E-Learning Indicators: A Multidimensional Model for Evaluating and Planning E-Learning Solutions

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Abstract

As a number of recent studies suggests the big breakthrough of using networked computers in education has not been achieved yet. Literally, thousands of E-Learning projects have been carried out that greatly differ in their outcomes. Very often it is difficult to assess how successful or unsuccessful these projects are. The evaluations of E-Learning projects very often emphasize the positive aspects of the approaches that have been followed and do not discuss in details the drawbacks, disadvantages, or reasons for the failures. In addition, new technologies or new methodologies applied in such projects are used as buzzwords to highlight their success. Until now, however, there is no a standardized way of evaluating E-Learning projects, their outcomes, future potential or their advantages and disadvantages. The main purpose of this research was to investigate possible approaches for systematic evaluation of E-Learning solutions. The result of this work is a multidimensional model of so-called E-Learning indicators. A practical value of that approach was analyzed in a number of case studies which are presented.

Keywords: e-learning, indicators, enhanced learning, evaluation of e-learning solutions

1 Introduction

One of the strongest arguments for promoting e-learning lies in its potential to improve and even revolutionize teaching as well as in aspects of learning to minimize the dimensional constrains of time and location. Recently there are a lot of studies show scepticism in thoughts about e-learning successfulness in general. The research question from which we started was: What makes a successful e-learning? In order to define and analyze this we have proposed, assessed, measured and evaluated e-learning factors that substantially influence learning. The purpose was to raise the awareness of the factors influencing e-learning in order to enhance learning and identify the nature of obstacles being faced by e-learners. We propose this methodology approach in developing any e-learning initiative. Because there are to many factors, personalization’s and specifics related to each situation and circumstances we consider that would be wrong offering one size solution for all. Therefore we propose to asses and improve the overall e-learning quality and dissemination of knowledge for each e-learning initiative and particular situation by
defining and measuring e-learning indicators for the specific circumstances, specifics and technology solutions. Then based on the results of the measured and evaluated e-learning indicators to develop sustainable e-learning initiative. We have proposed 18 e-learning indicators that were assessed, measured using Angel Learning Management System (LMS), and further evaluated. As a result of our analyses we have seen that e-learning content and attention in an e-learning process are the key factors referred to as e-learning indicators further in our study that influence and have a high impact on e-learning. Using this approach the objective was to determine the general issues, deficiencies and barriers in e-learning and propose a solution for them by undertaking different Case Studies and experiments.

2 E-learning Indicators
We have defined the e-learning indicators as the important concepts and factors that are used to communicate information about the level of e-learning and their impact on learning that could be measured and described then in simpler terms. We have defined as e-learning indicators: (1) learner education background; (2) computing skills level (3) type of learners they are, (4) their learning style and intelligence, (5) obstacles they face in e-learning (e-learning barriers), (6) attention, (7) e-content (suitability, format preferences), (8) instructional design, (9) organizational specifics, (10) preferences of e-learning logistics; (11) preferences of e-learning design; (12) technical capabilities available to respondents; (13) collaboration; (14) accessibility available to respondents; (15) motivation, (16) attitudes and interest; and (17) performance-self-efficacy (the learner sense their effectiveness in e-learning environment), (18) learning outcomes. We have used focus group and a web based survey of academic staff and students for the research of e-learning indicators following guidelines from Fetaji et al. (2007).

The e-learning indicators are assessed then measured and evaluated for the virtual learning environment Angel Learning Management System-LMS. The analyses and specification of the e-learning indicators: (1) learner education background together with his cultural background is set as indicator since it is a direct factor that is associated and impacts e-learning. According to Gatling et al, (2005), students today come from a variety of cultural backgrounds and educational experiences outside of the traditional classroom. How do students construct meaning from prior knowledge and new experiences? Based on this facts and interviews with e-learning specialist we have set it as important indicator. (2) computing skills level of the learner is set as indicator since it directly influences the way e-learning because of the computing skills requirements. “As we move toward the 21st century, anyone who is not “computer literate” will find themselves at a disadvantage when competing in the job market.” (Johnson, Gatling, Hill, 1997). The indicator (3) type of learners they are depends primarily on the balance in the two dimensions of the Learning Style scale model formulated by Richard M. Felder and Linda K. Silverman according to Felder & Soloman (n.d). The importance of the type of learner and (4) their learning style is for the both sides: instructor and student. For instructors it is of importance since it reflects the preferences of Learning style in their teaching and delivery style to students. We advise to tend to use each learning style to teach also in a delivery type suited to other types of learners and treing to bring it closer and generalize to include all the types using visualization and verbal communications, as well as other communication tools.
The indicator (5) obstacles they face in e-learning (e-learning barriers) is set as important based on interviews and speaking with e-learning specialists. Indicator (6) attention is set as very important, attention cues when the learners begin to feel some mental workload, Ueno, M. (2004). (7) content (suitability, format preferences), e-learning content we consider as vehicle of the e-learning process and knowledge construction. The quality of the virtual learning environment is mainly depending on the quality of the presented e-learning content. Fetaji, B. (2006). Indicator (8) Instructional design has gained significant prominence in e-learning for a number of compelling reasons. One of them is the possibility for instructional design to systematically address the need for creating and evaluating students’ learning experience as well as learning outcome. The other is instructional design can help faculty to focus on using the appropriate format and tools for the appropriate learning objectives. Fetaji, B. (2006). (9) indicator organizational specifics - every organization has its specific business processes that influences and impacts e-learning, Galotta et. al. (2004) (10) preferences of e-learning logistics- targeted at learners of different experience levels and organizational background/hierarchy, based on the ELA model - the European Logistics Association (ELA), Zsifkovits (2003); (11) indicator preferences of e-learning design; designing instruction that acknowledges that students differ in their learning preferences and abilities and that instruction needs to be flexible to address these differences, Kumar (2006). The next indicators (12) technical capabilities available to respondents (13) collaboration; (14) accessibility available to respondents, ares defined as important indicators in discussions with e-learning specialist and experts; (15) motivation, Motivation is essential to learning and performances, particularly in e-learning environments where learners must take an active role in their learning by being self directed (Lee, 2000). (16) attitudes and interest; A review of studies on attitudes toward learning and using information technology in education has revealed that most studies have shown that students’ attitudes toward technology are critical, Liu et. al. (2004); (17) performance: self-efficacy (the learner sense their effectiveness in e-learning environment); Self-efficacy refers to people beliefs about their capabilities to perform a task successfully at designated levels, Bandura (1997). (18) According to Jenkins, A. and Unwin, D., (1996) learning outcomes are defined as statements of what is expected that a student will be able to do as a result of a learning activity. It is set as important indicator in order to become effective in meeting students’ needs.

3 Evaluating e-learning effectiveness

Major challenge for e-learning researchers is to assess e-learning effectiveness. In order to do that we have proposed a methodology, called ELUAT (E-learning Usability Attributes Testing), which combines an inspection technique with user-testing based on 4 usability attributes we have set. The usability attributes we have set are: 1) Time to learn, 2) Performance speed; 3) Rate of errors; 4) Subjective satisfaction. The e-learning-methodology is necessary for presenting the e-learning in an efficient aspect.

The theoretical basis are pedagogical conceptions defined from Klauser et all (2004):
- Learning according to the constructivist perspective,
- usability of the e-learning environment and
research about user opinions.

We have based the measuring instrument on the use of predefined evaluation tasks (PET), which precisely describe the activities to be performed during inspection in the form of predefined tasks, measuring previously assessed usability attributes. We have named it as PET inspection technique and using this technique we evaluated usability attributes using evaluation tasks for a particular scenario. Evaluation tasks in this technique are determined by designing several user scenarios and choosing the scenarios that include the most of the options of the software. This kind of approach using this technique has shown very effective, straightforward and useful in determining the distance between learner activities and preconceived scenarios in several research projects we conducted. Using the ELUAT methodology and PET inspection technique we have gathered information on interactions between human actors (intervention strategies and content). Scenario contains at least a collection of components and a method. The components are roles, activities or activity-structures, which role does what (which activity) and at which moment is determined by the method which is made up of one or many plays formed by a series of acts. In an e-learning environment, information obtained from learner activity contain a certain pedagogical semantic. The observed route of a learner has been used to give feedback information on the level of learning and its effectiveness. We have considered the next learning modeling approaches: the content-oriented, the tool-oriented, and the task-oriented approach, and we have chosen the task oriented approach for which we developed the methodology to suite to our specifics.

**Fig. 1.** PET inspection technique task based form

<table>
<thead>
<tr>
<th>Task n#</th>
<th>Time for:</th>
<th>M</th>
<th>S</th>
<th>E</th>
<th>R</th>
<th>O</th>
<th>H</th>
<th>F</th>
<th>*</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Task completion</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Help search</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Recover from errors</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Time to Learn:</td>
<td>Total:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The PET inspection technique uses the next measurements: M – Menu Error; R – Repeat task; F – Frustrations; S – Selection error; O – Uses online Help, E – Other errors, H - Help calls, * - Subjective Satisfaction (5-very high, 4-high, 3-average, 2-low, 1-very low).

This methodology and the inspection techniques have been used in several different research projects and it produced valuable information for the design of the subsequent studies and proved as viable methodology and technique.

In order to evaluate the e-learning impact, the following main research questions were analyzed:

1. What are the usage implications for the student population?
2. Does the teaching approach embodied in the program contribute to perceived learning gains?

3. What are the opinions, feelings on the learners regarding the system usability and effectiveness in regards to learning?

We have tried to build our teaching and learning system based on two foundations: the needs of the intended students, and the learning outcomes of the course or program (i.e., the knowledge, skills, and attributes that students want). Our e-learning system was based on a plan that flow from a full understanding of these two fundamentals.

An understanding of the technological background of the intended students is crucial, including their expectations, their financial and other resources, their access to the Web or other online networks, their bandwidth limitations, and any other pertinent information about their preparedness and ability to participate equally and fully in the learning experience. In reality, of course, such a complete picture is rarely available, and a judgment call must be made on how much the system employs technologies that we know the students are familiar with and have access to, versus those that are new and unfamiliar, but are expected to become widely available. A good example is the extent to which distance students have access to high-speed connectivity. Considerations of student demographics and other factors would, of course, affect the timing of such a decision.

The clear identification of the learning outcomes is useful in many ways: in the design of a learning assessment system, in determining the degree of prior learning considered necessary, and in measuring the quality of the offering. The curriculum and associated teaching and learning system was devised and cross-referenced with those ends clearly in mind. The designed system project from its first design stage is set to comply with the Nielsen (2000) nine basic usability principles:

1. Use simple and natural language.
2. Speak the user’s language.
4. Be consistent.
5. Provide Feedbacks.
6. Provide clearly marked exits.
7. Provide shortcuts.
8. Provide good error messages.
We have chosen Empirical evaluation method and contextual inquiry, interviewing and observing users in context, in which a prototype is constructed and tested by users in real-world environment iteratively. We defined two classes of users as shown below.

<table>
<thead>
<tr>
<th>USER</th>
</tr>
</thead>
<tbody>
<tr>
<td>CLASS</td>
</tr>
<tr>
<td>-------</td>
</tr>
<tr>
<td>1</td>
</tr>
<tr>
<td>2</td>
</tr>
</tbody>
</table>

Class 1 – Course Administrator Users / Full access
Class 2 – Learners Users / Limited (Reading, Uploading files access)

In addition, we conducted performance measurement test to quantify usability requirements such as time to complete a task, time to learn, rate of errors and subjective satisfaction. We also made observations by watching the users with different backgrounds in computing and took notes by watching them using the prototype in every stage of development. For the final prototype we conducted Usability testing on full product and made testing on several users, different then the ones we used in the prototyping stage.

As indicated above in User classes, we have two user classes: Class-1 and Class-2. we have included the following usability attributes:

- Time to learn
- Speed of Performance
- Rate of errors
- Subjective satisfaction

Since planning is the most critical part for a successful test we have observed and followed the guidelines from Dumas and Redish (1999):

The general concerns of the test were: How well the help provided is? What is the learning and usage curve for the system? Obviously the user will be faced with a lot of decisions. The system is designed so that the user faces common and familiar interface and environment. The general goal therefore is: To improve the help options available to users so the novice user can without too much of a struggle find the information they need and start using the system.

Specific concerns were: How well the interface design, menu navigation, shortcuts, tips and the overall system performance are. How well can the user understand the logic behind the system and perform efficiently. The specific goal therefore is: To improve the interface design, menu navigation, shortcuts, tips and the overall system performance.

Ways to measure specific concerns we used were:

- Number of wrong menu choices and selection errors as well as other errors
- Time to complete tasks
- Time to recover from errors
- Time to learn
- Rate of errors and
- Subjective satisfaction.

The overall testing strategy that the project had followed is divided into: One-on-one testing and a group testing using the Co-discovery technique (working together) and active intervention technique (the observer is actively participating and assisting).

We had 10 participants who have tested the software. Five of them were course administrator users while five learners users. On-on-one testing had included five people from staff, most of them administrative users. The group testing has been performed on one group consisted of two participants, who were absolute novice learners users while active participation has been used for three other novice learners users.

After the usability test we had collected a great deal of data from the 10 participants we had, were 5 of them were experts while the other 5 novices. In order to handle those data we have used the triangulation
technique from Dumas and Redish (1999), were we look at all data at the same time to see how the different data supports each other.

![Problem List diagram](image)

*Figure 1. (Triangulation technique) Dumas and Redish (1999) p.310*

We tabulated the data for the performance measurements using the next usability attributes: time to learn, speed of performance, rate of errors, Subjective satisfaction, and Frustration for the both classes of users Experts and novices.

### Table 1. Usability research for Class-1

<table>
<thead>
<tr>
<th>Usability Attribute</th>
<th>Measuring instrument</th>
<th>Value to be measured</th>
<th>Current Level average</th>
<th>Worst acceptable</th>
<th>Planned target level</th>
<th>Best possible</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time to learn</td>
<td>Task Scenario</td>
<td>Time to complete task</td>
<td>18.8 s</td>
<td>30 s</td>
<td>20 s</td>
<td>10 s</td>
</tr>
<tr>
<td>Speed of performance</td>
<td>Task Scenario</td>
<td>Time to complete task</td>
<td>63 s</td>
<td>120 s</td>
<td>90 s</td>
<td>45 s</td>
</tr>
<tr>
<td>Rate of errors</td>
<td>Task Scenario</td>
<td>Number of errors</td>
<td>0.43</td>
<td>2</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Subjective satisfaction</td>
<td>Task Scenario</td>
<td>Satisfaction degree of users</td>
<td>4.03</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
</tbody>
</table>

* number. Subject satisfaction scale: very high 5, high 4, average 3, low 2, very low 1

### Table 2. Usability research for Class-2

<table>
<thead>
<tr>
<th>Usability Attribute</th>
<th>Measuring instrument</th>
<th>Value to be measured</th>
<th>Current Level average</th>
<th>Worst acceptable</th>
<th>Planned target level</th>
<th>Best possible</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time to learn</td>
<td>Task Scenario</td>
<td>Time to complete task</td>
<td>14.8 s</td>
<td>21 s</td>
<td>60 s</td>
<td>8 s</td>
</tr>
<tr>
<td>Speed of performance</td>
<td>Task Scenario</td>
<td>Time to complete task</td>
<td>16 s</td>
<td>25 s</td>
<td>90 s</td>
<td>10 s</td>
</tr>
<tr>
<td>Rate of errors</td>
<td>Task Scenario</td>
<td>Number of errors</td>
<td>0.43</td>
<td>3</td>
<td>2</td>
<td>0</td>
</tr>
</tbody>
</table>
We organized and analyzed the problems appeared from the testing in two dimensions: Scope (how widespread is the problem) and Severity (how critical is the problem).

Based on the problems identified we have changed the appearance of the interface and also provided more information on one page instead of several pages as previously. This will make it more usable according to the usability test and users comments. Generally the system is very much appreciated and well welcomed specially from the novice users. The option to submit different file types by uploading them is most appreciated together with the scrolling announcement section. Almost all the course administrator gave positive remarks and appreciations especially for the ease of use, simplicity-almost flat learning curve and logical interface as well as the speed of content management, adding, storing and changing content. Most of the users from this group have expressed the desire to use the system in the future, and referred to it as very logical and efficient and the entire project as a wonderful idea. Also from the learner users is appreciated the accessibility of content its logical appearance and simplicity. We also used the general principles and guidelines for HCI regarding the software design from Pressman (2005), and general principles and guidelines for document design and guidelines for online documentation Dumas and Redish (1999). All this guidelines were closely advised and reviewed when designing the Intranet Gateway system.

4 Conclusion

In order to answer the question what makes a successful e-learning we took the approach with e-learning indicators. We have proposed, assessed measured and evaluated the e-learning indicators that we think communicate the information about the level of e-learning and their impact on learning as such that could be measured and described then in simpler terms.

Using this kind of approach we have concluded that in order to have a successful e-learning no longer the general criteria or the same guidelines for all learners can be applied but individual learning services are needed that support learners according to their subjective preference profile.

The research study is following the e-learning trends needs and tries to address the issues and deficiencies from the findings realized in the secondary research.

The research study makes several contributions. First, it proposes an E-learning indicators methodology approach when undertaking any e-learning initiative. In order to define and analyze what makes successful e-learning, e-learning factors that substantially influence learning must be assessed, measured and evaluated. The purpose of this is to raise the awareness of the factors influencing e-learning in order to enhance learning and identify the nature of obstacles that will be faced by e-learners. We propose this methodology approach in developing any e-learning initiative. Because there are to many factors, personalization’s and specifics related to each situation and circumstances we consider that would be wrong offering one size solution for all.

Therefore we propose to asses and improve the overall e-learning quality and dissemination of knowledge for each e-learning initiative and particular situation by defining and measuring e-learning indicators for the specific circumstances, specifics and technology solutions. Then based on the results of the measured and evaluated e-learning indicators to develop sustainable e-learning initiative.

Secondly, the study proposes an e-learning indicators-(ELI) development model to be used for developing e-learning software solutions by concentrating on previously assessed e-learning indicators. The research is conveying the need for close correlation of software development and e-learning indicators. The research is proposing a new way of tackling the process of creation of e-learning solutions as interactive environments by integrating and undertaking the software engineering approach based on e-learning.
indicators. We recommend that technology should adapt to theories of learning and e-learning indicators we have assessed earlier. The proposed ELI process modelling based on e-learning indicators should be used as guidelines in development of e-learning software solutions.

Thirdly, the study proposes an ELUAT (E-Learning Usability attributes Testing) methodology for assessing e-learning effectiveness through the PET (Predefined evaluation Tasks) inspection technique. Fourthly, the study proposes PTPMELUAT methodology approach when designing and evaluating e-content and attention indicators, in order to assess the correlation between the e-content and attention defined as the most influencing e-learning indicators. This methodology is combining different types of testing: Psychometric tests, Psycho physiological measuring, and ELUAT through PET testing.

5 References