# A Cloud-based Framework for Quality Assurance and Enhancement as a Service (QAEaaS) for Universities with Blended Learning Approach

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*Abstract*—**The dynamic and multi-dimensional quality assurance process for Saudi higher education institutes under the National Commission for Academic Accreditation and Assessment (NCAAA) demands an integrated framework for management and support of internal quality reviews and evidence-based self - studies in a cost-effective way. Due to cross-institutional involvement, quality assurance compliance with NCAAA standards is even more challenging for institutes offering courses with blended learning paradigm in multiple campuses. This papers proposes a Cloud-based framework to realize Quality Assurance and Enhancement as a Service (QAEaaS) to facilitate the internal quality reviews by providing efficient data management and effective communication for different stakeholders. Architecture of the proposed framework is described with respective features to cope with the identified quality assurance challenges and issues faced by the Saudi higher education institutes.**

***Keywords-blended learning; cloud computing; higher education; quality assurance and enhancement***

## I. INTRODUCTION

The tendency for profound knowledge acquisition and sharing paradigms has led to the emergence of student-centered and technology-driven learning environments. Current budgetary constraints also demand to exploit ICTs, pervasive in our daily life, in higher education institutions (HEIs) to increase innovative capacities of the human capital for enabling them to contribute to economic and social growth [19, 22, 23]. Blended learning is an integration of technology with traditional pedagogical practices to enhance classroom activities, combine online learning with face-to-face lectures, or to include synchronous and asynchronous discussions [13, 15]. Despite the implementation challenges due to variations in models [2, 20, 22], HEIs are promoting blended learning to offer flexibility in time and place, increased instructor-leaner communication with cost-effective technologies, and most importantly improving students' performance by transforming them from passive listeners to active learners [5, 7, 26].

Towards thriving knowledge-based economy, transformation of existing educational infrastructure along with knowledge creation and distribution for research excellence is core of the Vision 2030 for modernization of the Kingdom of Saudi Arabia [28]. Although, traditional lecture-based face-to-face learning paradigm is the base of Saudi universities but several HEIs have already started incorporating advance technologies in traditional pedagogical practices [6]. Public sector universities like King Saud University, King Khalid University, King Fahd University of Petroleum and Minerals, and Umm Al-Qura University have made great efforts to apply low-impact and medium-impact blends (as defined by Ali et al., in [3]) design approaches to several courses. Saudi Electronic University (SEU), established in 2011, is the only multi-campus HEI offering blending learning for all the courses in both the bachelors and masters programs [25]. Nine campuses/branches with uniformity in learning policies, subject level learning outcomes and resources, assessment policies, and learning platforms make SEU unique in higher education fabric of the Kingdom. SEU aims for supporting self-learning based on the best available technologies of e-learning. Courses are deliberately blended with face-to-face and virtual academic activities managed through Blackboard as learning management system.

Like other public service sectors, quality assurance is of great importance in higher education. It is a multi-dimensional and dynamic process integrating institutional mission and goals, educational setting, program learning outcomes, and many other related concepts/activities to equip students with enough knowledge to fulfill demands of the labor market. Accrediting agencies are formed, both globally and locally, to establish standards and quality review processes to be followed by HEIs.

Saudi Arabia's National Commission for Academic Accreditation and Assessment (NCAAA) stipulates the quality assurance and accreditation (QAA) standards for higher education programs and institutes. NCAAA provides an extensive handbook to incorporate QAA standards for continuous improvement in quality of a particular program and

institute. Part 1 of the handbook introduces QAA process [16], Part 2 describes the required internal quality assurance arrangement [17], and Part 3 explains the external review process for QAA [18]. Internal quality arrangement is vital for successful quality management as NCAAA encourages HEIs to affirm quality assurance responsibility primarily and establish a quality review cycle for both short-term (annually) and long-term (every seven years) performance monitoring on predefined self-evaluation scales. Most of the HEIs are following ad-hoc paper-based approaches for these internal quality reviews and evidence-based self-studies. Evidences are mostly created, shared, and stored either manually or semi-automatically causing unacceptable delays and error-proneness.

Multi-campus HEIs following the blended learning paradigm across several campuses/branches also create and share evidences (i.e., course specification, course report etc.) to determine adequacy of the subject level educational activities as part of annual quality review and performance monitoring. The uniformity in learning and assessment artifacts across different branches demands an extensive collaborative effort for quality reviews. The inherent requirement for integrated access to (educational and) quality documents in blended learning environments and the cross-institutional involvement makes quality reviewing and performance monitoring even more challenging.

As realization of utility computing envisioned in 1960s, Cloud computing refers to a pervasive, easily accessible, and configurable set of distributed computing resource (e.g., interconnected servers, storage, applications as services) [27]. With Infrastructure-as-a-Service (IaaS), Platform-as-a-Service (PaaS), and Software-as-a-Service (SaaS) basic delivery models, cloud computing also supports variations in terms of specialized service delivery models. With promising features of scalability, support for virtual classroom environments, secure data storage, and ease of accessibility, Cloud computing has also been widely utilized in the education sector. It has not only assisted educational institutes in bringing academic resources at the door step of the students but also help them in surviving under severe budget shortages by utilizing pre-built Could-based information management resources [11].

Blended learning in the context of Saudi Arabia has been widely investigated for its impact on students' performance, its benefits, challenges for successful implementation, and the instructor-learner perspective on its future in Saudi universities [1, 4, 6]. To our best knowledge, the subject-level quality assurance and enhancement of a full-fledged degree program in a blended learning environment has never been explored. Data-driven nature of blended learning, and extensive use of the computing resources (peak demand) at a certain period of the academic year transforms the QAA into a resource hungry and cumbersome process. Hence, there is a dire need to exploit cloud computing paradigm for quality assurance and enhancement to manage internal quality reviews and evidence-based self-studies manifested for QAA process management in blended learning environments.

To cope with the QAA challenges, this paper describes a Cloud-based framework proposed for realizing collaborative Quality Assurance and Enhancement as a Service (QAEaaS) for Saudi HEIs with or without blended learning approach. The proposed framework is based on authors' experience and involvement (for more than 6 years) as course instructor, course coordinator, and quality assurance coordinator in QAA processes in two different HEIs (in two different countries) and lessons learned from formal and informal meetings with stakeholders from several other HEIs. Based on the best practices and guidelines provided by NCAAA and the uniformity of its QAA process, this framework can easily be utilized in most of the Saudi HEIs.

Next section explains the research methodology. The summary of the related work is presented in Section III while Section IV introduces internal quality assurance planning and reporting cycle specified by NCAAA along with the QAA process followed by a typical Saudi HEI (either single-campus or multi-campus). Section V highlights the challenges and issues in the current internal review practices for quality assurance. Section VI presents the proposed framework for Quality Assurance and Enhancement as a Service (QAEaaS) with architecture description and the main features. Section VII concludes this study.

## II. METHEDOLOGY

In order to gain sufficient knowledge of the quality assurance and enhancement and to increase the validity of the results we have used triangulation, i.e., a variety of research methods. We combined document analysis and expertise for collecting and analyzing information about the quality assurance and enhancement in different higher educational settings.

Document analysis is often considered useful for exploring comprehensive background information [30]. We used this method not only to investigate the NCAAA quality assurance process but also to explore the additional requirements familiarized for blended learning paradigm. Relevant document analysis also revealed important questions that need to be addressed for HEIs with multi-campus educational setups. For example, how to ensure the completeness and consistencies in QAA evidences created and shared among different roles across multiple campuses?

Expertise, the expert's opinion or assessment, is also a well proven research method for evaluating collected data and forecasting for reasonable decision-making [31]. Our experience as academicians and especially several years of involvement in quality assurance activities in a multi-campus HEI played a vital role in ensuring the validity of obtaining evidences and reliability of the recommended innovation i.e., Cloud-based framework to realize Quality Assurance and Enhancement as a Service (QAEaaS).

Comprehensive investigation of critical documents (NCAAA handbooks, program specifications, course specifications, course reports etc.) complemented with authors' experience in quality assurance in different HEIs helped in highlighting the challenges and provided a base for proposing a cloud-based framework to cope with these challenges.

## III. Related Work

Most of the previous work on utilizing Cloud computing in education sector is focused on on-demand usage of Cloud-based applications provided as SaaS by different could providers to reduce upfront cost [11]. With scalability and elasticity characteristics, Could computing is considered an affordable option for data-driven and information management services, e.g., management of students' databases and learning content, numerical modeling and simulation for collaborative research works, without setting up any major IT infrastructure and with minimum maintenance cost [12].

Blended learning, as an emerging learning paradigm, heavily relies on efficient IT infrastructure for efficient instructor-leaner communication, and synchronous and asynchronous discussion management. Could computing with only configuration requirements can easily facilitate extensive information management with terminal equipment and with cost-effective technologies [9]. Cloud computing has also increased the availability of the campus services and systems as the security and safety is ensured by the Cloud providers.

Quality assurance in Saudi HEIs have also been explored for different drives. Quality assurance policies and practices of four Saudi universities are reviewed to assess their accreditation efforts [33]. QAA policies and procedure organization, introduced by the NCAAA, is explained in [34]. Although, some of the HEIs are using internal web-based system for collecting QAA evidences but no unified cloud-based quality assurance framework is reported. The need of comprehensive quality assurance framework to facilitate QAA process is also highlighted in [32]. The study most closely related to our work is a Cloud-based quality management application, named COMPASS-OK [24]. This quality management system is mostly based on European Standards and Guidelines for Quality Assurance (ESG).

Despite of the above of studies our proposed framework is based on guidelines provided by the NCAAA and targets the Saudi HEIs.

## IV. Background

This section presents an overview of the NCAAA by highlighting quality review cycle with course specifications and reports. Current QAA practices followed by a typical HEI for preparing and sharing quality evidences are also described.

### A. National Commission for Academic Accreditation and Assessment

In Saudi Arabia, National Commission for Academic Accreditation and Assessment (NCAAA) plays a key role in defining quality assurance and accreditation standards for postsecondary programs and institutes (http://www.ncaaa.org.sa). For this particular study, we mainly focus on the quality assurance of the programs. The commission has developed 11 basic standards with key performance indicators (KPIs) for quality assessment and accreditation (QAA) of institutes and programs. These standards with templates for required documents (defined as ATTACHMENTS) are described in three different parts of an extensive handbook. Management of Quality Assurance and Improvement, and Quality of Learning and Teaching standards are focused on defining appropriate benchmarks and managing evidence-based internal quality assessment for performance monitoring.

Figure 1 depicts the internal quality assurance planning and reporting cycle proposed by NCAAA in Part 2 of Handbook for QAA in Saudi Arabia [17]. The left side of the figure specifies the plans to be prepared before the start of the course while the right side of the figure specifies the reports, containing evidences, prepared after the completion of the course.

A continuously adjustable Program Specification (T4) is defined for every new program to describe the context, mission, structure and organization, learning outcome mapping matrix, and other relevant information about the program. As each program is organized along different courses, Course Specification (T6) is prepared for each course to detail the description, mode of instruction, objectives, learning outcomes, and assessment task for the students. T6 also specifies a list of topics to be covered as part of the course. At the end of each academic session, course instructors are required to prepare Course Report (T5) to summarize students' results. It specifies distribution of the grades, course evaluation, planning for improvement, and action plan for the next academic session.

Annual Program Report (T3) is prepared to record vital information about program realization with KPIs and assessment, summary of the courses evaluation, and statistical analysis. T3 also summarizes the delivery of the planned courses, program management and administration, and the program course evaluation.

### B. Blended Learning and Quality Assurance in HEIs

To create a diverse and robust educational society, higher education institutes (HEIs) must be considered as dynamic communities of learners, instructors and staff committed to perform their duties at the highest standards. Among 27 public and 10 private HEIs in Saudi Arabia, some of the HEIs have multiple campuses/branches across the country. These multi-campus HEIs are offering undergraduate and postgraduate degrees with (or without) blended learning in different disciplines; business administration, computing science, health sciences etc. with thousands of students and faculty members.

Blended learning in multi-campus HEIs is realized through effectively utilizing the ICTs to support on campus and virtual academic activities [35]. HEIs strive to implement high-impact blend design approach and the courses are designed to be blended from the scratch. These courses are deliberately kept same for students in all the branches. Each course is structured with different percentage of campus face-to-face and virtual learning sessions. Different learning management systems

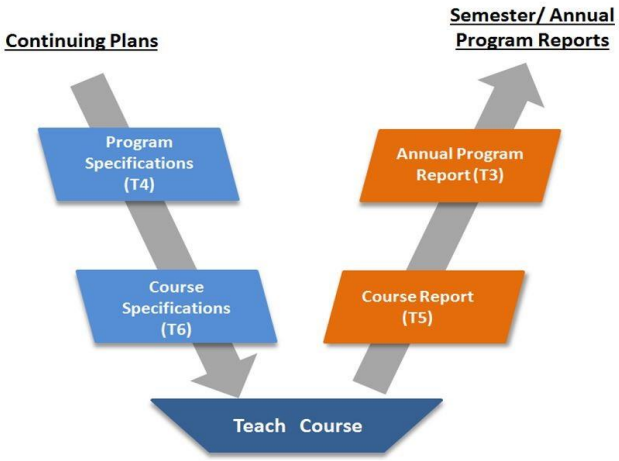


Figure 1. Quality assurance planning and review cycle

(e.g., Blackboard, Moodle) are used to organize virtual sessions, maintain communication among students and instructors, and to organize various synchronous and asynchronous assessment activities.

Both single and multi-campus HEIs prepare plans and reports, following the quality assurance planning and review cycle, to determine adequacy of the subject level educational activities as part of QAA process. Program Specification (T6) is prepared by the QAA committee. Below are the most common roles involved in conducting internal quality review for creating and collecting evidences in a typical HEIs.

*1) Course Instructor*

An individual primarily responsible for facilitating the learning of students in an assigned course. A course instructor delivers lectures in both face-to-face and virtual sessions, updates students' attendance, and creates and evaluates various assessment artifacts like assignments, quizzes, discussion boards etc., during the semester. At the end of the semester, each course instructor prepares a course report (T5) for each assigned course according to course reference number (CRN).

*2) Course Coordinator*

For multi-campus HEIs, in order to keep the course contents and assessment artifacts same across all the branches, each course has a course coordinator. At the start of each semester, the course coordinator reviews course specifications (T6) to be followed in all the branches. Course coordinator also manages this uniformity among branches by conducting regular meetings, assigning tasks for preparing assignments, quizzes, mid and final term exam papers. At the end of the semester, each course coordinator prepares an integrated course report (integrated T5) based on the course reports (T5) received from course instructors for different CRNs. Along with the course information, integrated T5 also summarizes gender-wise grade distribution of all the students of a particular course in both male and female branches. Integrated T5 is only created in HEIs offering the same course in more than branches.

*3) Quality Assurance Coordinator*

Following the guidelines of NCAAA, HEIs must establish a quality center to manage the QAA process. With the consensus of both quality center and the respective colleges, one Quality Assurance (QA) coordinator is appointed for each college (NCAAA Part2, 2015). QA coordinators play a vital role in developing and conducting internal quality reviews and evidence-based self-studies. All the T5s and integrated T5s are sent to the QA coordinator for reviewing and setting up the action plan for improvements to be applied in the next academic session.

## V. Challenges And Issues

Internal quality planning and review demands extensive communication and document sharing among various stakeholders. Although, some of HEIs have introduced web portals for quality evidences, blended learning and the requirement of uniformity in course contents (among all branches) results in a complex internal review process. Below are some of the major challenges faced by course instructors, course coordinators, and QA coordinator for conducting internal review and self-studies effectively.

### *A. Un-necessary Time Delays*

Currently QAA activities are mostly performed manually and all the stakeholders communicate through ordinary emails to share the required documents. Along with T5, each course instructor has to share graded students' answers with the high, middle, and the low marks for each assignment, midterm, and final exam. Depending of the number of assignments and enrolled students, each instructor may have to send/upload between 15 to 20 different files (with names in a specific pattern) for each CRN to the respective course coordinator. Course coordinator then has to critically review at least 150 files (15 files for each CRN in 10 different branches) for errors and typos.

The QA documents have to pass through certain channels (course instructors → course coordinators → QA coordinator) and even in case of a minor mistake (e.g., CRN missed by a student in an assignment or midterm/final exam) these documents have to follow the same route back to the concerned course instructor. Even the files must be named correctly in a specified format (e.g., ITxxx-37-38-2ndyyyyyHigh-Marks(5) for an assignment for course id ITxxx offered in 2nd semester of Islamic year 37-38 with CRN yyyy and grade High with obtained Marks(5)) by the course instructor. This causes un-necessary time delays and may lead to an awkward situation among stakeholders if the documents are sent back and forth frequently. Time limitation makes it even more challenging for course instructors to produce correct documents to be used as evidences for QAA.

### *B. Incompleteness and Inconsistency*

Producing and sharing notably large number of documents results in incompleteness and inconsistency. Missing the CRN and sometimes even the student's name or Id in various assessment artifacts is a common mistake. Such an assignment

or midterm/final exam answer sheet, if selected and shared as evidence, can result in un-necessary communication among the stakeholders for adding the missing information. Missing information in different sections of course reports is also a frequent problem. For example, sometimes the course coordinators were unable to add important recommendations and suggestions, sent by course instructors, into an integrated T5.

Course plans and reports are made up of interrelated sections. Multiple occurrences of the same interdependent data without any validation mechanism causes inconsistency. Furthermore, statistical calculations in one section of a report may require data from another report. For example, section C1 of integrated T5 contains distribution and analysis of the grades for a course and requires data from section C1 of different T5s with grade distribution of a particular CRN. Both course instructors and course coordinators have to spend considerable amount of time and effort to maintain consistency among different sections of these reports.

### C. *Increased Faculty Workload to Ensure Security*

As explained earlier, document sharing is mostly realized through ordinary emails. To ensure security, these documents are protected with suitable passwords. Passwords are then shared through other social networks. This doubles the workload on stakeholders and further delays the outcome.

### D. *Error Slip Through*

One of the major problems in timely completion of internal assessment reports is the rework of multiple interrelated data entries. The main reason for this high rework is error slippage from earlier documents where they are easier to find and remove. Extensive communication among course instructors, course coordinators, and QA coordinator further increases the chances of error slip through different documents resulting in incorrect and delayed data entries.

### E. *Inefficient Information Presentation*

Data collection and information presentation is essential for decision making. The use of graphics, in facilitating effective decision making, is a proven fact. Despite of all the hard work, the existing internal quality review process is efficient in producing effective data visualization. Upon receiving T5s and integrated T5s, course coordinator and QA coordinator have to collect quantitative data from various sections of these reports. Once they have collected quantitative data, they may have a lot of numbers. Then even for simple statistical analysis and visualization, for example standard deviation and bar graphs, another software has to be used. This may require extra effort to set data in appropriate format.

As a result, it is hard to get dynamic detailed reports. For example, tracing branch-wise or gender-wise grade distribution of students in a particular course over a specified period of time (say 5 years) is quite challenging. Mismatch between data presentation and the need of intended audience not only delays innovative decision making but also hampers strategic decision performance evaluation.

## VI. PROPOSED FRAMEWORK FOR QAEAAS

This section presents the Cloud-based integrated framework proposed for collaborative quality assurance and enhancement. This frames provides Quality Assurance and Enhancement as a Service (QAEaaS) on public cloud to facilitate the QAA process in an easy and cost-effective way. The framework aims for managing internal quality reviews and evidence-based self-studies conducted at HEIs for compliance with NCAAA standards. Realized as a Cloud-based application, the framework is focused to facilitate in connecting all the stakeholders (course instructors, course coordinators, and QA coordinator) to a centralized data storage. Different HEIs can access customizable artifacts (forms, reports, etc.) simultaneously provided by the framework to complete QAA tasks. This framework also minimizes the need of the IT infrastructure and human resources to manage the whole QAA process as complete QAA process (aligned with NCAAA guidelines) is managed and shared across multiple HEIs as QAEaaS through efficient cloud platform. QAEaas can not only serve NCAAA management to assess, gather, and share best practices followed by different HEIs for QAA but can also provide primary data to find improvement potentials in policy making.

### A. *Cloud-based Architecture*

Figure 2 depicts architecture of the proposed framework structured in three layers; User Interface, Application Logic, Data Storage.

Users from different HEIs (e.g., course instructors, course coordinators (for multi-campus HEIs), and QA coordinators can access QAEaaS with the User interface layer. Course instructors can upload documents, and input required data for different sections of the course report T5. The framework facilitates course instructors to automatically generate and download course report T5. Course coordinators can also download T5, can automatically generate integrated T5 and T6, and also provide feedback to course instructors. QA coordinator can not only provide feedback to the course coordinators but can also download all the reports with related documents in a single zip folder.

Application logic layer contains the business logic based on the guidelines provided by the NCAAA. It connects both the data storage and user interface layer for data manipulation. Data storage layer is focused on efficient data management and storage for fast retrieval and data security. Below we detail each layer with its main features and explain how they can be used to cope with the challenges and issues explained in Section 4.

### B. *User Interface Layer*

User interface layer contains the interface and presentation logic. User's visual experience must be enhanced using the latest technologies for the responsive web application. Developed using latest technologies like Bootstrap, the web interface provides visually appealing screens to show the users interaction options based on the their tasks and the HEI settings. This layer will also give tools for effective interaction

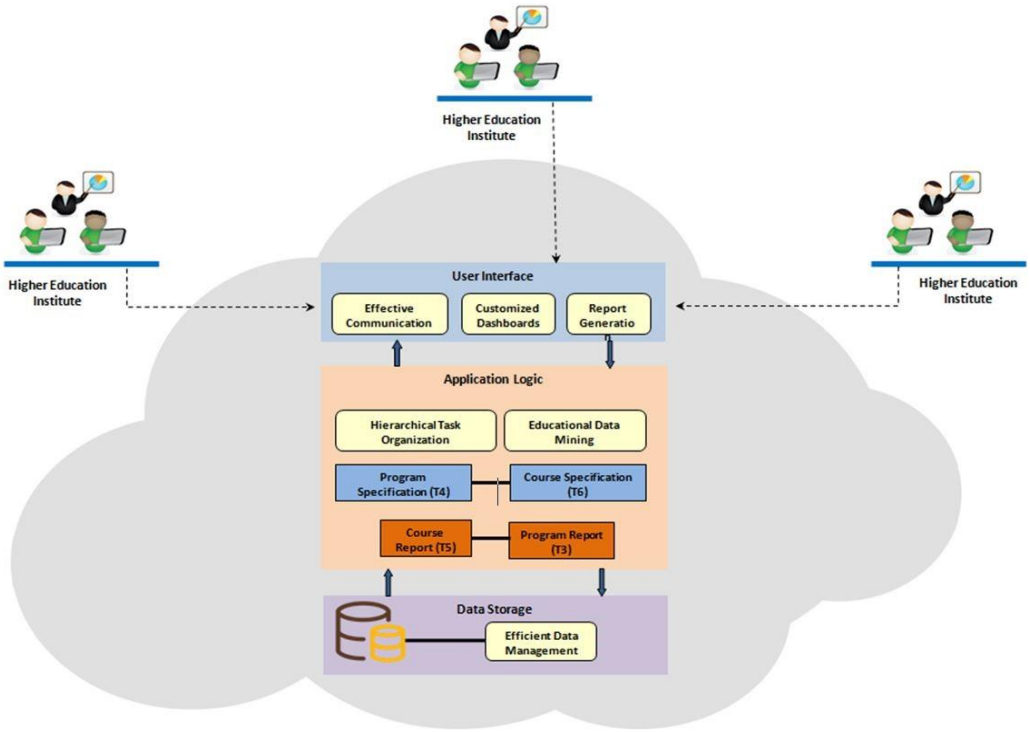


Figure 2. Architecture of the Cloud-based Framework for QAEaaS

and all the required features to perform CURD operations and report generation.

It passes the required data received from the respective user to the application logic layer under it, gets back the feedback response, and forwards it to the user. This layer also facilitates role-based user management for data security, so that users can only access QA data related to their respective HEI only. Below are the main features of the user interface layer.

*1) Effective Communication*

Effective communication among stakeholders is pivotal for achieving successful outcomes form internal reviews and evidence-based self-studies. In order to ensure that appropriate messages are sent, understood, and acted upon timely, the framework enables stakeholders to send customized emails and notifications with a single click. It encourages the course instructors and coordinators to start working on required course plans and reports right from the start of the semester.

Our framework supports continual creation and sharing of evidences to be used for NCAAA accreditation. Course coordinators can not only review the contents of the course reports being developed but can also monitor the progress of the course instructors. Instant feedback and reminders can be sent with minimum efforts.

Well-organized access to data with role-based user management further ensures effective communication among all stakeholders. Course instructors can be informed instantly about which assessment artifact to upload, edited or graded without using third party social media applications. The proposed framework also provides customized dashboards for deep understanding and better communication to facilitate timely decision making.

*2) Customized Dashboards*

A dashboard is an application of business intelligence and data integration for efficiently depicting current status of an organization. According to [10], a dashboard board is considered as a ”magnifying glass” keeping the focus of the stakeholders in a unified direction by visual representation and dynamic updating of data through a centralized data source. HEIs are also using dashboards to visualize the large influx of data in order to facilitate planning and decision making.

In order to cope with the rework, causing unnecessary time delays, and to control error slip through among the stakeholders, our framework will provide data dashboards to visualize the current status of the internal review process.

Dashboards are customized to provide course instructors, course coordinators, and QA coordinators with the information they need to monitor, and manage the key activities during the internal review and evidence based self-studies. Status of the evidences to be created and shared among course instructors and coordinators can easily be monitored and analyzed. A course coordinator can view the progress of each course instructor in completing various sections of T5 and can send customized email reminders and notifications with a single click. Real-time monitoring of the evidences and related

documents helps to reduce the time of validating and un-necessary communication that previously challenged the internal review process. Database schema defined based on the appropriate sections of course specifications, is the major source for these data dashboards.

*3) Automatic Generation of Course Reports*

HEIs are looking to grow while improving operational performance. Efficient reporting, with right data at the right time, for well-informed decision making is decisive for such growth. Our proposed framework provides a feature-rich module for managing dynamic reporting. Although, internal reviews deal with heterogeneous data, to be created and shared as evidences, but efficient data modeling realized through appropriate database schema can enable automatic generation of several course plans and reports. With a user-friendly interface, course instructors can generate and download T5s with a single click. Course coordinators can automatically generate integrated T5 and T6 (based on the T5 of each CRN), while QA coordinator can download all the generated reports and relevant data in specified format in a single zip folder. The reporting module will also provide the flexibility of partial report generation to review the look-and-feel of the final report.

Infographics is an effective form of communication to convey complex ideas. Our framework will also provide simple infograpahics to improve understandability of the quantitative data. For example, Figure 3 shows a pie chart depicting student grade distribution in a Software Engineering course for a particular CRN. It shows that percentage of students along with the grades they acquired. 20% of the students passed the course with D+, while only 5% of the students were able to get B+. Shown as 0%, no students were capable of scoring grade A or A+. Upon hovering the mouse over any slice, a Tooltip appears with number of students with illustrated grade. A similar pie chart can also be created by the course coordinator for integrated T5 to visualize the student grade distribution for all CRNs, being executed in all branches in a multi-campus HEI, for any course.

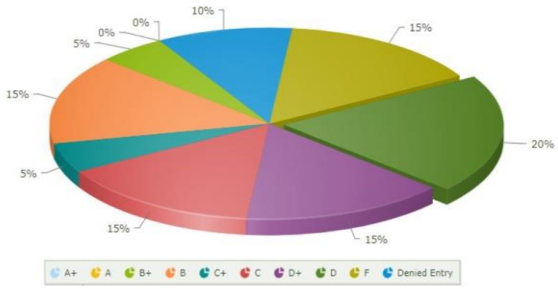


Figure 3. Student grade distribution in a particular CRN

## C. Application Logic Layer

Application logic layer contains the vital application logic to drive the core QAA process under NCAAA guidelines. Below are the main features of this layer.

*1) Hierarchical Task Organization*

Application logic layer has objects implementing the structure of the Program and Course specifications (T4, T6). Specification structures are based on their sections organizing the tasks to be completed by the relevant users. Tasks are oorganized in a hierarchal way to facilitate multi-user involvement. For example while the course instructor is working on the course report (T5), course coordinator can view progress of the report. Once submitted course coordinators can start their review and can immediately send his their comments on any wrong entry. The immediate communication specific to the section with wrong data can save a lot of time and effort.

In QAEaaS, tasks are to be defined based on the use cases specified within the requirement document. An initial version of this draft has already been developed by a group of undergraduate students are part of their capstone project. Commands for the successful execution of the application logic are invoked through APIs at the user interface layer. All the data manipulation is controlled by this layer as it is aligned with business logic of the QAA process followed by the HEIs. Hierarchical task organization also facilitate in handling variations in the QAA process (for example in case of multi-campus).

Role-based user management is recommend to realize data protection. Successful data modeling not only facilitates users management but also establishes data acquisition and storage to ensure reliability, and on time availability of the data for relevant users.

*2) Application of Educational Data Mining*

Educational Data Mining (EDM) focuses on applying data mining techniques to investigate large-scale data in an educational setting [8]. Several studies like [14, 21], have discussed the successful application of EDM for better understanding of students' behavior and their performance monitoring. As described earlier, QAA is a data-driven process and related activities result in large data accumulation. Our framework with efficient data modeling will also provide an opportunity to apply EDM techniques for knowledge discovery. Knowledge about students' performance trends, their progress in different subjects, and utilization pattern of available e-learning resources can support for improving the overall learning experience. Based on the data set formulated with data from various sections of T3 and T6, and other assessment artifacts (i.e., online quizzes, assignments, discussion boards, etc.) EDM can be used to highlight improvement potential for optimal resource utilization, and understanding of learning needs of the students for personalized learning.

Utilizing EDM under the QAEaaS can also equip NCAAA to mine data from specifications and reports discover interesting patterns and knowledge discovery about the learning paradigms and their impacts of QAA practices. Such knowledge can assist in effective decision making and can also

provide solid data-driven foundation for QAA process improvement.

### *D. Data Storage Layer*

Data storage layer is the lowest layer of the proposed framework for QAEaaS. To be implemented with data base management systems like MongoDB, this layer provides access to relevant data to the application logic layer. Objects defined for task structures in the application logic layer can manipulate based on the business logic formed to realize QAA process as specified by the NCAAA.

#### *1) Efficient Data Management*

HEIs like other big organizations generate and consume huge amount of data to perform routine tasks [29]. Following quality assurance process to reflect adherence to accreditation standards is one of major sources of this data generation. A typical Saudi HEI also produces and shares several documents in different formats (e.g., samples of assignment and midterm/final exams are stored as images, several plans and reports are stored as Microsoft Word files, etc.) to show compliance with NCAAA standards. These multi-format documents result in a collection of unstructured data which ultimately causes incompleteness and inconsistency.

Successful execution of internal quality reviews and evidence-based self-studies involves data-driven decision making. To facilitate such decision making, our framework will provide effective data management based on the principle of separation of concerns. Course plans and reports are thoroughly reviewed to separate the most relevant sections for each stakeholder. For example, section "B-Course Delivery" of the course report T5, to be prepared by the course instructor, is usually completed by the course coordinator to keep it same for all the T5s across different branches. While section "C-Results" of the same course report T5 must be completed by the course instructor only. Similarly, section "C-Results" of the integrated T5, which involves statistical calculations and consumes considerable amount of time, is dependent on the data of other T5s.

Appropriate database schemas must be defined for each section and a role-based user management module will be implemented to realize data protection. Successful data modeling not only establishes administration of acquisition and storage but also ensures the reliability, and timeliness of the data for relevant users.

## VII. Conclusion And Future Work

Quality assurance and accreditation for Saudi higher education institutes, to depict their compliance with National Commission for Academic Accreditation and Assessment (NCAAA) standards, is a challenging task. This study proposed a Cloud-based framework to realize Quality Assurance and Enhancement as a Service (QAEaaS) to facilitate the internal quality reviews by proving efficient data management, effective communication, hierarchical task organization, and customized dashboards for different stakeholders.

Complete realization of the proposed framework is the next major short term future work. Investigation of educational data mining techniques for e-learning resource utilization trends and provision of data-driven student-centered learning environment is an important future work direction.

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