E-Learning metrics

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Abstract

This paper presents some aspects on E-Learning metrics in order to improve the evaluation of the capability and maturity in E-Learning. Starting with quality assurance for E-Learning items, the article reviews the E-Learning Capability and Maturity models and proposes a fuzzy logic based method to estimate the level of capability and maturity.

Keywords: capability and maturity models, metrics, e-learning, fuzzy logic

1 Introduction

Quality in the field of E-Learning is already an important issue both in theory and practice. This paper considers the E-Learning paradigm and presents some aspects related to quality evaluation in the framework of the e-Learning Capability Maturity Model. There are some level of capability & maturity depending on the entity involved: SEI CMMI – software development (adapted for E-Learning), OCDMM – for online course design, ECM² – for global e-learning development (people, technology an processes), EMM – covering only E-Learning maturity, and E-CMM – a variant of SEI CMMI for quality improvement in higher education. Such approaches can be used during the implementation of the quality standard ISO/IEC 19796-1 for an E-learning organisation. The mentioned models were developed by (SEI, CMMI-2007) and (Albeanu & Popentiu-Vlădicescu, 2005), (Neuhauser, 2004), (Manford & McSporan, 2003), (Marshall & Mitchell, 2007), and (Baig et al, 2007) respectively.

The second section addresses the basic terminology and the main capability and maturity models for E-Learning. The third section describes a method based on fuzzy logic to establish a capability and maturity model starting with a questionnaire established for e-Learning practices, based on a capability-maturity model. Finally, some conclusions are presented.

2 E-Learning Terms and Capability-Maturity Models

Considering the study of (Anohina, 2005) and the references to be mentioned, in the following, the basic terminology related to the “Virtual Learning” has to be well understood when dealing with the assessment of capability and maturity for E-Learning.

“Computer based learning” can be used when the computer is not connected to a network, but materials are local according to (Admiraal, 2003) and (Ioniţă, 2006). Computer-based learning is not a subset of online learning, as we shall explain bellow. “Web-based learning” uses the HTTP protocol (Angelini et al, 2005), while “Internet-based learning” can use any IP-based protocol and is broader than web-based learning (Albeanu, 2007). The “Online learning” is based on networking (any kind of computer network). Internet-based learning is only a subset of online learning. The following technologies are addressed in online learning: text e-books, e-mail, forum, chat, interactive quiz tools, power-point slides, web-pages, audio and video materials, telephone (VoIP or classic), voice mail, instant messaging, video conference etc. More information and consideration can be found in (Gâf-Deac, 2001), (Pauls, 2003), (Ioniţă, 2006) and (Wright, 2006).

“E-learning” is a synonym for electronic learning (not only network-based or non-network-based) requiring an improved “e-Competence” according to (Admiraal, 2003), (Angelini et al, 2005), (Attwel,
2003), (Carabaneanu et al, 2006), Mac Labhrainn et al, 2006) and (Ehlers, 2007). “Distance learning” covers both electronic and non-electronic based learning (for instance, the ordinary mail). More details can be found in (Gåf-Deac, 2001). The “Technology-based learning” is delivered via any technology, and contains also the distance learning (including TV, Radio etc), according also to (McBride & McMullen, 1996), (David & Lourdeaux, 1998), (Gåf-Deac, 2001) and (Admiraal, 2003). The “Resource-based learning” is a general form of learning, using all necessary resources suitable for active learners. This type of learning has to be based on knowledge society advancement and resource-competence, according to (Albeanu, 2007). The “Collaborative learning” is a groupware paradigm using the following tools: forum, textual chat, file sharing, audio communication, screen sharing, integrated e-mail, instant messages, polling, group calendar, video communication, whiteboard, workspace awareness, application sharing, floor sharing, version control, collaborative browsing, virtual hand raising, voice chat, collaborative viewing, synchronization of content etc., as (Albeanu, 2007) mentioned. The “Distributed learning” is the resource-based learning with distributed resources (hardware, software and databases), according to (Albeanu, 2007). The term “Virtual Learning Environment” describes an integrated set of online tools, databases and managed resources used in education, not necessary using Virtual Reality Resources. However, a common view on virtual learning environments refers to on-line domains allowing both synchronous (chat, conference, etc) and asynchronous (e-mail, forum, file transfer etc.) collaborative interaction among teachers and learners, according to (Dillenbourg, 2000), Barajas et al, 2002), (McKeller & Manarg, 2005) and (Andreatos, 2006). The “Immersive Learning Environments” are based on Virtual Reality Resources supporting immersion (virtual room, CAVE, virtual worlds, etc) as (Fuks & Assis, 2001), (Albeanu, 2007) and (LightFeather, 2007) considered. The “Virtual communities” are groups of real or virtual entities sharing the same interests, values, jargon, leaders, titles, ways of communicating and exchanging information and knowledge, according to Andreatos (2006). A special case of virtual community is based on Internet interaction. However, other virtual communities are active in real world or and virtual worlds as (Allen et al, 2003) and (Andreatos, 2006) mentioned.

The reciprocal events that require at least two entities and two activities (actions during interaction) are called “Interactions”. Interaction is completely different from interactivity, which address only the interaction between user and technology. As interactions, we mention the following: learner-instructor, learner-learner, learner-content, learner-self instructions, and learner-interface. When deal with Person-Centred E-Learning the trainer should address: the learner’s intellect, his/her social skills, and personality, according to (Motschnig-Pitrik & Nykl, 2003).

The above considerations shows why “Virtual learning” is a subset of technology-based learning using Virtual Reality Technologies or and Virtual Environments, which is a consistent approach when referring to (Fuchs & Moreau, 2006): “Virtual Reality is a scientific and technical field using computer science and behaviour interfaces to simulate in a virtual world the real time behaviour of the 3D entities interacting among them and with users having been in a pseudo-natural immersion by specific communication channels”.

Quality in the field of E-Learning is already an important issue both in theory and practice. The Quality Standard ISO/IEC 19796-1 is the basic framework for quality development in organizations in the field of learning, education, and training, consisting of a description model and a process model. The ‘Description Model’ describes quality approaches (such as guidelines, design guides, requirements) and documents all quality concepts, while the ‘Process Model’ is a guide through the different processes when developing learning scenarios, as (Strache, 2007) revealed. The ‘Process Model’ is divided in seven parts: NA – Needs Analysis, FA – Framework Analysis, CD – Conception/Design, DP – Development/Production, IM – Implementation, LP – Learning Process, and EO – Evaluation / Optimisation. Every part is detailed in sub-processes. When applying a quality assessment plan, the researcher can obtain valuable information concerning the student expectations, like: professional or career enhancement, flexibility, technology innovation, applicable content, active participation, responses-feedback, affective feedback, focused messaging. Also, when dealing with virtual learning, any organization, trainer (instructor) or learner has to consider the following items: Context Standards (learning communities, leadership and resources), Process
Standards (planning online learning goals, professional evaluation, impact evaluation, design, learning, and collaboration), and Content Standards (equity and quality), as (Albeanu, 2007) mentioned.

Maturity models were used long time ago as (Manford & McSporran, 2003) already stated. Recently, an important model for software organisations was developed and applied for rating and improving the capability and maturity of such companies. (Albeanu et al, 2005) considered the usage of CMM (SEI, 2007) in the framework of a Total Quality Management approach when deal with software. Such an approach can be easily extended for companies working for E-Learning platforms or E-content development, as some researchers already proved depending on the addressed target: (Manford & McSporran, 2003), (Neushauser, 2004), (Baig et al, 2006) and (Marshall & Mitchel, 2007). Other assessment models are already available: (Hutter et al, 2004), (Barchino et al, 2006) and (ARACIS, 2007).

Maturity models, according to (Manford & McSporran, 2003), are based on the following aspects:

- **The metrics (measurement)** – which metrics can be used and how long did this task take? How much is the cost of such a development? For E-Learning software development the metrics are reviewed by (Albeanu, 2002). For E-Content provided by an E-Learning System, some metrics for text readability and understanding will be used, together with the requirement for interactivity. Other important attributes are: correctness, accuracy, precision, consistency and usability. An E-learning maturity index can be established based on the history of E-Learning items.

- **The maturity hierarchy** – consisting in a number of levels or stages showing the performance in particular organisational processes and providing useful information for improving capability. For E-Content development there are also stages of maturity a capability, but this not an easy task, as (Neuhauser, 2004) stated. Considering a five-stage hierarchy, OCDMM-developed by (Neuhauser, 2004) consists of the following levels: Initial, Exploring, Awakening, Strategizing and Integrating Best Practices. For every level, there are five key process areas: components and appearance (KPA1), individualized and personal (KPA2), use of technology (KPA3), socialization and interactivity (KPA4), and assessment (KPA5).

- **Proceeding to the next level is important because the processes that are better defined can lead to better products/services.**

The e-Learning Capability Maturity Model (ECM²), developed by (Manford & McSporran, 2003), comprises five levels as the software CMM approach provided by SEI. For every level some key performance areas (KPAs) are identified. These KPAs fall into three categories: people, processes and technology. The first level – called initial – represents the immaturity. Success of such a company depends on the abilities, efforts and organization of individuals. It is an ‘ad hoc’ style for product development. The second level – called independent – claims about the existence of some system for the management of e-learning projects, but each project operates independent from others possible with a large bias. The main advantage is the possibility of data collection from projects to be used as a basis for estimation and planning of future projects. The third level – called shared – guarantees the sharing of expertise between areas. The processes are well defined. The main characteristic of the fourth level – called organised – is that systems and procedures (related to staff, learner, trainer, project management) are available as organisation-wide and the products will be of predictable high quality. The last level – called learning – claims that the organisation has the necessary data to analyse failures during product development and deployment and perform cost benefit analysis on new technologies and evaluate new methods. This will be a guarantee for the success of the new projects and the all processes are considered as ordinary business activities. Compared against the Software CMMI the naming convention is changed to reflect more the field under consideration.

EMM can be used by organizations to “assess and compare their capability to develop, deploy and support e-learning”, according to (Marshall & Mitchell, 2007). The mentioned authors identify five dimensions of capability: delivery, planning, definition, management, and optimisation. Also five KPAs were proposed: learning, development, support, evaluation, and organisation. As we can see, this model is different from ECM², but all these models are hierarchical (usually five levels or dimensions) and measure a number of KPAs based on a maturity and capability questionnaire.
The maturity model for online course design, proposed by (Neuhauser, 2004), "may serve as a tool in planning and assessing" the courses provided by some organisation and improving their quality according to best practices and the state of the art in the field.

The next section will present a model to establish the degree of membership to a capability/maturity level for an organisation involved in e-Learning.

### 2 A Method to Establish the Maturity Level

Based on our previous experience in the assessment of capability and maturity of a research team, we found that three approaches can be used to establish the maturity level. The first one is deterministic. An 80% fulfillment of the requirements of previously and current level is necessary. The second one deals with subjective probabilities, as described in (Albeanu et al, 2005). In the following we present the third approach based on fuzzy techniques: fuzzy logic/membership degrees.

Firstly, one establishes for every item an indicator in the interval [0, 1]. This indicator can be interpreted as a partially truth (fuzzy logic) or a membership degree (MD – fuzzy set theory). Of course, when the degrees are binary values, the deterministic or probabilistic approaches can be used.

The other approach uses appropriate linguistic variables to describe the degree of satisfiability of every request in maturity questionnaire. For example, the second item in assessing the KPA, namely "Are learners engaged through multiple opportunities for input?" can be interpreted quantitatively: "How many learners are engaged through multiple opportunities for input?" with answers like: **ALL** (MD = 1), **almost ALL** (MD = 0.8), **More than HALF** (MD = 0.6), **almost HALF** (MD = 0.4), **Few** (MD = 0.1). When linguistic variables are used, a membership degree computing is necessary.

The main idea, in a fuzzy inference process, is to use a T-norm (triangular norm) for computing the membership degree, step by step. A T-norm is any function $T : [0,1] \rightarrow [0, 1]$, that satisfies the following four conditions:

- **Boundary conditions**: $T(0, 0) = 0$, $T(x, 1) = x$;
- **Commutativity**: $T(x, y) = T(y, x)$;
- **Monotonicity**: If $x < u$ and $y < v$ then $T(x, y) < T(u, v)$ and
- **Associativity**: $T(T(x, y), z) = T(x, T(y, z))$.

A T-norm may be used to define the fuzzy and of two fuzzy values, where $(x \text{ and } y) = T(x, y)$.

The best approach is to compute the membership degree at KPA level, then use the KPA results to obtain membership degree considering only KPAs at some level. Let us denote the membership degree for the KPA key process area by D_i. The indicator D_i is obtained using the responses at corresponding items using a T-norm operator. In the next step, we compute the following indicators, for OCDMM:

$K_2 = T(D_{21}, D_{22}, D_{23}, D_{24}, D_{25})$,

$K_3 = T(D_{31}, D_{32}, D_{33}, D_{34}, D_{35})$,

$K_4 = T(D_{41}, D_{42}, D_{43}, D_{44}, D_{45})$ and

$K_5 = T(D_{51}, D_{52}, D_{53}, D_{54}, D_{55})$.

At this stage we can process hierarchically the indicators $K_i$ ($i = 2, 3, 4, \text{ and } 5$) in order to obtain the membership degrees corresponding to the capability and maturity levels: $L_2 = K_2$, $L_3 = T(L_2, K_3)$, $L_4 = T(L_3, K_4)$ and $L_5 = T(L_4, K_5)$. Of course, $L_1 = 1$.

A large variety of T-norms are available in literature. However, for our purpose we found that the min operator ($((x, y) \rightarrow \text{ min } (x, y))$ is more appropriate. Other operators like: the algebraic product ($((x, y) \rightarrow xy)$), the bounded product ($((x, y) \rightarrow \max (0, x+y-1))$, the Einstein product ($((x, y) \rightarrow xy/(2-x-y+xy))$) and the Hamacher product ($((x, y) \rightarrow xy/(x+y-xy))$) are more pessimistic.

Considering our experience during Content development for e-Learning, and applying a questionnaire inspired from (Neuhauser, 2004), we found that our membership degree belonging to the second level is 0.7 and also the membership degree to the third level, is 0.6. These results confirm also the investigations based on deterministic and probabilistic approaches.

The concluding remarks and the section of references will close the present investigation.
3 Concluding Remarks
During the previous sections we presented some aspects on E-Learning assessment models in order to improve the evaluation of the capability and maturity in E-Learning. Starting with quality assurance for E-Learning items, the article reviewed some of the E-Learning Capability and Maturity models and described a fuzzy logic based method to estimate the level of capability and maturity. The Questionnaire grew up step by step to cover a large variety of aspects, but the assessment method can be used without restrictions concerning the number of questions. We appreciate that further investigation will be necessary in future, at least when we refer to the assessment of capability and maturity of the Romanian entities providing Distance Learning educational programs.

4 References


