment methodology to quantify the assessment of SOs, the College management provided tremendous help. This included reducing load on some of the key faculty members involved in the accreditation activities. AAC was given freedom to implement the assessment methodology. Also, the curriculum was updated significantly and departmental resources were provided to ensure smooth adoption in the College. In addition, the management also provided support to involve all stakeholders. It is important that the management is fully on-board when institutions embark upon the journey towards ABET adoption for their programs. An important factor to note here that the process of improving quality is slow and requires patience on part of management to see tangible results. At our institute there was change in the management structure after submitting the Self Study Report and before the visit that resulted in some challenges since new management might have different vision and implementation requirements.

### F. EASY TO VERIFY

A major objective of the assessment methodology is to provide a systematic approach to quantifying SOs in a way that any deficiencies in the attainment can be identified easily. This typically is a hallmark of well-designed educational and assessment strategies that also forms the basis of the continuous improvement process. This is challenging at times mainly due to a variety of direct and indirect assessment methods for SOs. In this sub-section, we emphasize the methodology for quantifying attainment of SOs from a variety of assessment methods. We start our discussion with the absolute grading system adopted at the College that is shown in Table 9.

**TABLE 9.** Grading system (out of 5.00).

| Percentage | Grade (in English) | Grade Code | GPA (Out of 5.00) |
|---|---|---|---|
| Between 95 and 100 | Exceptional | A+ | 5.00 |
| 90, and less than 95 | Excellent | A | 4.75 |
| 85, and less than 90 | Superior | B+ | 4.50 |
| 80, and less than 85 | Very Good | B | 4.00 |
| 75, and less than 80 | Above Average | C+ | 3.50 |
| 70, and less than 75 | Good | C | 3.00 |
| 65, and less than 70 | High Pass | D+ | 2.50 |
| 60, and less than 65 | Pass | D | 2.00 |
| Less than 60 | Fail | F | 1.00 |

Note that this grading criterion has been enforced by the Ministry of Education in all public sector universities in the country.

Two assessment approaches that are used to gather SOs attainment from the curriculum include summative and formative analysis. In both cases, the instructor is required to report data in the context of the relevant PI for the course. While applying the rubrics defined for the PI, the students are segregated into four categories—including Poor, Developing, Developed, and Exemplary—based on their performance.

**TABLE 10. Attainment level for direct and indirect assessments.**

| Assessment Type | SO Attainment Method | Target |
|---|---|---|
| Summative (Direct) | Percentage of students in Developed and Exemplary Categories | 70% |
| Exit Exam (Direct) | | 70% |
| Formative (Indirect) | | 70% |
| Faculty Survey (Indirect) | Adding the following respondents: 1) "Strongly Agreed", 2) "Agreed" and 3) 50% of "True Sometimes" | 70% |
| Alumni Survey (Indirect) | | 70% |

Table 10 shows that the attainment level for summative and formative analysis is defined as the percentage of students belonging to the Developed and Exemplary categories. The same definition is used for the Exit Exam. In Faculty and Alumni Survey, Likert scale of 1-5 was used that included the following options: 1) Strongly Agreed, 2) Agreed, 3) True Sometimes, 4) Disagree, and 5) Strongly Disagreed. The attainment level for the two survey is calculated by adding the following respondents 1) "Strongly Agreed", 2) "Agreed" and 3) 50% of "True Sometimes". The reason for adding 50% of "True Sometimes" respondents in the attainment level is the mismatch between the number of categories used in Alumni Survey and the number of categories used in Summative/Formative Analysis and Exit Exam. In the Alumni survey, there are 5 categories whereas Summative/Formative Analysis and Exit Exam rely on 4 categories.

### G. CONTINUOUS IMPROVEMENT

The continuous improvement process at the College is a two-tier process: Attainment of SOs (per cycle) and Continuous Syllabus Improvement (per semester). We begin our discussion with the attainment of SOs process. This process is informally also called Closing-the-Loop process. The attainment of SOs is conducted using data collected through direct and indirect assessments. The process for attainment of SOs is shown in Figure 7. This process is executed for every attainment cycle of SOs.

Direct and indirect assessment data is collected by the Academic Accreditation Committee that is responsible for evaluating and analyzing this data to quantify the attainment of SOs. Most importantly Academic Accreditation Committee develops actions to improve the attainment of SOs in the next cycle—these actions are penned down in the "Closing-the-Loop Action Plan" document. This plan along with "Direct/Indirect Assessment Data & SOs Attainment Results" are passed to the Department Board for review and approval. The Department Board approves the plan to issue

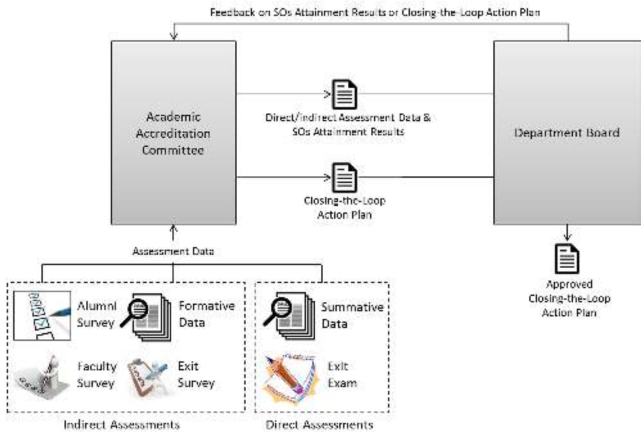


**FIGURE 7. Process for attainment of student outcomes (Per cycle).**

"Approved-Closing-the-Loop Action Plan". Alternatively, the Department Board might provide feedback to further improve the "Closing-the-Loop Action Plan".

The "Closing-the-Loop Action Plan"—prepared at the completion of every SOs evaluation cycle—consists of actions/suggestions/recommendations to improve SOs attainment. This plan can address shortcomings and suggest improvements to 1) PEOs, 2) SOs, 3) PIs and corresponding rubrics, 4) Curriculum, 5) Educational practices and strategies, 6) Processes for attainment of SOs and Course Learning Outcomes, 7) Processes for revision of PEOs and SOs, 8) Process for Curriculum revision, 9) Other College/Department/Program related processes and practices.

Now we shift our attention to the continuous syllabus improvement process that recurs every term. The central idea of this activity is to incorporate course feedback from previous semesters in the next offering of the same or related course under the umbrella of an expert group. The process is depicted in Figure 8. The focus of continuous improvement cycle at this (course) level is the evaluation and attainment of Course Learning Outcomes. At the end of the term,

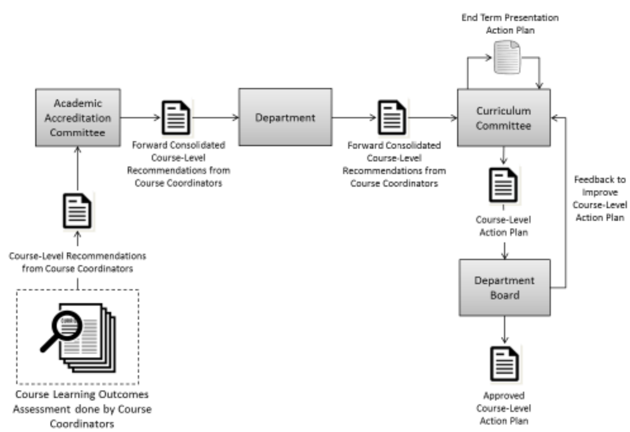


**FIGURE 8. Process for continuous syllabus improvement (Per term).**

each course coordinator assesses the attainment of Course Learning Outcomes for the course. In addition, the course coordinator is responsible for writing/assembling recommendations in the "Course Evaluation Form" that is attached with the course portfolio (folder). The Academic Accreditation Committee compiles all recommendations together in the "Course-Level Recommendations from Course Coordinators" document, which is forwarded to the Department that in turn forwards these recommendations to the Curriculum Committee. The Curriculum Committee—utilizing their internal hierarchy—assigns the relevant course coordinator to develop "Course-Level Action Plan" that is geared towards fixing the issue highlighted by the previous course instructors. The Curriculum Committee also develops the "End Term Presentation Action Plan" that contains recommendations and suggestions in the light of end term presentations carried out by course coordinators—this activity is done at the conclusion of each term. The "End Term Presentation Action Plan" is also consulted by Knowledge Groups and course coordinators to develop the "Course-Level Action Plan", which is later forwarded to the Department Board for review and approval. The Department Board approves the plan to issue "Approved Course-Level Action Plan". Alternatively, the Department Board might provide feedback to further improve the "Course-Level Action Plan".

The "Course-Level Action Plan"—prepared at the completion of every term—consists of actions/suggestions/recommendations to improve Course Learning Outcomes attainment. This plan can address shortcomings and suggest improvements to 1) Course Learning Outcomes, 2) Course Objectives, 3) Course Description, 4) Textbook and/or references, 5) Brief List of Topics, 6) Weekly schedule of the course, 7) Grading (assessment strategies), 8) PIs and corresponding rubrics, 9) Pre-requisite or related courses, 10) Program curriculum, 11) Educational practices and strategies, 12) Other College/Department/Program related processes and practices.

## VII. CONCLUSIONS

In an effort to improve quality of academic programs and student's intake, an increasing number of academic institutes are applying for ABET accreditation of their computing programs. A challenge here is that not much information is available for implementation mechanics and this results in confusion and wastage of resources especially during the initial phases. Also, there is scarcity of available literature outlining methodology and implementation of successful accreditation approaches for computing programs. Keeping this in mind, there is a need to document methodologies, educational practices, and strategies adopted by different institutes on their road towards accreditation. In the context of ABET, the most important facet is the methodology for assessing and evaluating SOs that forms the basis of the continuous improvement activities. This issue is addressed in this paper by providing elaborate implementation details of processes and strategies for CS and CIS programs on the path towards ABET accreditation. SOs attainment is calculated by a range of direct and indirect methods including summative data analysis, Exit Exam, formative data analysis, faculty survey, and alumni survey. This is followed by analysis of attainment results leading to SOs Action Plan document that forms the basis of continuous improvement activities. Note that although the paper adopts ABET-defined Student Outcomes for CS and CIS programs, but the methodology presented in this paper are applicable to newer ABET-defined or customized Student Outcomes that might be adopted by a program. The paper also discussed a number of challenges faced—related to designing and establishing assessment mechanisms—during the execution in order to conduct a qualitative assessment of the adopted approach. These challenges include qualitative analysis of the adopted approach and ascertain if it is 1) exhaustive vs. lightweight, 2) top down or bottom up, 3) fair/unbiased, 4) involves faculty members, 5) requires management support, 6) easy to verify, and 7) supportive of continuous improvement activities. We present these challenges as a general framework for assessing approach towards acquiring accreditation. Readers might also find the paper useful as a case study before they embark upon the journey of accrediting their computing programs. The successful accreditation of both programs by ABET makes this contribution a validated guide for aspiring institutions and practitioners to lay their foundation of a methodological assessment approach.

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