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A web-based intelligent report e-learning system using data mining techniques ☆

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ABSTRACT

This paper presents a PDCA (Plan, Do, Check, Act) method of improving web-based intelligent reports of an e-learning system as intelligent system, which was created and implemented at the Technical Faculty in Cacak, University of Kragujevac. The focus is on improving LMSs (Learning Management Systems) or e-learning systems by predicting behavior patterns of students and adjusting the structure of these electronic courses. An existing learning management system is improved by using data mining techniques and increasing the efficiency of the courses using custom modules. This study presents the design, implementation, and evaluation of the system. Future work should relate to the continued improvement of the PDCA-created system, as well as the introduction of additional modules and a comparative analysis of the presented and future results.

1. Introduction

The expansion of e-learning has led to the increased use of systemic and continuous improvement of e-learning systems. This is also evident on the examples of Electrical Engineering teaching courses. The use of these systems has resulted in a need for monitoring and enhancing behavior patterns of all participants, with the aim of continuous improvement of the teaching process and ultimate results – education services. The paper presents the creation of a web-based intelligent report e-learning system using data mining techniques with PDCA (Plan, Do, Check, Act).

Learning Management Systems (LMSs), with numerous opportunities in the PDCA, have the ability to track and analyze user activity. Here, administrators can get reports on the activities of participants and statistical approaches at the level of each course (i.e. responsible teacher), as well as at the level of the entire system.

Each LMS has a database that contains records on the activities of each user. This characteristic of the system is very significant, with "plenty of information readily available, just a click away" [1, p. 2]. However, many of these records require a special tool for processing and extracting useful information. Such tools have limited capabilities and their use is mostly limited by the administrator's choice, depending on the type of information. A universal solution for this problem lies in the use of data mining techniques, with the possibility of improving LMS [2,3]. Data mining or knowledge discovery in databases (KDDs) is the automatic extraction of implicit and interesting patterns from large data collections [4].

Part of the LMS report also requires improvement in terms of including web intelligence to detect significant patterns of behavior [5]. The need for such a solution includes intelligent and web-based aspects to meet the following requirements (in increments – the PDCA spiral):

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- The prediction of behavior patterns.
- More interactivity.
- Visualization of the results obtained.
- More real time data analysis.

The remainder of this paper has the following structure. Related work is given in Section 2. Section 3 highlights the proposed framework and model, and Section 4 gives the purpose, tasks, and goals of the study. In Section 5, the methodology of creating the system, as well as the creation of dimensions, the OLAP (OnLine Analytical Processing) cube, data mining models, and the architecture of the system is presented. The implementation and evaluation of the system is given in Section 6. Finally, Section 7 highlights the improvement of the system characteristics, as well as its use on the examples of Electrical Engineering course. Concluding remarks are found in Section 8.

2. Related work

In recent years, many studies have used a standardized methodology for PDCA. In this paper, we aim to improve the LMS through the enhancement of courses by using data mining techniques. Data mining involves the automatic extraction of implicit and interesting patterns from large data collections [4]. Below, we present background on the PDCA spiral.

There are many papers that deal with the promotion of virtual learning environments, where the focus is on improving the PDCA spiral, and therefore the grouping of numerous works through PDCA. Frequently, innovations in the field of computer science are not readily available in the classroom [6]. In addition to introducing new systems into teaching, it is necessary to make the interaction with these systems secure and effective, but also fun [7].

Prakasam and Suresh [8] presented the architecture of an intelligent e-learning system that simplifies and automates the process of teaching in e-learning environments. One aspect that this system can offer is to monitor student progress. The main difference between the system in Prakasam and Suresh [8] and the system presented in this paper is that the data mining techniques applied in the former uses data on the web, while in our system, data mining techniques are applied only to data from the Moodle server. Gomah et al. [9] created an intelligent system to give students recommendations on the basis of the student model, whereas the system in this paper aims to make the recommendations regarding the use of the e-learning system available to the teacher. In addition to the aforementioned modules, the way students make recommendations in [9] describes the Tutor module, which determines what aspects of the domain knowledge should be presented to the learner.

Virtual learning environments in the form of LMS are becoming more prevalent in universities, providing various opportunities for the organization of blended learning, but also for the implementation of the entire online teaching process through the facilitation of lifelong learning [10]. These systems have been recognized as good pedagogical support for most activities, using less effort, time, and money, and not limiting the place from which the students can connect [8,11]. These systems provide numerous opportunities to work with the students, various activities with the possibility of collaboration, and knowledge gained through verification tests. Numerous commercial LMS have been developed, such as BlackBoard (BlackBoard, 2007) and WebCT (WebCT, 2007), as well as free systems such as Moodle (Moodle, 2007) and Claroline (Claroline, 2007). One of the most popular free systems is in fact Moodle [12–14].

The approach used in this study, which involves a combination of business intelligence and educational data mining, provides a successful solution in Aziz et al. [15]. In the study [15], an intelligent system identifies groups of students with greater and lesser capabilities based on behavioral pattern analysis. In addition, the system also optimizes the time it takes to perform current and historical data analyses. There are a number of works in which the PDCA approach assures quality in e-learning. In Walasek et al. [16], the PDCA approach was used to plan, describe, create, implement, and evaluate a number of online courses. Here, all documents were created in accordance with the Deming cycle, thereby providing high quality electronic courses [16]. The work of Santos et al. [17] shows the use of the PDCA process approach in the evaluation of electronic tests. Through the four Deming phases, the study [17] describes the procedure of evaluation, as follows:

- In phase P (Plan), four tasks are defined: establishment of participants, design of questionnaires, locating passive participants, and pilot tests.
- Phase D (Do) provides information on completing the questionnaire, forwarded schools, and specificity.
- In phase C (Check), analysis gives concrete results in regards to the percentage of completed questionnaires.
- Finally, phase A (Act) gives identified measures to improve the obtained results.

Similarly, Tanigawa et al. [18] used the PDCA approach for the improvement of teaching materials, which presented the design, implementation, and evaluation of electronic courses.

The PDCA model represents a foundation from which more complex models can be created, as suggested in Valkanos [19]. In Valkanos [19] a new model (ADDURI) is created based on the PDCA model. This model (ADDURI) consists of six phases, namely: Analyze, Design, Develop, Use, Improve, and Review.

The analysis of papers that deal with the application of the PDCA model to improve a component of or the entire LMS in relation to our study highlights some similarities and differences, as follows:

Similarities: