Multidisciplinarity in Knowledge Transmision Management System (KTMS) evaluation.

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Abstract: Translational pluridisciplinary education has become a strong academic challenge in this century. The internet has proved its potential for creating online learning environments to support education. The development of the web based knowledge transmission management system (KTMS) faces many shortcoming, including lack of pedagogical consideration in the design of web-based learning Systems, lack of interoperability and shareable learning objects, and lack of interdisciplinary integration. These shortcomings are not easy to identify by common end users. Decision makers need formal indicators to guide their choice. This paper aim to provide a flexible criteria set for KTMS evaluation involving multidisciplinarity, sharability and collaborativity.

Keywords: knowledge, learning object, learning object repositories, evaluation criteria, education, multidisciplinary.

1. Introduction

Personalized e-commerce improves customer-relationship management (CRM) to provide better service by anticipating customer needs even if data are from different data source. This is because customer satisfaction is the most important focus in CRM systems design. Education aims is ensure that tools improve students' learning process. A Knowledge Transmision Management System (KTMS) is define to be a web portal or tool that provides resources for learning, teaching, training, or helping with executing work/problems. It can be a learning object repository (LOR), learning management system (LMS), courses management system (CMS), virtual learning environment (VLE), computer based training (CBT) portal or a simple website. Any Knowledge Transmission Management System (KTMS) must enable users to personalize their learning in order to adapt to changing business needs (career profile). These requirements expose many weaknesses of KTMS: interoperability, share ability, industry guidance for manageable system design, and pedagogical consideration in the design of web-based learning systems and multidisciplinary management [1]. Among other things, the transversality of certain disciplines such as bioinformatics does not facilitate the construction of a linear training profile, based on a set of pre-requisites of formal education discipline [2]. This feature is a weakness because it contradicts the need for specialization training and the increasing need for crossing disciplines (interdisciplinarity, pluridisciplinarity). But it may prove to be a strength in the construction of a flexible profile, including adaptability to a particular career profile.

We are witnessing a growing development of tools for managing the transmission of knowledge using computer engineering, called *computer-based teaching education* (CBTE). Users need to choose an appropriate tool; and to be able to evaluate the quality of the results obtained from using that tool. The existing evaluation criteria for KTMS tools are based on the specific needs of particular users or owners of these tools [3] [4] [5]. In addition, these criteria do not take into account the multidisciplinarity aspects of the new generation of academic disciplines (Bioinformatics, sociolinguistics, pharmacogenomics, nanotechnology, genetic toxicology, etc.) [6]. We propose new criteria to expand these KTMS evaluation criteria. Our approach is based on the use of communication evaluation tools and exigencies that relate to multidisciplinary.

2. Multidisciplinarity criteria for LORs evaluation

To make a decision as to the usefulness of a tool for managing the transmission of knowledge (KTMS), many objective and functional criteria are necessary. Our proposed criteria provide a 5 axis feature to measure a given KMS: pedagogy (P), technical (T), communication (C), interdisciplinarity (I), and other criteria related to the specific user context (O). Each criterion overall (P, T, C, I, O) can be detailed to refine the evaluation in a given axis, as with the technical criterion T (Figure 1).

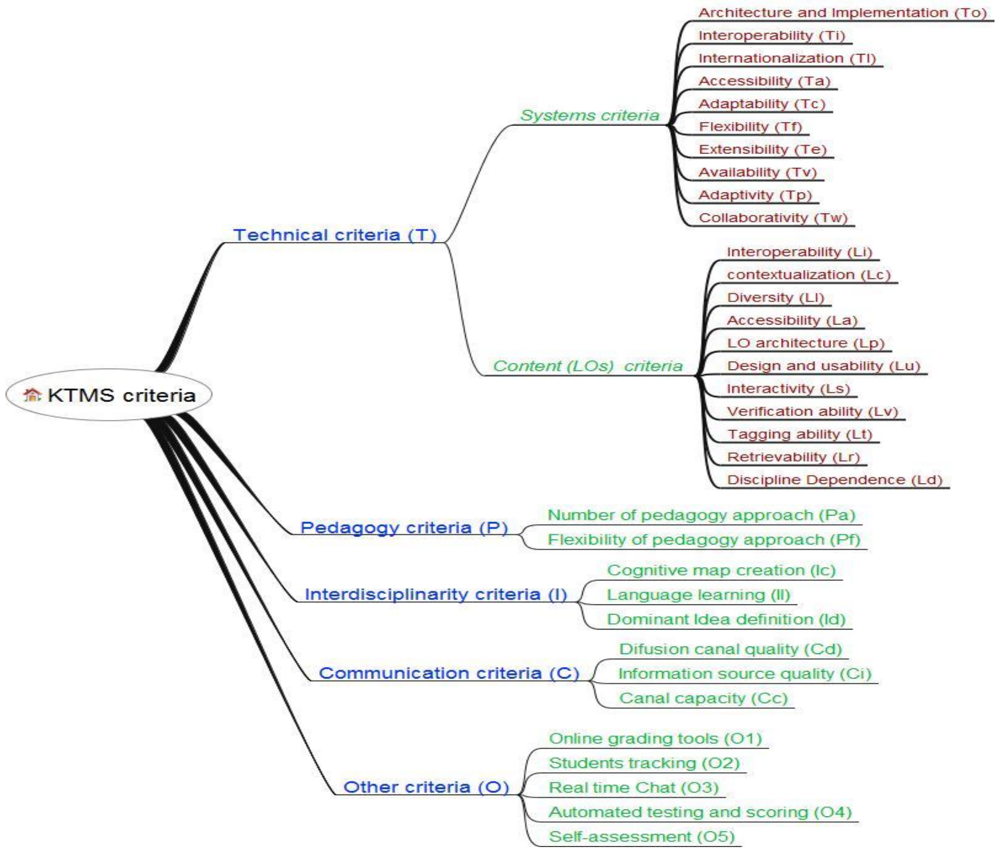

Figure 1: Overview concept map summarizing our multi-criteria set (5 global criteria and 34 detail criteria).

2.1. Pedagogy based criteria (P)

The evolution of pedagogical requirements of education, and the particularity of bioinformatics necessitates an adaptation of evaluation parameters in pedagogy [7][8]. We propose two criteria for KTMS pedagogy evaluation: the number of pedagogical approaches (Pa), and the flexibility of these approaches in the KTMS (Pf).

- **Number of pedagogical approaches (Pa).**

There are no standards in terms of pedagogical approach [9], but a few commonly used approaches are: competence-based teacher education (CBTE), humanistic-based teacher education (HBTE), problem based, team based, academic tradition, social efficiency tradition, developmentalist tradition, social reconstructionist tradition, writing for learn, etc. For efficiency (efficacy with optimal resources), knowledge transmission systems should allow the possibility to choose and combine several training pedagogical approaches. Pa describes the number of pedagogical approaches that can be used in the tool. Formally, we have:

$$Pa = [1...k] \qquad \text{(Eq.1)}$$

Where k is the maximum number of pedagogical approaches in the system.

- **Flexibility of the pedagogy approach (Pf)**

To use a single educational approach to efficiently transmit multi-disciplinary knowledge is difficult. An ability to change pedagogical approaches is important in a good KTMS. Pf criterion depends on the number of pedagogical approaches (Pa) described previously. Pf measure the ability of the KTMS, to use several pedagogical approaches simultaneously.

2.2. System and Content Technical criteria (T)

Content (Learning Objects, LOs) of KTMS (LORs, LMS, CMS, VLEs) do not yet possess international standards. [5] proposes a set of criteria by federation of seven main characteristics of (LOs). This criterion set can follow LOs in its life cycle (before, during and after, including in KTMS). These criteria cannot allow understanding of the multidisciplinary aspect of LO and KTMS. We propose two additional criteria to improve these limits: Ld (dependence between two or more disciplines for each given LOs), and Tc (collaborativity in the KTMS as ability to integrate collaboration, networking, sharing). We have 11 criteria for describing LOs (Table 1 grey background) and 10 criteria for KTMS design (Table 1 white background).

Table 1: BKTMS and content evaluation criteria description.
Table 1 shows the criteria for KTMS (LMS, LOR, VLE, etc) in grey background and their content (LOs) in white background, with collaborative and discipline dependence criteria Ld.

Criteria	Description	Code
Interoperability	Metadata accuracy, Compliance with the main import/export standards (IMS, SCORM, LOM, IMS).	**Li**
Contextualization	Is LO indivisible (atomic)? LO aggregation (granularity) level, Is LO modular? Does LO have a strong visual element?	**Lc**
Diversity / Internationalization	Is LO flexible (can be modified)? LO suitability for localisation LO internationalisation level, language.	**Ll**
Accessibility	Is LO designed for all? Compliance with accessibility standards (W3C).	**La**
LO architecture	Is LO architecture layered in order to separate data, presentation and application logics?	**Lp**
Design and usability	Aesthetics, Navigation, User-friendly interface, Information structuration, Personalization.	**Lu**
Interactivity	Member’s contribution strategies.	**Ls**
Verification ability	Automatic verification of capability with known protocols.	**Lv**
Tagging ability	Automatic metadata generation or simplified metadata tagging.	**Lt**
Retrievability	User should be able to retrieve LO in different ways.	**Lr**
Discipline dependence	LO should depend on more than one discipline.	**Ld**
Overall architecture and implementation	Scalability,Modularity (of the architecture), Possibility of multiple installations on a single platform, Reasonable performance optimisations, Look and feel is configurable, Security, Modular authentication, Robustness and stability, Installation, dependencies and portability.	**To**
Interoperability	Integration is straightforward, VLE standard support.	**Ti**
Internationalization and localization	Localisable user interface, Localisation to relevant languages, Unicode text editing and storage, Time zones and date localization, Alternative language support.	**Tl**
Accessibility	Text only navigation support, Scalable fonts and graphics.	**Ta**
Adaptability	Facilities to customise for the educational institution’s needs.	**Tc**
Flexibility	Personalisation aspects (facilities of each individual user to his/her own view of the platform).	**Tf**
Extensibility	Good programming style, Availability of a documented API.	**Te**
Availability	On licence, partialy open or open.	**Tv**
Adaptivity	all kinds of automatic adaptation to the individual user’s needs, Personal annotations of LOs, Automatically adapted content.	**Tp**
Collaborativity	Ability to integrate collaborative work, networking, sharing.	**Tw**

- **Discipline dependency (Ld).**

This criterion measures the ability of each LO to interact with other disciplines, and especially different disciplines. As in all pluridisciplinary domains, the multidisciplinary course content depends on the specialty of the person who builds it. Thus bioinformatics courses vary as a function of the professor's specialty (biologist or computational scientist) [10]. Pevzner proposes a bioinformatics course characterization approach using game theory, the goal (success) being to find the best strategy for a bioinformatics problem solution. Starting from their own background (biology or computer science), users take supplemental courses (computer science or biology) to enhance skills. This perception helps us to define the dependency discipline criterion in KTMS. This ability can be "high (3), medium (2) or low (1)". We have:

$$Ld = [1\ 2\ 3] \quad \text{(Eq.2)}$$

Formal explanation of the Ld criterion:

Let P be a pluridisciplinary problem (with n disciplines d1 .. dn), where obtaining the solution S requires the skills set Sk1, Sk2, Sk3.

Assume that, for a given skill Ski, a user may have Low level (L or 1), Medium (M or 2), or High (H or 3). The resolution of the problem P requires at least M level on each used skill Sk1, Sk2 and Sk3.

Let (u1..un) represent n users whose backgrounds are respectively (d1..dp) in p disciplines. Let C1 represent a course which delivers skills Sk1, Sk4 in the discipline d1.

The Ld criterion for the course C1 (LO) will define its ability to allow users to include a course containing skills Sk2 and Sk3 helpful to the resolution of the problem P. This ability may be high, medium or low. $Ld = [1\ 2\ 3]$ by equation (Eq.2).

Example: in bioinformatics (n = 2, biology and computer science), P can be DNA sequence alignment with Sk1=Algorithm, Sk2 =BLAST tool used and Sk3 = sequencing DNA (Figure 2).

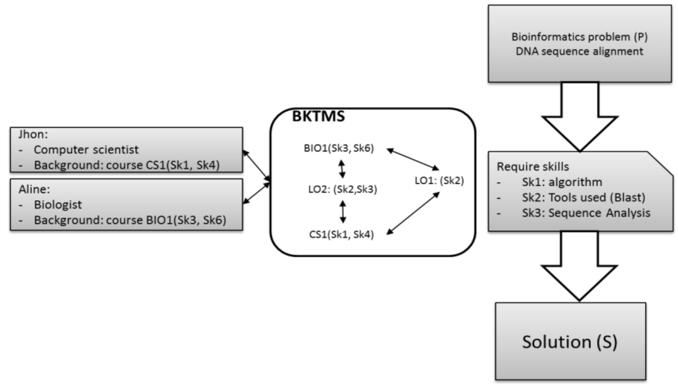

Figure 2: Example of bioinformatics discipline dependence Ld involved in 2 LOs (LO1, LO2) for a given KTMS.

Consider two users, John and Aline, with computer science and biology backgrounds respectively. Figure 2 shows the dependence that may exist in interdisciplinary training for Aline and John in this case.

- **Collaborativity (Tw).**

The development of pluridisciplinary programs like bioinformatics is accelerating, given translational science needs. Web technologies are changing with the involvement of users in system design as well as in the creation and management of massive data (Web3.0, web services, workflow). The interactivity, the connectivity, and the sharability become inherent in the performance of web-based systems like the KTMS. The Tw criterion measures the ability of the KTMS to facilitate collaboration, networking and sharing of resources.

2.1. Communication criteria (C)

Based on information theory, we propose in this paragraph a characterization of communication between users (student, teacher, etc) through the KTMS. Information from a sender to a receiver using communication channels (language, format, support material, software, etc.) is represented here in the KTMS. We have the broadcast or diffusion channel (Figure 3a), the multiple access channel (Figure 3b) and the multiple access broadcast channel. (Figure 3c).

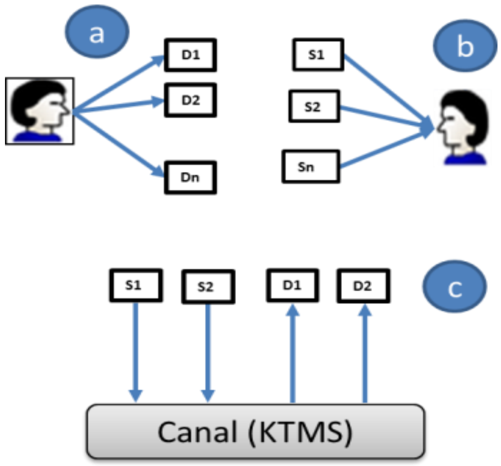

Figure 3: Communication channel types, broadcast (a), multiple access (b), multiple access broadcast (c).

KTMS functions can be modeled by a multiple access diffusion channel. Indeed, a KTMS can be represented as an intermediary between the source and destination in knowledge transmission. We study here how to improve the communication performances through those of KTMS which plays a preponderant role in knowledge efficient transfer. Like any communication channel, the performance is given by its capacity and its protocol (Jacquet et al. 2008). This corresponds to the possibility of a KTMS to meet all the needs of the user (the channel capacity), and to have a protocol that ensures the quality of transmission. The criteria proposed here are based on the Shanon theory for communication [11] and derivative works [12][13][14]. We have identified three criteria: Number of diffusion channels (Cd) (video, slide, image, animations, etc); Quality of information Sources (Ci); Channel capacity (Cc).
According to the previous cited works, we have:

$$C_m = max_X\left\{(h\left(T\left((X)\right)\right) - h(T(X)/X)\right\} \quad \text{(Eq.3)}$$

where
C_m is the channel maximal capacity
X is the information sent from the source
$T(X)$ is the information decoded by receptor (understand)
h is the entropy of X. Then h is the incertitude (error or probability) on the information received.
Since $h(X) \in [0..1]$, then, $C_m \in [0..1]$.
We describe then Cc as a characteristic function given by:

$$Cc(X) = \begin{cases} 8 \text{ } if \text{ } Cm = 0 \\ 6 \text{ } if \text{ } 0 < Cm \leq 0.5 \\ 3 \text{ } if \text{ } 0.5 < Cm \leq 0.75 \\ 1 \text{ } if \text{ } 0.75 < \text{ } Cm \leq 1 \end{cases} \quad \text{(Eq.4)}$$

<u>Use explanation process:</u>

- The sender encodes the information X: C(X).
  Example: the teacher built the course resource (containing knowledge)
- The sender transmits C(X) (using the KTMS), and the receiver get Y=T(C(X))
- The receiver decodes the information Y: D(Y). There are errors if D(Y) is different from X. (*for example, the administrator or student gives a bad evaluation in return*).

2.3. Interdisciplinarity based criteria (I)

Making changes in education requires a redefinition of the notion of academic discipline. It is problematic today to adjust some curricula to the old definition of academic discipline (e.g. math, physics, biology, english, etc.). One of the principal reasons for this difficulty is the intersection of disciplines (e.g. transdisciplinarity, interdisciplinarity, pluridisciplinarity). Here, it's important to mention the subtle difference between these X-disciplinarity (X=trans-, pluri-, inter-). As the prefix "trans" indicates, transdisciplinarity concerns that which is at once between the disciplines, across the different disciplines, and beyond all disciplines. Its goal is the understanding of the present world, of which one of the imperatives is the unity of knowledge. Pluridisciplinarity pertains to the study of research topics in several disciplines at the same time. Interdisciplinarity concerns the transfer of methods from one discipline to another. For example, a neuron in biology is used in mathematics and bioinformatics to build an algorithm [15]. This crossing aims to obtain programs that better reflect the societal and industrial innovations. Thus, the Interdisciplinary Criteria becomes a key feature in KTMS assessment.

The Biggs and Collis model (1982) was adapted to interdisciplinary programs by [6]. This model allows structuring of an interdisciplinary program at 3 levels. This view helps us to begin from the usual program structure (level 1), and integrate each additional discipline, using transitions for clarifying interactions between the disciplines involved. It also highlights the strength of the collaborative aspects of the disciplines of knowledge transmission.

The criteria proposed here measure the ability of a KTMS to integrate these three levels in design and content management. This amounts to measuring the multidisciplinary flexibility of the system. The three criteria are:

- **Pluridisciplinarity cognitive map creation (Ic).**

This criterion measures the ability of KTMS to create a specific cognitive map for pluridisciplinary cases (bioinformatics, pharmacogenomics, etc.).

- **Pluridisciplinarity learning language (Il).**

This criterion measures the ability of KTMS to manage a pluridisciplinary language interacting with languages of others disciplines (biology language + informatics language ≠ Bioinformatics language, Statistics + biology ≠ Biostatistics). Several dictionaries end glossaries are available for bioinformatics language ("Glossary of bioinformatics terms.," 2007;[17]. These references contain more than 1000 terms specific to bioinformatics or adapted for the bioinformatics context. It can be employed for the development of the bioinformatics knowledge transmission and learning language specification performance.

- **Dominant idea definition (Id).**

This criterion measures the ability of KTMS to help users in the identification and specification of the main topic in the pluridisciplinary course used (case study, applications, examples).

2.4.Other criteria (O)

Other criteria are related to user's specific needs. Five other criteria are proposed to satisfy context needs related to the grading (O1), user tracking (O2), chat (O3), test scoring (O4), and self-work (O5). These criteria are described in EduTools. These are implemented by: Online grading tools (O1), Students tracking (O2), Real time Chat (O3), automated testing and scoring (O4), Self-assessment (O5).

3.Conclusion

Faced with the KTMS evaluation issue, we proposed here a set of criteria that allow decision maker to measure the quality of a given KTMS. In our proposal, we focused on the weaknesses of existing criteria and the major limitations of internet-based KTMS. These weaknesses are multidisciplinarity, collaborativity and sharing that were integrated using communication tools.

The criteria set proposed is also flexible. This allows them to measure the qualitative and quantitative aspects of each feature. This work is far from covering all the needs of educators, but it still provides a preliminary step toward opening the door to a standardization of quality criteria for KTMS.

<u>Terminologies</u>

LOs: Learning Objects
LORs: Learning Object Repository
CBT: Computer Based Training
CMS: course management system
LMS: Learning Management System
KTMS: Knowledge Transmission Management System
BKTMS: Bioinformatics Knowledge Transmission Management System
SCORM: Sharable Content Object Reference Model
VLEs: Virtual learning environments
CBTE: competence-based teacher education,
HBTE: humanistic-based teacher education,
IMS: instructional management system
LOM: learning object model

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