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A PROPOSED AUTOMATED SYSTEM FOR QUALITY ASSURANCE SUSTAINABILITY OF ENGINEERING EDUCATION

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Abstract. *This paper presents a framework and methodology that facilitates implementing quality assurance principals at the field of Engineering Education. The focus is on delivering a "Semester Course Report" for all courses offered at the engineering school. The objective is to improve the quality of education, and to ensure sustainability of improvement achieved by continuous feedback of the running courses. The proposed framework is based on the programs outcomes, and thus courses outcomes as set and approved by the strategic plan of the university, feedback of program stakeholders, and the Accreditation Board for Engineering Technology (ABET). The system gives the instructor the ability to choose appropriate assessment tool for each outcome, and the Key Performance Indicators (KPI) that are planned to measure the quality of learning to end with list of actions that contribute to continuous improvement of learning process. An example of the automated produced report is used to illustrate the proposed methodology.*

1 INTRODUCTION

High education institutions and universities provide local society with a noble service through the process of education and learning [1]. In order for the universities to do this duty effectively, they need to apply a framework of procedures and good practices that aim to enhance their educational and learning activities [2].

Quality Assurance (QA) is one of the most important tools that universities employ to improve educational process by reviewing education programs systematically to ensure their conformance to the internationally accepted standards [3].

Faculty Course Assessment Report (FCAR) is one of the QA tools that high education institutions utilize to ensure effective management for their programs, and to ensure their students are assessed using standard methods that are implemented frequently. This tool uses information that are collected from both instructors and students to measure degree of acceptability or degree of course objective achievements, which will help defining a set of improvement actions that have to be followed. This report is created once a semester for each course offered at the school and for each instructor. The feedback attained from periodic review of FCAR is essential to sustain the improvement achieved [4-6].

Automating the process of generating FCAR will make the assessment process very simple, easy and will ease the analysis of collected data in order to identify the shortcomings in the learning process, and thus selecting the

appropriate remedial actions to get rid of these shortcomings. In addition, this will help reducing massive amount of administrative paper work that normally overwhelm the faculty staff especially at the early stage of preparing for an accreditation visit. Furthermore, it will reduce resistance against suggested changes and remedial actions for the current education process. Therefore, increase the faculty engagement in the course assessment process [6,7].

This paper suggests a method of preparing FCAR for courses offered at the Engineering college based on the courses outcomes. The system gives the instructor the ability to choose appropriate assessment tool for each outcome, and the Key Performance Indicators (KPI) that are planned to measure the quality of learning to end with list of actions that contribute to continuous improvement of learning process.

11 THE PROPOSED APPROACH

A friendly user interface is developed to help the course instructor delivering the course report within a very short time, and using a systematic procedure. The flowchart that describes the proposed algorithm to generate FCAR is shown in Figure 1.

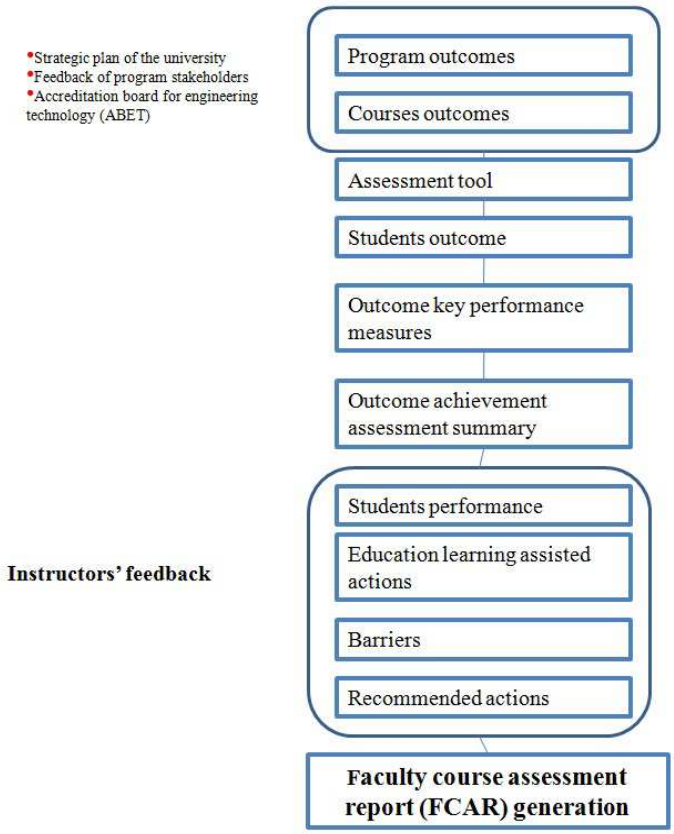

Figure 1. Flowchart of the steps used to generate faculty course assessment report.

The process starts by selecting the expected outcomes of the course among program outcomes that were set using feedback of the program stakeholders to match strategic plan of the university and approved by accreditation committee using drop down menu, as shown in Table 1. For each outcome, the instructor selects the appropriate assessment tool using drop down menu. The program provides the instructor with a large set of possible assessment tools; including: test questions, home works assignments, graded reports, quiz, presentation, term paper, project, class discussion, or any other class activities. The assessment tool drop down menu is shown in Table 2.

Program Outcomes	
a	**Apply knowledge of mathematics, science, and engineering principles in solving industrial problems.**
b	**Design, develop, and conduct engineering experiments and analyze outcome data.**

Table 1: The selected program outcomes for Engineering Material course offered by Industrial Engineering Department of Jordan University of Science and Technology.

Outcome	Assessment Method
a	**Test Question**
	Homework Assignment
	Graded Report
	Quiz
	Presentation
	Term Paper
	Project
	Other Class Activity

Table 2: The assessment method as selected by instructor to assess outcome (a).

After selecting the wanted assessment tool, a pop-up window appears to give the user ability to add the used test question, the measured skill and to attach a scanned copy of selected examples of the student graded exam paper, course report, quiz, as provided by Table 3.

Outcome a	Assessment Method : Test Question
Measured skill	Measure ability of students to relate basic science knowledge about **atomic structure and bonding** to properties of the material.
Question	

Outcome b	Assessment Method : Test Question
Measured skill	Measure the ability of student to **design an experiment** to produce material with a predetermined set of properties.
Question	

Table 3: Example of the pop-up window used to assign test questions to measure the skills corresponds to the selected courses outcomes.

Next, for each assessment method selected, and after choosing the question that will be used to measure the skill corresponds to a specific outcome, the program is designed to give the instructor ability to attach excel sheet that shows the list of students with their assigned scores, as shown in Table 4.

Outcome (a) students grades				
Serial number	Student Name	Student Number	Assigned Score	Notes

Table 4: Excel sheet that shows the class students scores for the measured outcome

In the next step and for each one of the predetermined course outcomes, the instructor select the key performance indicators (KPI) that the user intended to use for evaluating the student' performance in that outcome using a drop down menu, as the one shown in Table 5. The program gives the user the capability to measure one or more KPI. In addition, the user can add a customized KPI that better suit for the selected outcome assessment.

Outcome	Performance Measure (KPI)	Target
a	%Students who answer 50% of the question correctly	80%
	%Students who answer the entire question correctly	
	Average grade	65%
	Other	

Table 5 : Outcome performance measure drop down menu

For each one of the predetermined course outcomes, the program will show a set of tables, one table for each performance measure selected in the previous step. These tables are designed to compare between the desired target value of KPI as defined by the instructor, and the KPI attained value as computed from excel sheet based on the students performance. A histogram that demonstrates the distribution of students' grades in that KPI is also provided. An example of these tables is shown in Table 6.

Outcome	Performance Measure 1		Distribution of Grades
	Target	Attained	
[ABET a]			

Table 6: Target and attained KPI table with students grades distribution for outcome a and performance measure number 1

As mentioned earlier, the main goal of the FCAR is to measure the degree of course objective achievements, in order to identify shortcoming in the learning process and to define a set of improvement remedial actions that have to be followed in order to get rid of these shortcomings. The feedback attained from FCAR is essential to sustain the improvements achieved. In the proposed algorithm, the instructor's feedback is collected using four tables. The first table, Table 7, is assigned to report the students' performance; including: students class activities, exam performance, performance in homework's and assignments, teamwork skills, and the capability to search web and gather information. The instructor reports performance on a Likert scale, where 1 indicates that the overall performance is very poor and needs major improvement, and 5 indicates that the performance is excellent, and no major action needed. The reported information in this table are based on the instructors' observation throughout the semester.

Instructors' Feedback					
Students' Performance	**Overall rating**				
	Excellent	Very good	Good	Fair	Needs improvement
Class activity					
Exam performance					
Homework, assignments					
Teamwork and communication skills					
Gathering information capability					
Others					

Table 7: Instructors' feedback about overall rating of the students' performance

The information about activities that facilitate education and learning process is very important piece of FCAR. In this section, the quality of the used text book, transparency of exam questions, and clarity of supportive examples and analogies used by the instructor to explain the covered concepts and ideas are evaluated on a Likert scale (1-5). The quality with low score is a clue for a strong need for review, and it shed lights into aspects that have to be modified prior to the next time teaching the course. Table 8 represents an example of the proposed table for education and learning assisted actions.

Instructors' Feedback					
Education & Learning Assisted Actions	**Overall rating**				
	Excellent	Very good	Good	Fair	Needs improvement
Text book quality					
Exam questions transparency					
Supportive practical examples					
Supportive analogies					

Table 8: Instructors' feedback about overall rating of education and learning assisted actions.

Factors that act as barriers to the education and learning process have also to be reported. In the proposed algorithm, these barriers are classified into seven major groups, which are: language, class room, course contents, intangible outcomes, intangible assessments, insufficient examples, and technological barriers. Each group is made of factors that share a common thread, and it is designated by alphabetical letter from A to G, respectively. The factors that belong to the same group have two digit code, where the first digit is the parent group designation, and the second digit is a factor serial number. Table 9 shows the proposed table to report the aforementioned educational barriers. When the barrier is present, the instructor can add (√) to indicate its presence, and a percentile for its rating. In case the barrier is not significant with rating less than 50%, the (√) is not used in its corresponding' cell.

Instructors' Feedback				
Barriers		✓	Overall Rating (%)	Code
Language				
	Non mother tongue			A1
	Others: Specify			A2
Class room				
	Number of enrolled students			B1
	Noise in class room			B2
	Visual distractions			B3
	Lighting			B4
	Desks			B5
	Others: Specify			B6
Course content				
	Amount of topics covered			C1
	Structure and complexity of problems			C2
	Difficulty interpreting data			C3
	Others: Specify			C4
Intangible outcomes				
	Changed attitude and mindset of students			D1
	Capability of linking the material presented with program mission			D2
	Others: Specify			D3
Intangible assessment				
	Final answer questions			E1
	Inappropriate distribution of questions			E2
	Others: Specify			E3
Insufficient examples				
	Low number of solved problems			F1
	Limited class time			F2
	Unavailability of teaching assistants			F3
	Others: Specify			F4
Technological barriers				
	Insufficient computer laboratories			G1
	Unavailability of modelling and simulation software			G2

	The use of old hardware			G3
	Others: Specify			G4

Table 9: Instructors' feedback about educational and learning process barriers

The last section of the FCAR is designed to present some suggested recommended actions that can be taken in order to either eliminate barrier or reduce its impact on the educational and learning process. The program provides the instructors with ability to insert any actions that can be used to deal with a particular barrier. Implementing these recommendations is expected to improve the quality of learning process, and it will help sustaining the improvement achieved. Table 10 presents an example of the proposed recommended actions that are expected to reduce impact of education and learning barriers.

Instructors' Feedback	
Barrier Code	**Recommended Actions**
A1	Encourage students to enroll in an English course to improve their linguistic skills and proficiency
	Use simple vocabulary
A2	
B1	Recommend reducing class size by setting a limit for number of enrolled students
B2	Apply university rules that prohibit creating noise and disrupt lecture firmly
B3	Remove anything blocks students vision in the classroom
B4	Enhance lightening system in the classroom
B5	Use more comfort desks for the students
B6	
C1	Review course curriculum and eliminate any repetition and less important sections
C2	Look for new methods to present problems simply
C3	Use more examples to enhance students capability to interpret data
C4	
D1	
D2	
D3	
E1	Use different kinds of questions that measure capability to follow sequential steps to solve problem
E2	Review exams and redistribute questions to cover all sections included
E3	
F1	Increase number of solved problems at the class as much as possible
F2	Organize for extra lectures wherein extra problems can be solved
	Review course curriculum and eliminate repetition and unnecessary sections
F3	Request assigning teaching assistant for the course
F4	

G1	Coordinate with other departments for using their computer laboratories
	Increase number of accessible computers for the students
G2	Purchase specialized simulation and modeling software
	Encourage students to use free educational copy of the software's on web
G3	Renew instructional equipment and tools
G4	

Table 10: An example of the proposed recommended actions that are expected to reduce impact of education and learning barriers.

111 CONCLUSIONS

In this paper, we introduced a new approach for quality assurance sustainability in engineering education. The proposed approach provides an easy, simple, and efficient tool for accessing the assessment results as well as tracking the suggested recommendations and remedial actions. The proposed approach can be extended for use in any educational program as long as the program outcomes, and course outcomes are identified.

The outcome of the proposed approach is FCAR with the main focus on instructors' feedback about students' performance, educational and learning process facilitators, projected barriers, and recommended remedial actions. Implementing recommendations is expected to significantly enhance the quality of education and learning, and eliminate or reduce impact of process barriers.

The simple and the friendly user interface of the program will help reducing massive amount of administrative paper work that normally overwhelm the faculty staff.

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