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A conceptual model for designing an e-learning platform dynamically adapting to users' behavior

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Abstract. Creating an e-learning platform dynamically adapting to the users' learning styles and behavior is always a challenge. In this paper we describe a conceptual model for designing a dynamically adapting e-learning platform to the users' learning styles and learning behavior based on the analyze of users' events and actions. The proposed model can generate feedback for users at the individual and group level and also assist tutors to generate their feedback to the users. The paper presents the main conditions which must be fulfilled by this design, propose a way to construct learning content that facilitate the process of users' events recording and analyzing and a set of logical steps to follow in order to apply it at the level of an e-learning platform.

Keywords: e-learning platform, human-computer interaction, platform adaptability, learning styles.

1. Introduction

Adapting a platform dynamically to the users' profile and needs represents an important goal for any platform designers. Dix et al. (2004) considers that the interaction between users and system involve two complex participants. Therefore, in order to assure the success of the interaction, the interface must effectively translate between them. This is also true in the case of e-learning system. Norman (2013) showed that on the one hand we have users which are flexible, versatile and creative and on the other hand we have the system that is usually rigid, precise and relatively fixed in its operations. This mismatch between the two parts properly used can lead to enhanced capabilities.

In this context, making the interface easier to use it is very important aspect and can be done using many ways. Two main approaches are used until now: user centered design proposed by Norman (1986) and user sensitive design proposed by Newell & Gregor (2000).

Ardito et al. (2006) highlighted in the case of e-learning platform that it is crucial to realize it because it influences directly the usability. Markovi´c & Jovanovi´c (2012) showed how the interface can influences the quality of learning.

The users have different characteristics that are influencing the learning process, like: background knowledge, motivation, preferences, experience, cognitive abilities, psychomotor skills, cognitive styles, learning styles, interaction styles, personality, age, gender etc..

The combination of individual cognitive and non-cognitive characteristics affect considerably the learning performance according to Jonassen & Gabrovski (1993). This idea highlight that the assessment of these characteristics by monitoring the users' interaction is one of the most important factors used to implement adaptive e-learning systems.

Kobsa (1995) showed that the users' characteristics can be stored as user model.

Analyzing the users' model over the time, Nakic et al. (2015) highlighted a series of concepts on which the approaches in building adaptive learning systems are based on. Their findings shows that the most used concepts are: learning styles, background knowledge, cognitive styles and preferences. Based on these concepts were crystallized several features that are mandatory in case of an adaptive e-learning platform.

Researcher like Honey & Mumford (1992) considered that an adaptive e-learning system can be based at least on users' cognitive styles and users' learning styles. Other researchers like Hurley & Weibelzahl (2007) and Brusilovsky et al. (2009) consider mandatory for an adaptive learning system to focus on increasing the learners' motivation.

Detecting and evaluating users' characteristics allow the identification of their learning styles. Users with different learning styles have different needs in the learning process.

The identification of the learning styles can be done using different methods. Özpolat and Akar (2009) used machine learning techniques such as NBTree, Chang et al. (2009) used k-nearest neighbor, Lo and Shu (2005) used neural networks, Ortigosa et al. (2010) used decision tree in order to identify the learning styles of users.

Glavinić & Granić (2008) consider that different learning styles of users force learning platform to offer different ways for constructing the learning content and also different ways for presenting it to the users.

Regarding to the way that the learning platforms present the learning content Glavinić & Granić (2008) showed that there are two main approaches:

- linear information flow, that present the information according to a predefined educational program;
- intelligent information flow, that adapt the information flow according to the learners' capabilities, previous knowledge and evaluation results. In this category are included the intelligent tutoring systems.

An example of successfully adapting a platform to the individual users behavior once the users' learning styles are identified is TSAL, the model built by Tseng et al. (2008) based on two sources of information (the learning styles and learning behavior) only for learners.

The personalization of the learning content to the users' learning styles can be done using many methods. For example, Cabada et al. (2011) used an authoring tool. Yang and Wu (2009) used an attribute-based ant colony algorithm for a similar purpose.

Understanding the relations between the concepts in the process of learning is not a task always easy to be done. Using concept maps helps to understand them and also to evaluate the learning achievement. Before using the concept maps first step is to construct them. Usually this task is done by experts but stimulated by the rapid progress of methodology until today there are many attempts to find a way to fulfil the same task automatically. For example, Bai and Chen (2008) proposed a method based on fuzzy rules to build concept maps. Burdescu et al. (2010) used partitioning methods to build the concept maps.

In this paper is proposed a conceptual model of an e-learning platform that integrate many from the features presented above like detection of users' learning styles, using concept maps, providing many possibilities to present the learning content, recording users' events in order to detect their actions, analyze the users' behavior related to the platform interface or during the learning process in order to dynamically adapt platform to their behavior.

In the case of proposed platform design, users (learners) are assisted by platform and by tutors (teachers) during the learning process. The platform also assist tutors to help users during the learning process by analyzing the behavior for users and tutors and generating different types of feedbacks.

To achieve that, the platform's design must fulfil a series of conditions presented below.

The platform must:

1. allow the evaluation users in order to determine their learning styles. A way to do that was proposed by Felder & Soloman, (1996).
2. allow the classification of the delivered learning content by its subject. An example of classification that can be used is OER Commons classification. Identifying the subject of each learning content helps to improve the process of determining the proper learning content presentation's form according to the users' learning styles.
3. allow the delivery of learning content at least reactive to users' actions. Only in this case the e-learning platform can records when and how a user goes through the provided learning content during the learning process.
4. allow the possibility to monitor, identify and record the users' events and actions;
5. allow the possibility to analyze the users' behavior at individual and group level;
6. allow to generate feedback to users at individual and group level;

Taking into account the previous conditions a proposed e-learning platform design is presented in figure 1.

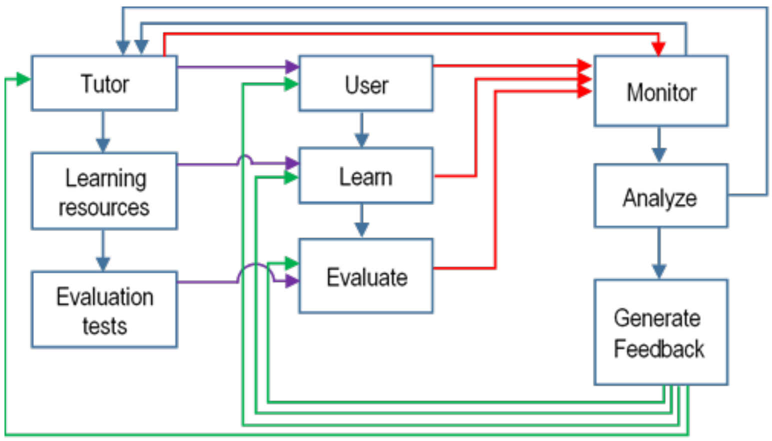

Figure 1. Dynamically adapting e-learning platform design

The platform design presented in figure 1 highlights the following:

- tutors create learning resources using *Learning resources* module and evaluation tests using *Evaluation tests* module;
- users assimilate the provided learning resources using *Learn* module;
- the users' knowledge level is evaluate using *Evaluate* module
- the e-learning platform records all the actions of users and tutors using *Monitor* module (red arrows in figure 1).
- the recorded events, actions and evaluations' results of users and the activities of tutors are analyzed periodically using *Analyze* module.
- the results of users' activities analyses are used to generate feedback for each user and the results of tutors' activities analyses are used to generate feedback for each tutor with the help of *Generate feedback* module (green arrows in figure 1).
- tutors can generate direct feedback to users by making their personal analyses of users' activities and evaluations' results (purple arrows in figure 1).

Using this design, the platform can adapt itself:

- to the users' behavior by providing adequate facilities and providing the learning content in the adequate presentation form according to the users' learning styles, subject of learning content and users' level of knowledge.
- to the tutors behavior by providing adequate facilities and information in the process of assisting users.

Because this platform's design allow tutors' access to information provided by Monitor and Analyze module regarding to users' activities and evaluations' results the tutors' direct feedback for each user is also improved.

2. Evaluating the learning style

Learning styles are used to identify how a user process information and learns. Users with different learning styles need different features for successfully assimilate the delivered learning content.

The learning content can be provided by the platform using many presentation forms like: text, drawings, images, audio, animation or video etc. In order to facilitate the learning process, the platform must have the possibility to present learning content by using the best combination of presentation forms according to the users' learning styles characteristics.

The evaluation and identification of the learning styles can be done using one of the models already created until now like:

- Kolb's (1984) model which can be used to classify the users in four categories: convergent learners, divergent learners, assimilators, and accommodators.
- Honey (1986) model which can distinguish between four learning styles: activist, reflector, theorist and pragmatist.
- Keefe's (1987) model which classify the users learning style in four categories: sequential processing, discrimination, analytic and spatial.
- Felder&Silverman's (1988) model which allow to discriminate between 32 learning styles by including users in specialized category: intuitive/sensitive, global/sequential, visual/verbal, inductive/deductive and active/reflective.
- Fleming's (1995) model which can categorize the users by their learning styles using the following categories: visual learner, auditory learner, read/write learner and kinesthetic learner. A system to achieve that was proposed by Keefe (1987).

All of these models have advantages and disadvantages signaled by the specialized literature like in the case of Kolb's model criticized by Koob&Funk (2002).

Once selected, the model will help to classify the users by their learning style based on specialized questionnaire which can be integrated into e-learning platform. A common way to realize that is to force all users at the beginning of the learning process to complete a specialized questionnaire according to the adopted model.

3. Designing reactive e-learning content

An e-learning reactive content must create the possibility to identify and record user's actions. In order to realize that, a flexible structure of the learning content and a series of events connected to that structure must be defined.

The learning content can be provided by the platform using learning object metadata (LOM).

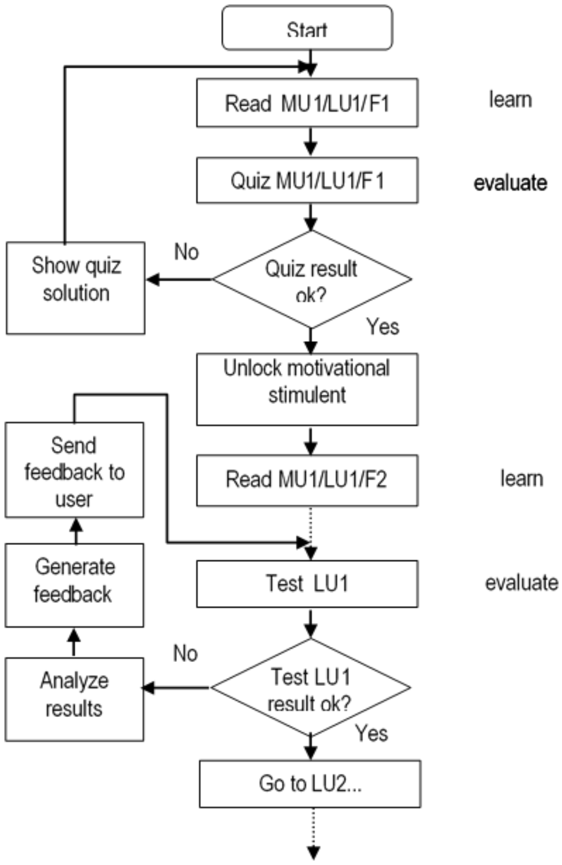

Figure 2. The flow of learning process based on IEEE-LOM structure and the corresponding user's actions

According to IEEE-LOM (2002) standard, LOM must be structured using four levels of granularity: fragments (F), learning units (LU), modular unit (MU) and set of courses (SC).

In the process of using the e-learning platform users generate platform interface's events like searching or using modules/components. A special category of events is that of events linked to the learning process like: information search, read/learn, evaluate etc.

The flow of learning process, using IEEE-LOM structure and the corresponding users' actions are presented in figure 2. The flow presents also only the immediate feedback generate by the platform at the level of a fragment.

Using this structure a learning content path can be easily created taking into account the logical sequence of the fragments, learning units, modular units.

To allow the adaptation to the users' learning styles, each fragment of the learning content must be created using all variety of presentation forms: text, images, audio, animation, video etc.. This will conduct to the creation of not only one but many learning resources to present the same learning content starting from the lowest level. This will complicate the activity of learning content creation but will also create the possibility for the platform to activate the best combination of learning content's presenting forms according to each user's learning styles.

4. Analyzing the users' behavior

The users' behavior can be analyzed using the following common data sources: e-learning server log, e-learning platform's log and e-learning platform's database.

First variant has the disadvantage of large volume of information from which only a part can be used to analyze the behavior of the users and that only after is filtered. The other two don't need to be filtered because they are already recording only the e-learning platform users' activity. The last one is the easiest to use.

Any user's action will be recorded as an event or as a succession of events related to an object and generated inside of a platform module. For example, *learn* action can be recorded inside of Learn module as successive mouse clicks (meaning: click on next page button, play button, scroll bar small or large change etc.) separated by larger time intervals than in the case of *information search* action when the intervals between clicks are usually shorter.

The recorded user's events will provide information that highlight how it use and interact with the learning content at the level of each fragment. All the events must be recorded by a specialized module of e-learning platform for monitoring the activities of all users.

All these events must be converted back into user actions associated with the events characteristics like, time, location in platform where user generated them, position in page, type of controls used etc.. The process of conversion is depending by the platform interface and capabilities and must be personalized at the level of each e-learning platform.

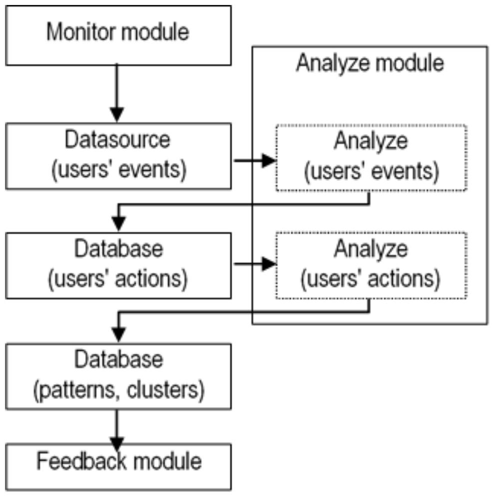

Figure 3. Flow of users' behavior analysis process

Using machine learning methods like neural network or cluster analyze etc., the users' events can be converted into users' actions and create flexibility starting from the individual level to the group level.

The analyze must be made periodically (once per day/week/month). A smaller period of time will allow faster feedback but it may create discomfort or confusion at the level of users because of too rapid changes of platform behavior and a larger period of time can create stability in case of platform use but will slower the feedback and will reduce the platform adaptability.

The flow of the users' behavior analysis process is shown in figure 3.

The analyze of users' actions can also be done using the data mining methods for discover and extract users' patterns at the individual or group level. The analyze is better to be done in a specialized module of the e-learning platform.

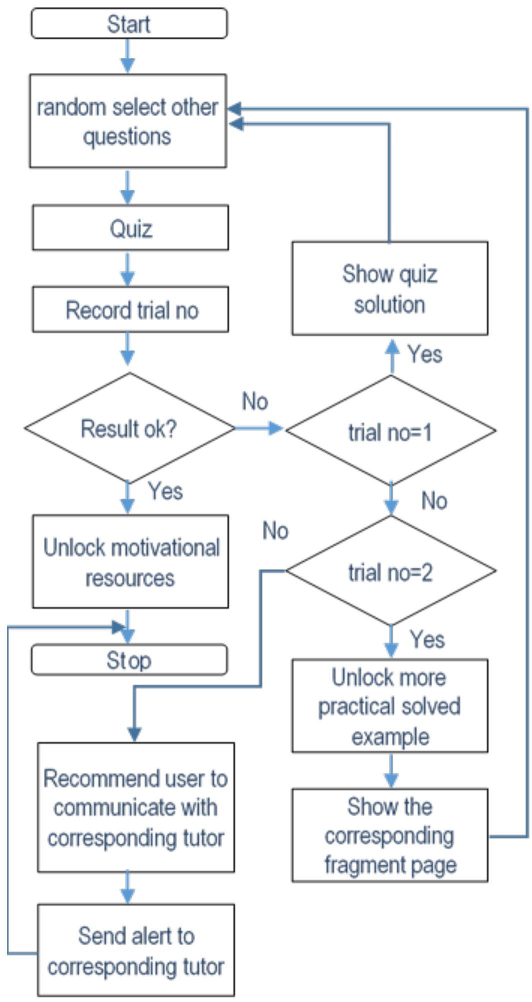

Figure 4. Flow of immediate individual users' feedback generation process

The results of the analyze will be used to generate feedback for each individual user, for all determined users' groups and for tutors.

5. Generating users' feedback

The feedback in the case of presented conceptual model can be provided for two levels: individual and group. At the individual level the feedback can be generated: immediate (like in the case presented in figure 2) or periodical (after periodical users' events and actions analyze). The feedback can be generated by platform's interface use, by information search and by learning activities.

This paper will focus only on the feedback generated by user's learning activities and will start from the following hypothesis:

- for each fragment a correspondent quiz is defined.
- an user assimilates a fragment if obtain good result at corresponding quiz.
- an user assimilates a learning unit if obtain good results at all corresponding quizzes.
- for each modular unit a correspondent test is defined.
- an user assimilates a modular unit if obtain good result at the corresponding test.

If the individual feedback is centered on the evaluation at the level of fragment, learning unit, module unit then an example of flow for generating corresponding immediate feedback at the level of a fragment will look like in figure 4. Using a rating system with respect to a scale from 1 to 10 (1-worst..10-best) for evaluating the learning content which provide the explanations for every fragment will help to generate the feedback at the level of users' groups.

Aggregating the feedback at the level of all fragments contained by a learning unit can provide a rating at the level of that learning unit. In a similar manner can be determined the rating at the level of a modular unit.

In this case if n_i represents the rating for F_i fragment then the rating for a learning unit will be:

$LU_j = \sum_{i=1}^{k} n_i$, where k – number of fragments from the learning unit j.

In a similar manner we can evaluate the rating of a modular unit:

$MU_l = \sum_{j=1}^{m} LU_j$, where m – number of learning units from the modular unit l.

This rating system allow using statistical analyze to identify the best manner to explain a fragment for any type of user's learning style.

The rating system can be also used to provide feedback for a group of users regarding the importance of a fragment, a learning unit or a modular unit in order to speed up the learning process. This type of feedback is provided for tutors also because they can use the information for improving the learning content and tests.

6. Conclusion

The presented design can be used at the level of a new or existing e-learning platform. It is centered on users but also assist tutors to generate feedback for users. It can provide feedback at individual and group level for users. It also provide two types of feedback during the learning process: immediate based on users' actions and results and delayed based on periodically deep analyze of users' behavior. It define a way to construct learning content in order to facilitate the record and analyze of users' events and actions.

No evaluation of improvements at the level of e-learning platform is provided. The conceptual model design is used to make changes in TESYS e-learning platform (an e-learning platform used in present at the level of Faculty of Economics and Business Administration - University of Craiova) in order to make it adaptable to the users' behavior.

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