$$Achievement\ Rate\ of\ CO = \frac{\text{number of students who attained the CO (scored above 60\%)}}{\text{total number of students in the class}} \times 100\% \quad \ldots (1)$$

For each section of the courses, if the achievement rate is found to more than 60%, CO for that section of the course has been achieved. Following that, excel files of the assessed COs for each semester are collected from course teachers along with an OBE report explaining the assessment process and indicating the achievement rates. These data are kept in a SQL database. And from there, combined CO achievement rates for all the sections of the course are calculated. A semester-wise OBE report is prepared by the OBE committee and presented to the department head. If the overall achievement rate of all the sections of a specific course has reached over 60%, then the CO attainment in the course level is considered to be achieved.

Since all the courses are mapped with at least one POI, the POI level attainment is assessed through the achievement rate of the mapped CO. POIs and mapped with KPA; hence there is load variance of different POIs of the same PO. Therefore to analyze the PO's attainment, each POIs have been considered with a weight according to their burden with KPA requirements. Utilizing the POI achievement level and weight, the overall PO attainments are calculated by the following formula.

$$Achievement\ Rate\ of\ CO = Achievement\ Rate\ of\ POI \quad \ldots (2)$$

$$Achievement\ Rate\ of\ PO = weight\ of\ the\ POI \times Achievement\ Rate\ of\ POI \quad \ldots (3)$$

When the PO achievement rate has reached over 60%, then the specific PO is considered to be attained employing commutative achievement of POIs and COs. If the PO's requirements have not been met and the PO is not acquired, then the OBE assessment process gap can be traced back to CO and the course from the database, and the OBE committee will recommend the CQI update of the specific course. Since OBE has been implemented in the EEE program at AIUB from Fall 18-19 semester, there was much to learn and understand outcome-based education. Hence, the management, OBE committee, and course teachers decided that the OBE structure should be implemented across all the EEE curriculum for all the existing EEE students. This seamless implementation would provide us insights into the OBE assessment and attainment process to be more effective.

Student level attainment of OBE and PO attainment will be given to students during graduation as OBE certificate, indicating which of the 12 POs has been attained. Although student batches before Fall 18-19 will not be getting full OBE reports. EEE students from Fall 18-19 onwards will receive the complete OBE certificate. PO attainments are accomplished by aggregated CO achievement of the mapped POI; hence students may achieve a particular PO through multiple semesters by different courses. Therefore, unless an entire four-year EEE program has been completed by a batch, the student level PO attainment cannot be calculated. For example, PO-a is assessed and evaluated with the help of four POI, namely P.a.1.C3, P.a.2.C3, P.a.3.C3 and P.a.4.C3. These POIs are mapped with 8 different courses. According to the semester wise flow chart, Electrical Circuits – 1 (DC) should be completed in Semester 2, Electrical Circuits – 2 (AC) in Semester 3, Electronic Devices and Electrical Machines – 1 in semester 4, Electrical Properties of Material, Analog Electronics and Signal and Linear System in semester 5, Industrial Electronics and Drives in semester 7. So, in order to get full attainment of PO-a, students have to complete these eight courses that can take up to semester 7, and then the overall attainment of PO-a in student level. The integrated database and reporting similar to grading system are under development which will be able provide this student level PO attainment analysis. Since the updated POI system OBE is being practiced only from Fall 19-20 semester, we are still unable to get the student level attainment analysis.

The following example data for the PO-a and PO-b attainment analysis is presented on Semester wise CO, POI and PO achievement rate. This data helps to analyze the effectiveness of overall OBE implementation.

A. Attainment of PO(a): Engineering Knowledge:

PO(a) is assessed and evaluated with the help of four POI, namely P.a.1.C3, P.a.2.C3, P.a.3.C3 and P.a.4.C3. These POIs are mapped with 8 different courses: Electrical Circuits – 1 (DC), Electrical Properties of Material, Electrical Circuits – 2 (AC), Signal and Linear System, Electrical Machines – 1, Electronic Devices, Industrial Electronics and Drives, and Analog Electronics. The methods, tools, criteria, and scale used in the assessment process are described in section 8.4. The expected level of attainment has been 60% or above. Knowledge Profile attributes K1, K2, K3, and K4 are incorporated in PO(a). The attributes of the Complex Engineering Problems, P1, P2, P3, P6, and P7, are addressed through the attainment of PO(a). The weight of the POIs was given according to the KPA mapping, P.a.1.C3 and P.a.2.C3 each was given 20% weights to calculate total PO(a), whereas P.a.3.C3 and P.a.4.C3 each were given 30% weights as these POIs had more load with KPA requirements.

A summary of the results (Table II and Figure 3) obtained after the assessment of Academic Year 19-20 (Three semesters) to demonstrate the PO(a) is being attained.

TABLE II: ATTAINMENT OF PO(A) FOR ACADEMIC YEAR 19-20

POI/PO	WEIGHT	KPA	ACHIEVEMENT RATES		
			Fall 19 -20	Spring 19-20	Summer 19-20
P.a.1.c3	0.2	K1	70.83%	87.95%	95.92%
P.a.2.c3	0.2	K2	76.79%	88.65%	89.88%
P.a.3.c3	0.3	K3, P1, P2, P6	87.68%	85.49%	87.00%
P.a.4.c3	0.3	K4, P1, P3, P7	91.57%	90.00%	95.19%
Overall PO-a	1	K1, K2, K3, K4, P1, P2, P3, P6, P7	83.30%	87.97%	91.82%

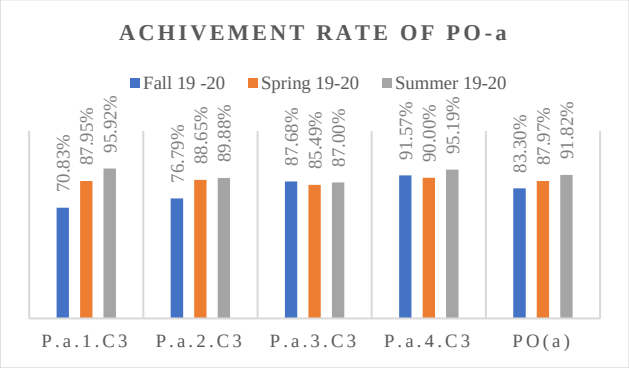


Fig. 3. Attainment of PO-a for Academic Year 19-20

From the results, it is apparent that collectively through POIs, the PO(a) has been achieved by 83.30% in Fall 19-20, 87.97% in Spring 19-20, and 91.82% in Summer 19-20.

B. Attainment of PO(b): Problem Analysis

PO(b) is assessed and evaluated with the help of four POI, namely P.b.1.C4, P.b.2.C4, P.b.3.C4 and P.b.4.C5. These POIs are mapped with eight different courses: Electromagnetic Fields and Waves, Modern Control System, Digital Signal Processing, Digital Logic Circuits, Power System Analysis, Electrical Machines – 2, Capstone Project, and Telecommunications Engineering. The methods, tools, criteria, and scale used in the assessment process are described in section 8.4. The expected level of attainment has been 60% or above.

K1, K2, K3, and K4 among Knowledge Profile attributes are incorporated in PO(b). P1, P2, P4, P5, and P6 of the attributes of the Range of Complex Engineering Problems are addressed through the attainment of PO – b. The weight of the POIs was given according to the KPA mapping. P.b.1.C4 and P.b.2.C3 each were given 20% weights to calculate total PO(b), whereas P.b.3.C4 and P.b.4.C3 were given 30% weights as these POIs had more load with KPA requirements.

A summary of the results (Table III and Figure 4) obtained after the assessment of Academic Year 19-20 (Three semesters) to demonstrate the PO(b) is being attained.

TABLE III: ATTAINMENT OF PO(B) FOR ACADEMIC YEAR 19-20

Poi/Po	Weight	Kpa	Achievement Rates		
			Fall 19 - 20	Spring 19-20	Summer 19-20
P.b.1.c4	0.2	K1	82.16%	91.28%	84.65%
P.b.2.c3	0.2	K2	76.60%	94.38%	93.01%
P.b.2.c4	0.3	K3, P1, P2, P6	84.60%	83.44%	82.09%
P.b.4.c3	0.3	K4, P1, P3, P7	76.56%	93.18%	89.94%
Overall PO-b	1	K1, K2, K3, K4, P1, P2, P4, P5, P6	80.10%	90.12%	87.14%

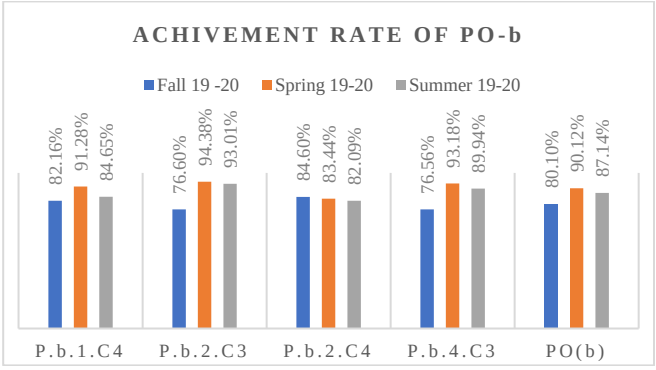
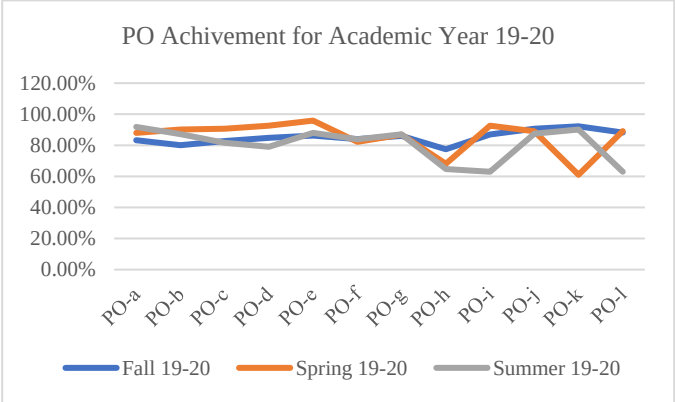


Fig. 4. Attainment of PO-b for Academic Year 19-20

From the results, it is apparent that collectively through POIs, the PO(b) has been achieved by 80.10%in Fall 19-20, 90.12% in Spring 19-20, and 87.14% in Summer 19-20.

V. COMPARATIVE ANALYSIS

All the data collected from the 12 PO attainment over an academic year, the achievement rates can be summarized in the following graph.



From the above curve, it can be observed that the Fall 19-20 semester's PO achievement rates were more stable, averaging an 85.28% achievement rate. For Spring 19-20, the average achievement rate is also 85.53%, but more achievements in the first seven POs fluctuate. Finally, the Summer 19-20, which was entirely online, the achievement rates were not stable. The first five POs that were more knowledge-based and lower cognitive domains seem to have more achievement rate. Whereas the lack of lab experience and skill training, the upper cognitive domain, psychomotor and affective domain POs suffer. As a result, the average achievement rate reduces to 80.56%.

Therefore, from the comparative analysis, the first five POs, mainly the cognitive domain teaching learning and assessment, should online or at least a mixture of both face-to-face and e-learning. This pedagogy will increase the achievement rates of the students and help to implement the OBE more effectively. Whereas for the last seven POs, face-to-face education is necessary as more skill-based education is required.

VI. Conclusion

In conclusion, the above presented data and the comparative analysis of Face-to-face, Online, and partial Online gives a clear demonstration that the cognitive domain course outcomes aligned with PO-a to PO-e are suitable for online teaching-learning. It also provides more effective teaching and assessment methods using an e-learning platform. Simultaneously, the skill-based course outcomes aligned with PO-f to PO-k require physical interaction with students for the teaching-learning process. The last PO - l, which focuses on Lifelong learning, can also be attained by an e-learning platform.

In addition to that, Outcome Based Education is more focused on student learning and outcome-driven compared to traditional course objective-based education. Therefore, student motivation, awareness, and self-driven learning methods are more suitable for e-learning platforms. Hence it is recommended that even after a pandemic when the universities go back to normal activities, some e-learning modules should be included in the curriculum to assess the student learning outcome.

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