E-learning System Design by Learning Management System (LMS) focusing on Emotional Aspects using Biological Signals

E-learning system design

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Abstract: E-learning is the computer and network-enabled transfer of skills and knowledge. Since new technologies are commonly thought to make a big difference in education, many universities have adopted learning management system (LMS) to support teaching and learning processes. Most LMSs applications allow for student registration, the delivery and tracking of e-learning courses and content, and testing; they may also allow for the management of instructor-led training classes. In e-learning systems, since emotions are important in the classroom, we proposed an e-learning system design by LMS that focuses on affective aspects using emotion detection technologies from biological signals to measure, detect, and analyze user emotions. We designed this to complement the effectiveness of e-learning.

Key words: E-learning, LMS, Emotion, Biological signal

1. Introduction

E-learning, which is an innovative technology that provides a strategy to improve the quality of teaching and learning anytime and anywhere has become heavily learner-centered and emphasizes pervasive and personalized learning technologies. As more and more technological tools become available for online education, interest continues to increase among educators and other professionals in the application of these tools in online courses [1].

Learning management system (LMS) are software applications that comprise learning and teaching online tools [1]. Many higher education institutions have implemented them to manage online learning and teaching by providing support to staff and students to improve the speed and effectiveness of educational processes and communication among learners as well as between staff and students.

In e-learning systems, emotions are an important approach to foster and develop the positive emotions of students. Emotional education can help students form beneficial attitudes about requirements, motivation, and interests. A biosensor is an integrated receptor-transducer device that provides selective quantitative or semi-quantitative analytical information using a biological recognition element [2]. To measure learner emotions, we used three biological sensors: electrocardiography (ECG), electroencephalography (EEG), and eye tracking.

In this research we used emotion detection technologies from biological signals and explored how emotions evolve during the learning process and how emotion feedback can be used to improve learning experiences. The purpose of this study is to design learning environments and tools that avoid such inappropriate affective states as boredom, anxiety, anger, etc.

2. Literature review

Kittanakere et al., who summarized the main goals of different e-learning systems [3], focused on the following active learning goals: accommodating various learning styles, explicitly placing the responsibility for learning on students, developing written and oral communication skills, clarifying the role of teachers as facilitators and mentors, providing better coverage of material, developing a sense of self-confidence and independence in students, including teamwork experiences, encouraging peer reviews, developing interpersonal communication skills when students are separated geographically, supporting the entire educational process when they are separated both geographically and temporally, and handling time management, including meeting deadlines.

Many of the above goals reflect the advantages of e-learning systems over traditional learning approaches; e-learning systems are also scalable. The number of learners that an e-learning system can handle with individual attention is much greater than can be accommodated in a classroom setting.

Kittanakere et al. designed an emotion sensitive e-learning system that emphasizes the entire learning process and is very cost effective. It categorizes a learner's emotional state as happy, neutral, or sad. Their system motivates discussion about incorporating the emotional aspects of teaching in e-learning systems to make them more intelligent. An intelligent e-learning system must adapt to the knowledge, the learning abilities, and the needs of each learner and provide a sense of individual care that will help students during the learning process.

Khan developed an e-learning framework that contained the following eight dimensions [4]:

- E-learning's pedagogical dimension addresses issues of content analysis, audience analysis, goal analysis, media analysis, design approach, organization, and the methods and strategies of e-learning environments.
- Its technological dimension examines technology infrastructure issues in e-learning environments and includes infrastructure planning, hardware, and software.
- The interface design dimension, which refers to the overall look and feel of e-learning programs, encompasses page and site design, content design, navigation, and usability testing.
- The e-learning evaluation includes both assessments of learners and evaluations of the instruction and learning environments.
- E-learning management refers to the maintenance of the learning environment and the distribution of information.
- The resource support dimension examines online support and the resources required to foster meaningful learning environments.
- The ethical considerations of e-learning are related to social and political influence, cultural diversity, bias, geographical diversity, learner diversity, information accessibility, etiquette, and legal issues.
- The institutional dimension is concerned with issues of administrative and academic affairs and student services related to e-learning.

"Khan framework" also applied and provides an e-learning system.

For e-learning, Huiqin et al. provided an emotional teaching design that consists of the following six parts based on virtual reality [5]:

- Learning goals must be designed before learning; their main components are emotional goals, which should be determined based on a student's individuality and personality to develop student emotions during the studying process.

- Learning content, especially emotional content, must be selected based on attributes and course content. It should enrich the emotional experiences of students and stimulate their interest in learning.
- Learning strategy: emotional interaction is an effective strategy for emotional education in e-learning. Such effective strategies as collaborative learning and group learning provide more emotional interaction between teachers and students.
- Learning ways efficiently combine visual and logic thinking for emotional education in e-learning. Learning content, which is represented as images, graphics, and video, can offer a multi-dimensional information environment that helps students' master content.
- Learning environments must be designed based on the learning content to simplify understanding for students. Stimulating scenes and warm atmospheres promote interaction between students and teachers.
- Teaching evaluations are an important step in teaching activities. Evaluations from teachers, students, and peers enhance mutual communication, and students may feel deep concern of teachers.

Shen et al. integrated heart rate (HR), skin conductance (SC), blood volume pressure (BVP), and brainwaves (EEG) to detect learner emotions [6]. Their emotion recognition results from physiological signals achieved a best-case accuracy (86.3%) for four types of learning emotions. The system is an affective e-learning model that only included a subset of the factors that could be considered to assess the emotional reactions of e-learning learners.

Prasanna et al. evaluated a user interface design of LMS by analyzing student eye tracking patterns through gaze plots and heat maps. The LMS interface was divided into three areas: top, left, and content. The student's area of interest was identified using an eye tracking pattern. Student eye movements were studied with a Tobii Series Eye Tracker Model T60/T12 and ManGold software to capture their eye tracking patterns when using LMS to complete tasks. The analysis identified some interface design issues in LMS. Based on this finding, they discussed the user interface design guidelines applied in LMS and suggested design improvements [7].

Based on our literature review, designing a system that focuses on user emotions with biological signals is very promising. Therefore, we propose an e-learning system design that avoids such inappropriate affective states as boredom, anxiety, anger, etc.

3. E-learning system

Our system also integrates biological sensors to measure, detect, and analyze user emotions. In this section we discuss the overall design of our e-learning system (Figure 1), which uses an LMS for delivering, tracking, and managing education and a web server that provides users with easy access by web browser on a personal computer. While students use our system, biological sensors measure such biological signals as EEG, ECG, and eye tracking to analyze and detect their emotions. The learners can express positive or negative emotions that significantly influence learning by the system.

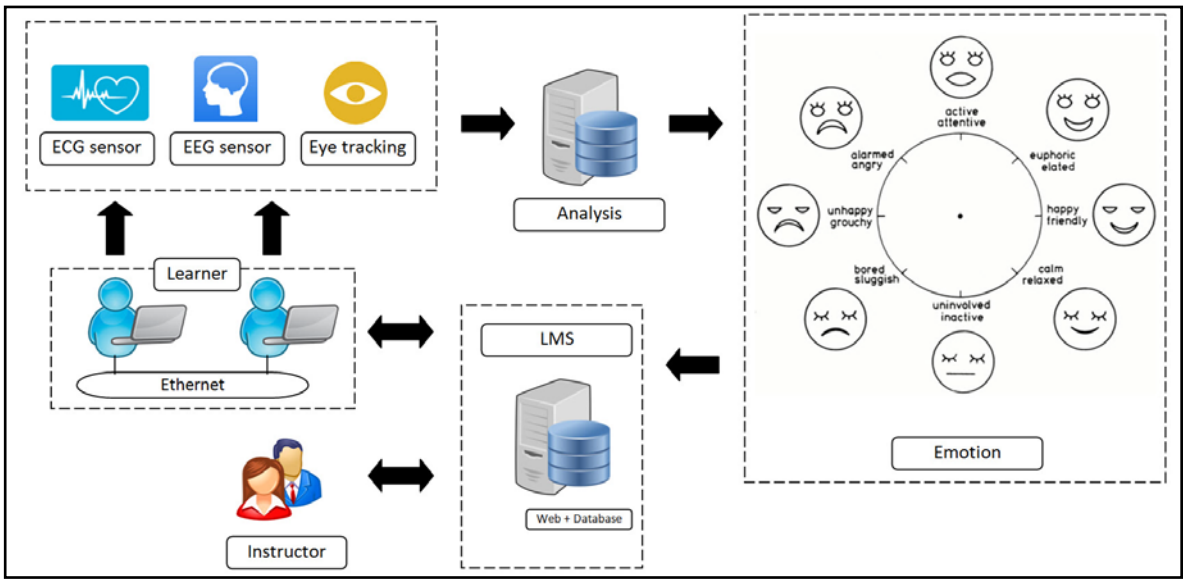

Figure. 1 Proposed e-learning system

We used an e-learning framework [4] that contained eight dimensions (Figure 2), which encompass the following online learning issues: pedagogical, technological, interface design, evaluation, management, resource support, ethical, and institutional issues. Each factor has several sub-factors, and each sub-factor consists of issues related to a specific aspect of an e-learning environment. These issues generate many questions that course designers ask themselves when planning or designing an e-learning system.

The framework design of our e-learning system that uses biological signals consists of five modules: learners, instructors, LMS, servers, biological sensors. It analyzes the emotions of learners, as shown in (Figure 3).

Our e-learning system's content is described below:

1. Learners engage in e-learning by registering with the e-learning system. They can choose any of the courses provided by the system.
2. Instructors, an important of this system, create and design courses, contents, tests, quizzes, and provide evaluations.
3. The server includes the web server, a database, and an LMS that provide services to other computer programs (and their users) in the same or other computers.

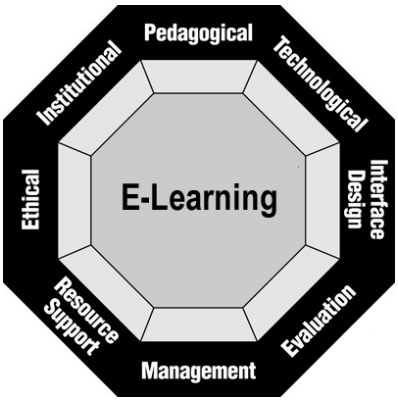

Figure. 2 Badrul Khan's E-learning framework

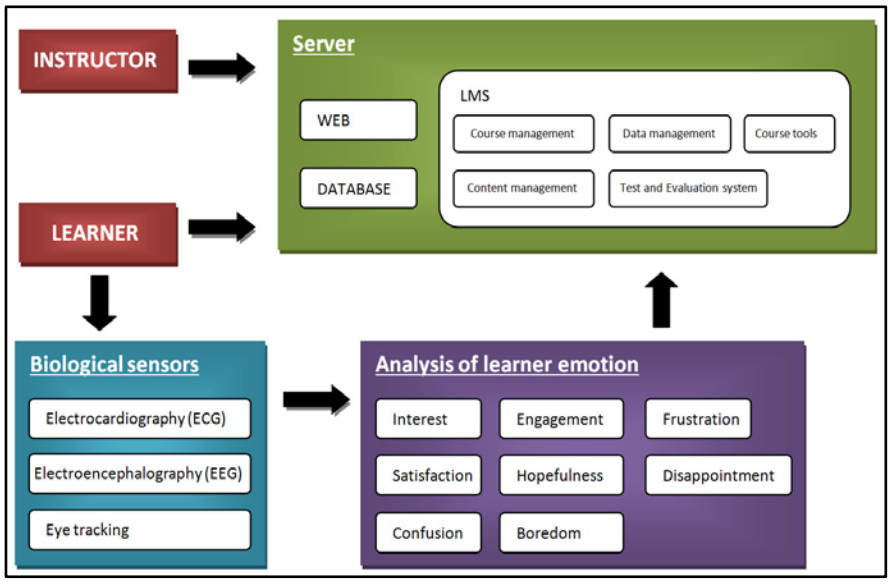

Figure.3 Framework design

- A web server is simply a computer program that dispenses web pages as they are requested. The machine on which the program is run is also usually called a server, and the two references are interchangeable in everyday conversation. Our design uses an internet information server as a web application server.
- A database server is a computer program that provides database services to other computer programs or computers.
- LMS is a software application or web-based technology for planning, implementing, and assessing a specific learning process. Typically, a learning management system provides an instructor with a way to create and deliver content, monitor student participation, and assess student performance. An LMS consists of the following five parts:
    - Course management stores, organizes, and communicates the course's information. It consists of three user groups, learners, instructors and administrators that can access the system anytime and anywhere.
    - Content management includes tools to create and support the content.
    - The test and evaluation system manages exams, quizzes, and tests in the database system. It also has tutorials that explain how to use it, interactive quizzes and tests, and quizzes to evaluate learners.
    - Course tools include a system that can help and guide each user.
    - The data management system manages the files and the folders of each user.

4. Biological sensors are EEG, ECG, and eye tracking to measure learner emotions.
    - An EEG sensor measures the voltage fluctuations from the electric ions within the brain's neurons. EEGs are classified into the following four types:

        Beta waves: 14-30 Hz, under normal conditions or with some anxiety

        Alpha waves: 8-13 Hz, during meditation or in a relaxed state

        Theta waves: 4-7 Hz, during slumber

Delta waves: 0.5-3 Hz, while falling into a deep sleep

Ohkura et al. analyzed user emotions by brain waves. When a person is relaxed, the proportion of the alpha waves among the brain waves becomes high. We apply this analysis method [8, 9].

- An ECG sensor measures the heart's electrical activity over a specific period of time. ECG signals can be interpreted as the heart rate in beats per minute (BMP). Ohkura et al. used ECGs to estimate user' emotions by the following indexes [8, 10].
    - R-R interval: time interval between the two R waves of the ECG or the inverse of the heart rate
    - Heart rate: number of heart-beats per minute
    - LF/HF: HF/LF ratio

        LF: lower frequency of component: 0.04-0.15 Hz

        HF: higher frequency of component: 0.15-0.4 Hz

    We defined the averaged heart rate and its variance as the average number of heart-beats a minute and its variance, respectively. Average R-R interval and its variance as the average interval time between the R-waves of the ECG and its variance, respectively. These are known indexes for stress, uneasiness, or relaxation and are used to measure dynamic feelings.
- An eye tracking method measures a person's point of gaze, which focuses on what a person is looking at and locates the eye spot. Porta et al. and Al-Wabil et al. related pupil size, fixation length, blink rate, and saccadic speed to estimate user emotions [11, 12]. For example, pupil size is related to actions and thinking. However, it can also depend on other factors than processing load: aural stimuli, light variations, or emotions unrelated to the task being performed. Fixation duration and blink rate that identify specific patterns can provide information about user emotion states.

5. Analyze learner emotions: This design system is for understanding how learner emotions evolve during the learning process and for developing learning systems that recognize and respond appropriately to emotional changes. We used Russell's circumplex model to describe a user's emotion space [13] (Figure 4). The basic set includes the most important and frequently occurring emotions during learning: interest, engagement, confusion, frustration, boredom, hope, satisfaction, and disappointment.

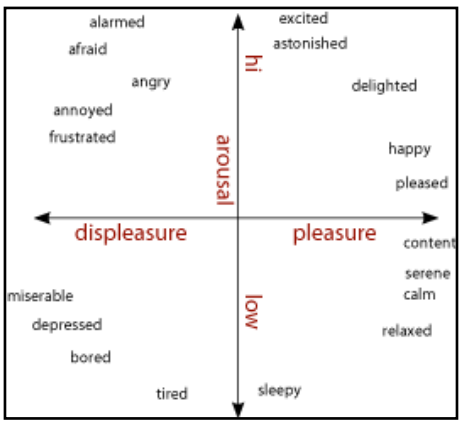

Figure 4. Russell's circumplex model

4. Conclusions

Our presented approach should only be considered a first attempt of designing an e-learning system that focused on emotional aspects. Using emotion detection technologies from biological signals, we explored how emotions might evolve during the learning process and how emotion feedback could be used to improve learning experiences. Learners themselves can express the positive and negative emotions that significantly influence their learning. In future work, we will improve our system by conducting further research on more complexes and identify what is the most effective design for student learning.

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