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A Unified Quality Control Model for E-Learning Systems

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ABSTRACT

Defining, measuring, and achieving quality of e-learning systems are not an easy task. Accordingly, one of the most essential goals for the higher educational institutes is how to reach a high and satisfied level of quality in their learning systems. Achieving such level needs adequate and continuous improvements for the whole e-learning environment elements. Therefore, we aim in our work to construct a unified framework for total quality management system (TQMS) that attempt to satisfy the quality requirements, needs, and standards. The objective of this paper is to present a quality control model for e-learning system that adopts the e-learning platform according to the on-line determination of both user's requirements and global standards. This paper proposed software architecture of quality Management framework for e-learning that could be adopted by different higher education institutes to control the quality of the e-learning process, and assure the quality of the e-learning process outcome. The proposed framework is based on a tri-dimensions quality model. The three dimensions are set of quality requirements for e-learning environment represented in Quality Assurance (QA) policies that will be formalized by using policy based approach, the specifications of e-learning platform that provide learning and teaching activities, and quality control process loop. The architecture for monitor and ensure quality control of the QA policies for e-learning system will deliver the whole learning services in an optimal way. It is also flexible and can be implemented over any e-learning system.

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1. INTRODUCTION

The essential goal of educational quality processes is to ensure the quality of academic and education process development to meet its required purposes. E-learning is an effective learning practice using technological means to convey digital content with learning support and services [1] that transfer knowledge from education's resources to the learners. However, without applying the term "quality" on E-learning key elements, the process of education will fail. However, the difficulty lies in the term "quality" is that having various meaning from different perceptions and based on the understanding and objective of educational purposes, it seems to be extremely hard to easily defined quality of education. According to Pawlowski [9], quality in the field of e-learning is not associated with a well-defined measure. It is variable with respect to scope, perspective, and dimension. The expected quality needs to rely much more on the objective and level of education itself, and then different quality standards may become applicable to

measure achievements and extents of quality at different levels of education [6]. Quality of e-learning can be understood as to provide high-quality learning opportunities enable students to acquire better cognitive skills [1].

Appling Quality Management (QM) approach can realise the quality of e-learning. QM defined as management system to direct and control an organisation with regard to quality [11]. Quality Management is an activities and tasks that determine and implement quality policy intended to achieving quality of product and services through developing Quality Assurance (QA) and Quality Control (QC) methods [18]. According to ISO, Quality QA is defined as part of QM focused on providing confidence that quality requirements will be fulfilled. QA generally means systematic and planned events as procedures, actions, attitudes, and policies that are required to offer enough trust in quality enhancement and maintaining, and also to assure that services and products are met the quality standards. Quality Control (QC) is a process whereby an authorized agency performs monitoring and check-up to determine if the institutional services or products meet the prescribed standards. Quality check in the higher education sector is most likely be administered by external entity to the institution for neutrality purposes. The result of quality control check is usually a collective responsibility of the institution. Since QC process is to approving product quality or rejected it after some criteria have been checked, this might be highly cost if there isn't systematic and planned managed processes ensure the quality requirements in order to check it with the quality standards. Hence, QC led to necessitate of carry out QA process to take place.In the context of e-learning, quality is to provide high-quality learning opportunities enable students to acquire better cognitive skills [1]. Ensuring and controlling the quality of e-learning can be through controlling institution QA policies that govern the academic activities carried out within e-learning environment. An effective academic activities, particularly teaching and learning process provided by e-learning environment are based on managing the requirements of multidimensional disciplines for academic quality including pedagogical methods, technological aspects, administrative strategies [2], [3] , and the e-learning users' requirements [6] such learning management, resource support, ethical, institutional support and students' learning services functionalities and international standards. Thus, QA policies must consider the above elements as e-learning quality requirements. So, e-learning specifications must be able to carry out academic activities that can meet the requirements of quality assurance policies. The proposed approach in this paper is to realising the quality of the e-learning through applying QC processes which monitoring e-learning specification in respect to QA policy as means that govern the e-learning in order to achieve academic quality management which help learners meet the standard to reach their qualification. The QC processes including: monitoring, data gathering, evaluation, and decision making stages.

The paper is organised as follows: in section 2, presents the e-learning environment architecture. Section 3 shows applying the quality control on the e-learning mode. Quality Control Model Framework (QCMF) for e-learning systems is proposed in section 4, as well as presents the architecture of quality control illustrates the mechanism of implementation of the proposed approach for the e-learning environment. Finally, section 5 shows case study. Section 6 will have the overall conclusion of this study and set future work.

2. RELATED WORKS

Many researchers have been worked to develop an E-learning quality framework; their focus was to adopting and adapting the quality evaluation models based on software quality approach such ISO 1926 model which focused on the software part of the process. The quality of the E-learning is being assessed based on general characteristics such as: usability, accessibility, reusability and portability of content, security and performance. For example, [7], [13] collected the major quality aspects of software development and reflected them on the Learning Management System (LMS) as software, [8] Proposed e-learning evaluation system based on a same model, also, [12] described a quality framework that is largely based on the ISO 1926 software quality discipline. This might be adequate if the target is to check the quality of the software as an isolated unit. However e-learning is not just technological software side but maintaining and managing of educational activities that are essential for evaluating the e-learning quality. For instance, one of the quality characteristic of software quality development is the usability, which can have a different meaning based on the process that is utilising the software. In e-learning, usability is also measured from the point of view of the learner, and its purpose is to ensure that the quality of the outcome of the e-learning process is similar to the one obtained through the traditional learning process if not better. Accordingly, this feature should be measured with taking learning aspects into consideration such as measuring pedagogical activities in producing usable learning material that improve learning. However, focusing on the software quality assurance and control for e-learning does not mean total absence of a comprehensive work that focuses on the quality of the e-learning process taking into consideration all aspects of the process. An example would be the work done in [1], where the focus is shifted from the software quality assurance to the quality

assurance of all the components of the e-learning system as can be seen in Figure (1). While the different aspects of the quality are being generally covered for e-learning, no formal measures or implementation details are being proposed.

In order to developing a model that can enforce the quality of e-learning systems, all elements that control the quality of e-learning systems including of technological, pedagogical and administrative domains need to be monitored, measured, and managed to governing the quality of e-learning. Designing such integrated quality control framework with e-learning will provide continues enhancement of learning process provided by e-learning system. Researchers worked to come with solid governing quality framework for the traditional learning. The same quality frameworks cannot be simply adopted for the e-learning process because of the differences in the environment in which the learning process takes place, the roles and characteristics of the learner, educators and many others aspects, factors, and attributes that must be considered.

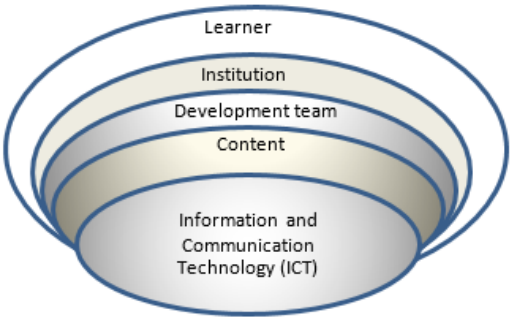


Figure 1. E-learning Systems Environments [1]

Governments and educational institutes started working on quality tools and frameworks to control the outcome of the e-learning process. Despite of all the efforts, having a standard quality framework for e-learning is very complex. Major reason causing the complexity of structuring a practical quality framework for e-learning is the large number of disciplines participating in the process. Other reasons for this difficulty [5] are:

a. Different educational systems
b. Different learning cultures
c. Learners preferences
d. Learners national and regional characteristics

This study is desire to construct a unified framework for total quality management system that attempt to assuring the quality requirements, needs, and standards as well as enforcing QA policies to E-learning in order to the promotion of e-learning quality for higher education institutions for a sustainable quality of learning and teaching. Therefore, implementation of a mechanism for QA and QC procedures for e-learning is very crucial process for quality of e-learning solutions. These procedures should take into account all the inter-related aspects of the learning process such as system design, learning content design and delivery, student development and support, student communication and representation, and student assessment in e-learning environment. There are a lot of standard architectures for e-learning systems and there are no single universal standard wholly agreed upon. As the Institutional requirements are usually the cause for differences from one institution to another. Therefore, in this paper, the nominate architecture depends on both the institutional requirement and the e-learning product itself. The e-learning model can be considered as a logical hierarchal multi-layer model [16], as shown in Figure 2.

The architecture address the functionality of learning processes such institutional support and students' learning services, interface design, evaluation, management, and resource support as well as considering pedagogical, technological and administrative models. The architecture model of e-learning composed of five different layers organized as follows:

Layer 1: Learning environment Layer, that include a general interface serves as an access point for the users, and allows them to see the necessary information depend on the user authorisation, as well as the login process to the system and the presented activities.

Layer 2: Management Layer, It is the main layer that manages the learning process services and content. It includes three sub-layers: System Management Software (SMS) responsible for support the general administrative aspects by managing the activities of the interaction managing general user, general event, and general communication and managing the interoperability of e-learning system with other systems. The

second sub-layer is Learning Management System (LMS) manages the processes surrounding learning activities. It includes management tools for all learning process services for all actors within e-learning environment starting from learner management tools, instructor management tools, course tools, administrator management tools, assessment, and evaluation. The third sub-layer is Learning Content Management (LCMS), it is a multi-user environment where learning developers can create, store, reuse, manage, and deliver digital learning content from a central object repository. It manages the process of creating and delivering learning content. LMS needs the interchange of user profile and user registration information with other systems, the location of the course from LCMS and gets the learner action from LCMS. The interoperability of LMS, LCMS and
SMS should be effectively integrated and consistently work together in order to realize the requirements of educational systems [2], [14].

Layer 3: Learning and Information Layer, this layer has all learning process information. It divided into two sub layers: Learning style sub-layer, where all learning scenario are defined based on tools enables the educator to develop and organised the course to fit all learner's preferences, such learner monitoring tool and feedback and tools enables learner to personalising their learning style. The other sub-layer is learning policy sub-layer, where all learning policies that govern the learning process outlines the minimum requirements and have been formalised.

Layer 4: Repository Layer: it is a relational database. This layer is divided into two sub layers. Learning Content and course data sub- layer: which learning object, learning object metadata, course information (test, quiz, lesions) are stored in this layer under LCMS control. The other sub-layer is user data sub-layer, which responsible for all user information including user portfolio, administrative repository, and assessment information and so on.

Layer 5: Multimedia Layer: the functionality of this layer is to create, design, edit, and store media component (audio, video, etc.) either from external or exist resources.

Operational academic activities performed based on the e-learning functions. Each function has a set of specifications based on the logical layers architecture that enables to accomplish academic activities (e.g. course delivery, student assessment, etc). Therefore, the academic activities which are delivered through a set of the e-learning environment tools, which in turn are based on the functionality of the logical layers of the e-learning environment need to be assured to be compliance with academic quality policy. Thus, there is a need of systematical approach for quality assurance of e-learning capable to control the quality of practical activities of the academic process. The quality control mechanism of e-learning environment can ensure the quality of the academic activities through monitoring the functionalities and attributes of e-learning specifications which allow performing these activities

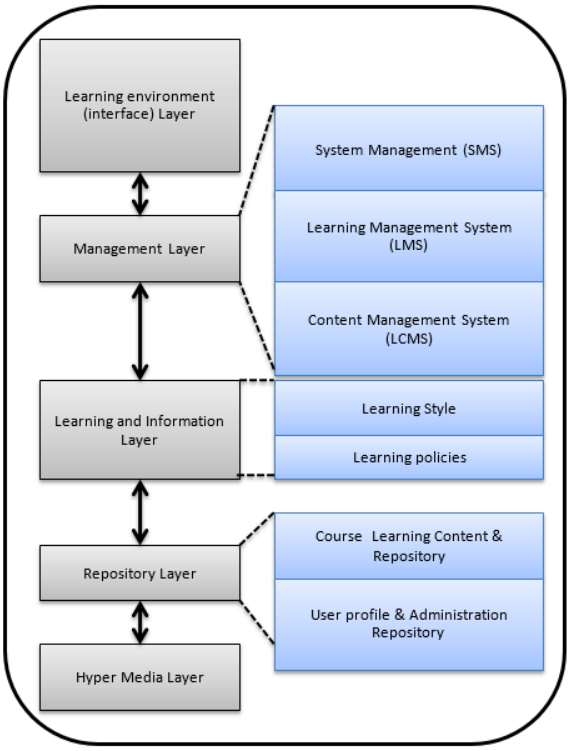


Figure 2. Logical Layers architecture of e-learning system [16]

3. PROPOSED FRAMEWORK

In order to developing the total Quality Control Framework (QCMF), quality control process activities should apply on the e-learning environment with consideration of QA requirements for e-learning environment. The quality control mechanism should control elements, disciplines, and aspects of the e-learning system among monitoring e-learning specifications that enable academic activities to be performed based on quality requirements. The framework should improve all levels of the institution with the aim of contributing to design an implementable QA/QC model for e-learning environment. The QC process ought to ensure e-learning specification by establishing QA policies that reflect the quality requirements for e-learning environment.

3.1. Quality Requirement to Assure e-learning (QA policy)

The first step to design QCMF is defining the quality requirements. According to [15] using (3p) model can provide a full picture of quality for e-learning. Three fundamental elements in quality approach are People, Product, and Process (3P) have to carefully consider and enough investigation for total enhancement and improvement. Thus, the process and functionality of the e-learning must achieve the pre-defined requirements with consideration of the stakeholder (administrator learner, manager, instructors) satisfaction. On the other hand, in order to support learning process, all elements that control the quality of e-learning including technological, pedagogical and administrative aspects as well as the integration of these aspects need to be ensured with take into account stakeholders' satisfaction; learning outcomes; environment facilities; and assessment facilities [14], [2], [3-4]. The quality assurance policies must reflect these quality requirements in term of academic activities and learning process in e-learning environment to control the quality of learning process in e-learning environment.

3.2. Quality Control on e-learning Architecture

Quality control (ISO 9001: 2000) involves overseeing the development process of a system to ensure the quality assurance procedures, and reports must be defined and applied during the development process [1]. Appling Quality control processes over the logical e-learning architecture for learning process will assist to guarantee the transformation of knowledge from its resources to the learners. The performance of e-learning environment components should be continuously monitored, analyse, and measure the specifications that relay on e-learning layers: interface, management, learning and information, repository and multimedia from different angles in order to control and enforce learning quality policies. The

continuous quality improvement loop for effective quality control model (general control loop or feedback loop) [10] applied to e-learning environment as shown in Figure 3 to ensure achieving quality objectives. The model focuses on controlling e-learning environment through monitoring e-learning specifications that enable academic activities to be performed based on quality requirements (starting from here requirements will be called QA policies).

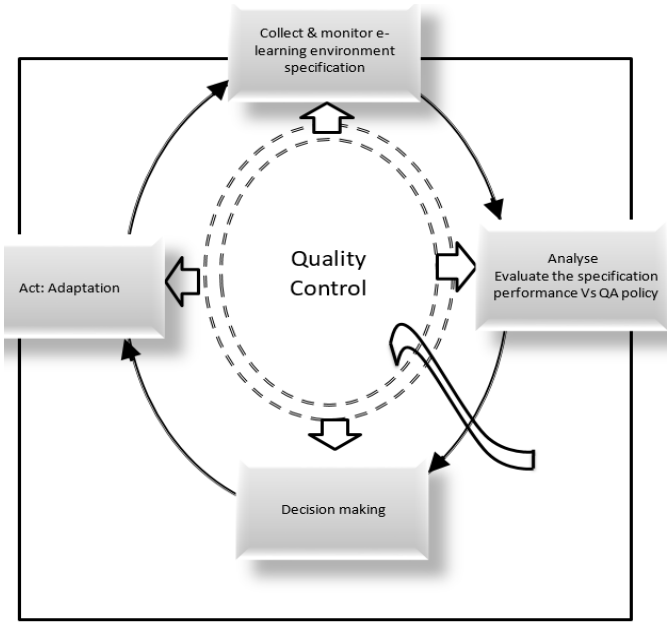


Figure 3. The proposed quality control loop for e-learning model

Monitoring the functionality of learning process in e-learning environment can be realised through observing the performance of the e-learning components specification. The monitored data that reflects the performance of each component's specifications need to be collected and analysed. Data gathering process collect all related quality data from monitoring process for analysing purpose. The next stage will be an evaluation of the quality regarding e-learning environment and its requirements of learning process quality took a place before taking action in decision and adaptation processes in the final stage of QC processes.

3.3. The proposed generic Quality Control Model Framework (QCMF)

The framework focuses on controlling e-learning environment through monitoring e-learning specifications that enable academic activities to be performed based on QA policies. A generic framework for total quality control model is proposed as shown in figure (2) for controlling and monitoring the e-learning environment. The proposed framework is based on a three-dimensional model as follows:

QA policies are a set of rules to maintain the aspects characterise quality of e-learning environment to support user's activities in the e-learning environment. The activities are based on pedagogical and technological quality, administrative aspects quality requirements. In addition, the considerations of learning process activities that support all involved stakeholders (administrator, manager, teacher, and learner) within the e-learning environment are taken into account in this dimension as well and it formalized as institution.

E-learning environment specifications. Academic operational activities are performed based on e-learning functions. Each function has a set of specifications based on the functionality of e-learning logical layers architecture that enables to perform academic operational activities (e.g. course delivery, student assessment, etc). The quality control mechanism of e-learning environment can ensure the QA policies through monitoring the operational academic activities includes E-learning academic, management, course delivery and development activities, as well as activities that provide and support recourse, services. General quality control loop is totally managing the quality for e-learning environment. It includes monitoring and data gathering, evaluation, decision and adaptation processes. The objective of designing Quality Control model is for managing and assuring the quality of e-learning specifications by monitoring and measuring the academic process activities from different angles. The behaviour of e-learning system will be monitored among e-learning components specification (functionality, and attributes) that facilitated by e-learning

environment participants which must be governed beads on QA policies (set of sequence quality procedures). The three dimensional QC model contains all quality control processes embedded into e-learning environment, and the learning quality requirements related to all stakeholder and the different e-learning aspects. Figure 2 illustrates the protocol technique of applying QC processes to e-learning environment. Each QC process stage checks the quality for e-learning specifications in respect to all aspects and stakeholder quality requirements. The suggested quality control model provided is to construct a unified framework for total quality management system (TQMS) that attempt to ensure and control the quality requirements, needs, and standards for e-learning environment. It is based on general control loop embedded into the e-learning model by the integration of the suggested three dimensions model. All quality control processes are embedded into e-learning environment with consideration of learning quality requirements related to all stakeholder and aspects (pedagogical, technological, services). Next section will discuss the implementation approach for such model.

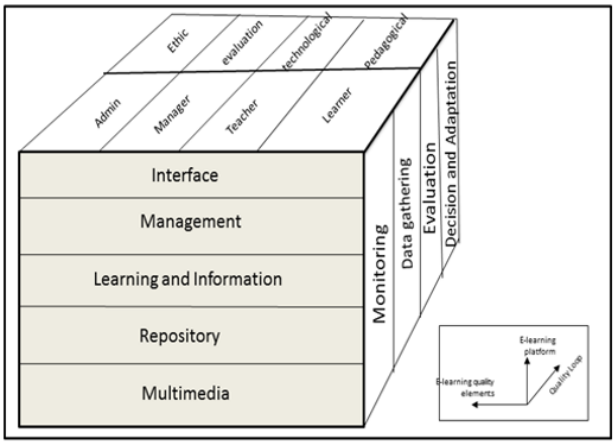


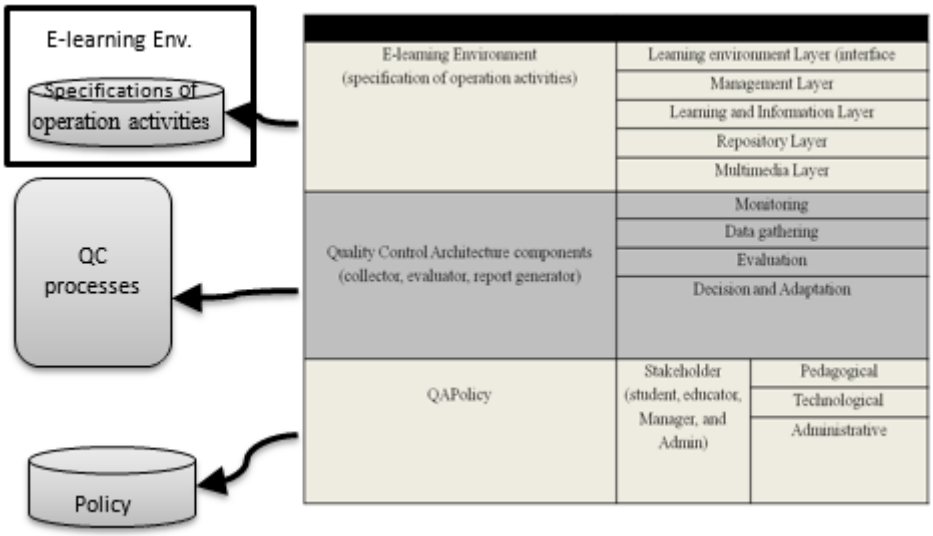
Figure 4. A generic total quality control model framework

4. IMPLEMENTATION

4.1. Architecture of Quality Control Model for e-learning system based on the proposed QCMF

The approach of this study is to control and ensure the quality of the e-learning environment through a mechanism of monitoring and evaluating the academic activities performed by the e-learning system specification against quality policy. The mechanism is based on suggested generic QC model presented in previous section. Table 1 shows the mapping of QC architecture components with generic QC model where both QA policy and e-learning specifications stored in policy and e-learning environment repositories respectively. The mechanism includes a software tool for monitoring purposes that collect and obtain all specifications of interest of e-learning environment from e-learning database in order to handle it for the purpose of checking and evaluating. Theses monitored data based on predefined quality requirements which are institution QA policies. The quality assurance policy is extracted and refined from institution quality assurance regulations at all levels and stored in policy repository. The output of this process will be includes policy that have been checked with the decision action in weather the current e-learning system have satisfied the policy by meeting its requirement or not. All information of this policy and the decision action will be passed to the next step where, a report of the current e-learning system quality "quality case report" will be prepared according to how far the system quality results meet the institution policy. The quality report have all evidences and facts of the quality case which includes positive and negative points of the current e-learning system, Figure 5 shows the architecture and Figure 6 shows the use case diagram for the system.

Table 1. Mapping of QC architecture components with generic QC. Model



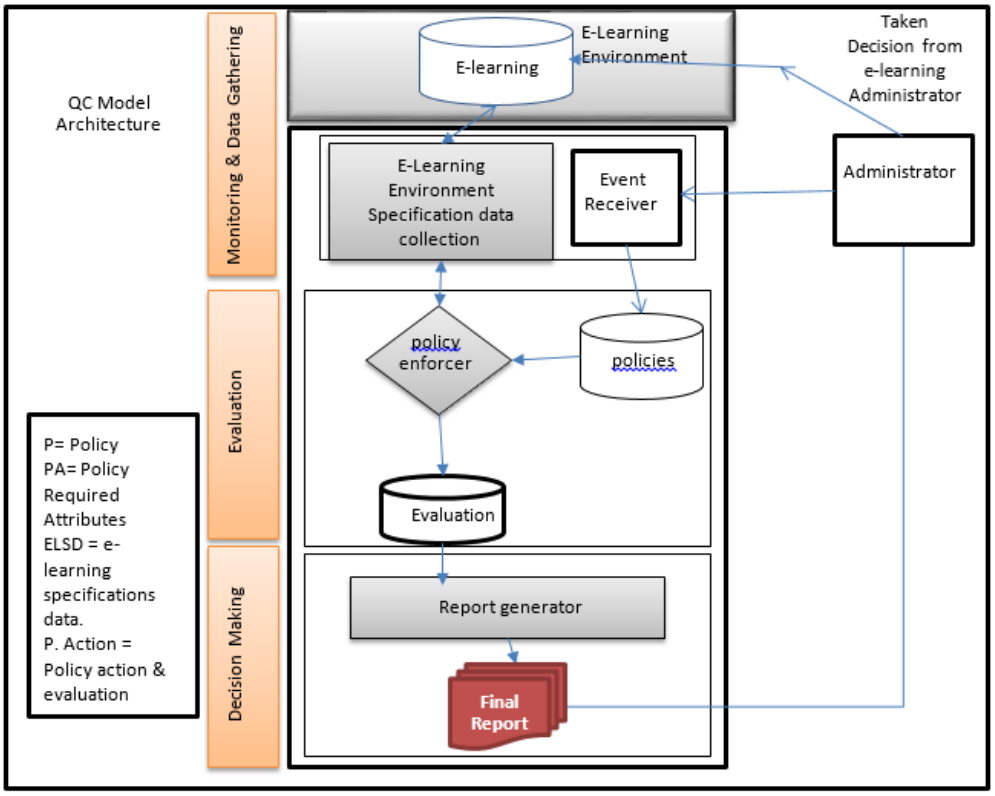


Figure 5. Quality control model architecture for e-learning. System

Detailed description of the functions for each component in the architecture will be introduced as follows.

4.1.1. Collector Component

This component will receive a set of properties of e-learning system that needs to be ensured from QA administrator (e.g. checking assignment start date functionality), each property will consider as firing event. Also it will receive a set of policies and its attributes represent quality requirements from evaluator component. Representation of the policy will be introduced in section (2.2.2.ii.). Collector component will access to the current e-learning system repository to fetch e-learning specification of these attributes and its

current values. The fetched data will send back a sequence policy attributes with its values to *evaluator* component.

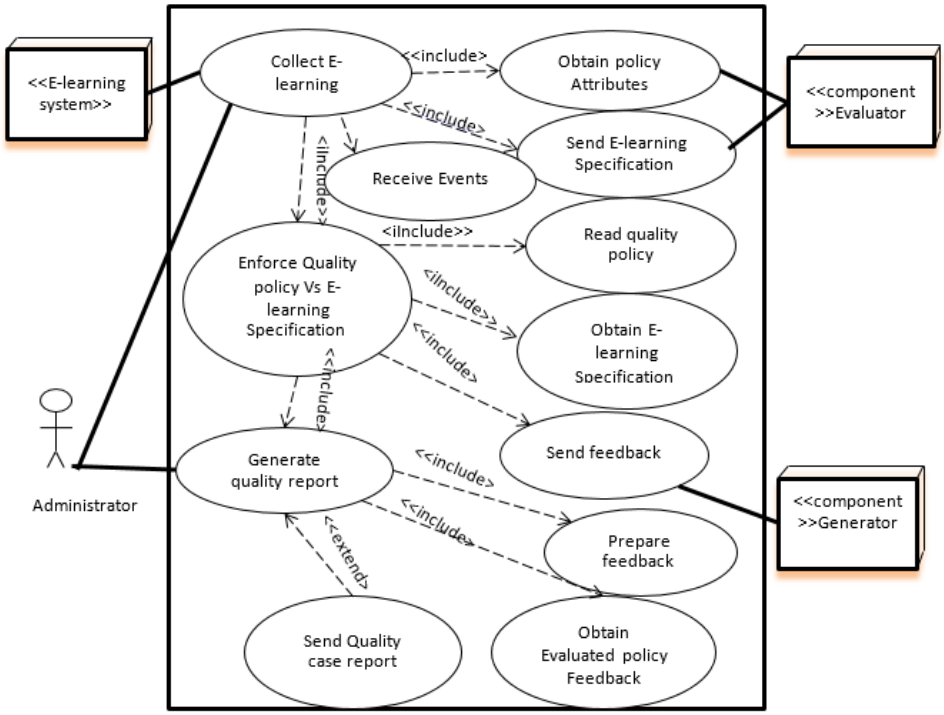


Figure 6. Use case diagram for QC system.

4.1.2. Evaluator Component

The evaluator represents the heart component of the system. The main functionality of this component is to enforce (execute) the current e-learning specification with required institution quality assurance policy in order to find out if these specifications satisfy requirement or not. It is includes inner components such checker, predefined institution quality assurance policy repository expressed using Event Condition Action (ECA) model see section, and evaluation results repository.

a. Enforcer: this component obtains QA policy as well as its attributes from QA policy repository; it will be triggered once event occurred. The policy attributes will be sent to Collector component which will obtain the values of the given policy attributes from Collector (see Collector component). These two input will be checked against ache other (enforce QA policy). The result of the enforcement will be stored in evaluation repository including: policy, policy requirements, e-learning specification data, and executed action decision of policy enforcement.
b. Policy repository: In the context of e-learning, policy is a set of rules that monitor and govern the specifications of the current e-learning system which must reflect the requirements of institution QA regulations. It represented by expressed these rules using policy management based approach such ECA model for policy representation.
c. Evaluation results repository: the purpose of QC process is continues improvement to maintain quality development and enhancement. This can be by reviewing the performance of the current state of the product. Thus, there is a need for such repository to prepare current quality state of the product. This repository includes: policy, policy requirements, e-learning specification data, and executed action of policy enforcement.

4.1.3. Report Generator

This component is preparing and generating what we call it "Quality Case Report" for system Administrator in order to take a decision and having overall view on the quality situation of the current e-leaning system. The quality report have all evidences and facts of the quality case which includes positive and negative points of the current e-learning system, it will include all feedback that includes: Institution QA

policy, policy attributes, policy attributes value, statement of executed action of policy enforcement (satisfy, not satisfy), and the reason of not satisfying policy.

4.2. Rule Structure and Representation

In a policy-based system management approach, the policy life-cycle begins with the specification of the high-level policies. These policies are specified by humans and typically have an informal representation. The abstract policies are then refined into enforceable policies (step 1). Thus, the concrete policies can be interpreted by machines. Policy controls the behavior of the managed system. The quality assurance policy is to control the behavior of the managed system (e-learning system), such that it meets the quality requirements. The source of the quality assurance policies is the intention of the quality assurance agent (stakeholders) to ensure their academic quality, and the target of the quality policies managed quality for e-learning environment, on which the quality policies should be enforced. ECA rule as management policy representation model is a well defined model for representing policy [17]. The expression of the ECA in includes event, condition, action parameters. The format of ECA model is:

On *event* **if** *condition* **do** *action*

It can be read as "if the event occurs and where the condition is true then the action will be executed". The evaluation of one or more specific policy rule's condition(s) will be triggered when a specific event occurred on the system's specifications that have been monitored and based on this event, one or more action(s) will be executed. The action is a call to perform function(s) has been predefined. In context of monitoring the e-learning, **Event** denotes the system activities that occurred in the e-learning system (e.g. behaviour invocation, transaction, or clock), **condition** denotes examination of the states of requires specifications of the e-learning system (e.g. system database state) and action denote the **action** denote decision function performance on the system and its format is *perform (t1…..,tn)* where " perform " represent procedure name and *ti* is its parameters.
Suppose one of e-learning QA policy requires to ensure assignment submission due date (deadline) have been announced to students no later than first week of academic calendar.
The policy will have the following rules:

R1:
ON Assignmentannounce (assignment As)
If ((duedate (As) = < (statrDate (SC)+7))
Do (set_policy_satisfi(duedate(As))

Assignment and StartDate are user data type, As, SC are variables, and se_policy _satisfy is a function called with parameter as. When assignment announcement specification is tested (occurred) by invoking a requites by system administrator, the assignment due date value in the current e-learning system is not more than 7 days of academic calendar start date value. The event will be assignment announcement. The condition will be checking the current value of due date field in assignment record in e-learning database and the action will be performing a function that insert policy, and its satisfied parameter indicators stored in predefined action function library. However, the other case is if the policy satisfies with sending the properly that violate the policy, in this case there is other rule govern and control the assignment due date such as sending a message to a person who is in charge as follow:

R2:
ON assignmentannounce (assignment as)
If ((true) ^ (duedate (As) > (statrDate (SC)+7))
Do(set_policy_Not_satisfi(duedate(As), send(duedate(As), T)

The action here is two functions: declare that this policy is not satisfied by the current e-learning system and insert it in the evaluation repository, and the other function is sending a message to the teacher telling her/him that the Assignment submission due date didn't announced as QA policy state and also insert it into the evaluation repository to keep it as an evidence of policy violation.

4.3. Case Study

A modest scenario of ensuring the quality of e-learning system by quality assurance policy is presented as follows. De MontFort University provides several distant learning courses by E-learning system as delivery tool for teaching and learning. One of these courses is M.Sc. in software engineering. The course

includes four modules with 12 weeks duration. Student assessment processes for course and module provided by e-learning system is one of activities that need to be monitored and controlled for the purpose to improve the quality of learning and teaching through achieving the requirements of the university QA policies. Assignment and Timely Feedback to student policy are part of the policies contributes to meet the assessment process objectives. Policy of assignment and timely feedback to student in the e-learning system can be achieved by implementing a set of requirement as following:

1- Together, Submission dates for assessed work for each module should be published in advance (particularly in first week of academic calendar) with assignment topic or title, number and assignment grads.
2- An assignment reminder notification need be sent to student remind her/him before the assignment starting date.
3- Assignment's materials must be send to all student with time stamped.
4- Any failure of handling assignment's material must be reported and recorded to the assignment's sender. (If we assume the e-learning system is reliable, stable, available we don't need this requirement).
5- Assignment's submitter (student) must be able to submit her/his assignment's work and not before submission starting date with submitter ID.
6- Once assignment's work submitted successfully, a successful notification recite must be sent to the assignment submitter (student) includes assignment
7- Topics, submission time and date.
8- All submitted assignment's works should be stored in assignment repository with assignment topic or title and assignment number.
9- Once assignment marked, a student's work should be returned, with clear feedback, no later than seven days after the submission deadline and should be stored in assignment repository with assignment topic or title and assignment number. (For external use, e.g. external examiner).

In ordered to ensure the quality of the current e-learning system, the e-leaning properties will be extracted from e-learning repository and e-learning log file. The properties must satisfy the execution of the policy's rule condition since it reflects QA requirements.

5. CONCLUSION

The proposed framework presents a QC model for e-learning system that adopts the e-learning platform according to both user's requirements and international standards. It constructed a formal architecture of quality management framework for e-learning that could be adopted by different higher education institutes to control the quality and assure the quality of the e-learning process outcome through assuring institution regulations and policies. As a future work, the proposed system will be applied for e-learning system to higher education institution to find the optimal learning path with regard to course designing, instructional design, content delivery tools and methods, student support tools and other related issues.

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