THE SUSTAINABILITY OF TECHNICAL EDUCATION: A MEASUREMENT FRAMEWORK

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Abstract: The term Sustainability aims to describe the capacity of meeting the needs of the present without compromising the future. Educators repeatedly say: "teach a man to fish and you feed him for a lifetime!" Indeed, the modern uses of the term Sustainability are inspiring in quality education. Yet, there hasn't been a serious effort to formulate quality education based on sustainability. In this paper, we define the "Sustainability of Technical Education." The Sustainability of Education is defined in terms of the ability of the educational system and approach to improve without reducing its capacity to endure. Based on our definition, we refine a framework for measuring the sustainability of education in higher-education institutions. The structure of the refined framework comprises criteria, measures, indicators, and a detailed set of rubrics. The paper evaluates the proposed definitions and framework, and sets the ground for a pilot study using a case-study methodology.

Keywords: Technical Education, Engineering, Assessment, Measurement, Sustainability.

Introduction:

Sustainability is a buzzword in modern times. Many areas have been attracted to use the term Sustainability to refer to keeping up, prolonging, and enduring. Sustainability have been used in areas such as development, ecology, energy, biology, to name a few. According to [1], sustainability is the noun form of the verb to sustain, and it means to keep up, prolong, endure, etc. The term Sustainability is sometimes coupled with the synonym Maintainability which means to keep in an appropriate condition or to sustain against opposition or danger. The main difference between Sustainability and Maintainability is the amount of energy and the type of effort needed to maintain or sustain. To sustain entails requiring more energy and to actively providing support to keep up and improve. Without sustainability, a collapse is expected. However, to maintain is a less demanding action that has no expectations for improvement. Without maintainability, a collapse is also expected.

The term Sustainability has been mainly adopted in Development. In [2], the World Commission on Environment and Development (WECD) defined sustainable development as "development which meets the needs of the present without compromising the ability of future generations to meet their own needs." Barbier, as cited in [3] interpreted the definition of the WECD by describing sustainable development as indistinguishable from the total development of society. Other definitions of sustainable development includes the following:

- "Sustainable means using methods, systems and materials that won't deplete resources or harm natural cycles" [4]
- Sustainability "identifies a concept and attitude in development that looks at a site's natural land, water, and energy resources as integral aspects of the development" [5]
- "Sustainability integrates natural systems with human patterns and celebrates continuity, uniqueness and placemaking" [6]

The term Sustainability is also used in business, management, biology, and ecology. In business, Sustainability is defined as the "triple bottom line" in terms of increasing profits, improving the planet, and improving people's lives [7]. In [8], the authors defined two kinds of business values, namely, situational and sustainable. According to the authors, leaders, companies, or individuals guided by situational non-sustainable values make decisions based on the existing situation and regardless of the interests of their communities. However, the term Sustainability is still not widely spread or formally defined in business terms. In management, Manock and Britton addressed Sustainability in a risk management context [9,10]. The authors discussed strategies, activities, and challenges to effectively managing risks, whilst maintaining continual improvement and development. In biology, the term Sustainability is mainly used for describing biological systems that remain diverse and productive over time. Ecological sustainability focuses on the society, economy, and the environment. The sustainability of the ecosystem is best understood in terms of human's impact on earth resources and the search for renewable energy.

The rich literature of sustainable development pro-dominates the public use of the term Sustainability. The practice of teaching for sustainable development is usually referred to as Sustainability Education, Education for Sustainability, or Education for Sustainable Development (ESD). ESD is the term adopted by the United Nations [11,12,13,14,15].

Nevertheless the principles of Sustainability are inspiring to many areas, very little work have been reported to address the Sustainability of Education (SoE). Damaj et al. in [16, 17] presented the first use of the term Sustainability of Education (SoE) within an engineering context. Damaj et al. promoted the idea of looking into how sustainable an educational institution is in terms of the continuity of functioning with quality. The authors also promoted the idea of preparing students with the sustainable values of being self-directed, self-learners and thus lifelong learners. The presented term was kept informal and supported only by good practices pertaining to a specific region. The authors didn't answer the question on how to clearly define the term SoE and how to develop a measurement framework for its assessment.

In this investigation, we define the term SoE and develop measurable SoE indicators. The investigation addresses issues related to SoE in general and for the Sustainability of Technical Education (SoTE) in Particular. Here, technical education is concerned with Engineering, Engineering Technology, Computing , and Applied Science.

This paper is organized so that the next section defines SoE and SoTE. The following section explains the measurement framework. A later section provides a general evaluation. The last section concludes the paper and sets the ground for future work.

Defining the Sustainability of Education:
In terms of education, we define Sustainability as the ability to continuously improve without reducing the capacity to endure. In other words, the SoE is Improvability and Endurance. The SoE is achieved at two levels, namely, the system and approach levels. At the system level comes the educational institution that should be able to improve without reducing its ability to endure. The institution should adopt an approach that strives to produce professionals that have sustainable values. Sustainable values include being self-directed, self-learner, lifelong learner, etc. Although Sustainable Development has inspired the creation of the term SoE, it is not to be mixed with the term ESD.

Improvability and Endurance are observed as the objectives or pillars of Sustainability (See Figure 1). To stress that the two objectives are to be well integrated, they are modeled as interlocking circles. The interlocking circles model helps to show the action and the required change to redress the balance between the two objectives. The interlocking circles model is depicted in Figure 2.

In Figure 3, we depict the desirable SoE, the possible realities of being sustainable, partially sustainable, barely sustainable, and the change needed. Being partially sustainable means having a satisfactory ability to improve with a growing capacity to endure. Being partially sustainable also means having a satisfactory capacity to endure with a growing ability to improve. The attribute of being barely sustainable means having growing ability to improve and capacity to endure. The attribute of being unsustainable means having low ability to improve and/or capacity to endure. The different attributes of SoE are shown in Table 1. We consider the case were one of the two objectives is found to be satisfactory while the other is low as less likely to exist; accordingly the corresponding area in Table 1 is left without shading and unclassified.

The Measurement Framework:
The proposed measurement framework of SoTE defines nine different criteria. Each criterion covers one part of the educational system and also the approach. Accordingly, each criterion has its own set of key performance measures (KPMs). For every KPM, there is one or more key performance indicator (KPI) to enable the measurement. Every KPI has its own analytic rubric that will aid the calculation of different indicators including a one main indicator called the Sustainability Indicator (SI) – see Figure 4. The sustainability criteria that we judge SoTE upon is shown in Table 2.

Criterion I, Leadership and Governance, measures the sustainability of the institutional strategic plans and the degree of its adoption of the principles of SoTE. Criterion I aims to widely cover governance issues, accreditation effort, quality assurance, policy management, review systems, and fundraising - all within the context of sustainability. The KPMs, and accordingly the criteria, are best understood in terms of the detailed KPIs. Student Learning by Coursework Program, Criterion II, monitors curricular issues related to SoTE. Here, the criteria also looks into program educational objectives, student outcomes, assessment plans, curricula, and issues related to plagiarism. Criterion III, Student Learning by Research Program, measures the sustainability of the research program including research support. Faculty Research and Consultancy, Criterion IV, looks mainly into the sustainability of faculty research objectives, professional development for research, consultancy activities, and research-teaching nexuses. Criterion V, Industry and

Community Engagement, focus on the sustainability of the relationship between the institution and the community in general including the industry and the alumni. Criterion VI, Academic Support Services, measures the sustainability of different administrative services, such as, the registrar, admissions, etc. Criterion VIII, Faculty and Staff Support Services, measures the organization climate, retention, professional development, promotion, and other incentives. Criteria IX, measures campus services, public relations, and marketing. The nine criteria are expanded into 34 KPMs; the KPMs are listed in Table 3.

The KPIs and their analytic rubrics are the most extensive part of the measurement framework. The KPIs and the rubrics are very carefully developed within the context of SoTE. The first version of KPIs includes 79 indicators of which 19 indicators are further divided into sub-KPIs. Yet, the proposed measurement framework contains a total of 171 KPI and sub-KPI with their analytic rubrics. The list of developed KPIs is shown in Table 3; here, the KPIs are sorted per KPM and per Number. A sample KPM with a few of its KPIs and rubrics are shown in Table 5. The rubric uses the scale Nascent, Beginning, Developing, Competent, and Accomplished. The design rationale of every KPI is area-specific and has required deep understanding of the technicalities of the measured area. Due to the wide coverage of the framework, we had to deal with many different areas related to higher education. The following strategies are adopted to insure the adequacy and verify the developed rubrics:

- Interviews with experts
- External reviews
- Comparisons with existing rubrics
- Developing a rich and standardized set of rubric descriptors

The presented framework provides opportunities for wide and deep measurements. The measurements could be interpreted per criteria, KPM, KPI, and/or combined forms. The 5-point rubric scale of KPIs – Nascent, Beginning, Developing, Competent, and Accomplished is mapped onto constant values. The measured KPIs are then each divided by measurements from a reference institution for normalization and for producing performance ratios. One of the combined measurement forms is the SI, which is the Geometric Mean of all ratios. Although the SI require the normalization with respect to reference measurements, other indicators are absolute.

To help understanding the calculation of the SI, a statistical and mathematical formulation is presented. The SI is a statistical composition of all of the nine criteria:

$$SI = C_1 \circ C_2 \circ \dots C_k \qquad where\ C_k\ is\ the\ k^{th}\ Criterion$$

The measurement for every criterion is done using a statistical composition of all of its KPMs:

$$C_j = KPM_{j.1} \circ KPM_{j.2} \circ \dots KPM_{j.n} \qquad where\ KPM_j\ is\ the\ j^{th}\ KPM$$

The measurement for every KPM is done using a statistical composition of all of its KPIs:

$$KPM_i = KPI_{i.1} \circ KPI_{i.2} \circ \dots KPI_{i.n} \qquad where\ KPI_i\ is\ the\ i^{th}\ KPI$$

Therefore, The SI is the statistical composition of all the KPIs of all KPMs of all criteria.

$$SI = KPI_{k.j.i.1} \circ KPI_{k.j.i.2} \circ \ldots KPI_{k.j.i.n}$$

Many of the selected KPIs are calculated using a formula. Other KPIs are mapped onto a number (6.25, 12.5, 37.5, 62.5, and 87.5) using the 5-point rubric scale – Nascent, Beginning, Developing, Competent, and Accomplished. The measured KPIs are then each divided by measurements from a reference institution for normalization and for producing performance ratios calculated according to the following formula:

$$ratio_l = \frac{KPI_{k.j.i.l}}{KPI^{ref}_{k.j.i.l}} \quad where\ ratio_l\ is\ the\ \ l^{th}\ ratio, and\ l\ \in \{1..n\}$$

Then, the SI is the Geometric Mean [18, 19] of all ratios:

$$SI = \sqrt[n]{ratio_1}, ratio_2, \ldots, ratio_n,$$

The overall SI provides a quantitative classification criterion. An assumed sample calculation for a single institution is shown in Table 6. The calculation of the SI for different institutions according to the same reference produces a classification; an assumed sample classification is shown in Figure 5.

General Evaluation and Case-study Setup:
Sustainability, in its general meaning and also as defined in development, inspires the creation of a framework for quality education. The SoE could be defined in terms of the ability, of the educational system and the approach, to continuously improve without reducing the capacity to endure. Here, sustainability is not defined over a specific period of time; it is a property that continues with no stop. Improvability and endurance are considered as the basis upon which sustainable education can be built.

The framework we propose provides reference criteria for institutional measurements of the SoE. Accordingly, the SoE criteria enable the development, probing, and tuning of broad aspects of the educational system and the approach. The criteria are made specific with the choice of KPMs, and made more specific by the choice of KPIs. The way we specify the criteria allows for widening the coverage by expanding the criteria, KPMs, and/or the proposed KPIs. In a hierarchal structure, the criteria, KPMs, KPIs, and rubrics construct a framework that enables the measurement of the SoE/SoTE. Several returns are noted for the developed framework including the following:

- Its conceptual base promotes for a new perspective that serves quality education
- Its conceptual base is refined into a clear measurement structure
- It formulates a novel methodology for measurement based on the modern concept of sustainability
- It well defines and captures the intended meaning of the term sustainability with simplicity
- The tree structure of measurement enables the drawing of conclusions at different measurement levels of abstraction, namely, the criteria, KPM, and KPI levels

- It supports, combines, and hybridizes both quantitative and qualitative measurement styles
- The criteria covers a wide area of institutional and programmatic aspects, and therefore it is horizontally wide
- The KPMs, KPIs, and rubrics enable a vertically deep measurement; it is a drill exercise that can reach micro levels
- It is scalable and upgradable without changing the statistical computation or the structure of the measurement
- The KPIs and rubrics are extensive, comprehensive, and provide a rich reference
- It provides a bouquet of statistical indicators including the SI
- It provides opportunities for inter-institutional measurements and cross-institution benchmarking
- It adopts ABET [20] terminology for its relevance to technical education, namely, Engineering, Engineering Technology, Computing, and Applied Sciences
- It could contribute to the standards of quality education and technical education

On top of all priorities comes the preaching for and the cultivation of the SoE principles, where all aim to build a sustainable education that can improve and endure endlessly. In addition, the proposed framework shares several common challenges with the regular efforts of providing quality education. The following challenges are pinpointed to be important to the adoption of the proposed methodology:

- The commitment, adequate investment, and support of the governing body of the institution
- The application of an educated change management
- The change dynamics of the institution
- The spreading of SoE awareness institution-wide
- The ensuring of institutional effectiveness
- The creation of a culture of assessment
- The cultivation of relationships with external constituents
- The availability of an adequate infrastructure
- The creation of a positive organizational climate

In this project, the theoretical proposition is that the presented measurement tool accurately a) describes the content and constructs that comprise sustainability of technical education in a higher education setting, and b) measures the sustainability. Work in progress aims to execute a multistage data collection procedure for a pilot study using a case-study methodology for one case that targets a single institution. The case study aims to answer the following questions:

- Do measurement tool scores reliably provide information about the sustainability of education that the institution provides?
- What is the correlation coefficient between the measurement tool scores and scores from other established instruments that measure the same or similar criteria?
- To what extent does the implementation of the study assessment bring benefits to participating Institution?
- To what extent does the implementation of the study contribute to demonstrating its value for the improvement of sustainability of education?

Conclusions:

The paper presents a new concept that defines the "Sustainability of Technical Education." A structured measurement framework is refined from the two defined pillars of Sustainability, namely, Improvability and Endurance. The measurement framework has 9 criteria, 34 KPMs, and a total of 171 indicators with their analytic rubrics. The measurements are statistically combined to produce a bouquet of indicators including the "Sustainability Indicator." The developed framework is well-structured, scalable, and widely covers educational aspects. Future work include carrying out a study using a case-study methodology for multi-sites. Future work also include expanding the measurement tool to capture wider institutional and programmatic aspects.

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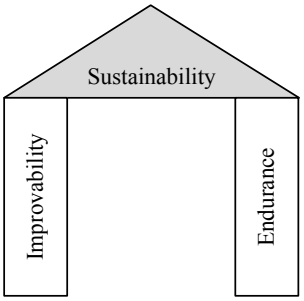

Figure 1. The pillars representation of SoE.

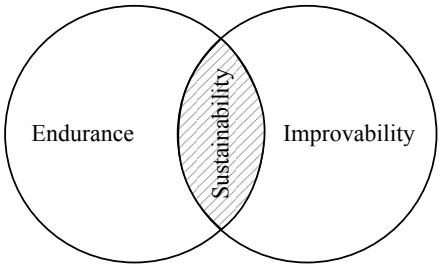

Figure 2. Interlocking circles representation of SoE.

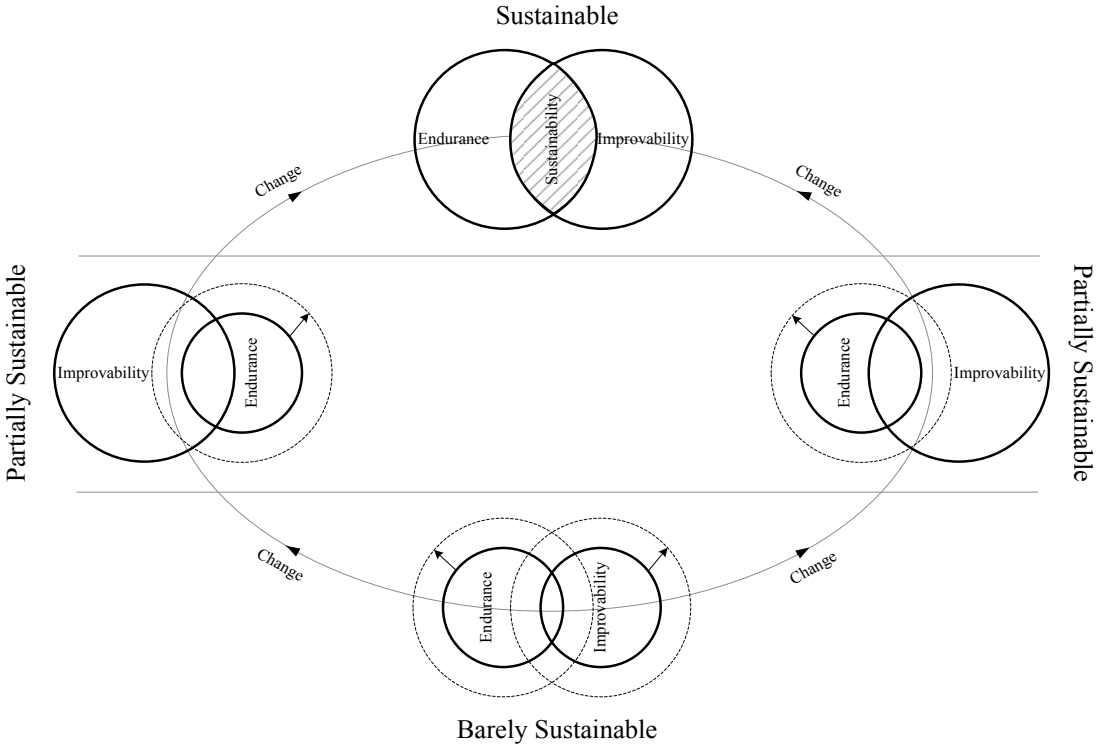

Figure 2. The two objectives of SoE; the desirable sustainability, the reality of being partially or barely sustainable, and the change needed.

Table 1. The attributes table of the SoE objectives.

The Attributes Table of Sustainability		Endurance		
		Low	**Growing**	**Satisfactory**
Improvability	**Low**	*Unsustainable*	*Unsustainable*	
	Growing	*Unsustainable*	Barely Sustainable	Partially Sustainable
	Satisfactory		Partially Sustainable	**Sustainable**

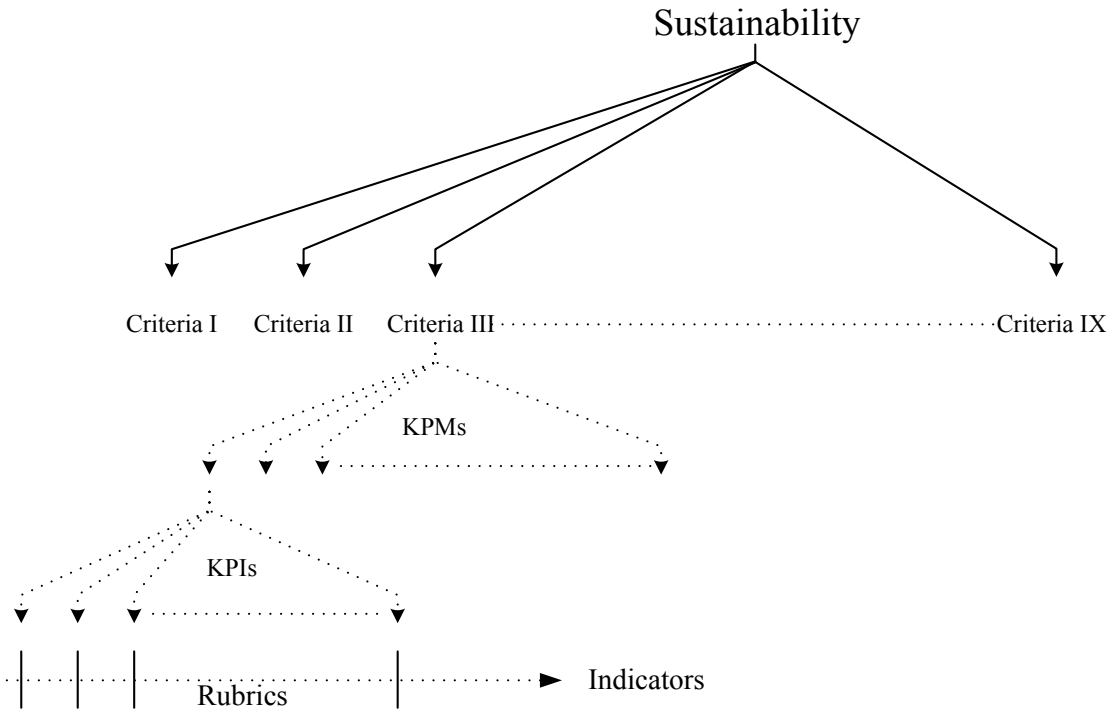

Figure 3. The measurement framework for SoE.

Table 2. The SoTE criteria.

No.	Criterion	No.	Criterion
I.	Leadership and Governance	VI.	Academic Support Services
II.	Student Learning by Coursework Program	VII.	Student Support Services
III.	Student Learning by Research Program	VIII.	Faculty and Staff Support Services
IV.	Faculty Research and Consultancy	IX.	General Support Services and Facilities
V.	Industry and Community Engagement		

Table 3. The KPMs per criteria. The numbering shows the Criterion and KPM numbers.

No.	Criterion/KPM	No.	Criterion/KPM
I	**Leadership and Governance**	**V**	**Industry and Community Engagement**
I.1	Strategic Planning	V.1	Industry and Community
I.2	Governance	V.2	Alumni
I.3	Accreditation and Quality Assurance	**VI**	**Academic Support Services**
I.4	Policy Management	VI.1	Admission
I.5	Entity and Activity Review Systems	VI.2	Registrar
I.6	Fundraising	VI.3	Information Technology Services
II	**Student Learning by Coursework Program**	VI.4	Student Learning Support
II.1	Program Educational Objectives	VI.5	Teaching Resources
II.2	Student Outcomes	VI.6	Library
II.3	Curriculum	**VII**	**Student Support Services**
II.4	Assessment	VII.1	Student Activities
II.5	Plagiarism	VII.2	Student Behavior
III	**Student Learning by Research Program**	VII.3	Student Grievance
III.1	Research Program	VII.4	Career and Employment Services
III.2	Student Research Support	**VIII**	**Faculty and Staff Support Services**
IV	**Faculty Research and Consultancy**	VIII.1	Staff Professional Development
IV.1	Faculty Research	VIII.2	Staff Promotion and Incentives
IV.2	Professional Development for Research	VIII.3	Faculty and Staff Organizational Climate and Retention
IV.3	Consultancy Activities	**IX**	**General Support Services and Facilities**
IV.4	Research-Teaching Nexus	IX.1	Campus Services
-	-	IX.2	Public Relations

Table 4. The list of developed KPIs showing the Criteria, KPM, and KPI numbers.

No.	KPM/KPI	No.	KPI
I.1	**Strategic Planning**	**V.1**	**Industry and Community**
I.1.1	Value and are committed to the sustainability of education	V.1.1	Cultivate relationships with the industry and community
I.1.2	Invest in quality education	**V.2**	**Alumni**
I.2	**Governance**	V.2.1	Cultivate alumni relationships
I.2.1	Able to Improve	**VI.1**	**Admission**
I.2.2	Retain the institution head	VI.1.1	Recruit Students
I.2.3	Retain academic administrators	VI.1.2	Retain Students
I.2.4	Retain staff	**VI.2**	**Registrar**
I.2.5	Retain faculty	VI.2.1	Facilitate Registration
I.2.6	Students to faculty ratio	VI.2.2	Keep records
I.2.7	Handle the effect of change of people in position	**VI.3**	**Information Technology Services**
I.2.8	Benchmark against other institutions	VI.3.1	Develop Plans
I.2.9	Develop faculty and staff	VI.3.2	Develop Policies and Procedures
I.2.10	Balance faculty load	VI.3.3	Develop infrastructure
I.2.11	Apply selective recruitment	VI.3.4	Probe products and services
I.2.12	Implement a work breakdown structure with defined authority and responsibility	VI.3.5	Manage organization and external relationships
I.2.13	Offer promotion opportunity	VI.3.6	Ensure funding
I.2.14	Value diversity	**VI.4**	**Student Learning Support**
I.2.15	Manage the change	VI.4.1	Provide training opportunities for student
I.3	**Accreditation and Quality Assurance**	VI.4.2	Assess training impact
I.3.1	Probe quality	VI.4.3	Provide academic advising
I.3.2	Work on autonomy	**VI.5**	**Teaching Resources**
I.3.3	Participate in institutional and professional accreditations	VI.5.1	Provide general learning facilities
I.4	**Policy Management**	VI.5.2	Maintain service per user policies
I.4.1	Develop and review policies	VI.5.3	Provide major-specific learning facilities
I.5	**Entity and Activity Review Systems**	VI.5.4	Adopt a maintenance and upgrade policy
I.5.1	Evaluates Institutional Effectiveness at the review level	**VI.6**	**Library**
I.5.2	Evaluates Institutional Effectiveness at the planning level	VI.6.1	Assure currency of resources and facilities
I.6	**Fundraising**	VI.6.2	Assure sufficient resources and facilities
I.6.1	Participate in Fundraising	VI.6.3	Service the community

…Table 4. Continue

No.	KPM/KPI	No.	KPI
II.1	Program Educational Objectives	VII.1	Student Activities
II.1.1	Develop Program Educational Objectives	VII.1.1	Incorporates sustainability outcomes into student activities
II.2	**Student Outcomes**	**VII.2**	**Student Behavior**
II.2.1	Develop Student Outcomes	VII.2.1	Adopt and apply a code of conduct
II.3	**Curriculum**	VII.2.2	Provide counseling
II.3.1	Align curriculum	**VII.3**	**Student Grievance**
II.4	**Assessment**	VII.3.1	Provide a grievance system
II.4.1	Plan assessment	**VII.4**	**Career and Employment Services**
II.4.2	Probe quality	VII.4.1	Provide career planning advice and training
II.4.3	Build a culture of assessment	**VIII.1**	**Staff Professional Development**
II.5	**Plagiarism**	VIII.1.1	Assess training needs, and provide and organize professional training
II.5	Control plagiarism	**VIII.2**	**Staff Promotion and Incentives**
III.1	**Research Program**	VIII.2.1	Adopt reward and promotion systems
III.1.1	Probe Quality	**VIII.3**	**Faculty and Staff Organizational Climate and Retention**
III.1.2	Align research objectives with the National, Regional, and International Research Directions	VIII.3.1	Measure, maintain, and improve satisfaction
III.1.3	Provide research facilities	VIII.3.2	Adopt and apply a code of conduct
III.1.4	Provide quality supervision	VIII.3.3	Provide a grievance system
III.2	**Student Research Support**	**IX.1**	**Campus Services**
III.2	Provide and pursue research funds	IX.1.1	Has a Campus
IV.1	**Faculty Research**	IX.1.2	Probes Quality
IV.1.1	Align research objectives with the National, Regional, and International Research Directions	IX.1.3	Improve the Campus
IV.1.2	Probe Quality	**IX.2**	**Public Relations**
IV.2	**Professional Development for Research**	IX.2.1	Assess the market
IV.2.1	Implement a Professional Development System	IX.2.2	Engage the market
IV.3	**Consultancy Activities**	IX.2.3	Publish university materials
IV.3.1	Observe consultancy activities as professional development	-	
IV.4	**Research-Teaching Nexus**	-	
IV.4.1	Incorporate research and scholarly activities in the learning process	-	

Table 5. Sample KPM, KPIs, Sub-KPIs, and rubric from Criteria I, II and V.

Criterion		**I – Leadership and Governance**			
General		**Rubric** (**N**ascent: Below the Beginning level, **B**eginning, **D**eveloping, **C**ompetent, **A**ccomplished)			
KPM	**KPI**	**Beginning**	**Developing**	**Competent**	**Accomplished**
Governance	Value diversity	The institution faculty and staff are homogeneous based on gender, nationality, race, age, etc. Only the core management group exercises academic freedom.	The institution has individuals with limited diversity based on gender, nationality, race, age, etc. Academic freedom is adequately insured and exercised among the top levels of the organization.	The institution has diverse individuals based on gender, nationality, race, age, etc. Academic freedom is insured and exercised among specific groups.	The institution has very diverse individuals based on gender, nationality, race, age, etc. Academic freedom is insured and exercised institution-wide.
	Manage the change	The institution adopts a top-down change approach. The environment of the institution is not dynamic, resistant to the change with weak commitment. Only the core management group maintains awareness.	The institution applies OD[1] on a multi-annual basis. The environment of the institution is somewhat dynamic with decreasing resistance and growing commitment to the change. The institution maintains change awareness among the top levels of the organization.	The institution applies OD on a term basis. The environment of the institution is dynamic with moderate resistance and commitment to the change. The institution maintains change awareness among specific groups.	The institution applies OD on daily or very regular basis. The internal environment of the institution is highly dynamic, with no resistance, and strongly committed to the change. The institution maintains change awareness institution-wide.

[1] Organization development (OD): planning, participation, diagnoses, intervention, and evaluation.

…Table 5. Continue.

Criterion		**II – Student Learning by Coursework Program**			
General		**Rubric** (**N**ascent: Below the Beginning level, **B**eginning, **D**eveloping, **C**ompetent, **A**ccomplished)			
KPM	**KPI**	**Beginning**	**Developing**	**Competent**	**Accomplished**
Student Outcomes	Develop Student Outcomes	The program is in the initial stages of defining its student learning outcomes. Relevant institution-wide learning outcomes and/or sustainability outcomes as related to improvability and endurance are not necessarily considered.	The program has articulated a manageable number of observable, measurable student learning outcomes within the context of the curriculum. The program may be developing performance criteria connected to the outcomes. Relevant institution-wide learning outcomes and/or sustainability outcomes as related to improvability and endurance may be considered.	Student learning outcomes are aligned with program goals and are defined by a manageable number of performance criteria. Outcomes are contextualized in the curriculum and reflect the national, regional, and international conversation on teaching and learning in the discipline. Outcomes are publicly shared and they include relevant institution-wide learning outcomes and/or sustainability outcomes as related to improvability and endurance (e.g., lifelong learning, critical thinking, etc.).	The program clearly demonstrates how its student learning outcomes support the program objectives and the university's core themes (i.e., strategic and learning goals). The program situates its outcomes in the national, regional, and international discussion around teaching and learning in the discipline. It routinely verifies the relevance of its curriculum, performance criteria, measurement tools and assessment processes by soliciting feedback from multiple stakeholders. Stakeholders, including faculty and students, engage in refining student learning outcomes and measures. The student learning outcomes include sustainability outcomes as related to improvability and endurance (e.g., lifelong learning, critical thinking, etc.).
Criterion		**V – Industry and Community Engagement**			
Industry and Community	Cultivate relationships with the industry and community	**Sub-KPI:** *Policies*			
		Demonstrate a basic knowledge of the imperatives of community engagement by implementing less accurate policies of community engagement.	Demonstrate an adequate knowledge of the imperatives of community engagement by implementing somewhat accurate policies of community engagement.	Demonstrate a sound knowledge of the imperatives of community engagement by implementing accurate policies that institutionalize a focus on community engagement.	Demonstrate a comprehensive knowledge of the imperatives of community engagement by implementing highly accurate policies that institutionalize a focus on community engagement.
		Sub-KPI: *Activities*			
		The policies minimally support community engagement by holding activities and programs that allow limited access to facilities, in addition to having less functional advisory boards (IAB, SAB) which limitedly ensure a reasonable likelihood of sustainable outcomes.	The policies somewhat support community engagement by holding activities and programs that allow adequate access to facilities, in addition to having somewhat functional advisory boards (IAB, SAB) which adequately ensure a reasonable likelihood of sustainable outcomes.	The policies mostly support community engagement by holding activities and programs that allow sound access to facilities, in addition to having mostly functional advisory boards (IAB, SAB) which soundly ensure a reasonable likelihood of sustainable outcomes.	The policies fully support community engagement by holding activities and programs that allow extensive access to facilities, in addition to having fully functional advisory boards (IAB, SAB) which thoroughly ensure a reasonable likelihood of sustainable outcomes.
		Sub-KPI: *Incorporate and adapt to the needs of targeted industries and employers*			
		Exhibit a limited improvement from focus on teaching and research only towards a partnership with industry. Adapt rarely to the needs of targeted industries and employers in the university proximate geographical space and beyond.	Exhibit an adequate improvement from focus on teaching and research only towards a partnership with industry. Adapt occasionally to the needs of targeted industries and employers in the university proximate geographical space and beyond.	Exhibit a proficient improvement from focus on teaching and research only towards a sound partnership with industry. Adapt frequently to the needs of targeted industries and employers in the university proximate geographical space and beyond.	Exhibit an exemplary improvement from focus on teaching and research only towards an extensive and enabling partnership with industry. Adapt regularly to the needs of targeted industries and employers in the university proximate geographical space and beyond.

Table 6. An assumed sample calculation of the SI for a single institution measurements (Ms).

Criteria	KPM	KPI	M	Reference M	M Ratio
I	I.1	I.1.1	37.5	62.5	0.6
I	I.1	I.1.2	87.5	87.5	1.0
I	I.1	I.1.3	62.5	87.5	0.7
…	…	…	…	…	…
II	II.1	II.1.1	6.25	62.5	0.1
II	II.1	II.1.2	12.5	62.5	0.2
II	II.1	II.1.3	87.5	87.5	1.0
…	…	…	…	…	…
…	…	…	…	…	…
…	…	…	…	…	…
IX	IX.1	IX.1.1	62.5	87.5	0.7
IX	IX.1	IX.1.2	87.5	62.5	1.4
IX	IX.1	IX.1.3	12.5	62.5	0.2
			SI (Geometric Mean)		**0.4**

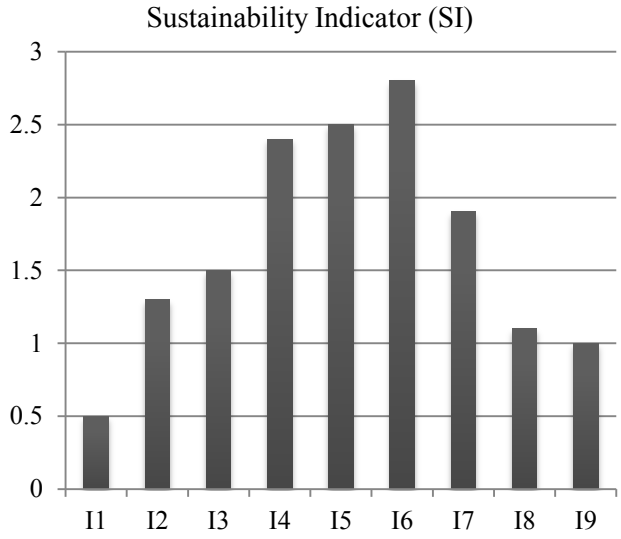

Figure 4. An assumed calculation of the SI for different institutions; I1 through I9.