A Quality Assurance Framework for STEM Programmes and Courses in University

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Abstract

This paper chronicles a Singapore University's 10-year quality assurance journey, as it explores the benefits which accreditation and quality assurance bring to higher education programmes and courses, and how accreditation and certification criteria from Science, Technology, Engineering and Mathematics (STEM)-related professional bodies or external agencies can be internalized for an academic audit, with the aim and objectives to develop a quality assurance and control framework to tighten the academic audit processes and to ensure that the learning outcomes of the university's programmes and courses are achieved through rigorous curricula and robust pedagogy. A review of an annual academic audit on the entire university, across five schools and encompassing 69 programmes and 902 courses was conducted. It was followed by an appraisal of a 10-year longitudinal and observational study of how the academic audit expectations and criteria have evolved throughout the years for STEM programmes and courses, and how these STEM programmes have managed to perform or keep up with the ever-changing requirements. This paper addresses the knowledge gap of which quality assurance mechanisms work well in STEM, and postulates that having an academic audit framework would be able to reap benefits such as an improvement in quality control and assurance; detection of malpractices or non-compliances, weaknesses and potential problems; support continuous improvement; retention of organization knowledge; and accountability to stakeholders. It focuses on STEM programmes but its principles can be applied across to other disciplines such as arts and social sciences, human development, business and law.

Keywords: Accreditation, Quality Control and Assurance, Academic Audit, STEM programmes

1. Introduction

Theory-practice link has been espoused to enable students to apply and integrate knowledge, skills, attitudes, values and experience with theories learned in the classroom [1,2,3,4]. In many universities, adjunct or associate faculties from the industry are hired and engaged to teach industry-relevant and applied courses, or courses infused with real-world case studies so that students can be workplace-ready and be able to "hit the road running", instead of having to unlearn and relearn because of the disconnect or dissonance between theory and practice. The approach or tenor is to get industry practitioners to complement academics to equip and prepare students for the real-world and be future-ready, which will require them to demonstrate transdisciplinary and transversal knowledge, skills, attitudes and values, coupled with the savviness and ability to apply what they have learned in classrooms to deal with increasingly volatile, uncertain, complex and ambiguous world. However, this comes with issues and challenges – how do you train these practitioners who are not full-time faculty and get them to adhere to strict university policies and procedures? What do you do with balky instructors or recalcitrants who are pertinacious with errant behaviour? The farming out or outsourcing of instruction and increasing dependency on associate faculties necessitates quality control over these associates through standardization exercises, monitoring and peer reviews.

For those familiar with audit, there are primarily three types of audits, namely: internal, external and government audits [23, 24]. The academic audit here refers to the internal audit conducted by the university to conduct a health-check on academic-related matters. Academic audit is necessary to prevent reputational damage, which can arise due to several reasons, such as breach in assessment integrity through divulgence of question paper, marking error, inconsistency and unfairness in grading, abysmal teaching, teaching with outdated or erroneous materials and lack of qualifications or unauthenticated qualifications of instructors. There is a long tail to this list.

2. Quality assurance through accreditation

Accredited degrees and courses are recognised by the professional bodies of the respective professions and are often or mandatorily required before one can work and practise in the field. There is extant literature on the benefits and challenges of accreditation. Accreditation protects the interest of all stakeholders – students, faculty, school/

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university, employers, industry and partners such as donors, sponsors and collaborators.

Table 1. Some of the Professions and Accrediting Bodies Globally and in Singapore (non-exhaustive)

Professions	Accrediting Bodies
Accountancy**	Association of Chartered Certified Accountants; Chartered Institute of Management Consultants
Architecture	Singapore Board of Architects
Business**	Association to Advance Collegiate Schools of Business
Dentistry	Singapore Dental Council
Dietetics	Singapore Nutrition and Dietetics Association
Engineering**	Engineering Accreditation Board (EAB)
Facilities Management**	Singapore International Facility Management Association
Law**	Singapore Ministry of Law
Medicine	Singapore Medical Council
Occupational Therapy, Physiotherapy, Speech Therapy	Allied Health Professions Council
Optometry	Optometrist and Optician Board
Pharmacy	Singapore Pharmacy Council
Project Management**	Society of Project Managers
Psychology	Singapore Psychological Society
Quantity Surveying**	Singapore Institute of Surveyors and Valuers
Social Work**	Social Work Accreditation and Advisory Board; Council for Social Work Education
Veterinary Science	Agri-Food and Veterinary Authority of Singapore
Workplace Safety and Health**	Ministry of Manpower

*denotes applicable to programmes offered in the university
** denotes applicable to programmes offered in the school

The benefits of accreditation for Higher Education Institutions (HEIs) include determining whether standards of education and professional and industry expectations have been met, supporting the branding and perception of programmes for prospective students, helping employers determine credibility of programmes and knowledge level of students, enabling alumni to progress to further certifications, encourages and supports planning and identifying areas for change and resources reallocation. [5-22, 25, 26, 30, 31].

In STEM, the Engineering Accreditation Board (EAB) is commonly regarded as the gold standard of accreditation. The EAB's objectives of accreditation are: to ensure that accredited programs satisfy the academic criteria and those are benchmarked to meet the standards of other mutual recognition agreements entered into by EAB, including the Washington Accord; to assist stakeholders as well as potential students and their parents, professional societies, and potential employers, in identifying specific engineering programs that meet the accreditation criteria; and to provide feedback to the educational institutions for the improvement and development of educational programs in engineering that can better meet the needs of the local industry. To do that, the EAB audits a range of issues relating to the programme, such as: outcome of the education provided; quality assurance processes, including internal reviews; assessment of student learning outcomes; activities and work of the students; entry standards and selection for admission of students; motivation and enthusiasm of faculty; qualifications and activities of faculty members; facilities; and Industry participation [30].

The accreditation of STEM programmes are arguably more critical because the fields can have significant impact on public health and safety, and are often highly competitive and globalised [29,30,31]. In the School of Science and Technology where this case-study is conducted, there are a few EAB-accredited degree programmes, such as the Electronics Engineering and Aerospace undergraduate programmes. There are also programmes accredited by Royal Institute of Chartered Surveyors, International Facility Management Association, Institution of Occupational Safety and Health. Some are accredited at course or module level, such as the Digital Delivery Management Scheme; some are international, such as those aforementioned, with local chapters or accords such as the EAB which is the local counterpart to the Accreditation Board for Engineering and Technology (ABET) for mutual acknowledgement and recognition internationally; some are local, i.e. Society of Project Managers and Singapore Institute of Surveyors and Valuers for professional bodies in Singapore, and the Ministry of Manpower's WSH Officer Registration. Interestingly, there could be mutual recognition between some of these accreditations as well, e.g. between ABET, IFMA Foundation and RICS. It has to be noted that 1) not all disciplines have

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accreditation – some industries and fields are more loosely organised and regulated, e.g. digital media, info-communication technology and mathematics; 2) there is a difference between accreditation for individuals (e.g. Professional Engineering Board) and programmes (e.g. Engineering Accreditation Board), and 3) accreditation of a programme or course can be a prerequisite to become a licensed/ chartered/ professional practitioner. For instance, a graduate from an EAB-accredited degree programme will be eligible to sit for his or her Professional Engineer examination after completing higher education studies and acquiring some experience in the industry.

Other accreditation schemes, such as the CSWE and AACSB for accreditation of business schools were also reviewed. It is noteworthy to highlight that even EAB and AACSB, the acknowledged "gold standards" and benchmarks used for accreditation in their disciplines, update their accreditation standards and requirements to stay au courant with trends and developments and stay relevant in the ever-changing educational landscape, which in turn reflects the desired Knowledge, Skills, Attitudes and Values (KSAVs) demanded at the workplace [30, 31].

To surmise, there has been a paradigm shift from inputs-based and process-based to outcome-based education in the past few decades, but more recently, there has been some advocating to pivot to competency and skills-based, as well as transversal competencies [32, 33].

3. Internalizing the accreditation and certification process – what to take in and what not?

Using accreditation as a form of quality assurance is widespread and pervasive, across regions and countries such as United States, United Kingdom, Switzerland, Sweden, New Zealand, Japan, Egypt, Jordan and Philippines [5, 8, 12 - 22].

The common requirements for accreditation, compiled from EAB, IFMA, RICS etc are: alignment of vision, mission and goals of university with programme, rigour of curriculum, instructional and assessment methods, qualifications and competencies of faculty, impact of scholarship/ research, industry engagement, and how programme is being administered efficiently and effectively. Several criteria used in EAB accreditation have been borrowed and applied for academic audit. Criteria from other accrediting bodies are amalgamated with EAB's and evaluated for relevance and applicability for internal academic audit. Notably, there are criteria such as staff quality, physical facilities, inclusion, diversity, and ethical standards which are overseen by other departments. Several of these criteria can be time-consuming and onerous. Hence, programmes undergoing accreditation can be given academic audit exemptions, with the assumption or understanding that if a programme could pass an external accreditation, it would most likely pass the academic audit; some programmes and courses can be excluded from academic audit because of locus of control; some criteria can be refined or customised to address the uniqueness of the school/ university[1]. One can argue that the academic audit is a simplified and abridged version of accreditation. In addition, the internal academic audit can be thematic and can focus on specific dimensions and aspects of the programme. More will be elaborated in later sections of the paper.

4. Audit principles and methodology

Scope, criteria, requirements and scoring rubric can be updated and changed as and when necessary, but the academic audit is anchored on these guiding principles:

1) Desired outcomes – whether the programmes/ courses achieve the desired outcomes in terms of content delivery, learning outcomes and assessment quality, amongst others.

2) Continuous improvement – quality assurance is a continuous process and is a key enabler in enhancing our programme/ course offerings and ensuring that they are kept up-to-date with industry needs. Sharing of good practices across programmes/ courses is important in our journey towards continuous improvement.

3) Benchmarking – our programmes/ courses will benefit from the engagement of professionals and industry practitioners beyond the University in keeping up with the times and being responsive to the latest developments.

4) Impartiality – given the nature of audits, individuals who are external to or not directly involved in the programmes/ courses shall be responsible for conducting audits.

The academic audit criteria are reviewed at every annual work-plan to decide whether the requirements imposed are useful parameters or proxies to gauge the efficacy of achieving desired outcomes. In the spirit of continuous improvements, innate characteristics are taken into consideration and programmes would not be penalised or flagged-out for inherent limitations. Hand-holding is provided to

[1] The Singapore University of Social Sciences is one of the six autonomous universities in Singapore. Since "social science" is eponymous with the name of the university, the internal academic audit seeks to tease out how social science or impact to community has been embedded into each programme

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administrators of new programmes or newly appointed administrators. Benchmarking from external accrediting bodies and engagement of external stakeholders ensure that academic audit processes and requirements are robust and our programmes and courses are rigorous. Finally, impartiality is safeguarded by appointing auditors who do not have conflict of interests, and the co-chairs monitor and moderate the performance of each programme and arbitrate when and where necessary.

4.1. Evolution of academic audit processes, criteria and requirements

First and foremost, we seek to comprehend what are the internal and external challenges that higher education faces these past 10 years? The trends and challenges include: diversity in students and faculty, increase in non-traditional students, mental health awareness, embracing artificial intelligence for learning, prevalence of online learning, virtual reality for education, job redesign and focus on closing skill gap, rise of massive open online courses, enrolment of international students, growing need for alternate funding options and changing pathway for fundraising campaigns [26 - 29]. In addition to that, the STEM school underwent radical transformation in status such as turning from a private university to a public one, and with a mandate to focus on social impact. The University and School, and correspondingly, academic audit has to keep up with these external environmental factors and internal developments. Figure 1 shows the university's academic audit cycle and process.

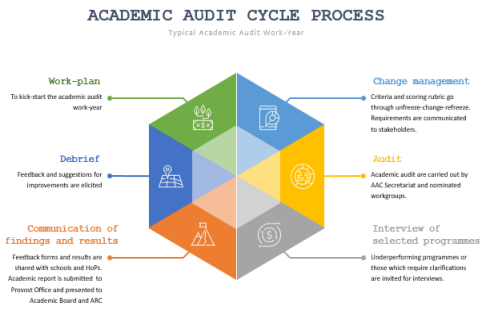

Figure 1. Academic Audit Cycle

Essentially, there is a work-plan to kick-start the academic audit cycle. This is when objectives, criteria and requirements, and scoring rubric are deliberated and harmonised.

Then comes change management, which will require the processes, criteria, and requirements to go through an unfreeze-change-refreeze. It will be prudent to point out here that communication to stakeholders is crucial here. They need to know, and so it will be necessary to unpack for them: what revisions have been made, are they subject to audit or can they get a waiver, what do they have to do and what materials do they have to submit if they are not exempted. The academic audit cannot afford to be esoteric, which was admittedly the case in the early days of the audit.

The hard work starts with the actual audit. Schools and Head of Programmes (HoP) must submit SER, accompanied with necessary documents or admissible evidence. Information which is already in the University Information Management Systems can be retrieved from the Secretariat without having to trouble the Schools and HoPs. Auditors are nominated and appointed to conduct the audit and appraise the programmes and courses as fairly as they can without bias and without being judgmental.

If information is amiss, or clarifications are necessary, interviews will be conducted. Findings and results are then communicated to Schools and HoPs. With the feedback forms, Schools and HoPs will know where they have fallen short. The academic audit report is also submitted to our Provost Office and presented to the Academic Board and Audit and Risk Committee.

Finally, a debrief or post-mortem is conducted to document lessons learnt and to elicit feedback and suggestions to improve the audit process. Table 2 shows an example of the academic audit requirements – what are criteria, observations, recommendations, and how the requirements have morphed throughout the 10 years, and plans in the pipeline are described, pertaining to C2 Instructor Electronic Course Evaluation.

Table 2. Observations, Recommendations and Changes of Academic Audit Criteria

Description of criteria C2 Instructor eCE (electronic course evaluation)	
Courses with poor instructors' eCE scores are flagged out. Instructor eCE serves as a platform for students to provide their feedback and evaluation for instructors and are tabulated at the end of every semester.	
Observations	**Recommendations**
C2-O1) There were several courses with instructor eCE scores below 3.8 for 2 consecutive semesters. Out of these courses, a handful of courses had instructor eCE scores of lower than 3.2 for one semester.	C2-R1) HoPs to i) conduct interviews more stringently, ii) communicate expectations clearly to teaching associates iii) refer underperforming associates to Teaching & Learning Centre (TLC) for coaching in order to improve their ability to

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Overall, there has been a marked improvement from previous years. C2-O2) This year, the AAC continued with the practice of accepting justifications from HoPs as a 'get-out clause' for deduction of marks due to poor instructor eCE scores.	teach and engage students, and iv) to have a larger pool of spare associates to replace underperforming instructors. C2-R2) Having a 'get-out clause' allows auditors and AAC to be more discerning in whether to penalize instructors for low eCE scores, which may sometimes be subjective and biased.
Revisions to this criteria during these past 10 years • Renewal of contract tied to instructor eCE and class audit scores • Random sampling of recordings to ensure instructors do not divulge exam questions to trade for better eCE scores. • "Get-out clause" for underperforming instructors. This can be invoked by the HoP only once, such as for an instructor teaching a new course. **Plans in the pipeline** • Senior AF scheme with delegation and empowerment with more responsibilities and remuneration. • Teaching awards increased to 10% have been introduced to incentive and encourage instructors to engage with students.	

4.2. Change management

Change management is important in every organization. If we are not changing, we will become obsolete in no time. If change management is not done well, there will be confusion, loss of trust and the project will be doomed to fail.

Every year, at the Academic Audit workplan, the academic audit committee applies Professor Vijay Govindarajan's 3 box strategy to unfreeze and change our academic audit criteria, requirements and scoring rubrics in terms of what should be kept but improved, remove redundant and non-value adding activities, and create new criteria to encourage continuous improvements [39] (see Figure 2). It is necessary to refreeze the criteria, requirements and scoring rubric so that Schools and HoPs have a clear idea and direction on what to do for the rest of the year or the semester leading up to the audit. It is to be noted here that in a "transition year", HoPs may be required to adhere to some requirements but they will not be scored.

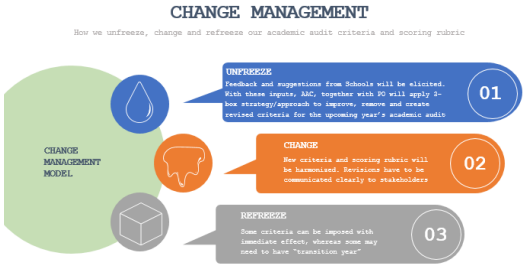

Figure 2. Change management of audit process, criteria and requirements

The academic audit for academic year AY2022 covered both Programme-criteria and Course-criteria. For academic audit AA2022, there were in total 7 course criteria and 4 programme criteria. The course criteria comprised C1 Quality of exam processes (with a weightage of 10%), C2 Learning outcomes statements expressed in prescribed format and conforming to course level (5%), C3 Appropriate assessments of learning outcomes (5%), C4 Instructor eCE score (5%), C5 Course eCE score (5%), C6 Class audit conducted (10%) and C7 Course reviewed by External Assessor (10%). the programme criteria comprised Self-Evaluation Report (40%), Programme Amendment Document (2%), Programme Advisory Committee (4%) and Programme External Examiner (4%).

The Average Course Requirement Total (ACRT) was computed by summing up all the Course Requirement Total (CRT), then divided by the number of courses. The ACRT and Programme Requirement Total (PRT) contributed 50% each to the overall achievable score of 100%.

5. Design and methodology of academic audit assessment

This section will focus on the scoring rubric of the academic audit assessment, and explain the considerations when weighting them and how these weightages have been adjusted throughout these years.

5.1. Scoring rubric

The scoring rubric (see Table 3) is used to guide the scoring of the criteria and requirements during the academic audit exercise. Some of these requirements are straightforward; others can have varying degrees of subjectivity, but these were partly alleviated by using gradations in the scoring rubric. Thus, the scoring rubric was provided so that

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auditors can have a common understanding between them when appraising submissions/ documents which are qualitative or requires some level of discretion. Auditors are advised not to be judgmental and reminded not to penalise programmes/ HoPs for matters not within their locus of control.

Table 3. Scoring rubric example

Course Criteria

Criteria	Max Score	Scoring Rubric (auditors to focus on boldfaced items)
C1 – Quality of Exam Processes	10m	Marks Deduction: • Did not provide evidence of briefings to markers (-1) • Did not provide evidence of briefings to admin support (-1) • Did not provide evidence of marking standardisation exercise (-3) • Did not provide evidence of exam marking monitoring (-2) • Did not provide evidence of plagiarism handling procedure (-3)

Painstaking efforts have been put in to unpack the criteria and requirements, and to assign weightages to reflect their importance to quality control and assurance equitably. The scoring rubric would be reviewed on an annual basis, together with the scope, criteria and requirements during the annual work-plan. There have been a series of revisions to the scoring rubric. These are some of the more significant revisions and their justifications:

- Unpacking and sharpening the phrasing of AA requirements so that the requirements are not esoteric to the audit committee and to prevent misunderstanding and confusion.
- Plugging gaps or addressing shortcomings/ flaws in academic audit criteria flagged out during post-mortem of previous audit exercises.
- Reallocation of weightages to draw attention to areas for improvement at systemic level

5.2 Limitations of academic audit

For AA2022, 69 programmes and 902 credit-bearing courses across five schools in the university were evaluated. Due to the sheer scale and scope of the audit, there are a number of limitations, such as:

- Scope of audit: only credit-bearing courses were evaluated. There are non-credit bearing courses in the university such as Service and Experiential courses which were not examined in detail. Courses which are run by vendors or have been approved for retirement were similarly exempted.
- Good programmes would not necessarily have good audit scores, and vice versa. Hence, discretion by audits have to be taken.
- Auditors are not subject matter experts and can make human errors in judgment.

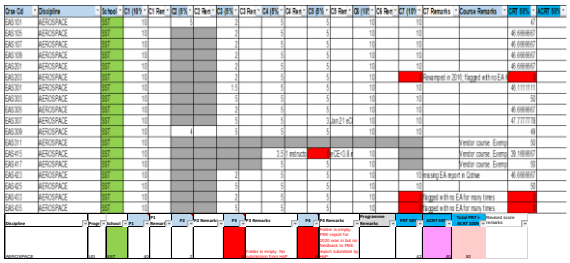
6. Empirical findings on academic audit of programmes and courses and time-series of performance over time

Next, in this section, we will share how a programme is appraised, and attempt to compare the findings with previous years' for a 10-year analysis and discussion.

6.1. Demonstration of appraisal of a STEM programme and constituent courses

Table 4 shows the C-scores and P-scores of the Aerospace programme which resides in the STEM school for AA2022. Non-compliance are highlighted/ color-coded in red in the scoresheet, which would be tabulated for the academic audit score.

Table 4. a) showing C-scores and
b) showing P-scores of the Aerospace programme in STEM school



Programmes which fails to meet the 85% threshold are considered to have failed the academic audit. As an incentive for programmes to do well for the academic audit, those who have passed the 85% threshold would be given a 2-year exemption from academic audit. Conversely, those who failed would be subject to more scrutiny in the next academic audit. The auditors would input scores and comments based on the requirements and scoring rubric in the scoresheet for programmes and their respective constituent courses they have been assigned to assess, and scores would be tabulated by the Secretariat at the end.

6.2. 10-year performance of STEM programmes

Table 5 illustrates the time-series performances of STEM programmes. It can be observed and inferred that there has been a continuous improvement in academic audit performance for STEM programmes. It should be noted that there are limitations in the comparison and exceptions because 1) the academic audit criteria and requirements were constantly getting updated, tightened and becoming more stringent year on year, and 2) there were disruptive times when there were handovers or newly appointed HoPs or Programme Executives, or 3) substantial revision of programme and course curriculum could result to a whole smorgasbord of new requirements to be imposed.

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Table 5. 10-year tracking of STEM programmes in the School of Science and Technology

SST Programme Audit Scores from 2013 - 2022

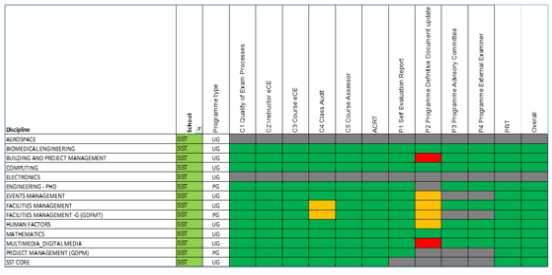
Programme Name	2013		2014	2015	2016	2017		2018	2019		2020		2021	2022
	Partial audit (Otherwise)	Full audit				C score (100%)	P1 score (100%)		C score (100%)	P score (100%)	C score (100%)	P score (100%)		
Aerospace Systems	NA	91	85	71	84	83.19	94.50	90	87	94	80	86	82	Exempted
Aviation Business Administration (PRT only)	NA	91	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Aviation Maintenance (PRT only)	35	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Biomedical Eng.	35	NA	82	94	95	NA	96	91	100	99	97	97	89	100
Building and Project Management	NA	100	98	90	95	NA	97	96	Exempted	97	96	90	87	96
Computing/ InfoComm Technology (Known as InfoComm Technology till 2019)	NA	99	93	89	94	NA	97	81	100	93	89	93	93	94
Digital Media (Known as Multimedia Technology till 2018)	35	NA	92	95	93	NA	93.5	86	Exempted	86	92	99	95	90
Electronics (Known as Electronics & Tech Eng. till 2019)	35	NA	100	91	98	NA	94.5	88	Exempted	88	94	93	91	Exempted
Events Management	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	95
Facilities Management	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	95
Facilities and Events Management	34	NA	98	96	93	NA	96.5	88	96	91	97	88	95	NA
Human Factors in Safety	35	NA	98	100	96	NA	100	98	Exempted	96	99	100	96	98
Mathematics	34	NA	95	100	97	NA	93.5	89	Exempted	72	94	93	94	94
SST Core	NA	NA	NA	NA	NA	86	NA	99	Exempted	81	99	75	97	100
Master of Engineering/ Doctor of Philosophy	NA	NA	NA	NA	89	NA	91.5	100	Exempted	97	Exempted	96	97	100
Graduate Diploma in Facilities Management (GDFMT)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	93
Graduate Diploma in Project Management (GDPM)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	97

Nonetheless, there has been continuous improvements in academic audit performance for the STEM programmes, which can be due to a number of reasons, such as accumulative familiarity with criteria and requirements, and genuine improvement in the quality of programmes and courses. It is also plausible that external accreditation of STEM programmes has a positive causal impact and effect on the academic audit performance which is proposed here to be a proxy for quality control and assurance of programme and courses.

6.3. Using Balance Scorecard to Compare Performance of STEM programmes in School of Science and Technology with Programmes in other Schools

Table 6 presents the performance of STEM programmes, using a Balanced Scorecard visual, whereby green denotes good, orange denotes satisfactory, red denotes poor and grey denotes exemption. It shows that generally, STEM programmes did quite well and better in relation to other schools and programmes, which can again be attributed to the positive spillover effect of accreditation.

Table 6. Balanced Scorecard of STEM programmes



6.4. Breakdown of mean scores at school and criterion level

Table 7 shows the breakdown for AA2022 for all P-criteria and C-criteria at school level. This can be used to identify any systemic issues at university or school level. Scores which were less than 85% of maximum possible score have been bolded. From the above, it can be observed that although the STEM school did well, it fell short or could have done better for criteria P2, namely Updates to Programme Definitive Document after an approval has been given by the Academic Board. To address this shortcoming, the school manager can simply send an email reminder to HoPs and Programme Executives to fulfil this academic audit requirement.

Table 7. Breakdown of mean scores for AA2022 criteria at school and criterion level

School/ Criterion	C1 exam processes/ 10%	C2 instructor eCE/ 10%	C3 course eCE/ 10%	C4 class audit/ 10%	C5 course assessor/ 10%	P1 SER/ 40%	P2 PDD/ 2%	P3 PAC/ 4%	P4 PEE/ 4%	Overall Mean/ 100%
NSHD (18 programmes)	9.43	9.94	9.95	9.64	9.93	35.00	**1.67**	**3.00**	3.58	91.7
SHBS (17)	9.73	10.00	9.87	9.92	9.83	38.44	1.93	3.71	4.00	97.8
SBIZ (15)	9.93	9.98	9.75	9.77	9.89	38.02	1.95	3.71	4.00	97.1
SST (14)	9.93	9.69	9.78	9.72	9.96	38.64	**1.28**	3.94	4.00	96.0
SLAW (2)	9.00	10.00	9.40	9.84	8.75	39.25	2.00	**2.50**	3.50	95.5
CLEL (4)	8.50	9.82	9.65	**7.88**	**6.92**	38.39	2.00	NA	NA	93.8
OGS (1)	NA	NA	NA	NA	NA	**33.00**	NA	4.00	4.00	85.0
Criterion mean	9.76	9.91	9.81	9.79	9.84	37.37	1.77	3.51	3.88	95.0

7. Experiences and lessons learnt during this 10 year exploration and journey

This section will detail the feedback and lessons learnt during this 10-year exploration and journey. The feedback was elicited from various stakeholders. Post-mortem of academic audit exercises and annual work-plans summarises lessons learnt and identify where improvements can be made to make the academic audit process more transparent, fair and to facilitate continuous improvement.

7.1. Feedback from stakeholders

This section captures feedback from various stakeholders such as the schools, programme administrators, AAC and other departments. Some of the positive feedback are:

1) The academic audit ensures quality control and assurance, which is critically important to the credibility of the university, especially since the university is reliant on Associate Faculties [feedback from the Provost].
2) The academic audit exercise standardises practices across the schools and sets benchmarks for new programmes or programmes which have not been doing so well to level up [Provost Office and Academic Audit Committee].
3) Ensures there is a snapshot and stock-take of how programmes and courses are faring for reporting to Board of Trustees and Ministry of Education. [Quality Assurance Unit and External Audit].
4) The self-evaluation report, which is a part or requirement of the academic audit can be useful for i) introspection and ensuring there is alignment of programme to university's vision and mission, ii) reporting and updating

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stakeholders, iii) to smoothen hand-overs[2] [School Deans, Vice-Deans, Academic Audit Committee members and HoPs]

5) The academic audit report can be repurposed or used as a reference document to be submitted to external and government audit such as QUFU and EAB accreditation. At the same time, the academic audit can be highlighted to demonstrate that there are quality control and assurance measures in place. [Quality Assurance Unit, External Audit, Schools and HoPs].
6) The AA performance can be used as a KPI to appraise staff and to detect malpractices or oversight and identify balky/ errant HoPs or Programme Executives who have not been adhering to policies and procedures [Provost and School Deans].
7) The academic audit elevates the quality of programmes and courses [Whole of university]

On the other hand, there are some negative feedback, such as:

8) The academic audit can be too over-encompassing in terms of scope and over-stepping the usual ambit of internal audit [HoPs].
9) Pain-points such as rigid adherence to Learning Outcomes which stifles creativity and freedom to set assessments which can be multi-layered and complex [HoPs].
10) HoPs often have to spend inordinate amount of time on academic audit which distracts academics from more productive and fulfilling work [HoPs].

Both positive and negative feedback are taken seriously and are considered as encouragement and constructive feedback to continually improve the academic audit process organically. For instance, the rigid adherence to Los, which has been a pain-point for HoPs have been liberalised. One example is how the requirement was incrementally liberalised, from rigid adherence to application of action verbs commensurate with the level of course pitched at, to allowing the application of alternative action verbs from equivalent Bloom's stages to full discretion to be exercised by schools and HoPs.

7.2. Insights and discussions of lessons learnt

Our empirical study focuses on 69 programmes and 902 courses in 2022, followed by comparison over the span of 10 years from 2013 – 2022, to understand about challenges faced in Higher Education, and how academic audit can be conducted to ensure quality control and assurance. This section will discuss the key observations, experiences and lessons learnt. These are bunched into clusters and discussed below.

1) Accreditation has a positive effect on/ correlation with Academic Audit Performance

   a. Figure 5 shows the time-series of overall performance of SST's STEM programmes. Overall, there has been an upward trend, suggesting that accreditation has a positive effect or correlation on quality control and assurance, as attested by previous studies [5, 6, 7, 8, 9, 10, 11, 12, 13, 14]
   b. In addition and generally, accredited programmes, tend to fare better than non-accredited programmes. This applies to STEM programmes, as well as programmes such as Accountancy, Law and Social Work listed and discussed in Table 1.
   c. This impact has trickled and spilled-over to programmes across other schools, suggesting that there is a free-rider benefit of accreditation.

2) Academic audit criteria and requirements must adapt to both external and internal environmental factors. Here is a summary of the key revisions, together with the rationale and justifications for the changes:

   a. It has been a learning process where there are often new discoveries or the goalposts have to be shifted to reflect and take into account the new circumstances and conditions.
   b. Exemptions can be granted so that programmes and courses would not be penalised or held accountable for issues outside their locus of control
   c. C-criteria should continue to be audited even after retirement of programmes for implementation fidelity and to be accountable to stakeholders, in particular, to students.
   d. Interviews should be conducted for clarifications and to understand nuances in the programmes and courses
   e. There should be cyclical and periodic audits to make academic audit less onerous. The lightened workload would allow HoPs to focus and work on different facets of the academic audit.
   f. Over time, there should be evidence-based academic audit whereby HoPs and Programme Executives have to submit admissible evidences to prove that an action has been taken after a feedback has been given

[2] In the university, rotation of duties such as headship is recommended. Therefore, there can be frequent hand-overs.

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g. Get-out clauses have been introduced to allow auditors' discretion and avoid rigidity of scoring/ auditing
h. Tax-breaks have been given to reward and incentivise good and commendable performance in previous audits
i. Reports should be sent to schools and AB so that eventually, the onus of quality control and assurance can be transferred back to schools

3) Academic audit can detect malpractices, weaknesses, current and potential problems found in underperforming programmes or courses.

a. New programmes or courses tend to underperform because there can be numerous criteria and requirements and there could be oversight on some of the requirements. E.g. PAC or PEE not set up or appointed.
b. Programmes with newly appointed HoPs and Programme Executives tend to do less well because of their lack of familiarity with academic audit criteria.
c. There could be programmes with inherent disadvantages or limitations. Special considerations and leeway must be granted. This would be surfaced to the Provost for his approval.
d. There can be systemic underperformance at school level or for specific criteria. For the former, it suggests schools are overlooking something; for the latter, it suggests a criteria has not been communicated and understood properly.

4) Academic audit findings can be used to initiate conversations and continuous improvements.

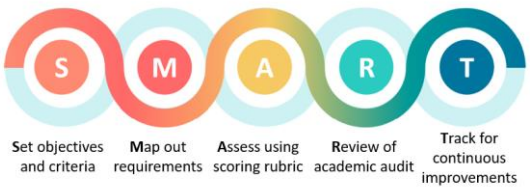
a. Feedback forms are handed-out to schools and programmes to raise issues which have been flagged out for anomalies and inconsistencies.
b. HoPs are then required to respond to the findings in terms of actions they are going to take or provide justifications on why they are not going to act on it.
c. These continuous improvements are tracked and monitored by schools, so that there is accountability from schools and HoPs
d. In some years we shake things up and did things differently, such as when we did not aggregate P-scores and C-scores, but look into them separately; or there could be a thematic review, such as the mapping of the government-championed Generic Skills and Competencies (GSC) or the Core Competencies and Skillsets (CCS) for Enhanced Electronic Transcript project.
e. The academic audit framework has been used for accreditation of external programmes so that there can be credit or course recognition of completed training or courses from other institutions.

5) The academic audit is useful but it can be tedious and stressful, and requires a significant amount of effort and time.

a. There has been a significant improvement in terms of the scores. In AA2022, only 3 programmes failed to attain the target score of 85% for the academic audit and none of the programmes scored below 50%. To be fair, 85% is a stringent benchmark.
b. There has been programme administrators obsessing over and quibbling for that 1% to achieve 100/100. To assuage this problem, scores would be redacted and masked, to only show bands such as excellent (above 85%), Pass (above 50% but below 85%) and Fail (below 50%) from 2023 onwards.
c. Feedback to tone down the academic audit exercise have often been suggested during University Town-hall.
d. It can be overwhelming to demand from programme administrators so many things at one time. Therefore, it is recommended to 1) space out submission deadlines and 2) adopt an audit cycle, i.e. biennially to 5-year cycles which examines various aspects of the programme and courses in different years/ periodically.
e. Digitalisation and automation of the academic audit process can reduce the workload and smoothen the workflow.

8. Discussion and Recommendations

This section will discuss the insights and recommendations for setting up a sustainable academic audit framework in a higher education institution. Although this study focused on STEM programmes, the framework can be applied across to other disciplines such as arts and social sciences, human development, business and law.



SMART Process and Framework	Use case's examples for illustration

Set objectives and criteria	E.g. Criteria - Quality of Exam Processes
Map out requirements	E.g. To provide evidence of marking standardization exercise carried out prior to exam grading for courses with multiple tutorial groups and instructors.
Assess scoring rubric	E.g. Did not provide evidence of marking standardization exercise
Review of academic audit findings	E.g. Interview conducted to understand why evidence was not submitted – was it due to non-adherence of work process or documentation oversight?
Track for continuous improvements	E.g. Programme administrator to demonstrate that actions has been taken to rectify and address the highlighted issue

Figure 3. 5-step SMART Process and Framework for Academic Audit in Higher Education

8.1. 5-step SMART Process and Framework for Academic Audit in Higher Education

A 5-step SMART process and framework is recommended for academic audit in higher education (see Figure 3). The stages are setting objectives and criteria, mapping requirements to align with criteria, assessing programmes and courses using scoring rubric, reviewing the findings and results of the academic audit with stakeholders, and finally, track for continuous improvements. The key activities are: to determine the objectives, criteria and requirements of academic audit which are relevant and au fait with both external and internal environmental factors; to set a scoring rubric which is not only fair and equitable, but also allow auditor to exercise judgment and discretion; to provide constructive feedback and have a two-way communication with programme administrators so that their voices are heard over grey areas and contentious issues; and to monitor and track actions taken to address feedback for accountability and continuous improvements.

8.2. Accreditation has a positive effect on/ correlation with Academic Audit Performance

Accreditation of STEM programmes by international and local professional bodies has a positive effect and correlation with academic audit performance. It is recommended to keep an eye on and keep abreast of paradigm shifts and developments of accreditation criteria and requirements, particularly those which are considered as "gold standards", such as ABET and AACSB, so that academic audit can be in-step and in tandem with accreditation benchmarks.

Academic audit criteria and requirements have to be adept to both external and internal environmental factors.

It is almost a whole-of-university exercise. Buy-in by everyone, both externally and internally is important. We have observed that when leadership or buy-in is lukewarm, there can be underperformance in school. We cannot afford for the academic audit, and its criteria and requirements to be esoteric – only understood by the Academic Audit Committee or workgroup auditors. Systems thinking and design thinking can be applied to understand environmental factors and nuances of programmes and their respective constituent courses, and to develop an academic audit framework which aligns with stakeholders' interests respectively. For instance, in this paper, this case study in Singapore shows that at on the onset of the academic audit, criteria and requirements were quite rudimentary. These criteria and requirements were subsequently tightened before they were liberalised, when strident improvements have been made in terms of academic audit performance, which can be regarded as quality control and assurance. This is reminiscent of having different business models and strategies during a business's cycles or stages of business growth, from start-up, to growth, established, expansion and renewal or decline.

Moreover, the work-plan at the start of each academic year would outline and harmonise the design and methodology of the academic audit. Sometimes, new requirements or priorities, or new ways to measure them were introduced. One case in point is the widespread use of Generative Artificial Intelligence and how universities are responding to it [38]. It is recommended that the principles of Continuous Integration and Continuous Delivery from Agile DevOps can be applied, to ensure requirements can be added or revised.

Academic audit can detect malpractices, weaknesses, current and potential problems found in underperforming programmes or courses, and can

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be used to initiate conversations and continuous improvements

Documentation can provide audit trail and academic audit, be it via ticking off a check-list by the AAC Secretariat, appraisal by AAC member or workgroup member, or data analytics can detect malpractices, weaknesses and potential issues. To incentivise programme administrators to treat it seriously, academic audit performance can become a Key Performance Indicator and be tied to staff appraisal. Hand-holding such as conducting workshops and consultation sessions for new HoPs and HoP of new programmes are provided before, during and after the audit. In addition, new programmes would not be scored in the first year but a glide-path and feedback would be given so that the programme administrators will be able to ease into the audit process.

For complex issues or when faced with uncertainty, interviews can be granted when they are initiated by programme administrators or arranged when initiated by AAC to dig deeper into the documents submitted by the programmes, and to clarify things to minimise misunderstanding in order to give a fair appraisal. Specific and actionable feedback are given so that programme administrators can address issues highlighted by auditors and committee members. These feedback are tracked (not taking actions/ actions taken/ actions to be taken at a later date).

Analytics are conducted to identify weaknesses at university, school and programme level. For instance, it was found that one school has been doing generally well, but had repeatedly failed to ensure detail of minutes were recorded properly. This can be considered a systemic issue because it occurred across a few programmes in the same school. By highlighting this issue, school managers and Deans can spotlight and tackle this problem instead of neglecting it and allowing it to become a recurring problem.

The academic audit is useful but it can be tedious and stressful, and requires a significant amount of effort and time

There can be knowledge transfer loss each time there is a staff turnover. Academic audit can document and convert implicit knowledge into codified knowledge, through a self-evaluation report by individual programmes, or feedback forms and Academic Audit Report to be shared with schools and HoPs. There are several benefits of implementing institutional knowledge management– there can be fewer information silos, reduced mistakes due to lack of experience, efficient on-boarding, continuity of service, growth for the organization and employee satisfaction, attested by findings from other researchers [34 - 37].

In addition, a manual compiling best practices and exemplary examples has been drafted and circulated to schools and programme administrators. This will aid in 1) providing benchmarking and supporting continuous improvement by current HoPs, as well as provide guidance to new HoPs or HoPs of new programmes; and 2) document and codify these information and guidelines to support organizational knowledge retention and conversely, minimise or stem knowledge loss.

Notwithstanding these advantages, over-documenting every process can lead to wasted employee time, reduced productivity, overwork and potential burnout [6]. There has to be acknowledgement of pain-points – the process can be onerous, arduous and time-consuming. Sometimes it can distract programme administrators from more productive and fulfilling work. To this end, the academic audit committee has offered tax-breaks to incentivise good performances and liberalising the academic audit to reduce workload for good performance in academic audits. This has the added benefit of allowing the academic audit committee to dedicate more time and effort to address new and underperforming programmes and courses.

9. Conclusions

This paper addresses the knowledge gap of evaluating the effectiveness of quality assurance mechanisms for Higher Education over time, in particular STEM programmes, and contributes to the body of knowledge by proposing a framework for quality assurance, and advocating benefits, critical success factors (CSFs) and challenges faced while doing so. In general, the top benefits are an improvement in quality control and assurance; detection of weaknesses and potential problems; support continuous improvement; retention of organization knowledge; and accountability to stakeholders.

The major challenges or impediments likely to be encountered are getting the support and buy-in of all important stakeholders, from setting up of the Academic Audit Committee to communicating process and criteria to the schools (How to initiate/ start); availability of information (How to provide); approach and method used to appraise the submissions (How to check); giving constructive and specific feedback instead of criticising and witch-hunting (How to report); tracking actions taken to address comments provided to programmes and courses (How to track).

To surmount the various challenges, the most important CSFs are criteria and requirements which should be benchmarked with or referenced to international and local accreditation standards; top

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management support and whole-of-university buy-in by proving to and convincing them that the academic audit process improves quality of programmes and courses and it is worth the university's efforts to do so; scope, criteria and requirements that have to grow incrementally and organically in line and in tandem with the university's stage of development; provision of support and guidance such as workshops and a manual documenting best practices and exemplary examples; and last but not least, to be open and transparent, and be receptive to feedback and criticism in the spirit of continuous improvements, since there is no one-size-fits-all solution to doing an academic audit for higher education. There should be humility to understand that there is always room for improvement, such as adoption of data analytics and digitalizing and automating the academic audit workflow.

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