Establishing a Performance Testing Approach for E-Learning Applications

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Abstract - Most of the E-Learning applications perform poorly in motivating employees to learn. To solve this problem, we need to examine what workplace e-learning requires and how workplace e-learning systems should be developed in line with those requirements. We investigated the problem by identifying the fundamental elements of the workplace learning environment including the learner, organization, learning content and social context, and their relationships. We found that workplace e-learning should align individual and organizational learning needs, connect learning and work performance, and support social interaction among individuals. To achieve this, a performance testing approach is proposed. Key performance indicators are utilized to clarify organizational goals, make sense of work context and requests on work performance, and accordingly help employees set up rational learning objectives and enhance their learning process. Using this approach, prototype system has been developed and a set of experiments have been conducted to demonstrate the effectiveness of the approach.

This paper also presents the use of software verification, validation and testing technique, traditionally used in the software development, in the design and implementation of E-Learning products. We examine the ways one can apply testing techniques in E-Learning life cycle. This includes the strategy adoption for the selection of testing technique along with tool acquisition and measurement. The objective is to develop a collaborative approach involving software testing and educational methodology.

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GJCST Classification: D.2.5

ESTABLISHING A PERFORMANCE TESTING APPROACH FOR E-LEARNING APPLICATIONS

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I. INTRODUCTION

E-learning refers to the use of computer network technology, primarily via the Internet, to deliver information and instructions to individuals. Due to its access flexibility and just-in-time delivery, e-learning is emerging as a popular approach for learning in organizations or workplace settings [13]. Despite the ever increasing practice of using e-learning in the workplace, most of the applications perform poorly in motivating employees to learn. Significant gaps exist between corporate interests and learner needs when it comes to e-learning [3]. For individuals, although knowledge can be learned by participating in e-learning programs, more often they do not think e-learning is helpful since the knowledge learned cannot help

improve their work performance. For organizations, e-learning is generally designed without meeting the organizational vision and mission. Moreover, current e-learning development tends to focus on technical issues of design and ignores pedagogical and organizational issues that are necessary for effective e-learning programs to address [14]. The dominance of technology-oriented approaches has made e-learning practices less goal effective, and they are therefore perceived to be poor in quality and design. On further review of the root of the problem, it seems that much of e-learning research is based on formal courses in educational institutions. However, corporations as learning arenas are different from schools. Workplace learning is built on practical tasks and work situations with the aim to serve organizational goals. Learning in the work environment takes place in the context of use and application, and as a result is often embedded in work practices. Moreover, learning is more collaborative in workplace settings, where sharing individual knowledge with co-workers is an important part of the learning practice.

The above mentioned problem highlights the need to design learning activities that address corporate interests, individual needs, and work context. The development of workplace e-learning should consider the alignment of individual and organizational learning needs, the connection between learning and work performance, and communication among individuals [16]. To solve the problem, a performance testing approach is presented in this study. A set of key performance indicators (KPIs) has been set up to represent a set of measures focusing on the aspects of organizational and individual performance that are critical for the success of the organization [12]. The KPI framework provides a clear picture for everyone in the organization of what is important and what they need to do and learn. The mechanism of the approach is explored and elaborated with conceptual frameworks and implementation details. To demonstrate the effectiveness of the approach, a prototype of a workplace e-learning system has been developed with relevant experiments to evaluate the effectiveness of the approach.

The vision of learning is that *everyone learns*. The software required for learning should include problem solving, critical thinking and interactivity. Here interactivity deals with the detailed learning process

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instead of GUI features only. Interactivity could be properly incorporated by well designed production process. After looking into the various models of learning such as classroom-teacher model, independent study model, cooperative learning or distance learning, the success lies in the careful development of learning material by skilled groups and its proper evaluation and improvisation, before final release. This leads to the strategic viability of E-Learning [7]. E-Learning could be defined as the acquisition and use of knowledge distributed and facilitated primarily by electronic means. It is a "classroom without walls". It is actually the convergence of the web and learning at all levels [6]. This involves new techniques of communicating ideas through computer networks, multimedia, search engines on the net and electronic libraries with endless possibilities. As noted in IEEE Spectrum [15], since the mid 1900s, correspondence schools in India were teaching shorthand and foreign language by mail. The organizations have started the concept of e-enterprise having proper emphasis on E-Learning. They are using content providers, authoring tools, training materials, portals, delivery systems and integrated solutions [2]. It is fully online, interactive, time and place independent.

In this situation, it is essential to develop the content and delivery system that will fit well with next generation cable television. High quality lessons are required to provide interactivity to the user. Traditionally evaluation is done at the end of the process highlighting the role of computer and professional evaluators. But the detailed description of testing methods for evaluation, customized to E-Learning, are not frequently available. One way to ensure individualization is to make frequent testing an intrinsic part of learning. Testing and learning would no longer be separated, but would be in intimate combination. Since the cost of development of very large amounts of highly interactive learning unit will be very high, this illustrates the need for structured testing approach.

II. DEFINITIONS

Workplace learning refers to learning or training activities undertaken in the workplace, with the goal of enhancing individual and organizational performance [13]. Attention to workplace learning has greatly increased due to the significant role of professional skills and expertise in organization development. Theories specific to workplace learning can be categorized into adult learning, organizational learning, and knowledge management (KM). *Adult learning* theories form the basis for the design of e-learning practices in work environments. Andragogy (learning strategies focused on adults) and self-directed learning are two fundamental parts of adult learning. The implication of adult learning theory in the workplace context is that learners would be motivated once learning objectives

have been rationally set that would meet their needs [5]. According to self-directed learning theory, learning programs should be designed to give emphasis to self-directed learning so as to help learners make sense of the workplace and their experiences at work [8]. *Organizational learning* concerns both the ways individuals learn in an organizational context and the ways in which organizations themselves can be said to learn [4]. Organizational theory implies that learning occurs and should be addressed beyond the individual level. Its pedagogical focus is on organizational systems, structures, and policies, along with institutional forms of memory to link individual and organizational learning. In relation to organizational learning, *knowledge management* (KM) represents another discipline. It refers to a range of approaches and practices used by organizations to identify, create, represent, and distribute knowledge for reuse, awareness, and learning [10]. Recent research has motivated the integration of knowledge management with e-learning for organizational development [16]. How knowledge management and e-learning apply to and affect organizations is a complicated, yet important question that requires a variety of conceptual, methodological, and technical approaches.

Learning as we measure it is a change in performance which occurs under the condition of practice. Evaluation is the process of gathering and interpreting evidence on changes in the behavior of all students as they progress through school. Software Testing is an activity in which a system or component is executed under specified conditions, the results are observed or recorded, and an evaluation is made of some aspect of the system or component.

Validation is the process of evaluating a system or component during or at the end of the development process to determine whether it satisfies specified requirements.

III. PERFORMANCE TESTING WORKPLACE FOR E-LEARNING DESIGN

There is no doubt that the goal of e-learning in the workplace is to enhance individual and organizational performance [13]. However, there is a lack of concrete strategies or approaches for achieving this goal in e-learning development. To solve this problem and meet the aforementioned requirements of e-learning in the workplace, a performance testing approach is presented in this study. Performance measurement is crucial for organization development, and therefore it is a main driver of learning in the workplace. In this approach, a set of key performance indicators (KPIs) can be set up to represent a set of measures focusing on the aspects of organizational and individual performance that are critical for the success of the organization. KPI is a flexible and popular approach

to conducting performance measurement in organizations. The mechanisms of why and how we use this KPI-oriented approach to workplace learning are elaborated as follows.

a) Performance Testing Approach

Performance measurement is used by organizations as a procedure to improve performance by setting clear objectives, assessing performance, collecting and analyzing performance data, and utilizing performance results to drive performance development [1]. KPIs are financial and non-financial metrics used to help an organization define and measure progress toward its goals. KPIs can be used to assess almost any aspect of work performance, depending on an individual organization's design. KPIs are typically tied to an organization's overall strategy, and they differ according to the nature of the organization and its strategy. In a KPI system, organizational vision and mission are converted into clearly defined key performance targets for the organization and its business units; based on the unit's goals and objectives, official expertise and capabilities required for each position in the unit can be defined. A KPI framework provides everyone in the organization with a clear picture of what is important and what they need to do. The KPI-based performance measurement approach has special meaning for learning in the workplace. KPIs bridge the gap between an organization's mission and vision and its employees' targets, and making organizational goals accomplishable. KPIs can be used to help employees set up rational learning objectives based on their job position and knowledge gap. It can be used as a systemic scheme to organize and manage learning resources in line with work context and performance requests. KPIs can also be used to facilitate social interaction among individuals by identifying employees' work context, expertise, and performance proficiency. In brief, KPIs can be used to support

- The alignment of individual learning needs and organizational interests,
- The connection between learning and work performance, and the social communication between individuals.

b) Performance Testing System Design

A KPI framework encompasses an organization's structure and job system. It consists of three levels: the organizational level, business unit level, and position level. KPIs on the organizational level are defined according to organizational goals and strategies. Derived from the organizational KPIs, the KPIs for each business unit are specified. Based on the unit KPIs, the KPIs for each job position within the unit are then defined. For performance measurement to be effective, the measures or indicators themselves must be accepted, understood, and "owned" by employees

as well as their managers. Therefore, the building of a KPI framework requires cohesion and integration of different strategies as well as tight cooperation among managers and employees from different units and at different position levels in the organization [11]. KPIs for a position in one unit can be reused in other units for a similar position, or where similar capabilities are required. In this study, due to the space limitation, we focus on KPIs at a position level that has a close relationship with learning or training programs in the workplace.

The KPI at the position level consists of three components: KPI item, rating criterion, and KPI value. *KPI items* are a set of performance indicators specified for a job position. For example, oral and written communication skills might be two KPI items defined for a sales job position. For each KPI item, a *rating criterion* is set up to assess performance. The proficiency level achieved by an employee on that item is called a *KPI value*. An employee's performance measure result is a set of KPI values for his or her job position.

Tests or quizzes can be used to assess how an employee performs with a certain KPI item. To preserve impartiality and objectivity, most organizations use 360-degree feedback to assess employees' performance. This means that the employee's performance can be assessed by the employee him- or herself, the employee's supervisor, his or her subordinates, and peers, in addition to taking standard tests. Each appraiser gives the employee a set of KPI values, and each appraisal is given a certain weight. As a result, a set of KPI values will be calculated to evaluate the employee's work performance. An illustration of the KPI framework at the position level is shown in Table-1.

IV. STAGES OF INSTRUCTION DESIGN

- Analysis of needs, goals and priorities.
- Analysis of resources and constraints.
- Selection of a delivery system.
- Preparation of a curriculum with reference to goals for each subject.
- Designing of the objective of each course.
- Designing of the organization of course.
- Design the lesson.
- Assessment of learner's performance.
- Development of the learning material.
- Revision if necessary.
- Summary Evaluation.

Employee ID	Job Position	KPI Item (Capability)	Rating Criterion	KPI Value (Assessment Result)
75435	Test Engineer	Bug Reporting	Test (Weight:1/3) Level 1 : score[0,20] Level 2 : score[20,50] Level 3 : score[50,70] Level 4 : score[70,90] Level 5 : score[90,100]	Score Obtained : 65 → Level 3 → Rating : 3
			Peer Assessment (Weight: 1/3) Supervisor Assessment (Weight: 1/3) Level Criterion defined: 0 : Do not Know 1 : Know little about this area 2 : Know basic knowledge about this area 3 : Have substantial knowledge about this area 4 : Use related knowledge to accomplish tasks 5 : Use related knowledge to achieve sound effect	Peer Assessment : Level 4 → Rating : 4 Supervisor Assessment : Level 3 → Rating : 3
			Overall	3*(1/3) + 4*(1/3) + 3*(1/3) =3.33
		Test Execution	…..	…..
57896	Test Manager	…..	……	…….

Table1: A Kpi Framework at the Position Level
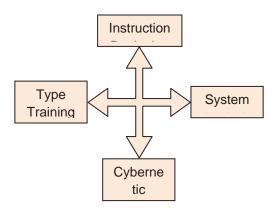

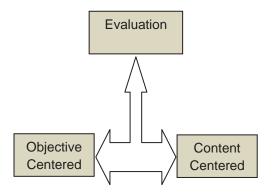*Figure 1:* Classification of Instruction Design

Figure 2 : Classification of Evaluation

V. Software Verification and Validation In E - Learning Application

As indicated in the publication of the report of Learning and Skill Council's Distributed and Electronic Learning Group (DELG) that the investment in the distributed and the electronic learning has to be rationalized. The question is whether our thrust is that everyone will do some E-Learning or we will provide effective E-Learning. For implementing later, we require to timely deliver using good-quality, well-designed material. The role of the reviewer is to determine the learning value and ensure quality of the contents. The some of the parameters they evaluate is the pedagogical effectiveness, ease of usage, suitability and conformity to the area of submission. Package should ensure the convenience of re-use, discovery and delivery. It could be done by validating it against the designed schema. This could be pre or post implementation review. The validation and verification techniques are used to ensure quality into the software during the development. Commonly used V&V methods are reviews, analysis and testing techniques. The verification activities include requirement, functional design, individual design and code verification. The Requirement in case of E-Learning should be in the form

of System Requirement Specification (SRS). Any inconsistency during the design or coding phase should be traceable to the requirement specification. SRS standards of E-Learning have to be established by the learning package providing group. Later through the reviews, inspection and walkthrough the representatives from the educational evaluation section could be invited for evaluation. Validation is normally done at the time of implementation, i.e. toward the later part of instruction design and implementation, through the involvement of students and teachers. It should be done through various testing methods. Although the developers follow some techniques for dynamic validation but the customized static verification at the end of each step is yet to be established.

VI. TESTING STRATEGY FOR LEARNING APPLICATION

E-Learning application presents a new challenge that due to response time, accuracy of information or ease to use, a E-Learning application presents a new challenge that due to response time, accuracy of information or ease to use, a student is compel to click another web site and shift to different application provider [9]. It is critical due to short cycle time, constant changing technology, and huge number of users or inability to control the user's environment. The critical issues while testing are handling student's query, student volume in terms of assignments, payment system for fees, security of student's account details and effectiveness of learning method. The choice is with the tester to use complete or partial verification, unit or integration and black box or white box testing depending on the nature of learning application and the profile of the student. The major testing techniques in this area are as follows:

a) Functional Testing

This black box testing could be used for the testing the forms for the course registration, fee submission and other interaction with the students. The procedure for checking pop-up windows, searches, online payments are also defined under this testing technique.

b) Usability Testing

The feedback about structure, feature, navigation and other factors are taken in this technique. Separate task lists are required to study students profile and the impact of the application. Testing will fail if the application contains outdated information, non-standard colors, long scrolling page, orphan page, excessive use of marquee etc. It involve student behavioral pattern while using the E-Learning application.

c) Mutation Testing

The intentional wrong entry could be done to check the behavior of the application. These mutations indicate the thoroughness of the program testing. Here each mutation is carefully selected and studied involving teachers and students.

d) Equivalence Partitioning

A set of classes of input conditions are made and tested. These classes should be standard for a particular level of education. For example, student's grades, assignments submission, scholarships etc.

e) Compatibility Testing

The E-Learning package should be compatible with the formal learning schemes. Redundancy should be minimized to make the two methods complementary.

f) Foreign - Language Testing

As the E-Learning applications are translated in different languages, the test is very critical. It should involve the testing of the following factors:

- Translation issue
- Text expansion
- Computation of Characters (Left-to-right / right-to-left)
- Localization issues

VII. CONCLUSION

Real time 2-way multimedia customized interaction is the real goal of E-Learning. It may include problem based scenarios, interactive case studies, virtual reality simulations, e-books, short learning objects, modules and projects. As there will be learning centers with micro-charging system, better speech/voice recognition software, bigger video screens and collective databases, testing will certainly be a critical issue. The major question regarding testing in future is the effectiveness, economics of testing in E-Learning and approaches. As it will be very critical for the survival of the institute or organization providing E-Learning facility, the ultimate goal should be goal is total test automation.

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