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Metrics Model for Indexing University Information Technology Teaching Professionals' Improvement in ICT Integration: A Review of the Literature

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***Abstract*– Despite the recent progress in the development of ICT integration indices to support management of teaching in institutions, very little empirical research focusing on metrics for continuous improvement in ICT integration indexing of university information technology teaching professionals has been conducted. This situation exists despite the leadership role that university Information Technology Teaching Professionals and continuous improvement indexes can offer. The aim of this study was to fill this knowledge gap by proposing a metric model for indexing that can support continuous improvement of ICT integration. In particular the study reviews the concept of ICT and integration in the context of university teaching, catalytic role that University IT teaching professionals can provide in improving ICT integration and the emerging continuous improvement challenges. A review is then done on existing Metric based indexes and continuous improvement models. A conceptual framework based on continuous organizational learning model of knowledge based organization and theory of multiple methodologies and applied in extending Wan et al., (2009) ICT integration four levels model is then proposed. Based on the framework an index model for improving ICT integration is proposed. It is hoped that the designed metrics model can be applied to provide a basis for continuous improvement of Information Technology Professionals ICT current low levels of ICT integration.**

***Index Terms*– ICT Integration Index, Improvement, Metrics and University Information Technology Teaching Professionals**

I. INTRODUCTION

ICT is an acronym that can be perceived to be moving towards achieving a word status due to its increased use resulting to its familiarity. One of the closely associated terms to ICT is the integration. The association depicts the ever changing nature of ICT which implies its semantics concern. Integration can be defined as the process of fitting a legacy system, practice to a new one, usually with the view of improving it. Such improvements need to be purposeful. Any system is perceived to have a legacy state, which can be previous or current state. ICT systems and organization practice is an emerging area of concern in terms of integration due to rapid change in information technology necessitated by globalization through internet. This has led to Internet of Things, cloud computing as opposed to desktop computing. Mobile computing as opposed to stand alone computing. These new trends have their legacy equivalents that require integration purposefully. One such area that needs immediate focus is the end user ICT systems integration issues, specifically teaching integration, which is the focus of this study.

End user in the context of university teaching includes students and university teaching professionals. They interact with or are actors to the ICT systems through either hardware or software interfaces such as microphones, screens (touch or visual), overhead projectors, courseware or other application packages during the teaching learning process. Even though considerable efforts have been made to integrate software to the hardware, fitting end user needs to the software and hardware appears to remain a big challenge in learning institutions such as universities. The next section II reviews these challenges, section II reviews how to address the challenges, section III reviews the existing metrics and indexes to address the challenge and IV reviews the role of Metrics scoping as a strategy and VI proposes a d conceptual framework and VII proposes a symbolic design model and conclusion .

II. THE ICT INTEGRATION IMPROVEMENT CHALLENGE IN UNIVERSITY TEACHING

Recent studies in Vietnam similarly found out that although lecturers recognized the potential of ICT, they did not necessarily put integration of ICT into their practice [1]. A study by [2] confirmed that ICT tools and practices have not improved education quality and quantity. A study by [3] also found out that lecturers and students in Federal University of Technology, Minna, had computers and laptops and can access the internet but, they do not use them for teaching and learning. This suggests that possession or availability of ICT resources is one thing while utilization of the resources is another. ICT alone therefore will not improve the effectiveness of teaching and learning; they need to be integrated into the curriculum through a systematic approach.

ICT integration studies in developing countries are not any different, study in Tanzania universities indicates that although majority of educators have gone through ICT training, they still lack skills in online marking and data management procedures. Despite training and positive attitude toward ICT integration, educators, regardless of their educational background, do not integrate ICT in teaching learning processes [4]. In Kenya, the status of integration of ICT by educators in higher institutions such as Kenyan teacher training colleges is largely unknown and these institutions experience low levels of ICT integration into teaching in all teacher training colleges [5]. According to studies by [6] there is no concrete framework for the integration of ICT into education, [5] therefore recommended that ICTs integration be made part of undergraduate training in universities in order to equip future teacher educators with ICT skills. The study by [6]) further recognizes enablers and barriers for ICT integration but none of the components has a quantifiable measure to show the extent to which it can influence or contribute towards the ICT integration process.

Migwi, (2009) [7] on the other hand confirms the argument that the rate at which these ICTs are transferred and integrated into the teaching and learning process is slow. New teacher graduates still have limited knowledge of how ICT can be used in their professional activities [8]. Study by [5], recommends the retraining of teacher-educators to ensure that they have sufficient skills to integrate ICT in teaching their specific subjects. One way of improving such training is to identify what these teachers need to be trained on. However, [9] noted that ICT integration process can be complex. This requires indexing training needs at different levels such as individual, institutional, demographically, regionally etc. This is as opposed to holistic training need identification which may pose a complexity challenge.

Indexing Universities IT teaching professionals (UITTPs) ICT integration can be an important pillar to the University as they are the specialists. They are the Apex of new Knowledge in ICT. Integration in other university section depends on them. Therefore indexing the UITTP will be the first step towards improving the University ICT integration. The UITTPs index of ICT integration can eventually affect the graduates' ability in effective use of ICTs. The UITTPs with better ICT index can have better influence to the graduates' ICT integration level [10] and [11]. The UITTPs with higher index can expose students to relevant ICT experiences during their teaching.

According to [12] the future of teachers depend on their preparedness to use ICTs, a lot of studies has aimed at enabling teachers integrate ICTs into mainstream classroom practice. Other studies have gone further to emphasize ICT integration in instructional processes [13] while others into specific programs like the integration of ICTs into teacher training curriculum [14]. Others studies by [15] and [16] also developed measurement tools to investigate teacher attitudes towards ICTs.

Despite all these efforts, [17] found out that some institutions such as teacher training programs have not facilitated the effective integration and use of ICTs for instructional purposes. This is against [11] argument that teachers ICT knowledge is valuable in ICT integration. [11] Underlines the importance of teacher training institutions to facilitate ICT integration practices in formal instructional settings. Teaching institutions like universities are therefore not exceptional.

World states have used continuous ICT learning and policy documents to improve low pace of ICT integration [18]. In Kenya, emphasis has been on developing of ICT policies [19]. Although the policy documents mandates monitoring the ICT integration, these indices are manual, static, and therefore lack reliability and valid indicators, as they lack real time feedback and are not continuous. On the other hand, use of Continuous ICT learning approach would improve pace of ICT integration as it ensures developing additional work skills and self-satisfaction [21]. This appears a more useful approach, however, given the current global crisis of preparing and supplying well-educated teachers, necessitated by fast changing technologies, globalization and rapid new demands on teachers [21] and the need to tap the integrators such as the UITTPs as source of innovation, university information technology teaching professionals need to continuously learn through cooperate and collaborative approaches and through strategic partnerships at institutional, country, regional and global levels. Little is known on effectiveness of such collaboration. Lack of effective collaboration indexes might have not enabled teachers to deal more effectively with the emerging complex issues of integration and the continuous demands of ICT integration.

III. ADDRESSING THE ICT INTEGRATION IMPROVEMENT CHALLENGE IN UNIVERSITY TEACHING

The challenge of continuously learning ICTs would therefore require dynamic management through empirically evaluated indices. These indices will need to be automated with mobile based Artificial Intelligence. This can enable dynamism, global-localization, flexibility, and precisely able to establish current ICT Integration Indexes (C- II) as a basis for future ICT integration learning needs and improvements.

A) Indexing to Improvement of ICT Integration

An index is a measure. "Ability to measure and expressing it in numbers enables knowing. But inability measure and express it in numbers makes the knowledge very meager and of unsatisfactory kind" (Lord Kelvin's, 1824-1907).

ICT integration index in the context of UITTPs would refer to measuring alignment of ICT instructional tools such as learning management systems (LMS), mobile learning devices and applications (e.g., social media apps, twitters, Instagram),projectors, screen pointers etc. to the existing of teaching (pedagogy) goals and objectives. Index would help assess the extent that ICT has been aligned with pedagogy. Such plans and implementation should meet current and future teaching needs [20]. In this study ICT integration would infer to both instructional process and product in which university teaching pedagogy and ICT must have common objective, standard protocols, designed together, with a common architecture and code. It is this later type of integration that can be referred to as "tight integration"

(Internet information manager (IIS) –Microsoft) or transformative.

A tightly integrated ICT index (ICT -III) therefore depicts a measure derived from metrics that bear a quality teaching skill value that results in university graduates productivity. Graduates or student satisfaction levels would be a standard measure of quality ICT integration index.

UITTPs ICT integration index as a measure in teaching would be critical for developing countries universities, since the pace at which ICT integration is taking place is worryingly slow, lack focus and non-systematic [23]. Although a lot of research has been done on ICT integration indices, but most of their focus has been on primary and secondary schools [13], [14] and have mostly been based in developed countries.

[1] Asserts that institutional ICT integration levels measurements or indexing and evaluations are necessary. [1] Investigations suggested that the ICT integration levels indexing in teacher training institutions are needed, and therefore conducted investigations in the perspectives of pre-service teachers. All these efforts can be viewed as ICT management diagnostic studies. Management diagnostics is rapidly gaining concern so as to have an overall impact or picture (index) of educational institution with regard to ICT integration levels (index) [24]. However, such indexes need to be based on sound basis or metrics.

B) Metrics modeling to Improve Indexing of ICT Integration

The term metric was first coined in 1793 at napoleon’s time by the French government to mean a new system of standards. Metric system based was based on what they termed “Meter” .Meter means one tenth millionth part of distance from the equator to North Pole when measured straight along the surface of the earth to Paris. Based on this ratio, other linear and non- linear metrics have been developed such as volume, and weight metrics. In 1868 American signed metric system into law. This made it possible to have a basis or standardization of measurement globally.

In organizations metrics is gradually becoming popular due to the concern to determine and control human productivity. This has led to purposeful measurements such performance. Performance metrics define in quantitative terms the performance of various activities in a business [25]. Types of performance metrics include those used to analyze business productivity, marketing and sales, financial performance, customer-relations management, and environmental metrics. This list is not all inclusive, as metrics may include anything within a company's domain of activity that can be measured analytically [25].

Metrics that measure productivity analyze factors such as output per hour, days lost to injury, and frequency of supply-chain interruptions. Quantitative productivity data may be used to justify retooling costs, or to reconfigure the manufacturing operation in its entirety. Production metrics may also reveal bottlenecks, slack in the system, or excessive waste. Some companies have significantly reduced manufacturing waste by tracking and analyzing discarded material, then using those metrics to adjust future orders for goods and materials up or down [25].

With the emerging need for continuous integration of ICT in universities managers need to have standards or basis for determining productivity of ICTs. Specifically determining the extent to which personnel use them effectively. Can we therefore have standards or basis (metrics) for indexing their continuous improvement in integration?

One major notable limitation to ICT integration is that it can lead to increase in complexity [9]; this results into varying performance levels (indexes). However, the addition of ICT to teaching should be such that teaching pedagogies does not lose their desirable properties but should act like a facilitator towards achieving the teaching objectives. Such addition should have a basis of monitoring (controlling) relative proportions of combination of ICT to teaching pedagogies. However, controlling the required relative proportions of ICT to the pedagogy require measurements based on appropriate metrics. Integration should be viewed as a process towards a product, in which teaching and ICT use process must have common objective, standard protocols. This implies that ICT and teaching objectives should be planned, designed together, within common architecture and code. It is such integration that will benefit university teaching.

It is a known fact that learners solve problems better with the aid of ICT, and it offers teachers better ways to enhance what and how they teach [26.]At the same time ICT can be used to abuse the practice of teaching. For example using ICT to cover the curriculum fast so as to maintain their credibility without giving meaningful learning experiences that meets learning goals .ICT integration therefore needs to be viewed as an information system strategy in that; while teaching has its traditional strategies (pedagogies), with well entrenched strategic goals. ICT integration in teaching therefore needs to be viewed in line with the legacy goals of teaching.

It has also been noted that traditional knowledge (legacy system) forms a basis for the survival of many societies. Therefore there is need to measure the extent of how traditional knowledge is accepted at individualized level and how it could be integrated into ICT plans and strategies in order to meet future needs [2]. It is therefore imperative to integrate the ICTs to the traditional teaching pedagogies rather than replace them.

Since ICT shouldn’t replace the existing systems of teaching and learning pedagogies, probably the best that can be done is to reengineer teaching through ICT integration. While reengineering small and simple systems may be easy and systematic to undertake, easy to measure as it were in the agrarian and industrial era, modern and postmodern era ICT integration involves complex, dynamic and rapid unsystematic integration. This is the situation in socio-technical systems such as university teaching. This complexity, could have led to the slow pace of ICT integration in developing universities resulting into varying ICT integration performance levels by university information technology teaching professionals. Metrics for determining current ICT integration performance levels on the traditional teaching pedagogies and their causal factors therefore remains important.

C) Software Based Metric in Improvement of ICT Integration

Software is an information technology that automates processes or systems. This makes it easy to handle complex systems such as continuous improvement. The main goal of a measurement software process is to satisfy certain information needs by identifying the entities (which belong to an entity class) and the attributes of these entities (which are the targets of the measurement process). Attributes and the information needs are related through measurable concepts (which belong to a Quality Model in this case, ICT integration). According to Fenton, attributes can be external or internal. Attributes whose value depends on the environment in which the software operates are external, as opposed to attributes that do not depend on this environment, which are internal.

Then, these attributes can be measured using metrics. A metric relates a defined measurement approach and a measurement scale. A metric is expressed in units, and can be defined for more than one attribute. Three kinds of metrics can be distinguished: direct metrics, indirect metrics, and indicators. A measurement approach is a generalization of the different approaches used by the three kinds of metrics for obtaining their respective measures. A direct metric applies a measurement method while an indirect metric uses a measurement function (which rests upon other direct and/or indirect metrics). Thirdly, an indicator uses an analysis model (based on a decision criteria) to obtain a measure that satisfies an information need [27].

The act of measuring software is a “measurement” (as an action), it can be defined as a set of operations that aim at determining a value of a measure, for a given attribute of an entity, using a measurement approach. Measures are then obtained as the result of performing measurements (actions).This study concentrates on one particular quality model, (ISO 9126), which is defined in terms of a set of characteristics and sub-characteristics, as well as the relationships between them, that provide the basis for specifying quality requirements and for evaluating quality. The entities of the study will be ICT integration improvement. Since the model proposed by ISO 9126 is a generic quality model for any software product, there will be need to particularize it.

Software based performance measurement (index) play varied roles in organizations management. According to ‘IEEE’ (1997), measurement can be used by developers to evaluate progress towards completion. It also enable managers to assess project health and progress towards milestones, customers are also able to determine quality and functionality of systems, while maintainers are able to make decisions on reusability and reengineering. Metrics tool being set of measures based on a particular target requirement [28] forms a basis to assess the attainment of requirements. These can eventually help align ICT to business objectives, achieving compliance and attaining operational compliance [28]. Accounting for ICT integration processes and deliverables helps inform stakeholders to understand issues (chaos). It helps in achieving compliance to operations strategy, ISO standards, and critical successes factors and minimizes business interruptions. It also helps in attaining operational compliance by measuring, controlling and managing, maximizing and value creation. Therefore it is imperative to determine ICT integration performance levels measures of universities. It is these performance measure that are also termed indexes. Are such indexes currently in use in university teaching context and how is the quality of such indices are? The next section examines these by reviewing existing literature on existing metrics models, examining their suitability in managing ICT integration improvement in University teaching context.

IV. THE EXISTING METRICS AND INDEXES FOR ICT INTEGRATION

Attempts to manage ICT integration through indices can be traced in studies by [29], which established four success ICT integration indicators: (a) content and pedagogy indicators, (b) collaboration and networking indicators, (c) social indicators, and (d) technical indicators, they termed them four competencies. [24]) later resorted to the [30]) report and maintained subcomponents of each of these competencies, and considered the number and coverage of items in each title and found these competencies to be insufficient for a reliable measurement. [31] Then proposed a new factor structure (indicators or indexes) which included e-learning, infrastructure, teaching-learning methods, policy, special education, health, teaching communities, ease of use, e-interaction, technical assistance and access. Unfortunately, these new indicators proposed by [31] suppressed other aspects such as; ICT in the curriculum, professional development among other indicators. Again although [31] study revealed relationships among these indicators and their best predictors, these indicators however suppressed the teaching professional skills indicators. The [31] framework therefore can’t be effective in measuring ICT integration process by the university information technology teaching professionals.

Considering the reliable and consistent factor structure proposed, an ICT integration index model should be based on the following:

a) theories of dynamics of learning organizations [32],
b) the importance of contributive instructional technology management [33],
c) the significance of planning and management through resorting to all organization members [34] and
d) effective management and collaboration [35] .
e) Teacher skills; these are critical as students tend to live as they are taught by their teachers in terms of their ICT use experiences [36]; [37]. Moreover, emerging technologies in educational settings requires new teaching methods [38]. If students do not observe the reflections of emerging technologies in terms of the teacher ICT skills in their classrooms, then it means that current collaborative practices facilitated through emerging technologies could be insufficient.

On testing ICT integration model [39] through administering a scale to pre-service teachers enrolled at an education faculty in Turkey; [39] still ignored the teaching professionals’ skills as an indicator therefore it was not included in the model.

The other weakness of the [39] model reflects in its characteristics of a strict hierarchy (static metrics); which may not make it responsive to indexing dynamic ICT environment such as collaborative ,individual or regional nor mobile based ICT integration needs. The model may not therefore be effective in indexing affective, creative, motivating and relevant uses of emerging ICT technologies by university teaching professional during their instructional process.

It can be argued that if instructors cannot use emerging technologies for instruction in a relevant and effective way then, other practices reflecting e-learning, e-interaction and learning communities may also fail however good they may be. Again, considering the notion of information transparency and accessibility, technology use varies significantly among educational institutions. An individual teaching professional cannot therefore access all details regarding the ICT infrastructure of different institutions in a standardized way since some constructs are either naturally latent or ambiguous depending on the context. Thus, proposing a static structural equation models through measurable constructs, and investigating interrelationships among these constructs can't help to diagnose the current ICT integration situations of institutions or at individual levels. Individual level indexing of UITTPs calls for internet of things (IoT).For example it would be important to index overhead projector problems at individual levels, LMS barriers at individual and at collaborative levels. However, the IoT poses big data challenge due to its diversity and ubiquity [40]; [41]; [42], there is therefore need to effect the index within a given continuous metric.

Some studies have also been done on ICT integration indexes in teaching for example, [43] proposed four performance levels index of ICT integration in teaching specified as LI, LII, LIII, and LIV .At LI this is where university teachers integrate ICT as verbal resource, level two (LII), where a university teacher integrates ICT as printed resources, level three (LIII) as hands-on experience and a combination of all the approaches at level IV [43]. However, these indexes alone are not enough as these levels requires continuous improvement and especially at individual integrator level. None of these previous studies has developed a metrics for individualized continuous improvement index. The lack of individualized indices exists despite the recognition that ICT performance assessment or impact on development is a necessity [44], and more so among African countries [20]. Secondly, Wan et al., show little on how comprehensive these indices are. Comprehensiveness is an important feature of good metric and can also be referred to as metric space [55]. The next section discusses this concept of metric scope.

V. METRICS SCOPE FOR INDEXING IMPROVEMENT IN ICT INTEGRATION

Scope originated from the *Greek word skopeîn*, meaning "to look" or "see". What and where human beings see has limits. It would be important therefore to determine the limits of an ICT integration. Comprehensive metrics scope (Space) in an organization context can be viewed to essentially comprise the enablers and barriers to integration. This argument is based on the planning theory of management that argues that a comprehensive plan scope entails enablers which include strength and opportunities of the current status of integration and barriers which include weaknesses and threats at the current ICT integration level [46].

Despite the ICT facilities made available, there is no guarantee that teachers will integrate the technology extensively in their teaching. Smart School reports [47], [48] research findings by [50] and [51]indicated that there was minimal use of ICT in schools and questioned why teachers in Smart School have minimal use of ICT in the classroom even after availing all the essential conditions, they therefore attempted to know the conditions that facilitates the teachers' ability to integrate ICT. Studies by [43] in Malaysian Secondary Smart Schools identified conditions that facilitated the implementation of ICT integration as ; availability of ICT resources, acquisition of ICT knowledge, accessibility to ICT resources, existence of support, teacher's commitment to the innovation, influence of external forces; desire to change school practice. Based on further analysis, these eight enabler attributes can be categorized into two, namely the essential and the supporting conditions. The essential conditions are the conditions needed for the ICT implementation, whereas the supporting conditions are the condition which assures the continuation of the ICT implementation. These essential and support conditions therefore can be viewed as enablers to ICT integration.

As already mentioned a continuous improvement entails learning. Any learning process begins from current knowledge and should take care of that individual learner's weakness and strength (Enablers). Based on this view this section review literature on existing integration metrics scope as discussed below.

A) Metrics scope for Indexing Current ICT Integration

As has been discussed above, integration level (index) here refers to the resultant process or practice (behavior-external) measures as portrayed by the ICT integrator. It can be viewed as the total resultant ICT integration behavior by an individual, organization or nation. Such ICT integration practice level measurement can be approached at individual level or organizational perspective. Individual level measurement studies in secondary schools, conducted by [43] found out that teachers integrated ICT at one of the four levels in their teaching. At level one (LI), the teachers behaviorally integrated ICT as a verbal resource, at level two (LII) through printed resources, at level three (LIII) as hands-on (courseware) experience and as a combination of all the above three practices at level four (LIV).

[43] further argues that at level one (LI); the teacher teaches with the aid of ICT as verbal resource, giving the website addresses or name of courseware that would help students to enhance their understanding of the topics. At level two (LII); the integrator teaches with the aid of ICT as printed resources; distributes printed downloaded information as teaching aids. Level three (LIII) also referred to as hands on experience; teacher teaches with the aid of computer, courseware, software or internet only. At level four (LIV); the teacher teaches with the aid of computer, courseware,

software or internet in delivering the lesson. She or he also gives out handouts with information printed from the Internet or courseware.

Teachers found to be in Level III and IV were perceived to be actively integrating ICT in their teaching and were very committed to the technology, they were very enthusiastic when they shared their experiences during the interviews [43]. However, these levels were influenced by the presence and absence of the conditions that facilitated the implementation of ICT integration in teaching. At institutional level analysis all schools in level III and IV had their teachers integrating ICT throughout their teaching.

[51] In an earlier study also studied levels of integration and segmented the individual ICT integrators into five segments; enthusiastic beginners, supported integrated, high school naturals, unsupported achievers, and struggling achievers. These sub groups of ICT integration performance level can be measured further on other basis such as; experience and comfort with technology, grade level taught, applications and practice used and the extent of support by colleague and others.

Synthesis of these measures therefore reveals that although all accomplished ICT integrators may be at the same level of integration, they may in addition have diverse and complex combination of factors that leads to a given performance level of success in ICT integration. This consideration may be useful in discriminating and dispersing university teaching ICT integrators within the same level of integration and or segmentation level. The ICT integration performance level (measures) therefore can be perceived as a product that is dependent on varied or complex causes or influences of conditions and processes which need to be characterized by certain few critical success factors (CSF) or metric determinants. The complexity of these socio-technical systems, require metrics and measures to determine degree or ICT integration levels at individual or organization levels. These levels can eventually be used for continuous improvement in ICT integration levels. Socio-technical system such as University teaching can have considerable metric variables which can be influenced by many and complex factors ranging from the essential ICT conditions measures to supportive measures (enablers) and barriers whose levels need to be determined before developing any metric for continuous improvement of ICT integration index.

Although, institutions, have responded to addressing the complexity in ICT integration through various approaches such as training workshops, continuous learning, and participatory approaches, most of these approaches have not significantly enhanced ICT integration to the desired performance levels. Continuous improvement in ICT integration performance levels requires metrics of the current integration levels as a basis of their improvement. There is also need to determine the cause of various observed performance measures (LI, LII, LIII, and LIV…LN) in advance so as take corrective measures at the root cause. There is therefore need to comprehensively determine the array of metrics set of measures that influence these performance levels (indexes).

B) Metrics Scope for Indexing ICT Integration Enablers

An effective index needs to be based on comprehensive metrics space. A space for a comprehensive ICT integration metrics may essentially comprise enablers and barriers to integration. This argument is based on the planning theory of management that argues that; a comprehensive plan scope entails enablers which include strength and opportunities of the current status [52] Integration barriers would include weaknesses and threats at the current ICT integration level. The next section explores some of these metrics sets.

Despite the ICT facilities made available, there is no guarantee that teachers will integrate the technology extensively in their teaching. Dynamic School reports [47]; [48] and research findings by [49] and [50] indicated that there was minimal use of ICT in schools and questioned why teachers in Dynamic School have minimal use of ICT in the classroom even after availing all the essential conditions. They therefore attempted to determine the conditions that enabled the teachers' ability to integrate ICT. Studies by [43] in Malaysian Secondary Dynamic Schools identified conditions that facilitated (enabled) the implementation of ICT integration as ; availability of ICT resources, acquisition of ICT knowledge, accessibility to ICT resources, existence of support, teacher's commitment to the innovation, influence of external forces; desire to change school practice.

Based on further analysis, these eight enabler entities can be categorized into two, namely the essential and the supporting conditions. The essential conditions are the conditions needed for the ICT implementation, whereas the supporting conditions are the condition which assures the continuation of the ICT implementation. These essential and support conditions therefore can be viewed as enablers to ICT integration.

C) Metrics scope for indexing the Essential Conditions

The essential conditions include availability of ICT resources and acquisition of ICT knowledge [43]. These conditions are needed for the implementation of ICT integration in the teaching. If one of these conditions is not present, then implementation of ICT integration would not take place. Some of the indices for these essential conditions include; infrastructure, policy, among others. ICT Infrastructure has been found to predict other attributes such as, access, ease of use, and technical assistance. The lack of sufficient infrastructure is known to be a major barrier to successful technology integration [53] - [61]. Infrastructure is the first step in terms of hardware; however, rich infrastructure should be accompanied with opportunities to access those facilities so that the integration becomes more effective [62], [59], [63], [64]. In this regard, ease of use [65], [66], [35], [56] and Technical assistance [67], [68], [69], [70]) are further indicators which are supposed to follow infrastructure. Infrastructure therefore need support, it has been argued that teachers may have 7/24 access to hardware, but constant support conditions are needed to use them effectively and responsibly.

D) Metrics scope for Indexing Support Conditions

Supporting teachers in integrating ICT in their practices is an ingredient for professional development [71]. However such support should be based on student's interests [72].The support should involve continuous learning that focuses on developing lifelong skills and that occurs via connection with the real-world rather than only the teaching [72]. The supporting metrics would therefore comprise; accessibility of ICT resources, existence of the support itself, integrator desire to change, the school practices, influence of external forces and teacher's commitment to the innovation [43]. It was observed that the presence of these support conditions in the schools enabled them to continue with the implementation of ICT integration. However, absence of these conditions resulted in the slowing down or discontinuation of the integration of ICT in the curriculum.

Since these supporting condition comprises mostly of human factors; their measurement requires dynamic metrics, individualized and participatory so as to effectively enable determination of the varying levels at any instance of ICT integration in university teaching process. Such timely and precise measure will ensure proper decision making on the quality of the teaching process, which will eventually influence the quality of the teacher skills, knowledge and attitudes. But a delayed, imprecise and untimely measurement of support as is in practice in universities today, may lead to untimely measures which becomes expensive to correct. The metrics of the support conditions level will be more importantly used to make decision on the nature of continuous improvement (learning) that each university teaching professional should be given. Some of the critical ICT integration support conditions indices therefore include motivation, and commitment and their influence are as discussed below.

E) Metrics scope for Indexing Motivation and Commitment

In a survey [51] of 12th grade teachers in USA found out that teachers motivation and commitment to their student learning and their own professional development was important. They also observed that ample technology, ample time to learn the technology provided and academic and cultural structure to encourage experimentation of work are sources of motivation for ICT integration. Collaboration during integration was also noted to have significant contribution to motivation and commitment.

F) Metrics scope for Indexing Attitude in ICT Integration

The attitude levels have been used to measure ICT integration levels. Suggestions have been made that attitude influence ICT integration in teaching in the various ways: positive rather than negative attitude levels towards use of ICT, where positively disposed teachers towards ICT were found to be better integrators; pupil choice rather than teacher directive learning, whereby pupils guided learning improved more ICT integration than teacher directed learning; pupil empowerment as learners rather than receiving instructions; preference for individual pupil study rather than pupils receiving instructions.

G) Metrics scope for Indexing Barriers in ICT Integration

This entails measuring of problems that emerge during ICT integration. The Malaysian technology-rich school observed time factor, irrelevancy of course content and technical malfunction as some of the barriers. Of these time has been observed to be the greatest barrier [43]. The issues raised here include; too short free time to prepare lesson using ICT, lack of enough time to surf internet for information, and scheming and selecting information taking a long time. However, teachers who were ICT competent, needed shorter time to prepare their lesson using ICT compared to teachers with low ICT competence. Regarding teaching time, all teachers felt that one-hour period was not enough for their students especially when they need to print their work at the end of the lesson. Observation data showed that students took about five to ten minutes to reach the classroom and five minutes to settle down. They took another five minutes to operate the computers. If they faced technical problem, the teacher took another five to ten minutes to start the lesson. These shorten the teaching time .Therefore developing effective metrics to these time barriers can significantly be used to continuously improve integration performance level.

Metrics for Course Training Content Relevance index

Most of the teachers attending ICT courses couldn't apply the acquired knowledge in their school. For example, software and hardware they learned during the course were not the same with what was found in school. Thus, they found their knowledge irrelevant to the school setting. They also felt that the course period did not teach them on how to integrate ICT in their teaching.

Metrics for Technology Mal-functioning ICT Integration index

This include server break down, inaccessibility from home. Other technical problems that the teachers faced during implementation of ICT integration in school include malfunction of computer, server, router and LCD.

These various array of metrics have recently been summarized into eleven indicators as identified by [3] which can be perceived to influence the level of ICT integration performance. They include: Teaching-Learning Methods, E-learning, E-interaction, Learning Communities, Infrastructure, Access, Ease of Use, Technical Assistance, Policy, Special Education and Health. This approach gives a fairly comprehensive metric approach to ICT integration measurement. However, the literature also shows that indicators of ICT integration are greatly varied by world region, economic development levels and by the objective of measurement among other factors. Therefore, understanding and appreciating the already existing system, futuristic view of integration process and use of objective measurement based on participatory and individualized measures remains important in developing a continuous ICT integration performance level metric. The success to integration of ICT in university teaching will therefore depend on how well the integrators understand their strategic goals of education and how well the ICT goals can be identified and aligned to the education goals. This requires continuous improvement strategies such as learning. The next section therefore reviews literature that can enable development of a dynamic (continuous) metric to address this complexity.

H) Metrics scope for Indexing Continuous Improvement

A continuous improvement metrics can be viewed as the metrics that can capture the improvement needs of the ICT integrator. Such improvement should be based on continuous participatory learning approaches, requirements (objectives) for continuous learning. Identification of the key CSF is necessary in developing such a continuous learning metric tool as discussed below.

Effective teaching at the universities is heavily dependent on the quality of continuous lifelong learning. Wetzel (2010) argues that learning can no longer be considered something that only occurs in an adult's early years, learning need to continue over a lifetime for career and personal success. Continual learning benefits career success through developing additional work skills and self-satisfaction**.** Multiple careers today is one fact that leads to the need to continually learn and prepare one for wherever the future leads an adult especially with the rapid change in ICT [20].

[21] Noted a global crisis in preparing and supplying well-educated teachers to cope with fast changing technologies, globalization and new ICT skills demands on teachers. As a result of the rapid changes and increasingly complex environments in which teachers would need to operate, it has become necessary to forge collaborative structures and strategic partnerships at institutional, country and regional levels to deal more effectively with the complex issues and demands, particularly in the context of scarce resources and challenges related to sustainability. Continuous learning by university teachers especially in ICT skills therefore remain the key even in a technologically rich and advanced environment like the universities.

It is therefore necessary to focus more on the three types of learning; continuing education, professional development, self-directed learning in relation to ICT .The continuous lifelong learning during teaching should target these three types of learning to integrate ICT in teaching as an indicator of teaching professional development. The teacher professional development therefore can be safely be taken here as a level of measure of the extent of ICT integration through continuous learning.

For all the benefits of continuous learning to be derived in learning to integrate ICT, it will require proper ICT integration framework, metrics and automated tools that are empirically evaluated. These will help improve effective collaboration for effective learning, free exchange of ideas and viewpoints, to fully exploit their capabilities, be active contributors in professional development activities, and be adaptive to changes that can help fit the industry ICT to the teaching output through the quality graduates. However the university teaching being a socio-technical environment brings complexity metrics that requires objectivity in reduction to deriving critical metrics. Modeling such a metric requires proper analysis of the existing (legacy pedagogy) ICT integration practices by the university information technology teaching professionals with the view of identifying scope and critical success metrics (CSM).

I) Metric Scopes Types

Any metric applies over one or more scope types. A scope type is a type of product or process over which the metric is measured for product metric, examples include “feature” meaning that we will compute a metric over a single feature, “support conditions for ICT integration”, “attitude of ICT integrators”, “ICT integration system”, “set of systems”. These obey an order relation corresponding to the containment order of the corresponding software elements: a feature belongs to an attitude, an attitude to a support condition and the support condition influences performance level of ICT integration.

A scope may be of a particular instance of a scope type. For example a given support condition is an instance of the scope type “attitude”. To compute a measure is to apply a certain metric over a certain scope of an applicable scope type. For example we may compute the value of the metric attitude over a certain ICT integration performance system.

Classes of Integration Metrics

The ICT integration metric framework should provide a number of predefined metrics but also enables users to define their own metrics in terms of the predefined ones. Metrics are divided into elementary and composite. An elementary metric measures the number of occurrences of a certain pattern in the product or process. A composite metric, defined by a user of the environment, applies a mathematical or logical formula involving other metrics (elementary or previously defined metrics). Composite metrics include raw and derived metrics; selection criteria.

Elementary metrics can further be divided into raw and derived metrics. Raw metrics are simple counts, built-in into the environment, of occurrences of certain basic elements. For example, support conditions can be classified into; raw metrics which measures the number of support conditions. It can be useful to define a new metric by subjecting a raw metric to one or more selection criteria.

Selection criterion for a raw metric is: a property with a fixed set of possible values (two or more) characterizing the patterns being counted by the metric. The reason for considering selection criteria and derived metrics is clear: without these notions, the environment would need to have predefined (raw) metrics including all possible combinations, such as “deferred and no invariant”. This would quickly grow out of hand. An example in this study we could be interested in measuring an ICT integration support, which may be either all the time, most of the time, averagely, not all. Separately, an ICT integration support may be of varied, quality, high or low; which can be measured as ‘support available all time but low quality or rarely but high quality’ as another selection criterion. A university administrator might want to know the number essential ICT integration condition types that all the time gets support services that are low quality; this may be defined as a derived metric by submitting the raw metric. Support service to both of these criteria should be connected by an “and” combinatory.

A composite metrics applies one or more mathematical operators to a set of metrics, either elementary (raw or derived) or already composite. They include the following kinds.

Linear Metrics

These are metrics of the form Σ ki mi , where the ki are real values and the mi existing metrics (either elementary or basic) with the same unit, other than RATIO. (It would be improper to add two ratios since they might be ratios of incompatible things.

Ratio Metrics

Metrics of the form m1 / m2 where the mi are two previously defined metrics, not necessarily with the same unit, neither of which a ratio (again because ratio is a catch-all category for all divisions, so we can't divide further without courting incoherence). The resulting unit is a ratio.

Scope Comparison Metrics

These are metric that measure the ratio of the value of a given non-ratio metric over two different scope types. For example by choosing the metric attitude level and the scope types "support level" and " ICT integration performance level of the system" it is possible to measure the proportion of attitude's influence in the ICT integration performance level of the system that belong to the current support level. However, not all metrics may be applied to all scopes therefore each raw metric has one or more basic scope types, on which the environment has built-in mechanisms to compute it. The list of basic scope types is part of the metric's definition. Then the rule to compute the metric on any scope of scope type (st) is as follows:

- If st is one of the metric's basic scope types, apply the environment's built-in mechanism to determine the result.
- If st is smaller than the smallest of the metric's basic scope type, the result is zero by convention.
- Otherwise, the computation will add the measures made on the constituent scopes, applying the rule recursively.

This rule applies to raw metrics; it immediately generalizes to derived and composite metrics. However there exists small subtlety in the rule that explains the possibility of several basic scope types rather than just one.

J). Critical Success Metrics Scope in Indexing ICT Integration

Metrics for continuous improvement of ICT Integration performance level can be viewed as an organization information system strategy, however it poses a complexity challenge. Such complexity can be approached through identification of critical success metrics. Developing an organizational information system strategy requires a clear understanding of the requirements and creating effective KPIs as part of a performance management initiative is still viewed as a new concept for most world organizations [73]. According to [74] identifying CSF influences performance level of world class companies. It does so in three ways:

i. helps in identifying gaps in the new product development capabilities, (deficiency requirements)
ii. help define how much improvement that is still needed (opportunity requirements)
iii. help identify how to prioritize improvement initiatives (prioritization criteria/ranking requirement) .

The [75] suggest two main methodologies for establishing the essential requirements; the enterprise analysis (business system planning) and the CSF. While enterprise analysis gives a detailed analysis of the entire organization in terms of functions, processes, and data elements, it leads to production of enormous data, making it expensive to collect and analyze. On contrary the CSF approach involves senior and middle managers who help identify requirements that are critical to the organization's success, this makes it quick and less expensive .This approach therefore can be adopted to allow the research to quickly identify and focus on the suitable critical metrics across all the university organizations in Kenya. However, CSF's main weakness is lack of rigor and detail; this can be dealt with using survey.

Not all ideas or opportunities that are generated can be implemented at ago, the organization therefore has to evaluate and prioritize the Key productivity indicators (KPI) also referred to critical success factors (CSF). The process requires proven methodologies, methods, tools and techniques for the effective ideas evaluation. This section reviews literature on these possible methodologies, techniques and tools that can be suitable for identifying critical success metrics for integrating ICT by the university information technology teaching professionals. It begins by exploring the role of CSM.

Effective Metrics through CS Entities Identification Process

This process is preceded by four main steps (Micromation, 2007); identifying business goals, and business objectives followed by setting the IT goals and the ICT goals after which the activities of identifying the CSF begins a process also referred to as requirement engineering. Requirement engineering should apply the principles of involvement of critical stakeholders, appropriate requirements documentation, verification and validation and finally requirement management.

Critical stakeholders are the people or organization that has indirect or direct influence on the system being developed [76]. In this context the stakeholders are the university management and the IT teaching professionals or any other user who may interact with the metric system for continuous improvement of ICT integration performance level. These stakeholders are array of people of diverse objectives, expectation agenda, this may pose conflict in coming up with the critical requirements. The process should be guided by shared vision, shared objectives, requirement documentation summarizing all the requirements and constraints agreed upon. In addition, for dynamic requirements, iterative and agile development life cycle approaches is likely to improve identification and involvement of stakeholders, negotiation and scenario based discovery of requirements and analysis at the social context before modeling. During the elicitation and negotiation of the requirements stage emphasis should be put on learning and consensus building (they therefore emphasize on effective communication. Towards effective communication, [77] reiterate the importance of collaborative tools and techniques such as scenario based methods, multi-criteria decision processes, facilitative techniques, interviews and documentary analysis.

After consensus building the agreed requirements should be refined, weighted and documented. The documentation can be formal description, informal or semi-formal. While formal documentation enhance validity of the requirements ,it may stifle the requirements change management especially for dynamic environment where requirements are volatile and rapidly changing like the university teaching environment. Informal documentation on the other hand may affect construct validity of the requirement, semiformal seem appropriate for dynamic systems, because it makes it easy to make changes with the emerging new requirements during the metric system design .After documentation the stakeholder should validate and verify the established requirements and appropriate conventional methods such as formal reviews ,inspection and or prototyping [78]); this can help reduce the risk of developing wrong metrics that are not aligned to the measurement targets.

In organizations such as universities, a framework provides a way to link strategic objectives from top to measures and metrics from bottom [28]). According [79], an effective metric framework should satisfy four properties: theor**y**, comprehensiveness coverage, relevance and trustworthiness.

To design the UITTP-ICT –II, this study will establish the existing metrics; gather individual UITTPs mind maps through participatory approaches to design an improved metric. This will help determine the current practice's array of entity sets that maps to influence current ICT integration index(C-ICT-II). After which critical success sets (CSS) will be examined from the array of comprehensive mind maps. The critical success sets will be those entity sets that will be effective in the alignment of the ICT to teaching pedagogy. Metrics that can enable continuous ICT integration improvement index will then be derived. Finally, the derived metrics will be embedded in a mobile phone-based application to enable evaluation of the metrics' effectiveness.

Theory includes arguments backing the statement of relevance, while coverage defines what is being measured in sufficient levels i.e., comprehensiveness to enable repetition of the measurements. It is therefore the degree of comprehensiveness of what is being measured to assure repeatability of the measurement. Achieving this requires participatory, individualized and continuous improvement approaches for exhaustive measurement. Relevance on the other hand specifies interesting properties of products or processes on which the measurement may provide insight. This need to be based on effectiveness of the representation principles of the coverage measurement above; as the coverage may be too complex to be fully represented; this requires use of critical success factors (CSF) and models. Fourthly, trustworthiness is an estimate of how much the results can be believed; in particular their precision (expected variations in case of repetition). This measure should therefore be based on sound evaluation principles such as experimentation or expert opinions.

VI. THE CONCEPTUAL METRICS MODEL FOR INDEXING ICT INTEGRATION

The study extends the [43] proposed four performance levels index of ICT integration in teaching specified as level (LI, LII, LIII, and LIV). This extension is necessary because

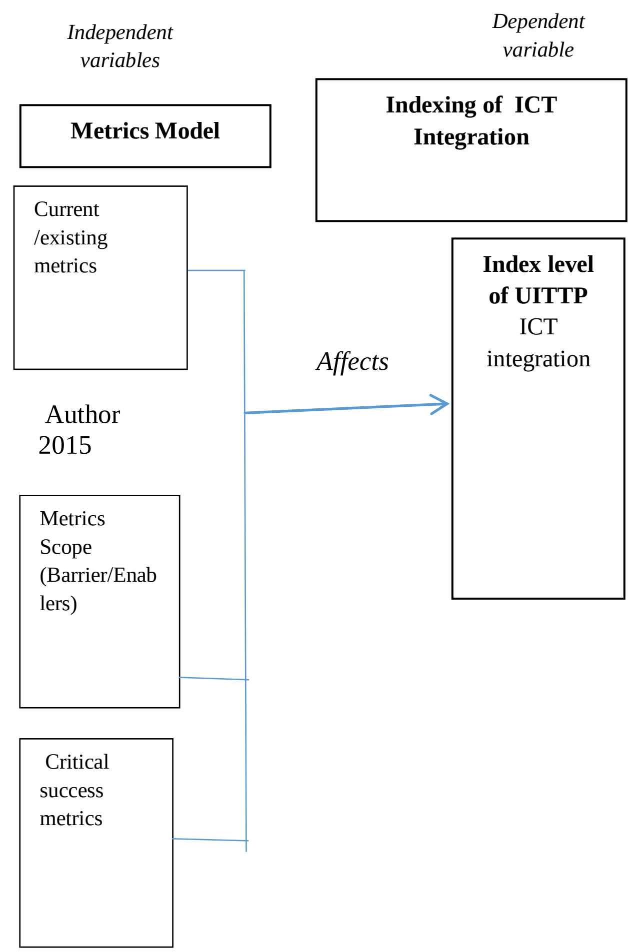

Fig. 1: Conceptual representation

presence of these indexes alone are not enough as these indices requires continuous improvement and especially at individual integrator level. None of these previous studies has developed metrics for individualized continuous improvement index. Such indices would provide a basis for identifying simple steps that developing countries could undertake to build vibrant, efficient and effective UITTPs knowledge based system.

This research will be based on two theories; Earls' theory of multiple methodologies [80] and organization learning theory as proposed by [81], suggests three elements of any information systems strategy: Understanding the current circumstances, an appreciation of what opportunities exist in the environment and a vision for future. It involves identifying and agreeing on business objectives through interview, debates and existing policies - gap (process); defining critical success factors (necessary for survival and growth); finding Information Technology that support or enable these CSF. The Earl theory is suitable for large, complex and complicated situations. It will provide a basis for the process of deriving metrics. This makes it suit ICT integration in university teaching, which is a broad complex system. The Earl strategy here will guide the process used to derive effective metric that is necessary to continuously improve ICT integration index (LI**)**, where university teachers integrate ICT as verbal resource, level two (LII), where a university teacher integrates ICT as printed resources, level three (LIII) as hands-on experience and a combination of all the approaches at level IV [43]. The improvement of ICT integration performance levels from LI to LV and to LN, are dependent on a continuous improvement of ICT integration Index for UITTP. This view borrows from [81] organization learning theory, where improvements in ICT integration need to be characterized by an individual or group learning, an effective UITP indexing need to be based on learning metrics. The university ICT integration index also need to be based on some scope (comprehensiveness) of the current ICT integration index, barriers and enablers of collaborative indices of the teaching process such as attitude levels of university teachers in using ICT, the supporting conditions for ICT integration and as moderated by the basic essential conditions of ICT integration such as hardware and software resources and policy that govern the people ware. This is as conceptually represented in Fig. 1.

VII. DESIGN CONSIDERATIONS FOR METRICS MODEL IN ICT INTEGRATION

Design is a specification of an object, manifested by an agent, intended to accomplish goals, in a particular environment, using a set of primitive components, satisfying a set of requirements, subject to constraints [82].

Here, a "specification" can be manifested as either a plan, or "primitives" from which the design object is composed. Here an Index is a model, while a model is a representation of a true object. A model can be viewed as a design strategy representing a solid starting point for implementation of an application as it reduces complexity, improves documentation design decision and also facilitate communication with the stakeholders [83].

Modeling metrics targeting university teaching IT professionals can be characterized by ubiquity as is in web based systems. While modeling web application, [83] suggest three dimensions of modeling scopes that can be. First is the model phase, which includes analysis, design and implementation modeling. These phases will need emphasis during the process of modeling of the metrics to improve its effectiveness. The second dimension is the aspects of model; which includes structured and behavior modeling, this dimension is critical in developing and implementing quality interface, which is out of scope of this study. Thirdly is the level of modeling which includes; content, hypertext, and presentation modeling. Effective metric system modeling would require consideration of these three dimensions. However this study will put emphasis on content modeling.

Content modeling provides information and application logics for the metrics system. It involves transferring the CSF requirements determined during analysis. It comprises structural and behavioral aspects. Such measures in this study would include and not exhaustive of; barriers and enabler metrics such as ; degree of ample technology, support, degree of amount of time to learn the technology provided, measure of the nature of academic and cultural structure to encourage experimenting their work and measure of the degree of collaboration.

A) The Need for Continuous Improvement in ICT Integration

According to [81] double loop organizational learning theory an organization's employee individual's mind map and actions can be aligned to the organization's objectives (first loop), and the difference (chaos) in such alignment need to be determined (second loop). It also borrows from knowledge based theories of model view of knowledge engineering. The knowledge engineering approach suits this study because the ICT knowledge of an individual university teaching professional need to be mapped and indexed to solve the problems of ICT integration. This model view also gives a closer approximate to reality; and perceives problem (chaos) as dynamic, cyclic, incessant process that is dependent on the knowledge acquired and interpretations made by the systems; this is similar to how experts solve problems in real life. It is thus suitable for application in individualized continuous improvement in ICT integration indexing. However; continuous improvement has the challenge of complexity. This calls for the need to index such improvements.

B) Symbolic Model and ICT Integration Level Improvement

As has been noted earlier, a metric can be an internal quantitative property of products (product metrics) or processes (process metrics), whose values are numbers either integer or real number. In our current framework, a measure should equal the value of a metric for a certain product or process [84]. For example, we can evaluate the metric "number of occurrence of the support conditions, essential conditions or the number of the problems that an ICT integrator faces", by counting the frequency in the system which yields a measure (performance level; LI, L2….Ln).

Product metrics measure properties of the elements being turned out and process metrics measure properties of the process whereby they are being turned out. The current foreseen product-oriented metrics of ICT integration would include the ICT integration performance levels (LI, LII, LIII, LIV LV), while metrics, such as "essential conditions, support conditions and problems conditions", are process metrics (internal attributes). To add product metrics requires interfacing with project management tool [84]; this is a desirable development feature that can ensure continuous integration.

Any metric should be relevant, related to some interesting property of the processes or products being measured. A metric theory is a set of metric definitions accompanied with a set of convincing arguments to show that the metrics are relevant.

C) Derivation of Metrics for Indexing Continuous Improvement in ICT Integration

Assumption: An index of ICT integration by university information technology teaching professionals can be influenced by multi-discriminate factors. These may include enablers and barriers, which may be characterized by: essential ICT integration factors (e), ICT integration support factors (teacher attitude and motivation, problems faced in ICT integration,) at varying relative rates or any other emerging determinants. This can be represented by the multi-discriminate function below:

$Y = [e\,(b_1X_1 + b_2X_2 + b_3X_3 \ldots\ldots\ldots\ldots.. b_nX_n)]$

Y=Index or level of ICT integration, as further defined by a range of indices; LI, LII, LII, LIV, LV. Where:

LI=Index level in which teachers use Verbal ICT integration

LII= Index level in which teachers use Written ICT integration

LIII= Index level in which teachers use Courseware.

LIV= Index level in which teachers use a Combination of all the three levels

LV= Index level in which teachers use transformative ICT integration

e= constant (essential conditions of ICT integration metric). Whereby if e=0 then there is no ICT integration, while the bigger the "e" value, the higher the rate of ICT integration.

b=coefficient of support conditions, as defined by:

X_1=Enabler metrics to UITTP to integration of ICT.

X_2= Barriers that the UITTP face in ICT integration.

X_n =any new type of variable identified due to continuous change in ICT integration.

Hence Y is the output due to relative indices of contribution of each of the ICT integration factors.

Based on these findings, it is clear that the presence of the enablers such as essential conditions ensures the implementation of ICT integration in the curriculum while the supporting conditions are seen to help in continuation of the implementation. These two conditions then may result into varying levels of integration depending on the nature of socio-technical factors defining the prevailing integration environment (teacher factors versus ICT factors).

D) Evaluation of Metrics for Indexing Improvement in ICT Integration

A metric is an internal measure and therefore can only be evaluated externally through the users. The evaluation of the metrics will depend on a usable tool. This section therefore reviews what entails a quality usable tool that can enable evaluation of the metrics.

Types of Computer Aided Learning Evaluation

When we consider possible approaches to educational evaluation, there are four general types described in the literature.

Evaluation of LT materials/CAL (computer assisted learning) is in fact intimately linked with the authoring and dissemination process. Thus approaches to evaluation reflect either what the authoring process seems to be before evaluation is considered, or else what the evaluators think it ought to be in order to make evaluation useful. Another way of putting this is that evaluation can be designed for different purposes or roles:

i. Formative evaluation: to help improve the design of the CAL.
ii. Summative evaluation: to help users choose which piece of CAL to use and for what.
iii. Illuminative evaluation: to uncover the important factors latent in a particular situation of use.
iv. Integrative evaluation: to help users make the most of a given piece of CAL.

The Summative Evaluation

In this context it refers to consumer reports on goods or service: to help decide which to buy or use. This view of evaluation is not expected to have any direct effect by telling the authors how to improve it. Nor is it expected to help consumers in how to use the product. It only informs which to buy [85] thus this view doesn't suit this study as there is need to involve the users on how to use and improve the metric model product.

Formative Evaluation

It is evaluation while it is being developed: testing it on user while there are still resources for modifying it. This is the simplest way for evaluation to help authors (developers); to try out the CAL material on users. This is likely to increase the time for the whole cycle of production, testing, and modification. Feedback to developers from sites who are early users of the material is a helpful substitute that gets round this constraint. Thus the main added result will not be a report, but the modifications to the design actually done.

Illuminative Evaluation

"Illuminative evaluation" refers to what might be called loosely, and perhaps incorrectly, ethnography. The basic idea is for the investigator to hang out with the participants (UITTPs, etc.) to pick up how they think and feel about the situation, and what the important underlying issues are. Its importance is as an open-ended method that can detect what the important issues are, without which other methods often ask the wrong questions and measure the wrong things. Illuminative evaluation is in effect a systematic focus on discovering the unexpected, using approaches inspired by anthropology rather than psychology [85].

Integrative Evaluation

In this evaluation method the argument or the question is no longer whether to use ICT or which package to use: this has been decided already. Instead, the question is how to make the best use of ICT materials already committed use. Classroom evaluations typically give lots of information that can be used for this. Thus a major use of classroom evaluations in practice is to be formative, not of the CAL itself, but of the overall teaching and learning situation. This of course can be and is responsive to local variations in how the CAL is used, and for whom. It can be a significant help in integrating CAL material into varying local situations and courses [85].

The Steps in Evaluating Metrics

Validation of metrics can be done both theoretically and empirically .Validation establishes soundness of the metrics [86]. Several studies on metrics have been done [87], [88], [89].

Basis of Metric Evaluation

[88] Came up with eight properties on which to evaluate a metric. However, its principles have been critiqued as being ideal for complexity metrics only. [89] Expanded these properties by including criteria for evaluating size metrics. Since the proposed ICT integration metrics will be size based, then [6] approach is more applicable in this case. According to [89], a *system* S will be represented as a pair <E,R>, where E represents the set of elements of S, and R is a binary relation on E (R ⊆E xE) representing the relationships between S's elements.

Given a system S = <E,R>, a system m = <Em,Rm> is a *module* of S if and only if Em ⊆E, Rm ⊆E xE, and Rm ⊆R. This will be denoted by m ⊆S.

[6] says size is recognized as being an important measurement concept and defines size of a system S as function Size(S) that is characterized by the following properties

Property Size.1: Non-negativity

The size of a system S = <E,R> is non-negative

Size(S)=0(Size.I) 2

Property Size.2: Null Value

The size of a system S = <E,R> is null if E is empty

E = ∅⇒Size(S) = 0(Size.II) 3

Property Size.3: Module Additivity

The size of a system S = <E,R> is equal to the sum of the sizes of two of its modules m1 = <Em1,Rm1> and m2 = <Em2,Rm2> such that any element of S is an element of either m1 or m2 (m1 ⇒S and m2 ⊆S and E = Em1 ⊆Em2 and Em1 ∩Em2 = ∅) ⇒Size(S) = Size(m1) + Size(m2) (Size.III) 4.

The last property Size.3 provides the means to compute the size of a system S = <E,R> from the knowledge of the size of its—disjoint—

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