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Original Article

Excel software for automated calculation of learning outcomes and graduate attributes in medical education

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ABSTRACT

Background: Assessment of learning outcomes (LOs) and graduate attributes (GAs) play pivotal roles in ascertaining the quality of education and graduates by accreditation agencies worldwide. However, the manual calculation of LOs in a medical program which consists of multiple courses containing hundreds of course learning outcomes (CLOs) spread across knowledge, skills, and value domains makes the process very complex and tedious.

Aim: This study aimed to develop software for the automated calculation of individual LOs and GAs for the MBBS program.

Methods: In this study, we have developed an Excel-based software program for an automated calculation of achievement of individual CLOs, program learning outcomes (PLOs), and GAs for the MBBS program.

Results: The study described the operational functioning details of the software program along with all the formulae and graphical representations of sheets. Achievement of PLOs and GAs for a cohort of the MBBS program was calculated as an example for demonstrating the final outcome of the software program.

Conclusion: The automated Excel software program produced a reliable assessment procedure for the achievement of CLOs and PLOs for courses and programs, respectively, in the MBBS program. Further, the software program auto calculates the individual student performance across the courses and program which can help in monitoring the individual performance of a student in the program.

Keywords: course learning outcomes, graduate attributes, medical education

INTRODUCTION

Medical colleges worldwide continuously strive for improving the quality of medical education by adopting outcome-based education to meet the accreditation requirements of NCAAA and the World Federation of Medical Education (WFME). Competency-based learning and training policies and programs were a significant catalyst for shifting away from the broad and general aims of educational programs.^[1] Learning outcomes (LOs) generally constitute as 'statements of what a learner knows, understands and is able to do after completion of learning' which had a profound influence on the nature of teaching and learning processes and the assessment methods in courses.^[2] Hence, the LOs are indicators of the success of any academic course/program.^[3,4]

The colleges according to the vision and mission set by the program aligned with the institution’s vision and mission, formulate the program goals, program learning outcomes (PLOs), and graduate attributes (GAs). The MBBS program at the College of Medicine, Shaqra has 18 PLOs which are aligned with the National Qualification Frameworks (NQF) for higher education in Saudi Arabia and the SaudiMED framework. Each course in the medical curriculum then develops the course learning outcomes (CLOs) to achieve the required knowledge, skills, and values in the profession. The whole program has 286 CLOs across the 34 courses in the knowledge, skills, and values domains. The CLOs are aligned with the PLOs as shown in the program matrix below (Figure 1).

The program learning outcomes were aligned with the program courses in the program matrix, according to the following desired levels of performance: (I = Introduced P = Practiced M = Mastered) as prescribed by the NCAAA.

PROGRAM LEARNING OUTCOMES MAPPING MATRIX 1445

Align the program learning outcomes with program courses, according to the following desired levels of performance: (I = Introduced P = Practiced M = Mastered)

Course code & No.	Program Learning Outcomes																	
	Knowledge and Understandings					Skills					Values							
	K1	K2	K3	K4	K5	S1	S2	S3	S4	S5	V1	V2	V3	V4	V5	V6	V7	V8
Health and Illness in the Community I HIC 211	-	I	-	-	-	I	-	-	-	-	-	-	-	I	-	-	-	-
Concepts and Principles of Medical Education CMD 211	-	-	I	-	-	-	I	-	-	-	I	I	I	I	-	-	-	I
Growth and Development CMD 212	I	-	-	-	-	I	-	-	-	-	P	P	-	P	-	-	-	P
Man, and His Environment and Metabolism CMD 213	I	I	-	-	-	I	-	-	-	-	P	P	-	I	-	-	-	-
Clinical Skills I CMD 214	-	-	I	-	-	-	-	-	I	I	-	-	-	I	-	-	-	I
Principles of Disease	-	I	I	-	-	-	I	-	-	-	-	P	-	P	-	-	-	I

Figure 1: Program learning outcome mapping matrix

Further, it is expected that the medical graduates of the MBBS program express the competencies of SaudiMED outlined in the PLOs of the College of Medicine. The GAs are also aligned with the NQF and SaudiMED PLOs.

At the end of the program, each student is expected to possess the following GAs: GA-1: Evidence-based medical expert, GA-2: Patient-centered practitioner, GA-3: Health promoter, GA-4: Cooperative collaborator, GA-5: Professional practitioner, GA-6: Lifelong learner and scientific scholar.

In the College of Medicine at Shaqra University, the PLOs, assessment methods, and teaching strategies are aligned together which are assessed using measurable performance indicators, with specific weightage given to each indicator. For each performance indicator, assessment tools, methods (direct and indirect), target population, and responsible body are identified. The evidence that will best demonstrate the extent to which the students have met the stated goals/PLOs are selected and drawn from a wide variety of sources like answers to specific test questions, student performance results, team project reports, seminar evaluation sheets, performance on professional exam and survey questionnaires. However, considering the variety of courses in a program with varying numbers of CLOs, manual calculation of individual CLOs, PLOs, and GAs is a herculean task with the possibility of significant errors in calculation. We have developed a customized Microsoft Excel-based software to calculate individual CLO, PLO, and GA, which has eased the life of the course organizers with minimal risk of

mistakes. This manuscript focused on the direct assessment method to calculate the CLOs, PLOs, and GAs using Excel-based software. The PLO assessment plan by the direct method is outlined in Figure 2.

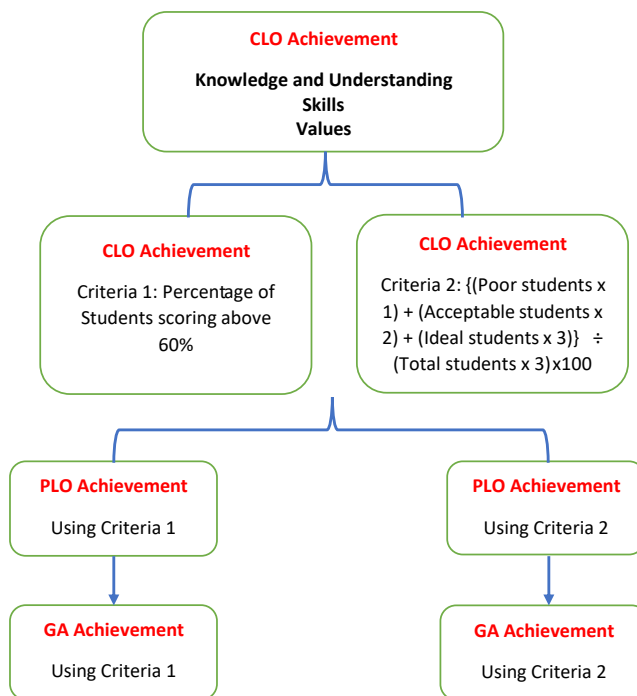


Figure 2: Representation of PLO and GA assessment plan by direct assessment method

METHODS

Brief outlines of the Excel program files and criteria

For calculating PLO and GA, we have made a Microsoft Excel program which included three kinds of Excel files, as listed below:

CLO filter Excel file: This Excel file is for automated sorting of the individual student marks according to the respective CLOs in a given block/course.

CLO Excel files for individual blocks/courses: These CLO files for different blocks/courses in the first to the fifth year of the MBBS program do the calculations of individual CLOs and subsequently the aligned PLOs. In these CLO files, there are multiple sheets and each sheet represents a separate CLO, in which the marks of the students are entered and the Excel program calculates the percentage of each student's marks and analyses it. Finally, the CLO achievement data is displayed in one sheet for all the CLOs in the sheet named as "CLO achievements". After entering the CLO data, Excel files of all the blocks/courses are kept in the folder named as "CLO Reports" for further analysis. The CLO achievement data from these files is automatically imported by the third type of Excel program file for the calculation of PLO and GA achievements based on this data.

PLO and GA calculation Excel file: This file is linked with the CLO files of all the blocks/courses and the data from all these CLO files is automatically imported into the sheet named as "imported data". From this imported data the data is analysed in different sheets and finally, the outcome of year-wise PLO achievements, and GA achievements are displayed in respective sheets based on the weightage of PLO and GA as mentioned below.

We have calculated the CLO/PLO achievement data by two criteria. Assessment by Criteria 1 reveals that how many of our students are successfully achieving a given PLO, while Criteria 2 tells the level of efficiency of the student cohort as a group has achieved for that PLO.

Criteria 1 (Individual performance): Number of students successfully achieved the PLO (expressed as %age of students scoring more than 60% in the assessment). (Adapted from Al Qassim University)

Criteria 2 (Group performance): Average performance of the cohort as a group. (Adapted from Hail University) It is calculated by using the following formula:

$$\text{CLO Achievement (\%)} = \left[\frac{(P \times 1) + (A \times 2) + (I \times 3)}{(T \times 3)} \right] \times 100$$

In this given formula: P: number of Poor students, A: number of Acceptable students, I: number of Ideal students, and T: Total number of Students.

Operational description of the Excel Program files

CLO Filter file:

We have prepared CLO filter files for MCQ, SEQ, MEQ, and OSPE/OSCE. These CLO filters segregate the student marks according to the CLOs assigned to the questions/items in the exam. As an example, we have detailed the description of the MCQ CLO filter Excel file below. Similarly, the CLO filters for SEQ, MEQ, and OSPE/OSCE are generated where only one set was used in the exam.

MCQ CLO filter file:

This Excel file has 4 sheets, named MCQ -set A, MCQ -set B, MCQ -set C, and Sheet 1, as shown in Figure 3. We use three different sets of MCQ question papers therefore we have dedicated three different sheets for sorting out the marks from the individual MCQ sets.

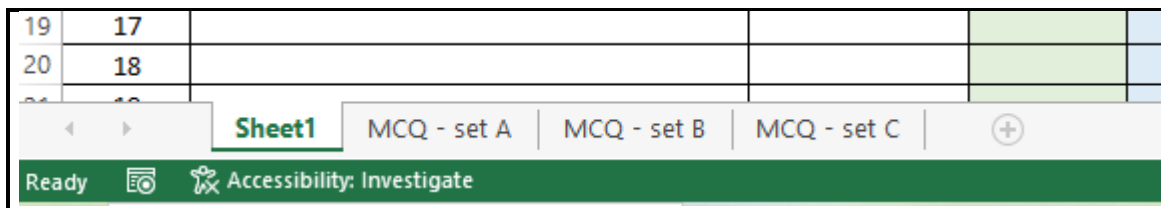


Figure 3: Creation of MCQ CLO filter files

In the MCQ set sheets, the student’s marks were segregated and summed up according to the assigned CLOs. “Sheet1” is meant for the display of the output data where the marks obtained by each student for each CLO are displayed. Maximum obtainable marks for each CLO in the question paper are also displayed separately on this sheet. As shown in figure 4, MCQ numbers were entered in row 2 and the CLO number assessed by individual questions were entered just above each question number in row 1. Student registration numbers were entered in column B in cells B3 to B52 (a total 50 rows, meant for 50 students). Now, the data of student marks for each MCQ was entered in the MCQ set sheet.

	A	B	C	D	E	F	G	H	I	J	K	L	M
1	S No.	Reg no.	CLO	1.3	1.1	1.1	1.1	1.2	1.1	1.3	1.2	1.2	1.2
2			Q No	1	2	3	4	5	6	7	8	9	10
3	1	1		0	0	0	1	1	1	0	1	1	1
4	2	2		0	1	1	1	1	0	1	0	1	1
5	3												
6	4												

Figure 4: Representation of MCQ filter sheet

If the student answered the MCQ correctly, 1 mark was given otherwise 0 mark was entered in the respective cell. Once the CLO assignment for all MCQs was done in the first row and subsequently

obtained marks for each student are entered accordingly. The marks obtained by individual students for each CLO are segregated and summed up by using the “SUMIF” function as discussed below. Formulae for this purpose are entered on the same sheet in rows number 59 to 110. CLO numbers 1.1 to 1.10 are entered in row 59 (cell C59 to L59), as shown in Figure 5. (10 CLO numbers were given, because the maximum number of CLOs in a block /course in our MBBS program is 10).

In cells B61 to B110, student’s registration numbers were automatically copied from cells B3 to B52 (Figure 4), by simply giving the cell references. Formulae to filter and sum up the marks for each CLO for individual students were given in rows 61 to 110.

The sum of marks for each CLO was done by using the “SUMIF” function. For example, the formula to sum the marks for CLO 1.1 for the student’s marks entered in row number 3 is “=SUMIF(\$D\$1:\$CY\$1,C\$59,\$D3:\$CY3). This formula took the CLO number given in cell C59 as a reference CLO number and searched this number in the CLOs assigned for each MCQ in row 1 (cell D1 to cell CY1), and then summed up the marks present in row 3 (cell D3 to cell CY3) assigned with this CLO.

In this way, the formulae were entered in each student row and for each CLO. The same procedure was done in the remaining sheets “MCQ – set B” and “MCQ – set C” and the marks of the students attempting the set A, B, or C were entered in their respective sheets only. After entering the “SUMIF” formulae, these rows were made hidden and secured so that there should not be any inadvertent modification, alteration, or deletion of the formulae.

	A	B	C	D	E	F	G	H	I	J	K	L	M
58													
59			1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	1.10	
60													
61	1	1	28	39	5	0	0	0	0	0	0	0	
62	2	2	17	35	7	0	0	0	0	0	0	0	
63	3		0	0	0	0	0	0	0	0	0	0	
64	4		0	0	0	0	0	0	0	0	0	0	
65	5		0	0	0	0	0	0	0	0	0	0	

Figure 5: Representation of sheet showing the sorted marks of MCQs for the given CLO for each student

Now, these CLO-wise summed-up marks were ready to be fetched by Sheet 1 for display which was done by another set of formulae discussed below:

In Sheet 1, rows in Columns B and C were assigned to enter the student names and registration numbers, respectively, as shown in Figure 6. The CLO numbers were entered in the first row from the cell D1 to M1. In this sheet, if the student’s name and registration number were entered in any row, the CLO-wise marks of that student appeared in the same row. Hence, it became very convenient to sort the data in the desired order of the student list. This functionality was achieved by combining the “VLOOKUP” and nested “IF” functions. Further, we added the “ISBLANK” and “IFERROR” functions in the formula, so that until unless we enter the name and registration number of the student, the sheet will not show an unnecessary ERROR message in each cell. For example, the formula used for the first student in the list for the CLO 1.1 was “=IF(ISBLANK(\$C3),”,IFERROR(IFERROR(VLOOKUP(\$C3,'MCQ-set A'!\$B\$61:\$L\$110,2,FALSE), VLOOKUP(\$C3,'MCQ-setB'!\$B\$31:\$L\$50,2,FALSE)), VLOOKUP(\$C3,'MCQ-set C'!\$B\$31:\$L\$50, 2,FALSE)))”.

The same formula was copied in all the remaining cells by using a fill handle, and by doing so the formula automatically adjusted the required cell references for each student and for each CLO.

	A	B	C	D	E	F
1	S No.	Name	ID	CLO 1.1	CLO 1.2	CLO 1.3
2				MCQ	MCQ	MCQ
3	1	A	1	28	39	5
4	2	B	2	17	35	7
5	3	C	3	28	52	10
6	4	D	4	26	55	9
7	5	E	5	18	24	6
8	6	F	6	24	35	6
9	7					
10	8					

Figure 6: Representation of the final output sheet for filtered marks obtained for each CLO by students.

In the same sheet, the total number of MCQs (maximum marks) assigned for each CLO was calculated by using the "COUNTIF" function. For example, the formula used to count the number of questions for CLO 1.1 was "=COUNTIF('MCQ - set A'!\$D\$1:\$CY\$1,Sheet1!P3)". the same formula was copied for each CLO by using the fill handle. This function counted the number of questions in the MCQ set-A belonging to the given reference CLO number (Figure 7). Each MCQ carries one mark therefore total number of MCQs for a CLO represents the total marks assigned for that CLO.

	P	Q	R
1	CLO Number	Total No of questions per CLO	
2			
3	1.1	33	
4	1.2	56	
5	1.3	11	
6	1.4	0	
7	1.5	0	
8	1.6	0	
9	1.7	0	
10	1.8	0	
11	1.9	0	
12	1.10	0	
13	Total MCQs	100	
14			

Figure 7: Representation of the total number of questions assigned to each CLO

This way, in Sheet 1, we obtained the data about the total marks assigned and obtained marks by each individual student for each CLO separately. Once the data was filtered out, it was ready to be copied to the CLO calculation Excel file.

CLO calculation Excel file for the block/course

The MBBS program has 34 blocks/courses, which has made us to design a CLO Excel file unique to each block/course because each block/course had its own specific CLOs and assigned PLOs.

In the Block CLO file, for each CLO, there was a separate sheet. Each sheet was named as per the CLO number as shown in figure 8.

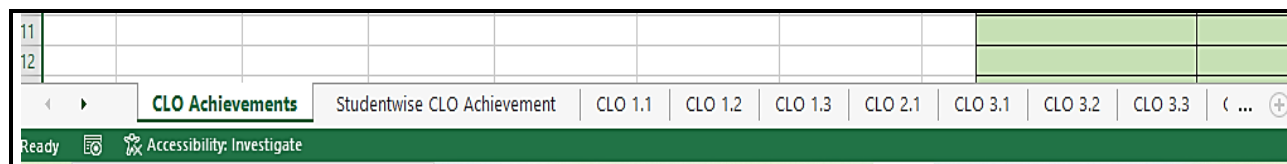


Figure 8: Representation of sheet assignment for each CLO

Column B of each CLO sheet is dedicated for the student names, and column C is for their registration numbers. Student names and registration numbers were entered in the sheet named “CLO 1.1”. In the remaining CLO sheets, these items were automatically copied from the sheet “CLO 1.1” by using the cell references. Each CLO sheet has separate columns for entering the marks from different assessment methods (MCQ, SEQs, MEQs, OSPE, OSCE, etc.) used to assess the concerned CLO. The names of the assessment methods were entered in row 17 (D17 to G17) and the total marks assessed by each method were entered just below the names in row number 18. Total marks assessed by the concerned CLO were summed up in cell H18 by using the “SUM” function. Individual student marks for each assessment method were copied from the CLO filter files. Now, the total marks obtained by the student for the concerned CLO were summed up in column H by using the “SUM” function.

The percentage of obtained marks was calculated in the column “I” (formula “=(L20/\$K\$18)*100”).

In the next column, “J” marks of each student are categorized as “Ideal”, “Acceptable” or “Poor” depending on the following criteria: Ideal: 90% or higher marks, Acceptable: less than 90 % but equal or more than 60 %, Poor: less than 60% Marks. Formula used for this purpose was “=IF(ISNUMBER(I20),IF(ISBLANK(B20),”,IF(C20=0,”,IF(I20<60%,”Poor”,IF(I20<90%,”Acceptable”,”Ideal”)))),”)”

Now a total number of students in “Poor”, “Acceptable” and “Ideal” categories were entered in the cells E10, F10, and G10, respectively, by using the “COUNTIF” function. The CLO outcome by Criteria 2 is entered in the cell F12 by using the formula “=IFERROR((((E10*1)+(F10*2)+(G10*3))/(F4*3)),”)”.

This Excel formula does the following calculation:

$$\text{CLO achievement (\%)} = [\{ (P \times 1) + (A \times 2) + (I \times 3) \} \div (T \times 3)] \times 100$$

In this given formula, P: number of Poor students, A: number of Acceptable students, I: number of Ideal students, and T: Total number of Students. The same procedure was followed for each CLO Sheet in the given block/course. The Screenshot of the CLO sheet (for CLO 1.1) is given in Figure 9.

After entering the data in each CLO sheet, the summary of all CLO outcomes was displayed in the “CLO Achievements” sheet. This sheet was linked to all the CLO sheets and copied the number of students under the “Poor”, “Acceptable” and “Ideal” categories from the respective CLO sheets (simple cell reference to the “E10”, “F10” and “G10” cells of respective CLO sheets were used for this purpose). In this sheet, the outcome for each CLO was displayed by both the criteria, “Criteria 1” and “Criteria 2”. CLO outcome by Criteria 1 was calculated by using the formula “=((F6+G6)*100/(E6+F6+G6))”.

Outcome by Criteria 2 was already calculated in each individual CLO sheet as discussed above and was copied from there by using the simple cell reference of cell “F12” of the respective CLO sheet. Figure 10 showed the screenshot of the “CLO Achievement” sheet.

CLO 1.1							
Total Students Number							
24							
Criteria				Manually enter the data in the cells highlighted by these colours. In other cells the values will be calculated automatically			
Poor		Acceptable		Ideal			
< 60%		60% - <90%		>=90%			
Number of Students in each Level							
8		16		0			
Actual Outcome							
55.56%							
Total Students Number Confirmation							
24							

No.	Students Name	Students ID	ILO Marks Distributions			Total Marks	Students marks as %	
			MCQ	SEQ				
			35	30		65		
Students Marks								
1	A	101	17.5	13		30.5	46.92%	Poor
2	B	102	17.5	13		30.5	46.92%	Poor
3	C	103	23.8	26		49.8	76.62%	Acceptable
4	D	104	30.8	22		52.8	81.23%	Acceptable

Figure 9: Representation of CLO 1.1 sheet

Medical Education Block							Academic Year	
Learning Domain	PLO Number	CLO Number	Number of students in each evaluation level			CLO Achievement		
			Poor (<60%)	Acceptable (60% to 90%)	Ideal (>90%)	Criteria 1	Criteria 2	
Knowledge	K3	1.1	8	16	0	66.7 %	{(No of Poor students x 1) + (Acceptable x 2) + (Ideal x 3)} ÷ (Total students x 3)	
	K3	1.2	3	20	1	87.5 %	56%	
Skills	S2	2.1	0	20	4	100 %	72%	
Values	V1	3.1	0	12	12	100 %	83%	
	V3	3.2	0	12	12	100 %	83%	
	V2	3.3	0	8	16	100 %	89%	
	V4	3.4	0	4	20	100 %	94%	
	V8	3.5	1	1	22	95.8 %	96%	

Figure 10: Representation of CLO achievement sheet

Excel file for PLO and GA calculations

After all the block/course CLO Excel files were ready with their CLO results. We used PLO and GA Excel files to calculate the PLO and GA outcomes of the MBBS program.

This Excel file worked in multiple steps as described below:

Calculation of year-wise weightage of PLOs and GAs: These calculations were done in the sheets named as “PLO weightage Year wise” and “GA Weightage”. The number of courses assessing a particular PLO in a year was summed up and % weightage to the overall MBBS program was calculated by dividing this by the total number of blocks and courses (i.e. 34) assessing this PLO and then multiplying it by 100.

Year-wise weightage of PLO assessment= (No of courses in particular year assessing that PLO ÷ Total No of courses in overall program assessing that PLO) X 100

Weightage calculation in Excel was done by assigning the number “1” for the PLOs assessed in a particular block/course (Figure 11).

Course code & No.	Program Learning Outcomes																	
	Knowledge and Understandings					Skills					Values							
	K1	K2	K3	K4	K5	S1	S2	S3	S4	S5	V1	V2	V3	V4	V5	V6	V7	V8
Health and Illness in the Community I HIC 211		1		1	1	1						1		1	1			1
Concepts and Principles of Medical Education CMD 211			1				1				1	1	1	1				1
Growth and Development CMD 212	1					1					1	1		1				1
Men, and His Environment and Metabolism CMD 213	1	1				1					1	1		1				
Clinical Skills I CMD 214			1						1	1				1			1	1
Principles of Disease CMD 221		1	1				1					1		1				1
Musculoskeletal and Integumentary Systems CMD 222	1	1	1			1					1	1		1				
No of Courses in this year assess PLO	3	4	4	1	1	4	2	0	1	1	4	6	1	7	1	0	1	5
Total courses sharing for that PLO	14	26	27	3	5	23	14	11	16	13	15	23	1	24	5	2	11	32
% of Courses in this year assess PLO	21.43	15.38	14.81	33.33	20	17.39	14.29	0	6.25	7.69	26.67	26.09	100	29.17	20	0	9.09	15.63

Figure 11: Representation of PLO weightage calculation for blocks/courses

The number of courses in a year assessing a given PLO was counted by summing up the numbers assigned for that CLO. The weightage of assessment for the given year is calculated by giving the formula to find the percentage of the courses assessing the PLO in the year to the total number of courses in the program assessing that PLO (Figure 12).

	PLO Weightage																	
↓ Year / PLOs →	K1	K2	K3	K4	K5	S1	S2	S3	S4	S5	V1	V2	V3	V4	V5	V6	V7	V8
% of Courses in 1st year assess PLO	21.43	15.38	14.81	33.33	20	17.39	14.29	0	6.25	7.69	26.67	26.09	100	29.17	20	0	9.09	15.63
% of Courses in 2nd year assess PLO	28.57	15.38	18.52	33.33	0	21.74	7.14	0	6.25	7.69	26.67	17.39	0	20.83	20	0	9.09	18.75
% of Courses in 3rd year assess PLO	28.57	19.23	18.52	33.33	20	21.74	0	0	12.5	15.38	26.67	17.39	0	20.83	20	0	18.18	21.88
% of Courses in 4th year assess PLO	21.43	26.92	22.22	0	0	13.04	50	45.45	43.75	53.85	13.33	21.74	0	12.5	0	0	27.27	25
% of Courses in 5th year assess PLO	0	23.08	25.93	0	60	26.09	28.57	54.55	31.25	15.38	6.67	17.39	0	16.67	40	100	36.36	18.75
	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100

Figure 12: Representation of year-wise PLO weightage percentage

Similarly, GA weightage was also calculated for each year (Figure 13).

GA Weightage						
↓ Year / GA →	GA 1	GA 2	GA 3	GA 4	GA 5	GA 6
% of Courses in 1st year assess GA	16.67	13.79	20	20.59	9.09	26.32
% of Courses in 2nd year assess GA	16.67	17.24	0	17.65	9.09	26.32
% of Courses in 3rd year assess GA	20	20.69	20	20.59	18.18	26.32
% of Courses in 4th year assess GA	23.33	24.14	0	20.59	27.27	5.26
% of Courses in 5th year assess GA	23.33	24.14	60	20.59	36.36	15.79
	100	100	100	100	100	100

Figure 13: Representation of year-wise GA weightage percentage

Importing the Data

The sheet named “Imported data” imported the CLO assessment data from individual CLO Excel files of all the blocks/courses in the MBBS program. For the sake of ease of giving references, the folder named

“CLO Reports” containing CLO Excel files of blocks/ courses, was kept in another folder along with this Excel file for PLO and GA calculation. Data from the CLO Excel files of all the blocks/courses was imported to the “Imported data” sheet, by giving the references to the cells of sheet 1 of all the CLO Excel files. Data imported include the Course name, CLO numbers, PLO numbers aligned to CLOs, CLO achievement by Criteria 1, and CLO achievement by Criteria 2. To cross-check whether the data was imported from the correct file, we have also given the link to the course name cell of the source CLO file in the third-row cell of the “imported data sheet” just below the label of the course. And if the name in both the second and third row of this file was exactly the same that meant the data was picked up from the correct CLO file. The screenshot is shown in the figure 14.

	AE	AF	AG	AH	AI	AJ	AK	AL	AM	AN
1	C9					P6				
2	HIC 1					Endocrine and Reproductive				
3	HIC 1					Endocrine and Reproductive Block				
4	PLO	CLO	Criteria 1	Criteria 2		PLO	CLO	Criteria 1	Criteria 2	
5	K2	1.1	72	57.33		K1	1.1	27.3	42.4	
6	K4	1.2	56	52		K2	1.2	18.2	39.4	
7	K4	1.3	92	70.66		K3	1.3	9.1	36.4	

Figure 14: Representation of the imported datasheet

Now, we copied the data (by giving cell references) from the “Imported data” sheet to another sheet named as “CLO achievements”. We used the data copied to this sheet for the next steps. We did not touch the “imported data” sheet again for the sake of avoiding any inadvertent errors, as this sheet was entirely made up of the links to multiple external CLO files.

Calculation of PLOs

PLO achievement calculations were done by Criteria 1 and Criteria 2 in two different sheets named as “PLO data C1” and “PLO data C2”, respectively. We prepared a table with the names of all PLOs arranged in the rows and the names of all the courses in the columns as shown in figure 15.

	A	B	C	D	E	F	G	H	
1	S. No.	1	2	3	4	5	6	7	
2	Course	Medical Education	Man, and His Environment	Principles of Disease	Growth and Development	MSK	Clinical Skills 1	HIC 1	End Rep
3	K1		4.2		4.8	13.3			
4	K2		4.2	33.3		20		72	
5	K3	77.1		16.7			100		
6	K4							74	
7	K5							44	
8	S1				14.3	26.7		68	
9	S2	100		58.3					

Figure 15: Representation of calculated PLO aligned to all CLOs in blocks/courses by Criteria 1

PLO achievement data for the courses was entered into this table by giving references to the appropriate cells from the “CLO achievements” sheet. In some blocks, there was more than one CLO for the given PLO, in such cases formula for taking their average was entered. The formula used for automated sorting and averaging was “=IFERROR(AVERAGEIF('CLO Achievements'!K\$5:K\$32,'PLO data C1'!\$A3,'CLO Achievements'!M\$5:M\$32),””)”. This same formula was entered in all the cells of the table. Obviously, the cell references in the formulae were different for each cell and were related to the respective courses and PLOs. This formula averaged the achievement for the given PLO if the same PLO is assigned for more than one CLO. In case, if a PLO is not aligned to any of the CLOs of the given course the formula will keep the cell blank. After the sorting and averaging of PLO achievement data, the same data was copied by the links to the two new sheets named as “PLOs Criteria 1” and PLOs Criteria 2”, for further calculation of year-wise PLO achievements. In these sheets, the data was represented in a different way, here the course names were displayed in rows, and PLOs were arranged in the columns to make it easier to sum up and represent the PLO achievements of courses under different years.

Yearwise PLO assessment was done for each PLO by taking the average of achievements of respective PLO by different courses in a particular year.

Example of the formula used is “=IFERROR(ROUND(SUM(C2:C8)/COUNT(C2:C8),0),”NA”)”

Overall PLO assessment for the program was done by averaging the PLO achievement in all five years for the given PLO.

Example of formula used is “=ROUND(SUM(C9,C17,C26,C35,C44)/COUNT(C9,C17,C26,C35,C44),0)”

The screenshot is given in Figure 16.

S.No.	↓ Blocks / PLOs →	K1	K2	K3	K4	K5	S1	S2	S3	S4	S5	V1	V2	V3	V4	V5	V6	V7	V8
1	Medical Education			77.1				100				100	100	100	100				95.8
2	Man, and His Environment	4.2	4.2									95.8	95.8		95.8				
3	Principles of Disease		33.3	16.7				58.3					100		91.7				91.7
4	Growth and Development	4.8					14.3					100	100		100				100
5	MSK	13.3	20				26.7					100	100		100				100
6	Clinical Skills 1			100							95.325	100			100			100	81.3
7	HIC 1		72		74	44	68							68	68	68			68
8	Average Achievement of PLOs in First Year	7	32	65	74	44	36	79	NA	95	100	99	94	100	94	68	NA	100	87
9	Endocrine and Reproductive	27.3	18.2	9.1			36.4					100	100		100				100
10	Haemopoietic and Immune Systems	30	20	10			10	20				100	100		100				100
11	Cardiovascular	63.6	63.6	63.6			86.4					100	100		100				100
12	Respiratory	90	100	90			100					100	100		100				100
13	Clinical Skills 2			89.1						93.75	100				81.3				81.3
14	HIC 2				37.5		75									100			100
15	Average Achievement of PLOs in Second Year	53	50	52	38	NA	62	20	NA	94	100	100	100	NA	96	100	NA	81	98
16	GI	62.5	100	62.5			100					100	100		100				100
17	Urinary System	66.7	22.2	11.1			22.2				88.9	100	100		100				100
18	Nervous System	37.5	75	12.5			62.5					100	100		100				100
19	Integrated Multisystem	88.9	66.7	22.2			44.4					100	100		100				100
20	Clinical Skills 3			100						92.875	100				100				92.9
21	Clinical Skills 4		93.1							93.1									93.3
22	HIC 3				44.4667	33.3	60									86.7			86.7
23	Average Achievement of PLOs in Third Year	64	71	42	44	33	58	NA	NA	93	94	100	100	NA	100	87	NA	93	98
24	ENT		100					100	88.9	100	98.1333								
25	Medical Imaging	100						100			100								100
26	Dermatology	25	62.5	100				100	100	100									100
27	Ophthalmology	100	87.5	87.5			100			100	87.5		100		75				100
28	General Surgery		100	100			100	100	100	100	100		100		100				100
29	Internal Medicine		50	62.5				100	100	100	87.5	100	100		100				100
30	Orthopedic Surgery		84.2	84.2			100	84.2		84.2	100		100						100
31	Average Achievement of PLOs in Fourth Year	75	81	87	NA	NA	100	97	97	97	96	100	100	NA	88	NA	NA	100	100
32	Family Medicine		100	100		87.5	100		100							100			100
33	Psychiatry		100	100		100	87.5	100	100	100							100	100	100
34	Emergency Medicine		100	87.5			100		100	100	87.5		100		100				100
35	Paediatrics		52.0833	59.375		75	100	100	100	100	87.5		100		100				75
36	Gynae Obs		100	100			100	100	100	100		100	100		100				
37	Forensic Medicine		75	87.5		56.25	87.5	100	62.5	100					100	100			100
38	Medical Ethics			100			91.6667								100				100
39	Average Achievement of PLOs in Fifth Year	NA	88	91	NA	81	90	100	94	100	88	100	100	NA	100	100	100	94	100
40	Overall average of 5 years	50	64	67	52	53	69	74	96	96	96	100	99	100	96	89	100	94	97

Figure 16: Representation of PLO achievement data sheet of all the blocks/courses.

Calculation of GAs

Calculations for GAs are done by both the criteria in the sheets named as “GA year-wise C1” and “GA year-wise C2”. Here, also the PLO data from the “PLO data C1” and PLO data C2” were taken through links and in a given course the PLOs serving to a GA are summed up and averaged as shown in the screenshot below in Figure 17.

		GA1	GA2	GA3	GA4	GA5	GA6
S. No.	↓ Blocks / Aligned PLOs →	K1, K2, S1	K3, S2, S3, S4, S5	K5, V6	V2, V4, V8	V7	K4, V1, V3, V5
1	Medical Education		89		99		100
2	Man, and His Environment				96		96
3	Principles of Disease	33	38		94		
4	Growth and Development	10			100		100
5	MSK	20			100		100
6	Clinical Skills 1		98		91	100	
7	HIC 1	70		44	68		71
Average Achievement of GA in First Year		33	75	44	93	100	93
8	Endocrine and Reproductive	27	9		100		100
9	Haemopoietic and Immune System	20	15		100		100
10	Cardiovascular	71	64		100		100
11	Respiratory	97	90		100		100
12	Clinical Skills 2		94		84	81	
13	HIC 2	75			100		69
Average Achievement of PLO in Second Year		58	54	NA	97	81	94
14	GIT	88	63		100		100
15	Urinary System	37	50		100		100
16	Nervous System	58	13		100		100
17	Integrated Multisystem	67	22		100		100
18	Clinical Skills 3		98		100	93	
19	Clinical Skills 4	93	93		100	93	
20	HIC 3	60		33	87		66
Average Achievement of PLO in Third Year		67	57	33	98	93	93
21	ENT	100	97				
22	Medical Imaging	100	100		100		
23	Dermatology	44	100		100		
24	Ophthalmology	96	92		92	100	
25	General Surgery	100	100		100	100	
26	Internal Medicine	50	90		100		100
27	Orthopedic Surgery	92	88			100	
Average Achievement of PLO in Fourth Year		83	95	NA	98	100	100
28	Family Medicine	100	100	88	100		100
29	Psychiatry	94	100	100	100	100	
30	Emergency Medicine	100	94		100	100	
31	Paediatrics	64	89		100	75	
32	Gynae Obs	100	100		100		100
33	Forensic Medicine	81	88	78	100		100
34	Medical Ethics	92	100		100	100	
Average Achievement of PLO in Fifth Year		90	96	89	100	94	100
Overall average		66	75	55	97	94	96

Figure 17: Representation of year-wise GA calculation sheet by Criteria 1

Year-wise GAs were calculated by averaging the GAs of courses in the respective years. And, finally, an average of year-wise GA achievements was done to find the overall GA achievements for the complete program (Figure 17).

Results and Discussion

Rigorous assessment of LOs plays an important role in outcome-based medical education and has become a major strength in ensuring that the learner has acquired the intended knowledge, skills, and values competencies. [5,6] Further, the attainment of these competencies shapes the medical graduates' professional medical lives to overcome the challenges.

Individual PLO and GA assessments identify the achievement of an individual in terms of learner outcome across multiple courses in the program. Although the process is complex, cumbersome, and time-consuming but development of customized automation tools or software programs makes it relatively easier to assess the LOs which has led to overcoming the major challenge in the implementation of outcome-based education in the college and/or institution. [5-7] This has been a vital component of the accreditation process.

This study demonstrated the details of the Excel software program and its operational functioning which has automated the process of calculating individual CLOs, PLOs, and GAs achievements in the MBBS program of the College of Medicine. The software program helped in the assessment of the courses in the program for the achievement of individual LOs and can also monitor individual student's progress and performance in a course and program.

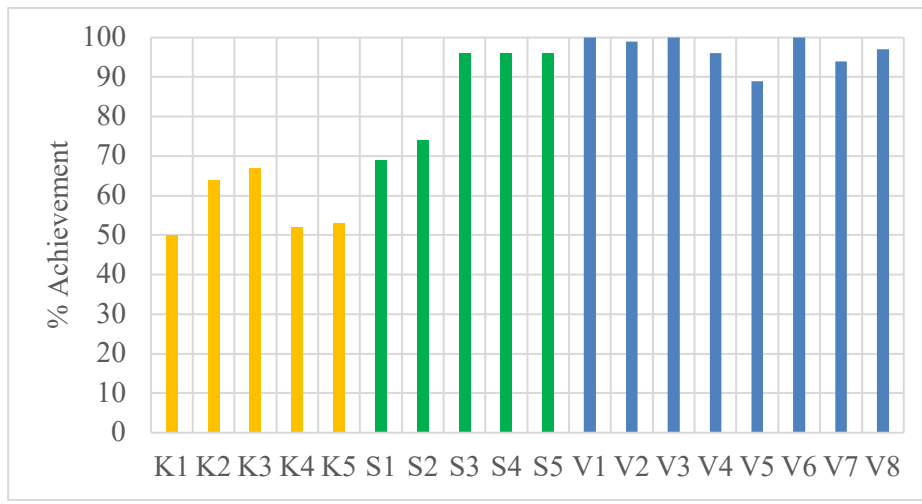


Figure 18: Individual PLO achievement of a cohort by Criteria 1

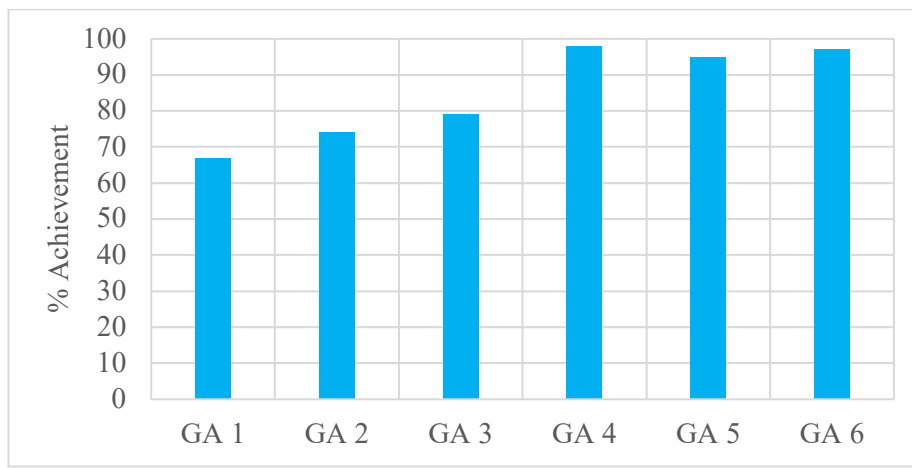


Figure 19: Individual GA achievement of a cohort by Criteria 1

Following the use of the developed Excel software program, the assessment of individual PLO and GA achievements by Criteria 1 was done in a cohort (1440-1444) in the MBBS program of the College of Medicine, as shown in Figures 18, and 19, respectively.

CONCLUSION

The automated Excel software program has produced a reliable procedure to assess the achievement of LOs at the level of individual students, courses, and programs in the MBBS program. This study aimed to make explicit the implementation of a well-documented and reliable automated procedure across the courses in the MBBS program for the calculation of LOs. The limitation of the software is that it requires to be customized for each course and program as the number of CLOs, PLOs, Gas, and their alignment varies from program to program. Further, it only works as an offline tool after downloading it. The online opening of the software in the Google Excel program can corrupt the files and values.

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(https://drive.google.com/drive/folders/1Dxs9pAWD2AYi5cyXbE5YKQl3CGEHu6dX?usp=drive_link)

The Excel program may be downloaded for trial. This program will work correctly after downloading only. It gets corrupted if you open it in the Google Sheet.

Conflict of Interest

The authors declare no conflict of interest relevant to this article.

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