Quantitative Evaluation Framework of Educational Software

Paula Escudeiro[1], José Bidarra[2]

[1]Departamento de Engenharia Informática, Instituto Superior de Engenharia do Porto, Rua Dr António Bernardino de Almeida, 431, 4200-072 Porto, Portugal
Tel. +351.22.834 05 00 Fax +351.22.832 11 59
pmo@isep.ipp.pt; paula@dei.isep.ipp.pt

[2]Departamento de Ciências Exactas e Tecnologia, Universidade Aberta, Rua Escola Politécnica, 147, 1269-147 Lisboa, Portugal
bidarra@univ-ab.pt

Abstract*: In this paper we propose a Quantitative Evaluation Framework used to evaluate educational software systems built with X-TEC (Techno-Didactical Extension for Instruction/Learning Based on Computer) model, in order to validate and strengthen the potential quality of e-Learning systems.*

The Quantitative Evaluation Framework and the Techno-Didactical Extension for Instruction/Learning Based on Computer model are based on the paradigms of software engineering applied to the construction of educational software.

The Quantitative Evaluation Framework evaluates the Educational software quality on a three dimensional space. Each dimension aggregates a set of factors. A given factor is a component that represents the system performance from a particular point of view.

The quality of a given system is defined in a tri-dimensional Cartesian quality space and measured, in percentage, relatively to a hypothetically ideal system, represented in our quality space.

This Quantitative Evaluation Framework may also be applied to evaluate other educational software allowing for a comparison between different tools.

This orientation is very important due to the high quality demand placed upon educational systems.

Introduction

Despite the theoretical benefits that e-learning systems can offer, difficulties can often occur when systems are designed without consideration of learner's characteristics (Fredman and Liu, 1996; Liang and McQueen, 1999).

In general, educational software systems are based on methodological approaches which are fundamentally concerned with processes or data.

The gap between the typical skills and terminologies of these two stages usually leads to a problem: the final product is far away from the initial requirements proposed by the author. Consequently, these approaches usually imply the high risk of obtaining low quality products. The X-TEC model tries to solve this problem (Escudeiro Paula and Bidarra José, 2006)

To evaluate the educational software systems based on X_TEC model we propose a generic Quantitative Evaluation Framework (QEF). This framework may also be applied to evaluate other Educational Software Development Models (ESDM), allowing for a direct comparison between different tools.

Quantitative Evaluation Framework

Educational software quality is evaluated on a three dimensional space.

A dimension aggregates a set of factors. A factor is a component that represents the system performance from a particular point of view.

The dimensions of our Cartesian quality space are: Functionality (F); Efficiency (E) and Adaptability (A), represented in fig 1.

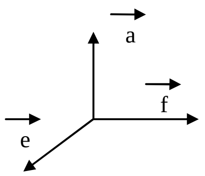


Fig 1: Cartesian quality space

For the evaluation of educational software systems based on the X_TEC model we propose a generic quantitative evaluation framework. This framework may also be applied to evaluate other Educational Software Development Models (ESDM), allowing for a direct comparison between distinct tools.

The quality q, of a given system is defined in our tri-dimensional Cartesian quality space, Q, and measured, in percentage, relatively to a hypothetically ideal system, I, represented

in our quality space by the coordinates (1, 1, 1).

Quality dimensions

The quality space, *Q*, aggregates, in the dimensions – *Functionality; Efficiency and Adaptability* – a set of factors that measure the relevant characteristics of an ESDM.

The *Functionality* dimension reflects the characteristics of the educational software related to its operational aspects. It aggregates four factors: feasibility, inviolability, easy of use and integrity

The *Efficiency* dimension aggregates four factors: data structure, programming structure, learning objects, imperfections recovery.

Through this dimension we measure the system's ability for presenting different views on the course content with minimum effort.

The *Adaptability* dimension is the aggregation of five factors: flexibility modularity, reusability, scalability and maintainability. Through them we can measure to what extend the scenario and course content are efficacious – whether they are focused and able to present different instructional design theories and different learning environment in a common platform.

The quality for a given system coordinates may be obtained through the application of one of several aggregation forms. We will compute these coordinates as the average of the factors that contribute to it; the average is simple and gives the same relevance to all factors. Quality dimensions are based on the following factors:

Functionality (*F*)

- Feasibility (Y)
- Easy of use (O)
- Integrity (I)
- Inviolability (T)

Efficiency (*E*)

- Data Structure (D)
- Programming Structure (U)
- Learning Objects (L)
- Imperfections recovery (I)

Adaptability (*A*)

- Flexibility (B)
- Modularity (M)
- Reusability (R)
- Scalability (S)
- Maintainability (N)

For each system being developed we will have to identify the importance of each factor to the dimension. The dimension coordinate is them computed as the weighted mean of these factors:

Dimension $_i$ = $\sum_n (p_n \times factor_n)$, $\sum_n (p_n) = 1$ and $p_n \in [0,1]$

Where:

n is the number of relevant factors for the dimension.

Each factor is evaluated by:

Factor $_n$ = $\frac{1}{\sum_m pr_m} \times \sum_m (pr_m \times pc_m)$

Where:

M is the number of valid requirements for the factor.

pr $_m$ is the weight of the requirement m

pc $_m$ is the fulfillment percentage of the requirement m.

The dissimilarity between the system under evaluation and ideal system is measured by:

D = $\sqrt{\sum_j \left(1 - \frac{Dim_j}{100}\right)^2}$

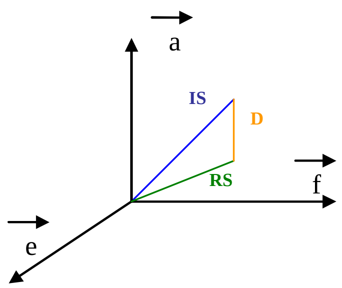
Finally the quality of the system is computed as:

Q = $1 - \frac{D}{\sqrt{n}}$, Q $\in [0,1]$

or

$$q = \left(1 - \frac{D}{\sqrt{n}}\right) * 100,\ q \in [0{,}100]$$

The quality of a system is measured as the distance between the ideal system (projected system) and the real system (final system).



The system quality is in the inverse proportion of the distance between the Ideal System (IS) and the Real System (RS).

If D=0 Then Q=1

If D=maxim, $D_{max} = \sqrt{n}$ Then Q=0

The measure of the system quality is obtained from a six steps process:

1st – Requirement classification

2nd – Factor classification

3rd – Result evaluation

4th – Dimension performance

5th – Global deviation

6th – System quality

1- Requirement Classification

The ideal system has a set of requirements that indicates what the system must do.

We start by associating weights to requirements, [0,1] based on the relevance of the requirement for that particular dimension, according to:

10 – Fundamental

8 – Very Important

6 – Important

4 – Necessary

2 – Optional

0 – Irrelevant

Dimension

Requirements	Functionality	Efficiency	Adaptability
	Pr n	Pr n	Pr n
	Pr n	Pr n	Pr n
	SUM()	SUM()	SUM()

Fig 1: matrix of the dimension requirements

2- Factor Classification

Each factor contributes to the dimension value. This contribution is represented by a real number, P_n, between 0 and 1, indicating the relevance of the factor to the dimension. The dimension value is a weighted mean the factor that contributes to that dimension

Dimension = $\sum_n (p_n \times factor), \quad \sum_n (p_n) = 1$ and $p_n \in [0,1]$

3- Result Evaluation

It is very important to validate the requirements, so that system performance can be accurately evaluated.

The matrix in fig 2 shall be fulfilled during the evaluation process. Once it is completed the system quality is automatically computed.

Dimension

Requirements	Factors		
	Pcm	Pcm	Pcm
	Pcm	Pcm	Pcm

Fig 2: matrix of the factors

4- Dimension Performance

The performance of a dimension is obtained through, the factors of each dimension.

Factor = $\sum_m (pr_m * pc_m)$

And the dimension performance is given by:

Dimension = $\sum_n (p_n \times factor), \quad \sum_n (p_n) = 1$ and $p_n \in [0,1]$

5- Global Deviation

The global deviation is obtained as the Euclidean distance between our system coordinates and the ideal system, whose coordinates are (1,1,1)

$$D = \sqrt{\sum_{j}\left(1-\frac{Dimj}{100}\right)^{2}}$$

Global deviation

6- System Quality

The system quality is computed by:

$$Q = 1 - \frac{D}{\sqrt{n}}, \quad Q \in [0,1]$$

$$q = \left(1-\frac{D}{\sqrt{n}}\right) * 100 \quad q \in [0,100]$$

System Quality

We say that system quality is q% which means that the system is able to perform q% of its initial specifications.

Conclusions

In this work we propose a method to measure quantitatively the quality of a given educational system.
Quality evaluation frameworks, like the one we propose here, are crucial to help validating educational systems and ensure that they are adequate and follow the original specifications, before using them in the learning environment.

We are already applying X_TEC, for the development of educational software systems with our students, and using the quality evaluation framework to evaluate them. Our purpose is to realize the ability and applicability of our quantitative evaluation framework in real world solutions.

The QEF may also be applied to evaluate other Educational Software Development Models (ESDM), allowing for a direct comparison between different tools.

References

Allesi, S. e Trollip (1985)	S. Computer Based Instruction: Methods and Development, Prentice Hall, Inc. Englewood Cliffs, New Jersey, USA, 1985
Bates Tony, (2000)	A. W. Tony Managing Technological Change: Strategies for College and University Leaders. San Francisco, 2000
Bloom Bertram B. Mesia, and David R. Krathwohl, (1964)	Bloom B. S. Taxonomy of Educational Objectives,: The Affective Domain & The Cognitive Domain. New York: David McKay Co Inc.
Booch, (1994).	G. Booch, Object Oriented Analysis and Design With Applications, Second Edition, Benjamin/Cummings, Menlo Park, Califórnia, 1994.
Clark 1994, Gery, (1994)	Gery, GJ Making CBT happen. Boston: Weingarten.

	Clark, RE Media will never influence learning. Educational Technology Research and Development
Coad and Yordon, (1991)	P. Coad and E. Yourdon, OOA –Object Oriented Analysis, 2nd Edition, Prentice Hall, Englewood Cliffs, New Jersey, 1991
Crossley, K. e Green (1990)	Le Design des Didacticiels: Guide Pratique pour la Conception de Scénarios Pédagigiques Interactifs. ACL-Editions, Paris France 1990
Eckerson (1995)	Eckerson, Wayne W. "Three Tier Client/Server Architecture: Achieving Scalability, Performance, and Efficiency in Client Server Applications." *Open Information Systems 10,* 1 (January 1995): 3(20).
Escudeiro, Paula; Bidarra José, (2006)	X-TEC: Techno Didactical Extension for Instruction/Learning Based on Computer, Orlando, Florida, SITE 2006
Gagné, (1996)	Gagné, Robert M. and Medsker, Karen L. (1996). *The Conditions of Learning Training Applications.* Florida: Harcourt Brace & Company.
Jacobson, (1992)	Jacobson, Object Oriented Systems Engineering, Addison-Wesley, 1992.
Keller/Back (2004)	Keller, M.; Back, A.: Blended-Learning-Projekte im Unternehmen, Learning Center der Universität St. Gallen, St. Gallen, 2004
Merrill, (1981)	Merrill, M.D., Kowallis, T., & Wilson, B.G. Instructional design in transition. In F. Farley & N. Gordon (Eds.), Psychology and education: The state of union
Minken, I., Stenseth, B. E Vavik L., (1998)	Educational Software. ULTIMA-Gruppen A/S, Haden, Norway, 1998
Pressman Roger S., (2001)	Pressman, Roger S. Software Engineering a Practitioner's Approach, 5 th Edition, McGraw-Hill Companies Inc, 2001
Purinima Valiathan, (2005)	ASTD-Linking People, Learning & Performance. Learning circuits- American Society for Training & Development
Rumbaugh et al, (1991)	J. Rumbaugh, M. Blaha, W. Premerlani, F. Eddy, and W. Lorensen, *Object Oriented Modeling and Design,* Prentice Hall, Englewood Cliffs, New Jersey, 1991.
Yourdon, (1998)	E. Yourdon, *Managing the System Life Cycle*, 2nd Edition, Yourdon Press/prentice Hall, Englewood Cliffs, New Jersey, 1998.