Student Outcomes Assessment: An Evaluation Tool to Gauge Level of Competencies of Computer Science Students

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Abstract – *An effective assessment method is needed for measuring the extent that student outcomes meet academic accreditation body criteria. This measurement is performed by mapping course learning objectives with program educational objectives passing through student outcomes. The College of Computer Studies (CCS) of one selected university in the province of Batangas conducts "Student Outcomes Assessment" periodically as indicated in its Bachelor of Science in Computer Science (BSCS) "Curriculum Map". The "Curriculum Map" contains the Student Outcomes, Performance Indicators, and the list of Professional Courses under the BSCS Program. Markings as to Introduce(I), Reinforce(R) and Emphasize (E) are also indicated. An "Assessment Matrix" is then created to show Student Outcomes (SO) and the corresponding Performance indicators (PI) mapped out to Strategies, Assessment Method, Source of Assessment, Time of Data Collection, Assessment Coordinators, and the Evaluator of Results. This paper presented and described the BS Computer Science Curriculum Map of SY 2015-2016; identified if performance target was met for each Performance Indicator resulting to student outcomes assessment; and recommended courses of action based on the assessment results. The study utilized the quantitative descriptive research design. The respondents of the study are the 24 or 100% population of the BSCS graduates of batch 2019 of Lyceum of the Philippines University - Batangas. Batch 2019 was identified as the respondents since they were the graduates under the BSCS Curriculum effective School Year 2015-2016. Results of the study revealed that the BS Computer Science program curricula and the teaching strategies employed by its professors to deliver learning is aligned with the expected student outcomes of the program. BS Computer Science students at the time of graduation possess the knowledge, skills, and behavior parallel to the program's expected student outcomes. Recommendations can be used for continuous enhancement of the BSCS curricula.*

Keywords – *Competency assessment, curriculum map, performance indicators, student outcomes, student outcomes assessment*

INTRODUCTION

Student outcomes relate to the knowledge, skills, and behaviors that students acquire as they progress through the program and describe what students are expected to know and be able to do by the time of graduation. Defining program educational objectives and student outcomes provide faculty with a common understanding of the expectations for student learning and supports consistency across the curriculum, as measured by performance indicators. Assessments offer a framework through which one can identify, collect, and prepare data to evaluate the attainment of student outcomes and program educational objectives. Effective assessments use relevant direct, indirect, quantitative, and qualitative measures appropriate to the outcome or objective being measured. Appropriate sampling methods may be used as part of an assessment process. Assessment of student learning keeps climbing upward on the national higher education agenda. The many reasons for this include persistent prods from external bodies such as accrediting and governmental entities and, increasingly, the recognition by institutions of the need for more and better evidence of student accomplishments [1]. Efficient and effective assessment strategies require an understanding of the alignment between educational practices and strategies and can be accomplished by mapping educational strategies that could include co-curricular activities to learning outcomes. Strategies for data collection and analysis need to be systematic and consistent and focus on assessment relative to the performance indicators [2]. Within higher education, the importance of learning outcomes has become well-established. They are expected to guide the teaching and learning process, assessment, and curriculum development, while at the same time act as foundational elements to transition towards national qualifications frameworks, competency-based education, and international partnerships [3].

Within the educational community, assessment process focuses on learning, teaching and outcomes. Information is provided for improving learning and teaching. Therefore, a well-established assessment process plays a vital role for improving student outcomes which, in turn, results in fulfilling program educational objectives. However, such a process entails setting well-defined course learning objectives, student outcomes, and program educational objectives. In addition, an effective assessment method is needed for measuring the extent that student outcomes meet academic accreditation body criteria. This measurement is performed by mapping course learning objectives with program educational objectives passing through student outcomes [4].

The vast majority of institutions have statements of learning for all undergraduate students and growing numbers have aligned learning throughout the institution. Institution-level assessment results are regularly used for compliance and improvement purposes, addressing accreditation and external accountability demands along with internal improvement efforts. Accreditation remains the driver and main use of institution-level information about student learning. However, various internal improvement efforts, including program review and program improvement, also regularly benefit from institution-level assessment results. Institutions are trending towards greater use of authentic measures of student learning, including rubrics, classroom-based performance assessments and capstones, which is consistent with what provosts indicate are most valuable for improving student outcomes. The key take away is that institutions are using a variety of data collection approaches that yield actionable information, reinforcing the principle that there is not "one right way" to assess student learning [5].

The College of Computer Studies (CCS) of Lyceum of the Philippines University - Batangas conducts "Student Outcomes Assessment" periodically as indicated in its Bachelor of Science in Computer Science (BSCS) "Curriculum Map". The "Curriculum Map" contains the Student Outcomes, Performance Indicators, and the list of Professional Courses under the BSCS Program. Markings as to Introduce(I), Reinforce(R) and Emphasize (E) are also indicated. An "Assessment Matrix" is then created to show Student Outcomes (SO) and the corresponding Performance indicators (PI) mapped out to Strategies, Assessment Method, Source of Assessment, Time of Data Collection, Assessment Coordinators, and the Evaluator of Results.

OBJECTIVES OF THE STUDY

This paper presented and described the BS Computer Science Curriculum Map of SY 2015-2016; identified if performance target was met for each performance indicator resulting to student outcomes assessment; and recommended courses of action based on the assessment results.

MATERIALS AND METHODS

DESIGN

The study utilized the quantitative descriptive research design. Attainment of Student Outcomes of the BS Computer Science program is typically assessed in a 4-year cycle; in which the SOs used are as specified in the ABET Criteria for that particular cycle. The central idea was to collect and assess data from all curriculum courses that are part of the evaluation process.

RESPONDENTS OF THE STUDY

The respondents of the study are the 24 or 100% population of the BSCS graduates of batch 2019 of Lyceum of the Philippines University - Batangas. Batch 2019 was identified as the respondents since they were the graduates under the BSCS Curriculum for School Year 2015-2016.

INSTRUMENT OF THE STUDY

Data from class records reflecting scores in the summative assessment were collected and used in this study. Results of the final exam, On the Job Training Revalida, and oral defenses of students were used as assessment methods for the matrix.

DATA COLLECTION AND ANALYSIS

Quantitative data analysis was used. Data collected from class records were tabulated and analyzed based on IRE markings in the curriculum map. For Performance Indicators, Final Exam/Oral Defense/ OJT Revalida was chosen as the primary assessment method and the assigned faculty completed the scoring rubrics. The identified method was selected as a means of assessment since it covers all the learnings required in each identified course strategy. A performance target of 80% was set for all Performance Indicator. Based on the established strategies and assessment methods, student grades were averaged and compared against the performance target. Whether performance target had been met or not, recommendations were given. The study concluded as to whether student outcomes had been achieved at the time of graduation.

RESULTS AND DISCUSSION

LYCEUM OF THE PHILIPPINES UNIVERSITY-BATANGAS
College of Computer Studies

CURRICULUM MAP - BACHELOR OF SCIENCE IN COMPUTER SCIENCE

SCHOOL YEAR 2015-2016

	STUDENT OUTCOME		PERFORMANCE INDICATORS	FIRST YEAR SEM 1 CS1	FIRST YEAR SEM 2 CS2	FIRST YEAR SEM 2 CS3	FIRST YEAR SEM 2 CS4	SECOND YEAR SEM 1 CS5	SECOND YEAR SEM 1 CS6	SECOND YEAR SEM 1 CS7	SECOND YEAR SEM 1 Ethics2	SECOND YEAR SEM 2 CS8	SECOND YEAR SEM 2 CS9	SECOND YEAR SEM 2 CS10	THIRD YEAR SEM 1 CS11	CS12	CS13	CS13A	CS14	CS15	CS16	THIRD YEAR SEM 2 CS17	CS18	CS19	CS20	CS21	THIRD YEAR SUMMER CS22	CS23	CS24	FOURTH YEAR SEM1 CS25	CS26	CS27	FOURTH YEAR SEM 2 OJT
A.	An ability to apply knowledge of computing and mathematics appropriate to the discipline.	1	Understand the concepts of mathematics and computing.	I		R								E		E																	
		2	Identify the relationships of mathematics and the principles of computing.	I		R				R				E		E																	
		3	Apply the knowledge of mathematics in developing computing solutions.			I	R	R	R	R				E		E																	
B.	An ability to analyze a problem, and identify and define the computing requirements.	1	Learn to analyze the problem.			I	R	R	R			E		E																			
		2	Identify the requirements.			I	R	R	R			E		E																			
		3	Propose a solution.			I	R	R	R			E		E																			
C.	An ability to design, implement and evaluate a computer-based system, process, component, or program to meet desired needs.	1	Identify the problem and its requirements												I		R	R		R				R	R	R	R	R	R	E	E		
		2	Analyze the problem.												I		R	R		R				R	R	R	R	R	R	E	E		
		3	Gather data.												I		R	R		R				R	R	R	R	R	R	E	E		
		4	Formulate several solutions.												I		R	R		R				R	R	R	R	R	R	E	E		
		5	Select the best solution to the problem.												I		R	R		R				R	R	R	R	R	R	E	E		
		6	Apply the selected solution.												I		R	R		R				R	R	R	R	R	R	E	E		
D.	An ability to function effectively on teams to accomplish a common goal.	1	Researches and gather information.									I										R	R		E						E	
		2	Fulfill duties of team roles.									I										R	R		E						E	
		3	Shares in work of team.									I										R	R		E						E	
		4	Listens to other teammates.									I										R	R		E						E	
E.	An understanding of professional, ethical, legal, security and social issues and responsibilities.	1	Understand the professiobnal, ethical, legal, security and social issues.								I																			R		E
		2	Practice the code of professional ethics.								I																			R		E
		3	Demonstrate the characteristics of a responsible IT professional.								I																			R		E
F.	An ability to communicate effectively with a range of audiences.	1	Recognize the need to communicate.									I											R								E	
		2	Utilize appropriate communication techniques suitable to the identified type of audience.									I																			R/E	
		3	Demonstrate effective communication skills.									I											R								E	
G.	An ability to analyze the local and global impact of computing on individuals, organizations and society.	1	Identify the current status of local and global computing environment.		I				R		R		R													R		E			E		
		2	Determine the impact of computing on individuals, organizations and society.		I						R		R													E					E		
		3	Respond responsibly and adjust to the current computing environment.								I																	R			E		
H.	Recognition of the need for and an ability to engage in continuing professional development.	1	Acquire learning from attended seminars and training.								I																					R/E
		2	Observe the real-work environment.								I																					R/E
		3	Gain competency from industry immersion.								I																					R/E
I.	An ability to use current techniques, skills and tools necessary for computing practice.	1	Learn the different techniques and tools needed for computing processes.		I					R			R					R		R					R		R	E	E			
		2	Equip oneself with the techniques and skills appropriate in the computing field.		I					R			R					R		R					R		R	E	E			
		3	Apply the different techniques and tools needed for computing practice.		I					R			R					R		R					R		R	E	E			
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 trade-offs involved in design choices.	1	Analyze the effectiveness of the existing system based on the algorithmic and mathematical principles used in the design of computer-based systems.							I					R	R	R	R					R		R	R	E	E					
		2	Determine the requirements for revision of the systems.												I		R	R		R			R	R	R	R	E	E					
		3	Improve the design, as necessary.												I		R	R	R	R	R	R		R	R		R	R	R	R	E	E	
K.	An ability to apply design and development principles in the construction of software systems of varying complexity.	1	Identify the requirements and propose feasible solutions.																		I	R		E								
		2	Conduct a comparative analysis of the feasible solutions to the problem.																	I	R	R	R	R						E		
		3	Choose the best solution and develop the system.																	I			R	R						E	E	
	LEGEND:		I - INTRODUCE R - REINFORCE E - EMPHASIZE																													

Figure 1. *BSCS Curriculum Map SY 2015-2016*

Figure 1 presents the Curriculum Map of Bachelor of Science in Computer Science effective SY 2015-2016. The figure includes Student Outcomes and Performance Indicators corresponding to the 30 Professional Courses from CS 1 to OJT. The indicators I for Introduction, R for Reinforce and E for Emphasize are positioned strategically to indicate sequencing of learning based on the Course Intended Learning Outcomes (CILO) and Performance Indicator (PI).

A curriculum map consists of a collection of unit plans that align to a set of the content standards. The unit plans define the scope of the content being covered by considering the desired learning outcomes. The unit plans are also tied to a defined sequence based on the appropriate scaffolding of the content standards. This is commonly referred to as the 'scope and sequence' document [6]. A well-designed curriculum map and the process that goes with developing it have much to offer academic programs reviewing their curricula as part of a larger program review effort. Faculty are often energized when discussing big picture learning goals for the program and benefit from seeing visual representations of the curriculum as a whole, where they can see how their particular courses fit into the program. Students and advisors can also benefit from the big-picture perspective of the curriculum: when students wonder why they must take a certain course – particularly if the course seems especially difficult or uninteresting to them – advisors can demonstrate how the course contributes to the overall learning for the degree. The process can also encourage dialog among faculty groups teaching the same course about which program-wide goals and outcomes the course should address. The completed map offers a succinct list of the knowledge, skills, and attitudes the faculty consider most important for students to learn while at the

same time indicating which desired learning is perhaps not addressed, poorly addressed, or even over-addressed by a program's required courses. Further, the map can show whether the curriculum is working in a logical manner such that novice-level learning is positioned early in the curriculum while more advanced learning happens later [7].

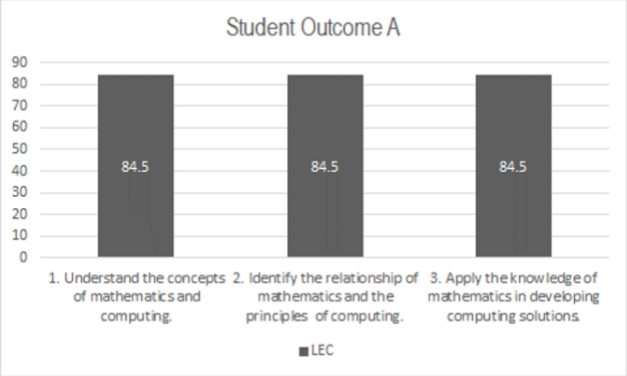

Figure 2. Assessment of Student Outcome A

A whole section of the BS Computer Science batch 2019 was assessed. This represents 100% of the population where summative data were collected from *CS12 – Discrete Structures*. For all Performance Indicators, Final Exam was chosen as the primary assessment method and the assigned faculty completed the scoring rubrics. Final exam was selected as a method of assessment since it covers all the learning required in each identified course strategy. A Performance Target of 80% was set for the course. For all the indicators, 84.5% was obtained as the average percentage grade achieved by the students who demonstrated each of the criterion for the course. *Hence, the Performance Target was met and exceeded for "Student Outcome (A). An ability to apply knowledge of computing and mathematics appropriate to the discipline".*

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, final exams, quizzes, assignments, homework, and/or labs. Typically, this data is collected by aggregating all assessments for a specific Course Learning Outcomes mapping to a particular PI [8].

Math matters in Computer Science since it teaches students how to use abstract language, work with algorithms, self-analyze computational thinking, and accurately model real-world solutions. Math teaches understanding and communication through abstract language. Computer programming has its own languages, which are very abstract. Using syntax, one must represent specific processes, commands, and visuals through punctuation, symbols, and single words. To someone with no experience thinking or communicating in abstract languages, learning a programming language can be terrifying. However, abstract programming languages are very similar to the mathematical language that students learn in math class. From simple equalities to complex mathematical representations, learning mathematics teaches students the art of reading, comprehending, formulating thoughts, and communicating with abstract language. Mathematical language and computer programming languages aren't *exactly* the same. But experience using *any* abstract language gives beginning computer scientists an advantage [9].

Mathematics is one of the most effective, general problem-solving tools students can learn. Although one does not necessarily require mathematical skills to be a reasonably competent programmer, mathematics is essential for reasoning in domains outside the narrow range of programming. It not only provides a common language for expressing ideas, but it is an extremely powerful tool for thinking about and representing problems. Mathematics and general problem-solving skills are important since today's jobs require quantitative reasoning, are very diverse, and in their professional student life's will be faced with problems from a wide range of disciplines. For students studying Computer Science, Discrete Mathematics and problem-solving principles are important foundations [10].

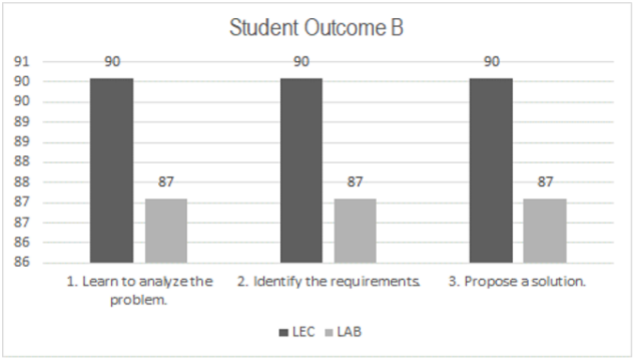

Figure 3. Assessment of Student Outcome B

A whole section of the BS Computer Science batch 2019 was assessed. This represents 100% of the population where summative data were collected from *CS9 – Multimedia Technologies*. For all Performance Indicators, Final Exam was chosen as the primary assessment method and the assigned faculty completed the scoring rubrics. The final exam was selected as a method of assessment since it covers all the learning required in each identified course strategy. A Performance Target of 80% was set for the course. For all the indicators, 90% was obtained as the average percentage grade achieved by the students who demonstrated each of the criterion for the lecture component and 87% for the laboratory component. *Hence, the Performance Target was met and exceeded for "Student Outcome (B). An ability to analyze a problem, identify and*

define the computing requirements" in both lecture and laboratory components of the course.

In the educational community, assessment process focuses on teaching, learning, and outcomes. It provides information for improving teaching and learning. Therefore, a well-established assessment process plays a vital role for improving program outcomes which, in turn, results in fulfilling program educational objectives. However, such a process entails setting well-defined courses learning objectives, program outcomes, and program educational objectives. In addition, an effective assessment method is needed for measuring the extent that program outcomes meet academic accreditation body criteria [4].

Problem Based Learning (PBL) is a student-centered pedagogy in which complicated real world problems are used as an essence to improve and promote student learning as opposed to presenting direct facts and conventional concepts. It also helps in improving their critical thinking ability, problem solving skills, cognitive skills and their overall performance as compared to traditional teachers' centric approach. The data collected from the learning platform helps in the qualitative analysis of the students' behavior in a particular course and also bring out the conclusions with respect to teachers' involvement. The learning platform used for PBL session supports face to face learning, online and blended learning solutions which facilitate and improve upon traditional educational methods. Students are allowed to upload and share content; access the resources provided by teachers and learn in a peer environment. It also facilitates communication and collaboration between people, whether students or teachers. Questionnaires are prepared to take feedback from the students on the PBL session being conducted and to analyze the improvement in their skills based on certain parameters. While PBL can be applied in any discipline, its appeal within Computer Science is clear. Many of the courses, such as programming, networking, data mining, software engineering etc., can be designed using PBL approach. With the rapid advances in this field, it is also of particular concern on how students can be self-motivated to be good independent learners [11].

A whole section of the BS Computer Science batch 2019 was assessed. This represents 100% of the population where summative data were collected from *CS26 – Networking 4*. For all Performance Indicators, Final Exam was chosen as the primary assessment method and the assigned faculty completed the scoring rubrics.

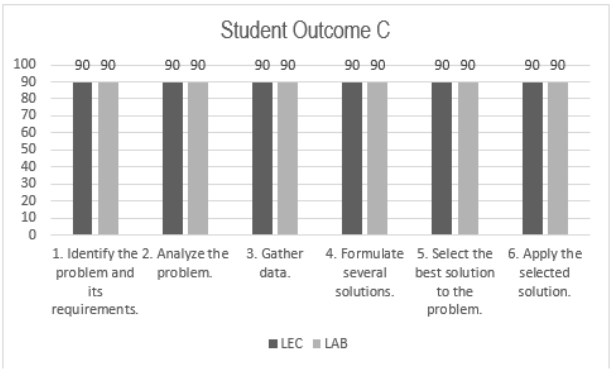

Figure 4. Assessment of Student Outcome C

The final exam was selected as a method of assessment since it covers all the learning required in each identified course strategy. A Performance Target of 80% was set for the course. For all the indicators, 90% was obtained as the average percentage grade achieved by the students who demonstrated each of the criterion for both lecture and laboratory components. *Hence, the Performance Target was met and exceeded for "Student Outcome (C). An ability to design, implement and evaluate a computer-based system, process, component, or program to meet desired needs" in both lecture and laboratory components of the course.*

Student outcomes describe what students are expected to know and do by the time of graduation. In order to assess the extent to which an outcome is met, it is necessary to define an outcome in terms of measurable performance indicators. Rubrics allow collection of relevant data and their consistent interpretation [12].

The process of learning involves mistakes and errors. In these situations, students often review course materials and search the Internet or other sources to assist them in solving their problems. Seeking for a solution is usually time consuming and does not always insinuate a better learning experience. Having a computer-based system which generates effective feedback that guides students to the solution can improve the learning process. Feedback is frequently provided in a typical classroom setting; however, most of the information is poorly received because feedback is presented to groups and so often students do not believe such feedback is relevant to them. Currently, the gap between students who excel the most and those who excel less is a challenge that teachers, school administrators, and government officials face frequently. Adaptive learning environments provide personalization of the instruction process based on different parameters such as sequence and difficulty of task, type and time of feedback, learning pace, and others. One of the key features in learning support is the personalization of feedback. Adaptive feedback support within a learning environment is useful because most learners have different personal

characteristics such as prior knowledge, learning progress, and learning preferences. Tailoring feedback according to learner's characteristics and other external parameters is a promising way to implement adaptation in computer-based learning environment [13].

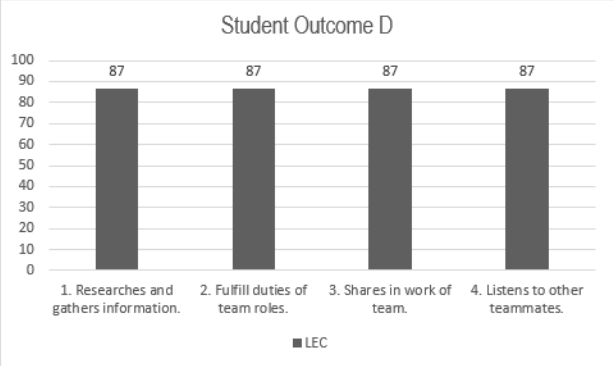

Figure 5. Assessment of Student Outcome D

A whole section of the BS Computer Science batch 2019 was assessed. This represents 100% of the population where summative data were collected from *CS27 – CS Thesis Writing 2*. For all Performance Indicators, Oral Defense was chosen as the primary assessment method and the assigned faculty completed the scoring rubrics. The oral defense was selected as a method of assessment since it covers all the learning required in each identified course strategy. A Performance Target of 80% was set for the course. For all the indicators, 87% was obtained as the average percentage grade achieved by the students who demonstrated each of the criterion for the course. *Hence, the Performance Target was met and exceeded for "Student Outcome (D). An ability to function effectively on teams to accomplish a common goal".*

ABET defines student outcomes as "what students are expected to know and be able to do by the time of graduation. These relate to the knowledge, skills, and behaviors that students acquire as they progress through the program", while assessment is defined as "one or more processes that identify, collect, and prepare data to evaluate the attainment of student outcomes. Effective assessment uses relevant direct, indirect, quantitative and qualitative measures as appropriate to the outcome being measured. Appropriate sampling methods may be used as part of an assessment process." [14].

Few would dispute the importance of teamwork as a learning outcome for students in Computer Science and Computer Engineering. Computing and engineering are by nature collaborative processes, and most production systems are designed by teams working over long periods of time. Software engineers need good communication skills, both spoken and written. They need an analytical capability, and they need to be able to manage a project from end to end while working well with their colleagues." Communication and teamwork skills are increasingly being sought when hiring Engineering and Computer Science graduates [15].

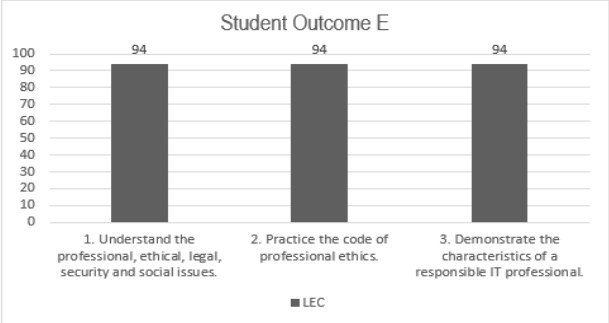

Figure 6. Assessment of Student Outcome E

A whole section of the BS Computer Science batch 2019 was assessed. This represents 100% of the population where summative data were collected from *OJT – On-the-Job Training*. For all Performance Indicators, Revalida was chosen as the primary assessment method and the assigned faculty completed the scoring rubrics. The Revalida was selected as a method of assessment since it covers all the learning required in each identified course strategy. A Performance Target of 80% was set for the course. For all the indicators, 94% was obtained as the average percentage grade achieved by the students who demonstrated each of the criterion for course. *Hence, the Performance Target was met and exceeded for "Student Outcome (E). An understanding of professional, ethical, legal, security and social issues and responsibilities".*

Computer Science faculty have a responsibility to teach students to recognize both the larger ethical issues and particular responsibilities that are part and parcel of their work as technologists. This is, however, a kind of teaching for which most of have not been trained, and that faculty and students approach with some trepidation. Indeed, some in Computer Science have gone so far as to require students in undergraduate courses to perform ethics consultations for local industry. However, educating students to engage ethical challenges is often left to the cross-disciplinary portions of university curricula. Researchers in computing, as in all professions, hold multiple and often conflicting sets of values, as well as different ways to approach living up to one's values. It is important to be clear that the purpose in teaching ethics is not to unify the field around a particular value system but to encourage reflection and precision of thought among computer professionals [16].

A whole section of the BS Computer Science batch 2019 was assessed. This represents 100% of the population where summative data were collected from *CS27 – CS Thesis Writing 2*. For all Performance Indicators, Oral

Defense was chosen as the primary assessment method and the assigned faculty completed the scoring rubrics. The oral defense was selected as a method of assessment since it covers all the learning required in each identified course strategy. A Performance Target of 80% was set for the course. For all the indicators, 87% was obtained as the average percentage grade achieved by the students who demonstrated each of the criterion for the course. *Hence, the Performance Target was met and exceeded for "Student Outcome (F*). *An ability to communicate effectively with a range of audiences".*

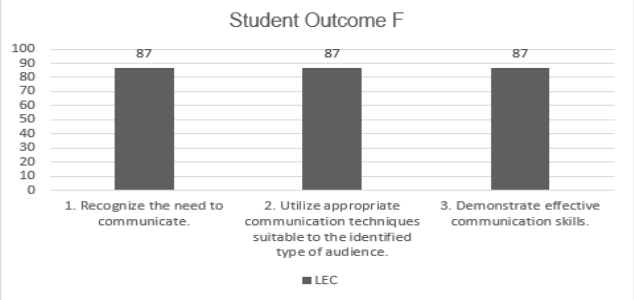

Figure 7. Assessment of Student Outcome F

Science academics already carry a heavy workload under the current higher education system. One specific hurdle facing these lecturers in teaching communication skills is that they are specialized in one specific scientific area and cannot also be expected to be masters of educating undergraduates on communication, a topic they also may find challenging [17]. Science academics rarely have the time, resources, or formal training to communicate their own research to non-scientific audiences let alone to develop the skills, resources, and courses components required to teach such communication thoroughly.

As scholars across business and communications disciplines continue to identify and evaluate essential skills needed to achieve the level of productivity, performance, and excellence needed for competitive advantage, competence in oral communication, employers identified writing, speaking, and listening skills as fundamental. These skills are the prerequisites students' personal and professional success in the twenty-first workforce. Communication skills are essential for performing in business, academic, and professional environments. No matter the situation one faces in personal or professional contexts, one will need to communicate effectively and interact people of diverse cultures, utilizing speaking and listening skills to create and sustain impressions. For instance, in a personal and professional settings, trips to various places, including mingling with colleagues and classmates, requires effective interpersonal communication skills [18].

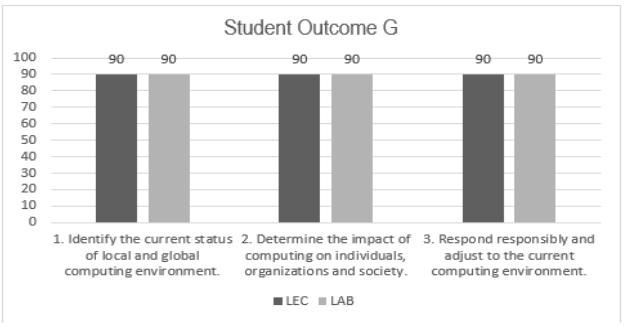

Figure 8. Assessment of Student Outcome G

A whole section of the BS Computer Science batch 2019 was assessed. This represents 100% of the population where summative data were collected from *CS26 – Networking 4*. For all Performance Indicators, Final Exam was chosen as the primary assessment method and the assigned faculty completed the scoring rubrics. The final exam was selected as a method of assessment since it covers all the learning required in each identified course strategy. A Performance Target of 80% was set for the course. For all the indicators, 90% was obtained as the average percentage grade achieved by the students who demonstrated each of the criterion for both lecture and laboratory components. *Hence, the Performance Target was met and exceeded for "Student Outcome (G) An ability to analyze the local and global impact of computing on individuals, organizations, and society" in both lecture and laboratory components of the course.*

The Internet of Things and Cloud Computing draws the next big leap ahead in the future of the Internet. From these advanced technologies, new applications arise continuously that open exciting new directions for research and business. Computing enhances communication, interaction, and cognition. Email, texting, chat, video conferencing and video chat have fostered new ways to communicate and collaborate. Social media continues to evolve and foster new ways to communicate. Widespread access to information facilitates the identification of problems, development of solutions, and dissemination of results. Public data, such as databases of temperature readings or databases of court cases, provides widespread access and enables solutions to identified problems.

Computing has global effects – both beneficial and harmful – on people and society. Innovations enabled by computing raise legal and ethical concerns. Privacy and security concerns arise in the development and use of computational systems and artifacts. Widespread access to digitized information raises questions about intellectual property. The innovation and impact of social media and online access is different in different countries and in different socioeconomic groups. Mobile, wireless, and networked computing have an impact on innovation throughout the world. The global distribution of computing resources raises issues of equity, access, and power. Groups

and individuals are affected by the "digital divide" — differing access to computing and the Internet based on socioeconomic or geographic characteristics. Networks and infrastructure are supported by both commercial and governmental initiatives [19].

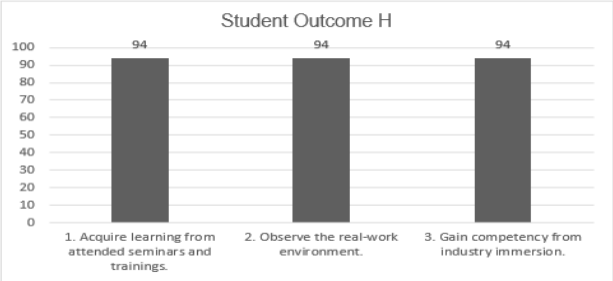

Figure 9. Assessment of Student Outcome H

A whole section of the BS Computer Science batch 2019 was assessed. This represents 100% of the population where summative data were collected from *OJT – On-the-Job Training*. For all Performance Indicators, Revalida was chosen as the primary assessment method and the assigned faculty completed the scoring rubrics. The Revalida was selected as a method of assessment since it covers all the learning required in each identified course strategy. A Performance Target of 80% was set for the course. For all the indicators, 94% was obtained as the average percentage grade achieved by the students who demonstrated each of the criterion for the course. *Hence, the Performance Target was met and exceeded for "Student Outcome (H). Recognition of the need for and ability to engage in continuing professional development".*

Continuing professional development for academics is critical in times of the increased speed of innovation and intensification of responsibilities of the academia [20]-[21]. New competencies are essential to fulfil the required functions in the field of knowledge and teaching, but also leadership and administration. 'Professional development for all elements of the academic role (including teaching and research) needs to be considered as a normal part of professional life for all academic staff' [22].

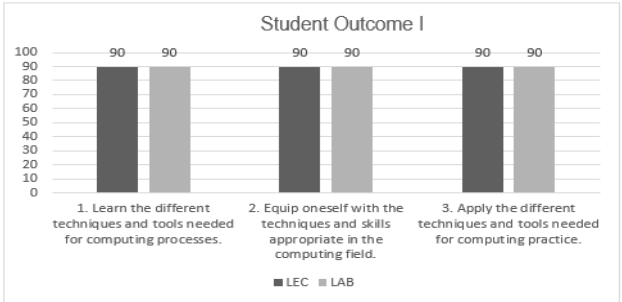

Figure 10. Assessment of Student Outcome I

A whole section of the BS Computer Science batch 2019 was assessed. This represents 100% of the population where summative data were collected from *CS26 – Networking 4*. For all Performance Indicators, Final Exam was chosen as the primary assessment method and the assigned faculty completed the scoring rubrics. The final exam was selected as a method of assessment since it covers all the learning required in each identified course strategy. A Performance Target of 80% was set for the course. For all the indicators, 90% was obtained as the average percentage grade achieved by the students who demonstrated each of the criterion for both lecture and laboratory components. *Hence, the Performance Target was met and exceeded for "Student Outcome (I)* An ability to use current techniques, skills, and tools necessary for computing practice" *in both lecture and laboratory components of the course.*

Society has come to rely on the technology created by the computing industry to fulfill the functions of daily life, resulting in both exciting career opportunities and above-average salaries for individuals who choose to pursue a Computer Science career. While the job outlook remains overwhelmingly positive, the evolution of the Computer Science field over the last few decades has created a demand for professionals with more than just the basic coding skills. Now, professionals looking for success must have a strong combination of technical, interview, and soft skills unique to this specific sector [23].

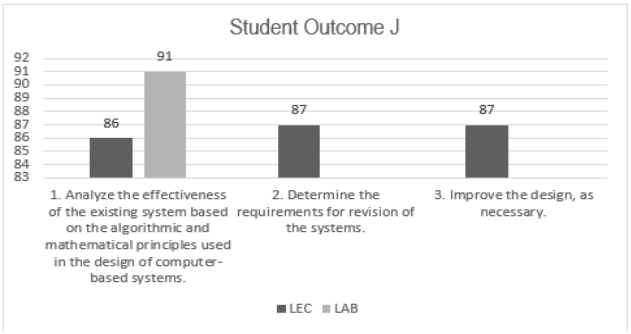

Figure 11. Assessment of Student Outcome J

A whole section of the BS Computer Science batch 2019 was assessed. This represents 100% of the population where summative data were collected from *CS23 – Elective 3 and CS 27 – CS Thesis Writing 2*. Final Exam and Oral Defense were chosen as the assessment methods and the assigned faculty member for each course completed the scoring rubrics. Final Exam and Oral Defense were selected as the methods of assessment since each cover all the learning required in each identified course strategy. A Performance Target of 80% was set for the course. For PI J.1, 86% was obtained as the average percentage grade achieved by the students who demonstrated each of the criterion for the lecture component and 91% for the laboratory component. For PI J.2 and J.3, 87% was obtained as the average percentage grade achieved by the students who demonstrated each of the criterion for the course. *Hence, the Performance Target was met and exceeded for*

"Student Outcome (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 trade-offs involved in design choices".

Outcome Based Education is being adopted at a fast pace at HEIs, becoming focal point for higher education reforms in countries worldwide. Indeed, all academic accreditation agencies and bodies advocate the inclusion of OBE features in curriculum structures as an essential requirement. The OBE model is based on a student-centered learning philosophy in that it focuses on the outcomes. With that principle in mind, the structure and frameworks of various program curricula are accordingly designed [24].

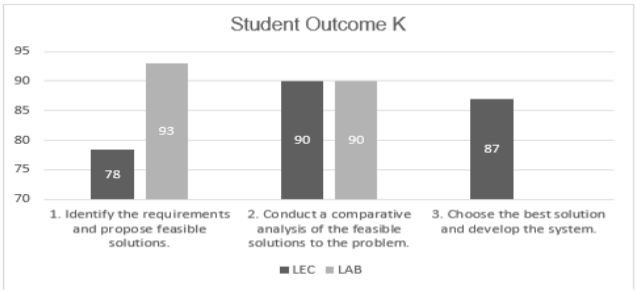

Figure 12. Assessment of Student Outcome K

A whole section of the BS Computer Science batch 2019 was assessed. This represents 100% of the population where summative data were collected from *CS 20 – Software Engineering, CS 26 – Networking 4 and CS27 – CS Thesis Writing 2.* For PI (1) and PI (2), Final Exam was chosen as the primary assessment method and the assigned faculty completed the scoring rubrics. For PI (3), Oral Defense was chosen as the primary assessment method and the assigned faculty completed the scoring rubrics. The Final Exam / Oral Defense was selected as a method of assessment since it covers all the learning required in each identified course strategy. A Performance Target of 80% was set for the course.

For PI (1), 78% and 93% were obtained as the average percentage grades achieved by the students for the lecture and laboratory components respectively. For PI (2), 90% was obtained as the average percentage grade achieved by the students for both the lecture and laboratory components. For PI (3), 87% were obtained as the average percentage grade achieved by the students.

*Hence, the Performance Target was met and exceeded for "Student Outcome (K.2) and (K.3) An ability to apply design and development principles in the construction of software systems of varying complexity". Performance Target was not met for (K.1) "*Identify the requirements and propose feasible solutions".

The factors affecting a student's academic performance arise from both internal and external reasons. Internal factors include personal conditions and study habits which are mostly student-related and may lead to good academic performance. External factors, on the other hand, include home-related, school-related and teacher-related factors and are contributed to the external environment of students that are beyond their control [25].

CONCLUSION AND RECOMMENDATION

The BS Computer Science program curricula and the teaching strategies employed by its professors to deliver learning is aligned with the expected student outcomes of the program. BS Computer Science students at the time of graduation possess the knowledge, skills, and behavior parallel to the program's expected student outcomes.

The following Recommendations can be used for continuous enhancement of the BSCS curricula. To the Dean and Department Chairman of the College of Computer Studies, to continuously document methodologies, educational practices, and strategies adopted by different HEIs on their road towards accreditation. To the Dean and Department Chairman of the College of Computer Studies, to monitor methodology for assessing and evaluating SOs that forms the basis of continuous improvement of the curricula, and to ensure that the program's requirements are consistent with its program educational objectives and designed in such a way that each of the student outcomes can be attained. To the Dean and Department Chairman of the College of Computer Studies, to conduct periodic review of Student Outcomes and Performance Indicators. The program must regularly use appropriate, documented processes for assessing and evaluating the extent to which the student outcomes are being attained. The results of these evaluations must be systematically utilized as input for the program's continuous improvement actions. To the Dean of the College of Computer Studies, to ensure that each faculty member teaching in the program have the expertise and educational background consistent with the contributions to the program expected from the faculty member. To Professors of the College of Computer Studies, to continuously impart learning aligned with the Student Outcomes and Performance Indicators of the program, and to exhibit sufficient responsibility and authority to improve the program through definition and revision of program educational objectives and student outcomes as well as through the implementation of a program of study that fosters the attainment of student outcomes. To Professors of the College of Computer Studies, to perform Student Outcomes Assessment at the end of each 4-year cycle.

Lastly, to LPU-B Management, to continuously acquire accreditation of the BS Computer Science program both locally and internationally. Institutional support and leadership must be adequate to ensure the quality and continuity of the program, and to ensure that classrooms,

offices, laboratories, and associated equipment must be adequate to support attainment of the student outcomes and to provide an atmosphere conducive to learning.

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