Business Rules Driven Automated Quality Assurance Governance System for Higher Education

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Abstract

Although higher education institutes have paid serious attention to quality assurance, implementation issues have been reported frequently. Since the existing information systems do not adequately support automatic verification, manual verification of quality assurance compliances has become a challenge. Therefore, this study first analysed the prevailing higher education quality assurance context to identify the prevailing issues. Secondly, Quality Assurance Governance System integrated with a quality assurance rule manipulation mechanism was designed based on the business rules concept to address the identified issues. Thirdly, the key modules of the proposed Quality Assurance Governance System were developed as a proof-of-concept. Finally, the proposed quality assurance rules manipulation mechanism and modules of the Quality Assurance Governance System were evaluated. The study found that one of the main issues in the existing systems is the lack of integration among various modules and a rule manipulation mechanism. Therefore, the study concludes that quality assurance requirements could be better captured as rules using the proposed rule templates, while rule manipulations and compliance could be verified in real-time through the proposed Quality Assurance Governance System. Nevertheless, the results of the evaluation suggest that rigid rule implementations may make the system inflexible and create stakeholder resistance. Thus, this can be mitigated by implementing the proposed rule enforcement levels.

Keywords: Business rules, Quality assurance, Higher education, Management Information Systems

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Introduction

Higher education is a rapidly growing service sector encompassing education, research, and community services as the main functionalities (Avitabile, 2017). Recently, higher education institutes paid enormous attention to quality assurance (QA) of the study programmes, graduates, and institutional operations (Gamage et al., 2020). Internal and external are the two main components of a QA system. Internal QA ensures that QA objectives are achieved in internal activities, while external QA evaluates the level of quality compliance by cyclic reviews (Gamage et al., 2020; Wickramasinghe et al., 2014). QA standards, policies, and procedures are referred in this study as QA compliances.

The QA system ensures that the quality is maintained and enhanced based on the formulated QA compliances (Mustaffa et al., 2007; Yulherniwati et al., 2020). The higher education authorities have formulated these QA compliances, and QA reviews verify the extent to which higher education institutes realise these (Metzinger & Boras, 2016). But, some of the QA compliances are descriptive and thus, make it difficult to monitor the level of compliance (Kwandayi, 2021). Since QA is a dynamic process with continuous improvements, QA compliance monitoring is also dynamic and subject to continuous improvements (Gaftandzhieva et al., 2020; Metzinger & Boras, 2016). Therefore, the manipulation of QA compliances is complex.

Literature highlights that QA systems of higher education institutes face several implementation issues, such as academics' resistance, ignorance, lack of interest and cooperation in implementing quality assurance activities, and detachedness of the QA process from daily operations (Anderson, 2006; Imbulgoda, 2019; Peiris et al., 2014; Pornphol & Tongkeo, 2019). For example, the key QA process implementation challenges are inefficient governance and management, unsupportive organisational structure, and lack of a dedicated workforce (Mahbub, 2017). Further, the lack of a proper mechanism for monitoring QA compliance is one of the main limitations of existing QA systems (Shah et al., 2011; Yulherniwati et al., 2020).

Further, the literature suggests that QA process improvements and facilitation through information systems are one of the solutions to overcome the prevailing QA issues, challenges, and limitations (Pornphol & Tongkeo, 2019). Among these solutions, scholars have suggested developments of Knowledge Management Systems, Portals, Decision Support Systems, models, and frameworks (Haris et al., 2017). For instance, many scholars have proposed information system solutions that overcome the QA issues by improving higher education workflows (Elhoseny et al., 2017; Gaftandzhieva et al., 2020; Legowo et al., 2019). These suggested information system solutions automate the routine type of QA activities while avoiding unnecessary and redundant tasks. However, existing information systems have not adequately focused on monitoring QA compliance (Yulherniwati et al., 2020). The root cause of this issue is a shortage of timely and sufficient information about compliance with standards and benchmarks.

This study aims to address this issue through four steps. First, the study analysed the prevailing higher education quality assurance context to identify the prevailing issues. Second, the higher education Quality Assurance Governance System (QAGS) was proposed as an integrated information system with an independent QA rule manipulation mechanism to overcome the identified issues. Here, the study introduces the QA rules concept that represents QA

compliances in information systems based on the business rules concept. A set of illustrative QA rule templates were also developed. Appropriate rule enforcement levels were defined to mitigate rigid rule implementations. Third, the key modules of the QAGS were developed as a proof-of-concept (PoC) taking only the higher education teaching and learning (T&L) process into consideration. Finally, the proposed QA rule manipulation mechanism and QAGS modules were evaluated.

The emphasis on the necessity of integrated information system solutions and proposing, designing, and testing an independent QA rule manipulation mechanism can be identified as the key contributions to this study. The proposed QA rule manipulation mechanism provides dynamic and flexible rule handling through a physically and logically separated QA rule base. Even though this study focuses on the higher education teaching & learning process, the proposed solution can be expanded to QA compliance in other areas of higher education as well.

Literature Review

This literature review explores the prevailing issues, challenges, limitations, and respective solutions of the higher education QA systems in local and international contexts. Further, a potential solution approach is also explored. Accordingly, this review is organized into two sections where the first section explores the prevailing issues of implementing QA systems and suggested solutions while the second section explores how the business rules concept has been applied in the information system context.

Issues with Existing Quality Assurance Systems and Prevailing Solutions

Higher education institutes foster education quality through well-developed QA compliances such as QA standards, policies, and procedures (Pornphol & Tongkeo, 2019). Nevertheless, the implementation of QA systems faces various issues, challenges, and limitations. On one hand, institution-specific factors and behaviour factors hinder the implementation of QA systems. For example, the lack of management involvement (Mahbub, 2017), inefficient governance and management (Imbulgoda, 2019), unsupportive organisational structure (Paintsil, 2016), and lack of dedicated workforce (Mahbub, 2017) are several institute-specific issues in the implementation of QA systems. Further, difficulties in monitoring and maintaining documents and inaccessibility of critical data (Jensen et al., 2010) hinder the QA implementation. Moreover, the lack of contribution from academic staff (Anderson, 2006; Peiris et al., 2014; Pornphol & Tongkeo, 2019), extra work created by QA (Imbulgoda, 2019), and the lack of stakeholder participation in critical activities (Brookes & Becket, 2007; Groen, 2017) are common QA stakeholder related issues. Concurrently, the lack of a proper mechanism for monitoring compliance with QA standards, policies, and procedures is one of the main limitations of existing QA systems (Shah et al., 2011; Yulherniwati et al., 2020).

On the other hand, there are information system-specific issues for QA. Information system-driven supportive mechanisms to facilitate the QA process are not rare. Further, Information systems ensure greater effectiveness of workflows and QA compliances (Pornphol & Tongkeo, 2019). For example, Elhoseny et al. (2017) have suggested an intelligent information system solution to ensure higher education institutes' quality towards an automated e-university. Tsolakidis et al. (2015) proposed a framework and a system for the QA of higher education

institutes. Legowo et al. (2019) proposed a quality assurance information system for accreditation assessments for ISO-certified universities. Further, Gaftandzhieva et al. (2020) proposed an automated data accumulation and aggregation mechanism for the HE quality evaluation.

Although these solutions have addressed the prevailing QA issues differently, the realisation of QA compliances has not been addressed adequately (Yulherniwati et al., 2020). This literature has highlighted the necessary improvements of information systems in internal QA implementation such as the provision of information about standards implementation progress, and standards compliances. Accordingly, existing information systems need further improvements to cater the verification of QA compliances by adopting appropriate concepts and techniques. To this end, this study further examined how rules are represented and manipulated in an information system.

As observed, business rules are utilized to govern the business process (Nagel et al., 2019). These business rules are widely used to control and influence the behaviour of a business in an information system context (De Jesus & De Melo, 2014; Ezekiel et al., 2018; Nagel et al., 2019). Generally, institutional policies and procedures function as business rules. At the abstract level, business rules describe what actions a business should perform under defined constraints to achieve the desired objectives (Do Prado Leite & Leonardi, 1998). Accordingly, there is a potential to apply the business rules concept to implement QA compliances. However, business rules-driven information system developments and the way to adopt them to QA compliance should be further examined. Here, specifications of QA compliances should be considered such as the most of these QA compliances themselves are descriptive and subjected to frequent updates (Gaftandzhieva et al., 2018; Kwandayi, 2021). Further, some QA compliances, such as QA standards, are ambiguous, and some have yet to be published formally (Bandara, 2018). The following subsection explores to what extent these issues can be addressed using the business rules concept.

Manipulation of Business Rules in the Information System Context

Business rules exist as terms, facts, constraints, and derivations (Kaula, 2016). They contribute to standardising the institutional workflow. These business rules govern the logical relations among the activities of a business process (Vasilec et al., 2009). Thereby, business rules can prevent undesirable consequences of day-to-day activities and ensure quality. Therefore, the business rules concept can be applied to define QA compliances in terms of QA rules and then manipulate them in an information system scenario.

Classification of business rules enables the identification of rules of a specific domain (Arévalo Maldonado et al., 2014). Table 1 has listed the widely used business rule categories. In addition to that, Arévalo Maldonado et al. (2014) have explored a broader business rules classification. However, existing literature has not focused on classifying business rules in higher education or the QA domain.

Further, a business rule can be applied at different enforcement levels (Bridgeland & Zahavi, 2008; Weilkiens et al., 2016). The enforcement levels define the severity of the action imposed by the rule. For example, scholars have referred to five basic enforcement levels: 1. strict, 2. pre-authorised, 3. post-justified, 4. Override, and 5. Guideline (Bridgeland & Zahavi, 2008;

Weilkiens et al., 2016). If a strict rule is violated, the person who violates the rule is penalised. The pre-authorised rule can be violated by getting the relevant authority's approval. If a post-justified rule is violated, later clarification should be obtained. Override is a more flexible enforcement level that can be violated by explaining. The last enforcement level is the guideline which suggests only but is not enforced. In addition, Ross (2019) has introduced six enforcement levels: 1. strictly enforced, 2. deferred enforcement, 3. pre-override, 4. post-justified override, and 5. override with explanation and 6. guideline. The deferred enforcement level is strictly enforced in this context, but enforcement may be delayed. Accordingly, the flexibility of the operations can be enhanced via the different business rule enforcement levels.

Table 1: Classification of Business Rules

Study	Classification
Ross (2010) , Haj et al. (2021)	Behavioural rules and structural business rules
Karami and Iijima (2010)	Fact rules, integrity constraint rules, derivation rules, and dynamic rules
Witt (2012), Sharma et al. (2014)	Structural assertions, action assertions and derivations

Business rules can be represented differently in information systems. For instance, in traditional process automation, these rules are tightly bound to the business process workflow and scattered across the application code (Novaković & Deletić, 2009; Qu et al., 2020). As a result, a modification of business rules necessitates reprogramming of the information system. This means that information systems become obsolete quickly in an environment characterised by rapidly changing business rules. Therefore, it is necessary to separate these rules from the process workflow of the system. Utilization of a rule engine is one of the solutions for separating the business rules from the application code (De Jesus & De Melo, 2014; Qu et al., 2020). This separation offers several benefits, such as rules being easier to be managed and shared independently across the system (De Jesus & De Melo, 2014; Nelson & Sen, 2014). Further, this can facilitate flexible system development and maintenance. Accordingly, business rules implementation methodologies have been substantially improved. Therefore, the business rules concept and related technologies can be adopted to implement QA compliances successfully.

In summary, this literature review suggests that the lack of a proper mechanism for monitoring the compliance of QA standards, policies, and procedures is one of the main limitations of existing QA information systems. Although general rule manipulation has been integrated into information systems, these rules are scatted across the source code. Therefore, re-programming is required when the rules are revised. However, QA compliances are subjected to frequent updates and need to be managed separately. Nevertheless, existing information systems do not adequately facilitate to implement the QA compliances. In addition, the literature suggests that business rules can prevent undesirable consequences of the day-to-day activities of a business, and compliance with business rules can be implemented in information systems separately. As revealed, the business rules concept has not been adopted in the higher education QA information system design and development. Accordingly, higher education QA compliances can be implemented as QA rules adopting business rules-related technologies. Hence, this literature review highlights the necessity of a systematic and more efficient QA rules manipulation mechanism.

Methods

This study utilises four main steps. First, the prevailing higher education QA context was analysed through process observation, focus group interviews, analysis of existing information system functions, and analysis of the QA review report to identify the prevailing issues. Second, QAGS integrated with a rule manipulation module was designed based on the business rules concept to address the identified issues. Third, as a proof of concept, a web-based system was developed to showcase two key modules of the proposed QAGS. Finally, the proposed QA rule manipulation mechanism and the developed modules of the QAGS were evaluated. A state higher education institute in Sri Lanka was chosen for quality assurance context analysis primarily based on the convenience of accessing internal and more detailed information. In addition, evaluators were also selected from the same university to evaluate the QA rule manipulation mechanism and QAGS development. The next paragraphs of the methodology section discuss these four steps in detail.

Analysis of Prevailing Higher Education QA Context

First, prevailing issues in higher education QA were identified. Here, four techniques were used to identify the prevailing issues in the existing QA systems. 1. Existing higher education QA process was examined. This examination mainly focused on the internal QA of the T&L process, related workflows, evidence and document preparation, and external QA reviews. 2. Focus group interviews were conducted with 35 higher education institute members involved in the QA process to explore the current QA practices and associated issues. These 35 members include the Dean of the Faculty, Heads of three academic departments, 29 lecturers, the Assistant Registrar, and the System Analyst of a selected faculty in the state university system. 3. Existing information systems applications, such as Student Information Management System (SIMS), Learning Management System (LMS), and Academic Accountability and Workload System (AAWS) were examined. 4. Existing QA-related documents, such as QA Review Manuals (i.e. Programme Review and Institutional Review), Examination manuals, internal QA-related circulars, and QA Review Reports, were also reviewed to explore QA compliances in the higher education system.

Designing the QAGS Integrated with a Rule Manipulation Module

As the second step, QAGS and rules manipulation mechanisms were designed. As illustrated in Figure 1, this study proposed the QA rules concept in the information system context. These QA rules are extracted from QA compliances such as QA standards, policies, procedures, Examination manuals, and QA circulars. These QA rules are maintained as a shared rule repository of the proposed QAGS. These rules are governed by the rule manipulation module of the proposed QAGS. The QAGS provides an automated platform to implement QA activities by verifying QA rule compliance.

Further, in this study, the QA rules concept was extended by introducing rule categories, rule templates, and enforcement levels. Three main QA rule categories were introduced to cater the QA process, and respective rule templates were created. Further, appropriate rule enforcement levels were defined to manage the severity of the QA rules.

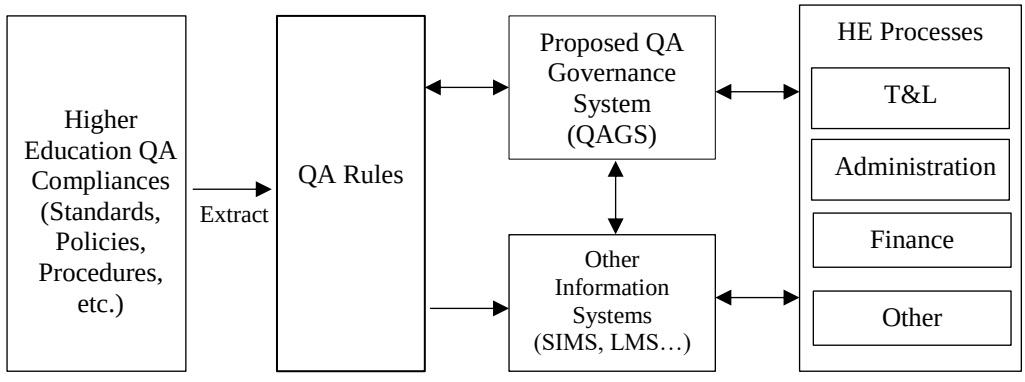

Figure 1. Operationalization of QA Rules over the Information Systems

Next, the proposed QAGS was designed. First, modules of the QAGS were specified and design aspects of each module were further explored. Accordingly, four main modules were included as Activity Planning and Monitoring Module, QA Rule Manipulation Module, QA Document Management Module, and QA Performance Evaluation Module. Nevertheless, this study mainly focuses on the design and development of the Activity Planning and Monitoring Module and QA Rule Manipulation Module. To this end, a rule-based sub-system was designed under the QA Rule Manipulation Module.

Development of QAGS as a Proof-of-Concept

The third step of this study was the development of QAGS. Here, the proposed QAGS was developed as a web-based information system using PHP and MySQL databases. The activity Planning and Monitoring Module and QA Rule Manipulation Module were developed to demonstrate the proposed QAGS. The functions of the modules were limited to facilitate the T&L process. Then, the QAGS was hosted online allowing evaluators to access it remotely.

Evaluation of QA Rules Manipulation Mechanism and QAGS Development

Evaluation of the QA rules manipulation mechanism and QAGS development is described as the fourth step of the study. The evaluation was done by two groups of evaluators through focus group discussions and a questionnaire survey mainly to see how the proposed QAGS has addressed the identified QA issues. Table 2 outlines the evaluation criteria utilized by each group of evaluators. The first group of evaluators consists of 16 QA authorities, including the Director, Quality Assurance Council, UGC – Sri Lanka, and 15 members of the four Faculty QA Cells of the selected university. This evaluation was focused on the proposed QAGS solution including the QA rules manipulation mechanism.

Table 2: Evaluation of QA rules manipulation mechanism and QAGS development

Evaluation	Group of Evaluators	Evaluation Criteria
Evaluation of proposed QA rules	QA authorities	Proposed QA rules manipulation mechanism was evaluated based on:

manipulation mechanism		1. How QAGS facilitates to implement QA compliances in the information system context? 2. How to manage the flexibility in implementing of QA rules in the proposed QA rules manipulation mechanism?
Evaluation of QAGS web-based system development	Direct and indirect stakeholders of the teaching and learning process	Evaluation of QAGS based on three information system success factors (Çelik & Ayaz, 2021; Ojo, 2017), 1. System functionalities, 2. Information quality and 3. User satisfaction

The second group of evaluators consisted of direct and indirect stakeholders of the teaching and learning process, i.e., university academics, support staff, and administrative staff members. An online questionnaire with two main sections was used to collect the responses. The first section consists of questions relating to demographic data, and the second section contains questions on system module evaluation organised under three sub-sections. These sub-sections mainly concentrate on three information system success factors, i.e., system functionalities, information quality, and user satisfaction (Çelik & Ayaz, 2021; Ojo, 2017). Except for the demographic questions, other questions were scored using a 5-point Likert scale (Strongly Disagree-1 to Strongly Agree-5). The questionnaires were filled out after a demonstration of the QAGS. A total of 52 responses were collected, including 40 academics, 8 academic support staff, and 4 administrative staff representing different faculties of the selected university. Exploratory data analysis techniques were used to analyse the collected data through the questionnaire.

Results and Discussion

The results of this study are described in four main sections. First, the issues identified through analysing the prevailing systems are presented. Second, the design of the proposed QAGS and rule manipulation module are presented. This includes the proposed QA rules concept, rule categories, respective rule templates, and sample rules. Third, QAGS web-based system development is illustrated. Finally, evaluation results of the proposed QA rule manipulation mechanism and QAGS development are presented.

Issues Prevailing in the Existing QA Process

The prevailing QA process observation and stakeholder interviews revealed that a proper mechanism has not been established to manipulate QA compliances. Therefore, QA compliances are verified manually. But this verification has become inefficient and inconsistent due to three main reasons. Firstly, there is a large amount of QA compliances that need to be processed consistently. Secondly, some of the QA compliances are too complex and difficult to interpret. And thirdly, there is a dynamic nature to the compliance requirements which was added to the challenge.

Analysis of the existing information systems revealed that these systems have not focused on facilitating the manipulation of QA compliances. These systems have not recognised QA compliances separately. However, it seems that the system's code has integrated specific QA compliances. Thus, updating these embedded QA compliances requires changes in the coding level. Furthermore, the current QA compliance manipulation is limited and fails to consider the importance of the flexibility of rules. These rules have been enforced with greater rigidity and limitations. Accordingly, to ensure compliance with QA standards, it is essential to enhance the functionality of current information systems.

In addition, QA review reports have not highlighted using a proper mechanism to overcome the drawbacks of the manipulation of QA compliance. However, they have emphasised the scarcity of using information systems for efficient QA process implementation.

QA Rules Manipulation Mechanism

As the literature review shows, business rules concepts and related technology improvements can be used to implement QA compliances. Accordingly, this study proposes that QA compliances can be defined as QA rules that guide and influence the activities in achieving the QA objectives. This QA rules manipulation mechanism aims for dynamic and consistent rule handling by separating the QA rules from system coding. Accordingly, this study identified three main QA rule categories and respective rule templates. And sample rules were developed for each template. Next, QAGS was designed including a rule manipulation module. In addition, two main modules were developed as a web-based information system to demonstrate the QA of the T&L process and suggested a QA rules manipulation mechanism.

This study defines QA compliance as QA rules that guide and influence higher education activities assuring the respective QA standards, policies, and procedures. These QA rules are implemented and realised in an information system scenario. As shown in Figure 1, QA rules are extracted from existing QA standards, policies, procedures, etc. And these rules are maintained as separate shared rule-base in information system scenarios.

In the QA rule manipulation mechanism, rule enforcement details such as enforcing authority, enforcement status, rule's active duration, and enforcement levels are critical. Rule enforcement authority is responsible for creating and updating the QA rule within the system. This privilege can be granted to the system administrator or respective managerial positions, such as Head of the Department, Dean, or Assistant Registrar. The QA rule enforcement status defines the current state of the rule, i.e., active or inactive. This rule enforcement state is necessary since some QA rules have to be temporarily inactive. The first enforcement date and expiry date provide the lifecycle information of a QA rule. This information reflects the lifespan of a rule based on its application.

The rule enforcement level is required since the enforcement level changes more often than the rule itself (Bridgeland & Zahavi, 2008). This study adopted enforcement levels suggested by Bridgeland and Zahavi (2008) and Ross (2019) as QA rule enforcement levels. These enforcement levels are substantially enough to maintain flexibility in enforcing the QA rules. Accordingly, QA rules can be identified under five enforcement levels, i.e., 1. Strictly enforced,

2. Pre-override, 3. Post-justified override, 4. Override with explanation, and 5. Guideline. Table 3 depicts a sample of QA rules identified under each enforcement level.

Table 3: Enforcement Levels of Quality Assurance Rules

QA Standard, Policy, or Procedure	Enforcement level	QA Rule Statement
Responsibility for the approval of programmes and courses, at the university level, is with the Senate and the Council (Wayamba University of Sri Lanka, 2018)	Strictly enforced	Senate and the Council approvals are required to offer the Programmes and courses
In the SLQF credit system, the student workload of a study programme is defined as 1500 notional learning hours per academic year (UGC, 2015b)	Strictly enforced	Student workload of a study programme not less than 1500 notional hours per academic year
The Senate has the authority to appoint and revise the examiners with the nomination/ recommendation of the respective Faculty Board	Pre-override	The Senate can appoint and revise the examiners with the recommendation of respective Faculty Board.
Academic calendar needs the recommendation of respective Faculty Board, in each academic year/semester	Pre-override	If an academic calendar is to be revised, a Faculty Board recommendation should be taken
Exam results need senate approval	Post-justified override	Nevertheless, examination results can be published subject to senate approval.
Continuous assessments of each course unit are defined in course specification at the commencement of the semester	Override with explanation	The type of the continuous assessment can be determined according to the requirements of the course unit.
The Faculty/Institute regularly and systematically gathers information about student satisfaction with the support services. Information collected is used for improvement of the services (UGC, 2015a).	Guideline	Respective authority can monitor and rectify the process of gathering information about student satisfaction with the support services and remedial actions on improving the support services.

These QA rules can be categorised according to their applications in the QA process. Here, three main QA rule categories can be identified, namely: 1. Constraints, 2. Inferences, and 3. Action enablers. A constraint-type rule is a statement of condition that limits or controls the actions. An inference type rules make an appropriate conclusion on a particular situation. An action enabler rule allows taking action based on a specific condition.

After specifying the rule categories, respective rule templates can be created. These rule templates formally present the rules using well-defined rule phrases (Burattin et al., 2015). Further, these rule templates provide more convenient rule management facilities for the end-users by mitigating the complexity of rule manipulation. Therefore, even inexperienced system users can use these rule templates to create rules consistently, ensuring uniformity (Burattin et al., 2015; Loucopoulos & Kadir, 2008). This study created specimen rule templates for selected rules extracted from Programme Review Manual and different QA policy documents formulated by the UGC and individual universities.

Before discussing the main rule categories, it is necessary to consider the terms and facts. Accordingly, terms and facts are defined first, and then they are used to define rule templates (Loucopoulos & Kadir, 2008; Prakash et al., 2021). A term is a word or phrase relevant to defining a quality aspect of the higher education context. The following template can be used to express a term.

<term> *is defined as* <description in the QA context>

The following four examples demonstrate how terms can be defined in the higher education context.

i. An examiner *is defined as* a teacher appointed by the Senate to evaluate the knowledge, ability, or proficiency of students through an examination (University of Moratuwa, 2013)
ii. A supervisor *is defined as* an academic member appointed to supervise a dissertation, research project, or similar academic work (Rajarata University of Sri Lanka, 2019)
iii. A question paper setter *is defined as* a person who prepares the examination paper (Uva Wellassa University, 2017)
iv. Semester Grade Point Average (SGPA) *is defined as* the student's academic performance during a semester

In addition, a fact is a statement that depicts the relationship between terms. The following templates can be used to define a fact.

<term1> *verb* | *verb phrase* | *prepositional phrase* <term2>
<term1> *has a property of* <noun/term2>
<term1> [*may* | *shall*] *have* | has <term2>

The following four examples demonstrate how facts can be defined using the above templates.

i. The examiner *evaluates* the examination paper
ii. The Course Coordinator *plans* the delivery of a unit of study (Rajarata University of Sri Lanka, 2019)
iii. The Curriculum *has a property of* version
iv. Course unit *has* a course specification

1) Constraints

A statement that specifies a mandatory feature of the activity to assure quality.
The following rule template can be used for constraints.

<noun/ business term> *must* [*not*] | *may* [*not*] | *shall* [*not*] <verb-phrase> <constant or non-verb phrase>

Three example rules depicted in table 4 demonstrate how constraints type QA rules can be defined using the template above:

Table 4: Constraint type QA Rule examples

	Standard	Rule Statement and Rule Template
i.	The IQAU shall meet once a month and report the progress of its activities to the Senate. The number of meetings per year shall not be less than ten (Rajarata University of Sri Lanka, 2020)	Rule statement: The number of annual meetings of the IQAU/CQA shall not be less than 10 Rule Template: <Number of annual meetings of the IQAU/CQA> *shall not* <be less than> <10>
ii.	All academic programs shall be reviewed, minimally, once every five years adhering to the guidelines prescribed by the IQAU (Rajarata University of Sri Lanka, 2020)	Rule statement: All academic programmes shall be reviewed every five years minimally Rule Template: <Number of years for an academic programme version> *must not* <exceed> <5>
iii.	The Faculty/ Institute provides timetable and course specifications before the commencement of the academic semester (UGC, 2015a)	Rule statement 1: The Faculty provides the timetable before the commencement of the academic semester Rule template: <Publish date of the timetable in a semester> *must not* <exceed> <start date of the semester> Rule statement 2: The Faculty provides the course specifications before the commencement of the academic semester Rule template: <Publish date of the course specification of a course unit> *must not* <exceed> <starting date of the semester>

2) Inferences

If a condition is met or a fact is true, then a conclusion can be inferred.
The following rule template is proposed for the inferences QA rules.

If <condition 1 [true]> [and condition 2 …] *then* <conclusion>

Two examples depicted in table 5 demonstrate how the inference type QA rule can be defined using the above template.

Table 5: Inference type QA Rule examples

	Standard	Rule Statement and Rule Template
i.	If the student's SGPA falls between 1.50 and 1.99, the student will be placed on Academic Warning (University of Moratuwa, 2012).	Rule statement: If a student's SGPA is between 1.50 and 1.99, the student falls on the "Academic Warning" state Rule template: *If* <student's SGPA is between 1.50 and 1.99> *then* <student falls on "Academic Warning" state>
ii.	Any student with an SGPA of less than 1.50 will be placed in "Academic Probation" state (University of Moratuwa, 2012).	Rule statement: If a student's SGPA falls less than 1.5, the student is placed on "Academic Probation" state Rule template: *If* <student's SGPA falls less than 1.5> *then* <student is placed on "Academic Probation" state>

3) Action Enablers

Action enablers are ECA rules (Event, Condition, Action). It is a statement that triggers one or more activities under specific conditions.

The following two templates can be proposed for the action enablers type QA rules.

When <condition is true> *then* <action>

If <condition 1> [and condition 2 …] *then* <action>

Three examples listed in table 6 demonstrate how action enabler type QA rule can be defined using the above templates:

Table 6 : Action Enabler type QA Rule examples

	Standard	Example QA Rule
i.	If a student is in an "Academic Warning" state, notify the respective mentor.	Rule statement: When a student is in "Academic Warning" state respective mentor should be notified. Rule template: *When* <student is on "Academic Warning" state> *then* <notify the respective mentor>
ii.	Allow filling out the Student feedback form on the Degree programme after the completion of the degree of the student (University of Ruhuna, 2020)	Rule statement: When a student completes the degree, he/she should be allowed to fill out the student feedback form on the degree programme. Rule template: *When* <completion of the degree of the student> *then* <allow to fill the Student Feedback Form on Degree programme>

iii.	If the lecturer has not conducted a peer review up to one month before the semester end, notify by email.	Rule statement: If the lecturer has not conducted a peer review up to one month before the semester end, notify the lecturer by email. Rule template: *If* <lecturer has not conducted peer review and the date is equal to one month before semester end> *then* <notify by email>

These rule templates can present the QA compliances in the proposed QAGS. However, more descriptive QA compliances may take more work to implement as QA rules. Such rules can be partially automated. More precisely, the respective authority can manually verify the process based on the rule and update the information system accordingly. Then, the system maintains the required rule verification information, which can be provided as evidence during the QA reviews. For example, standard 5.1 of the Programme Review Manual verifies whether the teaching and learning strategies are based on Institute's/ Faculty's mission and curriculum requirements. The head of the department can verify this rule when approving course specifications and updating the information system with relevant information. However, the information system should facilitate the required workflow to implement this procedure.

Quality Assurance Governance System (QAGS)

The proposed QAGS in this study facilitates automating QA governance and manipulating QA compliances. Figure 1, in the method section, illustrates the manipulation of QA compliances as QA rules. QA expects complying respective QA rules in performing a particular task. QA Rules are extracted from higher education QA compliances such as QA standards, policies, and procedures. And these rules are stored in QA rule base that performs as a separate shared rule repository. This rule-based approach detaches the rules from the source code and provides a more flexible rule management platform. To this end, QA Rule Manipulation Module was included in the QAGS. A rule-based sub-system can be designed to manipulate the QA rules in the QA Rule Manipulation Module.

As illustrated in figure 2 , this rule-based subsystem consists of a rule engine, rule base, and rule management interface (De Jesus & De Melo, 2014; Kluza & Nalepa, 2019; Li, 2012). The rule engine enforces the QA rules at the execution stage of the activity. The rule management module facilitates the basic rule operations such as creating, editing, and revising rules via the user interface. The rule base provides the required storage facilities for this rule-based approach. However, the QA rules that need to be enforced and triggered must be communicated from Rule Management Module to the rule engine.

In addition to this QA Rule Manipulation Module, the QAGS consists of three main modules, i.e., Activity Planning and Monitoring Module, QA Document Management Module, and QA Performance Evaluation Module. However, this study mainly focuses on designing, developing, and evaluating the Activity Planning and Monitoring Module and QA Rule Manipulation Module.

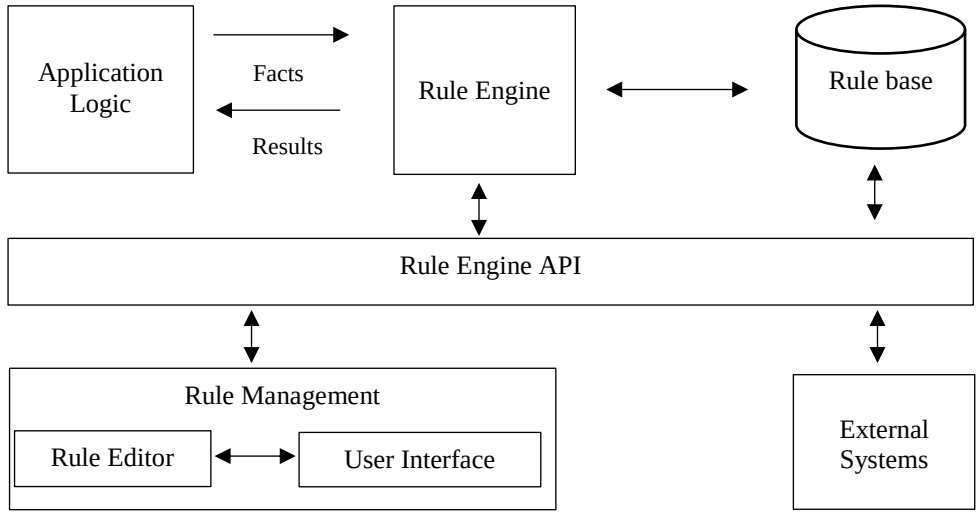

Figure 2. Quality Assurance Rule-based Subsystem

Development of the Modules of Quality Assurance Governance System

The QAGS was developed as a web-based system using PHP and MySQL databases. Accordingly, the Activity Planning and Monitoring Module, and QA Rules Manipulation Module were developed. Only selected key functionalities were implemented in order to facilitate the QA of T&L activities and QA rule manipulation. In addition, a user management module is also included to facilitate the primary uses of the system such as course lecturer, course coordinator, Head of the Department (HoD), and the dean of the faculty. Then system was hosted allowing evaluators to access it remotely.

The Activity Planning and Monitoring module encloses the main activities of the T&L process, such as planning the T&L activities, performing the student contact activities, and monitoring the performing activities against the plan. The QA Rules Manipulation Module facilitates defining, updating, and enforce the QA rules. In addition, privileged users have the facility to manage rule enforcement levels to alter the severity of the rules.

Evaluation of QA Compliance Verification Mechanism and QAGS Development

As described in methods section, the evaluation was done by two group of evaluators through focus group discussions and questionnaire survey. First group of evaluators consists of 16 QA authorities and evaluation was conducted through focus group discussions. This evaluation was focused on proposed QAGS solution including the QA rules manipulation mechanism. The second group of evaluators consisted of direct and indirect stakeholders of the teaching and learning process, i.e., university academics, support staff and administrative staff members. An online questionnaire was used here to evaluate the QAGS development.

The first group evaluation revealed that the proposed QAGS would minimise the additional burden in the QA process while integrating the QA process with routine activities. Further, the

proposed QA rules manipulation mechanism could verify QA compliances by applying the QA rules concept. However, some QA compliances are challenging to automate due to their descriptiveness, complexity, and more human-oriented nature. Further, evaluators did not recommend a more rigid rule manipulation mechanism. They agreed with the proposed QA rule enforcement levels that provide flexibility in rule implementation at the proposed information system.

The second group evaluation was mainly focused on QAGS modules development. This evaluation collected 52 responses through the online questionnaire. Among the 52 total responses, 40 (76.92%) were academic staff members, 8 (15.38%) were academic support staff members, and 4 (7.69%) were administrative staff members. At the university level, the sample represents 6.25 % of academics, 12.12% of academic support staff and 10.52% of administrative staff of the University.

Success of the QAGS was evaluated based on three information system success factors, system functionalities, information quality and user satisfaction (Çelik & Ayaz, 2021). As revealed by the analysis of the results, the mean values of the system functionalities, information quality and user satisfaction are 4.16, 4.15 and 4.03, respectively. Accordingly, responders positively evaluated the system functionalities, information quality, and user satisfaction with QAGS development.

Conclusion

In this study, QAGS was introduced to facilitate the higher education QA process according to the findings of the prevailing situation analysis. One of the significant contributions of this study is suggesting a mechanism for manipulating QA rules based on business rules, ensuring compliance with QA rules. It includes QA rules concept, rule categories, respective rule templates, sample rules and design of the QA rule-based sub system. In addition, these concepts and rule manipulation mechanism were implemented by developing the web-based QAGS including QA rules manipulation module.

The evaluation of QA rules manipulation mechanism and QAGS development revealed that QAGS would minimise the additional burden and detachedness of QA process with routine activities. Based on the results of this study, it is possible to implement the suggested QA rules manipulation mechanism for ensuring compliance with quality assurance rules. Therefore, study concludes that quality assurance requirements could be better captured as rules using the proposed rule templates, while rule manipulations and compliance could be verified real-time through the proposed Quality Assurance Governance System.

However, since this study mainly focused on teaching and learning, the proposed higher education QA rule templates need to be expanded to other processes in future research. Further, since more rigid rules manipulation mechanism is impractical, this study shows the importance of rule enforcement levels. Therefore, a more convenient QA rule implementation scenario can be expected through this flexible rule manipulation mechanism. Thus, the proposed verification mechanism of QA rules compliances, rule categories, templates, rule enforcement levels and QAGS will be a good input for the QA information system solution developers in the higher education context.

Additionally, it is important to note that this study was conducted solely on one state higher education institute in Sri Lanka. Therefore, it is necessary to conduct further investigations on other higher education institutes to ensure the results can be generalized. In addition, the sample encloses limited staff members of the selected faculties of the institute, and the sample should be increased to validate the results successfully.

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