Exploring B-Learning Scenarios Using Fuzzy Logic-Based Modeling of Users' LMS Quality of Interaction in Ergonomics and Psychomotor Rehabilitation Academic Courses

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Abstract. The multidisciplinary field of human-computer interaction can be seen as an open-ended concept used to refer to the understanding of different relationships between people (users) and computers. The pedagogical planning within the blended learning environment with the users' quality of interaction (QoI) with the Learning Management System (LMS) is explored here. The required QoI (both for professors and students) is estimated by adopting a fuzzy logic-based modeling approach, namely FuzzyQoI, applied to LMS Moodle data from two undergraduate courses (i.e., Ergonomics and Psychomotor Rehabilitation) offered by a public higher education institution. In order to facilitate the understanding of the learning context and curricula organization of the both courses, the MindMup tool from the i-Treasures Pedagogical Planner (www.i-treasures.eu) is employed. The results presented can inspire LMS administrators to include the measure of QoI and reflect upon issues like system-quality, system-use and user-satisfaction into their current evaluation techniques of LMS based b-learning systems efficiency.

Keywords: Blended-Learning Scenarios, LMS Moodle, Quality of Interaction, Fuzzy Logic-Based modelling, Ergonomics and Psychomotor Rehabilitation courses, Human-Computer Interaction, Pedagogical Planning, i-Treasures.

1 Introduction

Education is a domain that is closely interconnected with the multidisciplinary field of human-computer interaction (HCI). The latter can be seen as an open-ended concept used to refer to the understanding of different relationships between people (users) and computers. HCI research examines both the improvement and evaluation of educational technologies (e.g., multimedia systems, interactive simulations, computer-assisted instructional materials) [1]. In fact, information and communications technologies (ICTs) have provided an unarguable potential for change, allowing the development of inclusive approaches regarding teaching and learning; however, there

M. Kurosu (Ed.): Human-Computer Interaction, Part III, HCII 2014, LNCS 8512, pp. 233–243, 2014.

is still insufficient knowledge regarding best practices in higher education institutions (HEIs), mainly concerning the use of online environments and communication tools [2]. Fortunately, intelligent and interactive Learning Management Systems (LMSs) appear to mobilize agents of innovation and provide flexibility and accessibility in educational contexts [3]. Additionally, a combination of traditional F2F and online learning has initiated the concept of blended (b-) learning, combining different delivery methodologies that have the potential to balance out and optimize the learning development, deployment costs and time [4].

To facilitate the realization of b-learning in practice, flexible and adaptable Course Management Systems (CMSs) are needed. LMS Moodle platform can be seen as such example, since it is a universal well-known LMS that supports b-learning [5], which belongs to the kind of LMS that is intentionally built on a particular pedagogical strategy (e.g., behaviorism, cognitivism, constructivism, connectivism), allowing management of user data, usability issues, and exhibits adaptation capabilities [6], [7]. On the one hand, the development of learning environments can be seen as an opportunity to implement/develop innovative tools, which enable the enhancement of a new quality of learning; on the other hand, the adoption of LMSs has led to the introduction of new instructional approaches and to the promotion of different educational contexts within the online environment. According to Conole et al. [8], the user's interaction with a LMS (e.g., Moodle) is actually realized within online learning environments (OLEs), which are characterized by fastness and immediacy, i.e., the ability to quickly access a vast amount of information coupled with a plurality of Web 2.0 tools. Apparently, the efficiency of the LMS depends on how effectively the users can access its multi-faceted benefits when interacting with it. However, an essential factor, in determining the efficacy of online instruction, is the users' quality of interaction (QoI) with LMSs; yet, in many cases, QoI has not been properly acquired, mainly, due to its inherent qualitative character.

2 Methodology

2.1 The *FuzzyQoI* Model

In the effort to develop a system of evaluation, e.g., the QoI of LMS users, intelligent systems can play an important role, i.e., can provide a model of the domain expert's evaluating system, using advanced features and adaptive functionality [9], [10]. Based on the latter, a Mamdani-type [11] fuzzy logic-based QoI modeling, namely FuzzyQoI scheme, was proposed by Dias and Diniz [12]. The FuzzyQoI model constitutes a Fuzzy Inference System (FIS) structure that is able to produce evaluative inferences upon input data. In particular, the latter correspond to the key-parameters and variables (metrics) of LMS Moodle involved within a b-learning environment concerning the user's interaction with the system, whereas the outputted inference forms a quantitative measure of the user's overall QoI [12]. The block diagram of the FuzzyQoI model is depicted in Fig. 1. As it is apparent from the latter, the users (professors/students at a HEI) interact with the LMS and the available 110 LMS Moodle metrics are corresponded to 12 categories that serve as inputs to the FIS structure.

In an effort to efficiently handle the 12 input variables, they are grouped in three groups and a nested sequence of five FISs (FIS1-FIS5) is used to form the proposed FuzzyQoI scheme. The first level includes FIS1, FIS2 and FIS3, which output the values of View (V), Addition (AD) and Alteration (AL), respectively. In the second level of inference, V, AD and AL are considered as intermediate variables and are used as inputs to the FIS4, which outputs the value of Action (AC). Finally, in the third level of inference, the AC is considered as intermediate variable and along with Time Period (TP) and Engagement Time (ET) rom LMS are used as inputs to the FIS5, which outputs the estimated QoI as the final output of the FuzzyQoI scheme [12]. For the construction of the knowledge base of the FuzzyQoI scheme, an expert in the field of analyzing LMS Moodle data within the context of b-learning was used, for defining the structure of the membership functions used for each FS and the corresponding IF/THEN fuzzy rules (600 in total). In particular, a three-level of trapezoid membership functions corresponding to Low, Medium and High values, respectively, are used for the FIS1-FIS4, whereas a five-level of trapezoid membership functions corresponding to Very Low, Low, Medium, High and Very High values were adopted for the final FIS5, increasing, this way, the resolution in the segmentation of the universe of discourse of the AC, TP and ET inputs and QoI output in the final FIS5. Analytical description of the FuzzyQoI model can be found in [12].

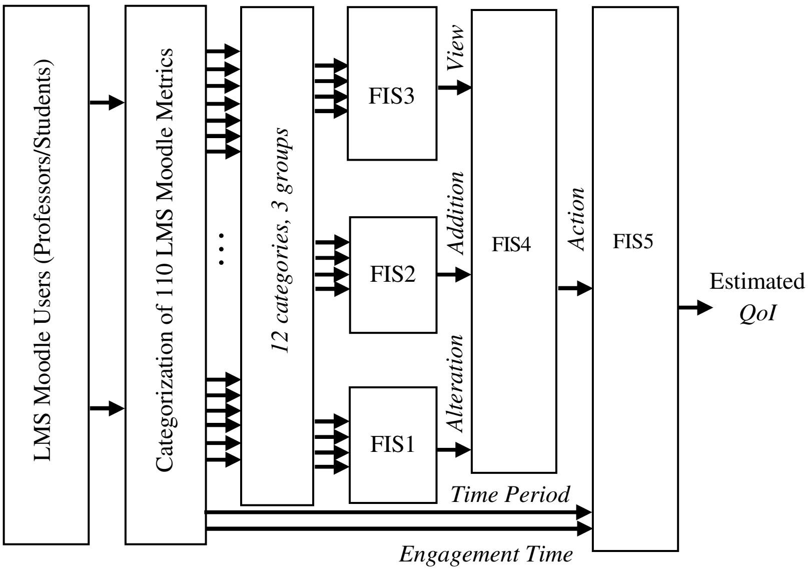

Fig. 1. Block-diagram of the FuzzyQoI model [12]

2.2 The Pedagogical Planning (PP)

The organization of educational scenarios during the LMS interaction is facilitated here with the adoption of the Pedagogical Planning (PP) [13]. The realization of the latter is achieved by adopting the MindMup tool from the i-Treasures Pedagogical Planner [14], which is a scalable cross-browser Web-based application developed in PHP, MySQL and JavaScript.

The PP is essentially a teacher-oriented online tool, yet in the way it is used here, it could serve as a combinatory tool that incorporates both designing and planning of the educational interventions and feedback from the realization of the b-learning delivered instruction. In this way, causal relations between professors' and students' at the level of their LMS-based QoI could be identified and professors' metacognitive processes could be fired towards the enhancement of their pedagogical planning and delivery.

The PP comprises of both authoring and display capabilities, with specially designed functions and interface features in both cases. In particular, target population, learning context, content domain, objectives and metrics, along with available tools (such as MindMup), are the core characteristics of the PP (www.i-treasures.eu).

3 Dataset and Related Courses Principal Components

Here, the FuzzyQoI [12], was applied to LMS Moodle data from two undergraduate courses, i.e., Ergonomics and Psychomotor Rehabilitation, offered by a public HEI (Faculty of Human Kinetics, University of Lisbon, Portugal). The data from 73 students and 13 professors, including 69247 interactions in total (40109 from Ergonomics Course and 29138 from Psychomotor Rehabilitation Course), were used and analyzed for the duration of two academic semesters, corresponding to a 51-week LMS Moodle usage time-period (August 26, 2009-August 18, 2010).

In order to identify any possible changes in the users' interaction behavior correlated with a specific time-period section, the resulted time-period sections (e.g., semesters, exams, interruptions) were used as landmarks. More specifically, the Semester 1 (S1) and Semester 2 (S2) are denoted on the graphs with the vertical solid lines located at weeks 2 and 16 (S1) and weeks 23 and 38 (S2) (see Figs. 4-7); the Interruptions are defined as: Christmas (weeks 16-18), Carnival (weeks 24-25), and Easter (weeks 30-31).

Figures 2 and 3 illustrate the PP of the both courses in the form of the MindMup output, where the principal components, i.e., scientific domains, learning objectives, learning context, LMS Moodle tools and forms of assessment, are shown in the form of connected branches.

Fig. 2. The MindMup output of the PP of the Ergonomics course context

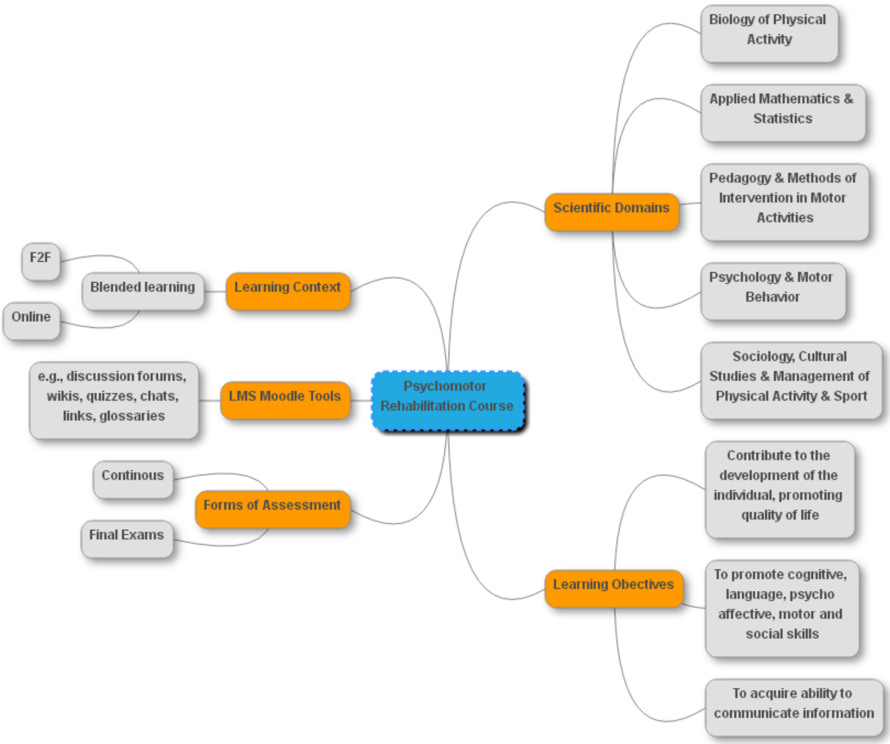

Fig. 3. The MindMup output of the PP of the Psychomotor Rehabilitation course context

4 Results and Discussion

4.1 The Estimated QoI

Figure 4 depicts the estimated QoI for all cases explored. In particular, from Fig. 4 (top panel) it is clear that the 10 professors incorporated in each course delivery had a dissimilar behavior, regarding their QoI with the LMS. Specifically, for the case of Ergonomics Course (EC), Professor #4-EC exhibited smooth interaction with the LMS located at the beginning of S1, and he totally abandoned it until the end of the academic year. The Professors #3 and #2-EC, like the previous one, exhibited low QoI values, however, located at the beginning and at the end of S2, respectively. On the contrary, in general, all the other Professors (#{1,5,6,7,8,9,10})-EC showed a constant interaction with the LMS, exhibiting her/his high QoI values almost across the whole academic year; however, based on S1 LMS interaction, more notorious and sustained values of estimated QoI was identified (i.e., reaching, continuously, high-very high QoI values for more than one week) compared to S2.

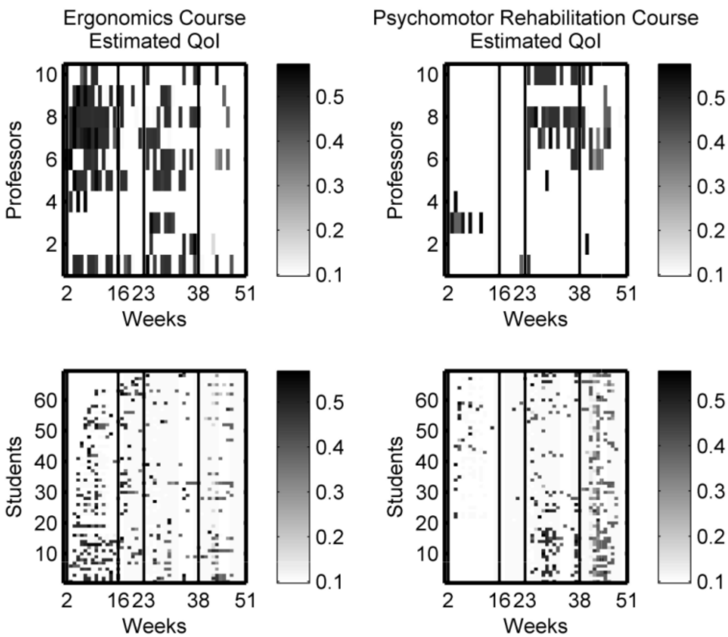

Fig. 4. The distribution of the estimated output QoI from the FIS 5 (see Fig. 1) of the FuzzyQoI model of the Ergonomics (left column) and Psychomotor Rehabilitation (right column) courses and corresponding users (professors: top, students: bottom)

For the case of Psychomotor Rehabilitation Course (PRC), some Professors (#{3,4})-PRC exhibited sparse interaction with the LMS, just located at the beginning of S1. In contrast, all other Professors (#{1,2,5,6,7,8,9,10})-PRC just initiated the LMS-based process in the S2; however, in some weeks, a high-very high estimated

QoI was identified for the Professors #7, #8 and #10-PRC, moving toward a more productive behavior, in general. Concerning the students' QoI values (Fig. 4: bottom panel), they were higher at S1 rather than in S2 for the case of EC, whereas the opposite effect was noticed for the PRC case.

Focusing at the mean estimated QoI shown in Figure 5, it is clear that the interaction with LMS for both users (professors and students) was higher in the case of the EC (top panel) than the case of PRC (bottom panel). Almost across the whole academic year, in the case of the PRC, the students showed a tendency to exhibit synchronized QoIs with the professors; however, in the case of the EC more synchronization was evident during the period of the S1.

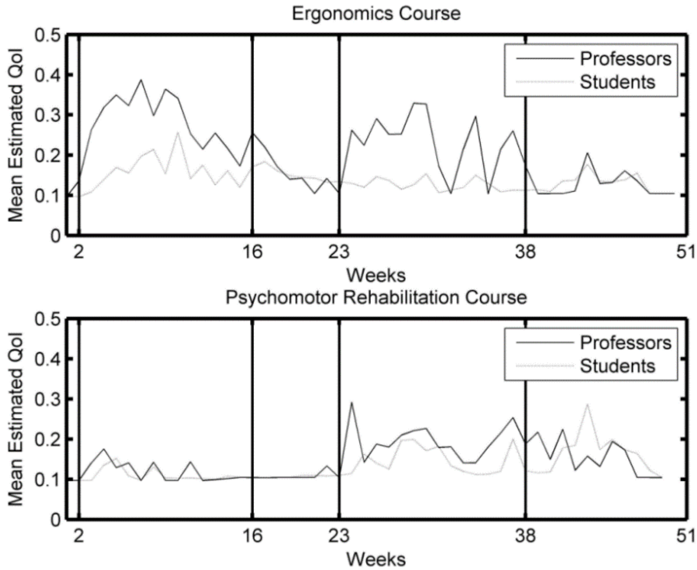

Fig. 5. The mean estimated QoI of the EC (top panel) and PRC (bottom panel) courses and corresponding users (professors: black line, students: gray line)

4.2 Deeping into the Results: Common Users

In the two courses, some common users (three professors and four students) appeared. Focusing at their QoIs it can be seen from the Figure 6 (top panel) that the three common professors had a dissimilar behavior in each course, regarding their QoI with the LMS. Focusing on Professor #1's performance in both courses, it is clear that he exhibited low interaction with the LMS in EC; however, in the S1, a more productive and sustained behavior was identified for the PRC case.

Just appearing in S2, Professors #2 and #3 seem to interact with LMS in a more effective way in PRC rather than EC. In general, regarding the students' QoI values (Figure 6: bottom panel), they exhibited low QoI values in both courses. In particular, for the PRC is possible to understand that all students interacted with the LMS at least more than one week across the whole academic year. Focusing at the mean estimated

QoIs shown in Figure 7, it is clear that the mean interaction with LMS for both courses was higher in the S2. In fact, both users, in both courses, initiated the LMS-based process at the beginning and mid of S1 with apparent motivation.

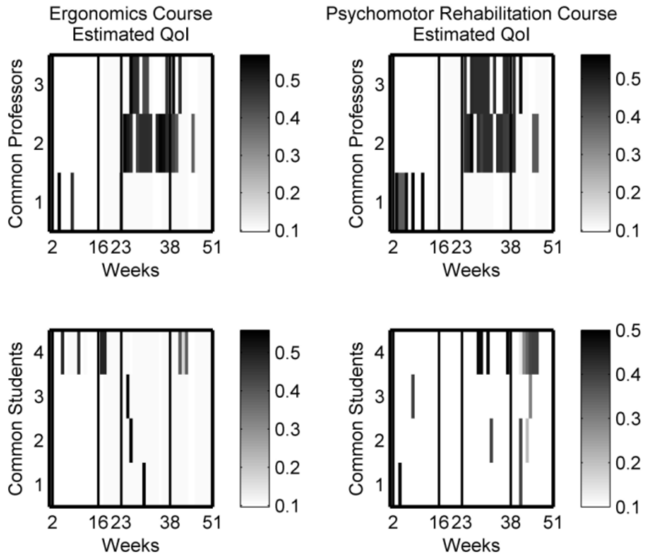

Fig. 6. The distribution of the estimated QoI of the FuzzyQoI model of the Common Users of the EC (left column) and PRC (right column) and corresponding users (professors: top, students: bottom)

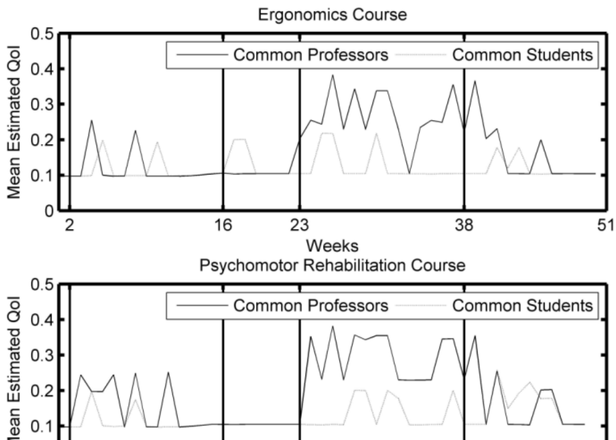

Fig. 7. The mean estimated QoI of the Common Users of the EC (top panel) and PRC (bottom panel) and corresponding users (professors: black line, students: gray line)

The results described above could be reflected to PP of Figs. 2 and 3, based on b-learning scenarios, setting the shift towards more interactive and appealing online LMS Moodle resources (e.g., quizzes, discussion forums, blogs, videos, e-portfolios), which could accompany the F2F interaction and complement the effort towards developing a more multifaceted and enriched way of learning. Practically speaking, it is apparent that the proposed approach could be extended to various educational scenarios and use-cases (within [15] and outside the i-Treasures project) posing a dynamic character to the role of LMS towards an intelligent LMS [16], assisting both teachers and students to enhance the quality of the educational environment.

4.3 Correlation Analysis Results

Stemming from the results of Figs. 5 and 7, a correlation analysis that explored any possible association between the mean QoI values of the professors' and students' of both courses (i.e., EC and PRC) was carried out. In particular, the cross-correlation R (with probability of false alarm p) along with the coefficient of determination R^2 across users/courses and between/within subjects were estimated (see Table 1).

Table 1. Cross-correlation R (with probability of false alarm p) along with the coefficient of determination R^2 across users/courses and between/within subjects. Bold values indicate statistically significant cross-correlations $(p < 0.05)$. EC: Ergonomics Course; PRC: Psychomotor Rehabilitation Course.

Between subjects		
	Professors (n=10)	Students (n=69)
	PRC	PRC
EC	$R = 0.114$ $(p = 0.446)$ $R^2 = 0.013$	$R = -0.0411$ $(p = 0.774)$ $R^2 = 0.0017$
Within subjects		
	Common Professors (n=3)	Common Students (n=4)
	PRC	PRC
EC	$\boldsymbol{R = 0.8337}$ $(p = 10^{-13})$ $R^2 = 0.6951$	$R = -0.0163$ $(p = 0.9115)$ $R^2 = 2.6 \times 10^{-4}$
Between subjects		
	EC	PRC
	Professors (n=10)	Professors (n=10)
Students (n=69)	$\boldsymbol{R = 0.5090}$ $(p = 0.0002)$ $R^2 = 0.2591$	$\boldsymbol{R = 0.4786}$ $(p = 0.0005)$ $R^2 = 0.2291$
Within subjects		
	EC	PRC
	Common Professors (n=3)	Common Professors (n=3)
Common Students (n=4)	$R = 0.160$ $(p = 0.2670)$ $R^2 = 0.0256$	$\boldsymbol{R = 0.3068}$ $(p = 0.0320)$ $R^2 = 0.0941$

From Table 1, when considering the "between subjects" analysis, two statistically significant estimates of R across users and courses, namely for professors' and students' of EC ($R = 0.5090$) and PRC ($R = 0.4786$), were found. Moreover, concerning the common users (i.e., "within subjects" analysis), a strong R value was exhibited for common professors across courses ($R = 0.8337$). In addition, only one statistically significant estimate of R was exhibited, namely across common professors and common students of PRC ($R = 0.3068$).

In general, we notice that, unlike the common students, the common professors act almost similarly regarding their mean QoI at both courses and that most of the students are in a similar pathway with the LMS behavior of professors. These trends reveal the dependencies at the LMS Moodle interaction of the OLE users, revealing the existence of a somehow "causality" between professors and students, which should be taken into account in the design and planning of the online-related resources (see Figs. 2 and 3), in an effort to maximize the effective engagement of all stakeholders in the OLE.

5 Conclusions

Overall, the results have shown the potential role of QoI to shift the educational scenarios and strategies towards a more dynamic design, yet taking into consideration the inherent tendencies and attitudes of the users' interaction within the b-learning context. Furthermore, LMS-based educational strategies could also be reflected in areas that incorporate HCI for practical paradigms, such as the educational scenarios of the use cases of the i-Treasure platform, facilitating the capturing of the intangible cultural treasures. Finally, among others, it is our expectation that the results presented here can inspire LMS administrators to include the measure of QoI and reflect upon issues like system-quality/use/satisfaction into their current evaluation techniques of LMS based b-learning systems efficiency.

Acknowledgements. This work has received funding from the EU Seventh Framework Programme FP7-ICT-2011-9-ICT-2011.8.2, under the grant agreement n° 600676: "i-Treasures" Project (www.i-treasures.eu). The authors also thank Dr. C. Ferreira at FHK for his assistance in the retrieval of the LMS Moodle data.

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