Adaptation of Feedback in e-learning System at Individual and Group Level

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Abstract. This paper discusses the issue of feedback personalization and adaptation in e-learning systems, and distinguishes between adaptation to the individual user and to groups of users. We briefly review the scope of feedback use in e-learning systems and outline the necessity of feedback adaptation in an e-learning system. We are trying to answer the following question: what is the difference between personalization of feedback at the individual and the group level. Particularly, we are focusing on the analysis of the differences in user modeling for feedback personalization/adaptation in e-learning systems. We discuss what kind of characteristics could be included in the learner model for individual and group personalization. The main purpose of this paper is to attract the attention of the research community to the problem of the feedback personalization and to be helpful in further studies and implementation of individual and group personalization of feedback in e-learning systems. We present some recent feedback adaptation experiments that try to determine the usefulness of certain types of adaptation.

Keywords: Personalized Feedback, Feedback Adaptation, Personalized e-learning, Individual and Group User Model, Individual Characteristics

1 Introduction

Feedback is an important part of the learning and interaction in e-learning systems. In this paper we consider feedback as information the user receives from the system as the result of his/her action. Thus, feedback in e-learning is the mechanism that tends to replace the teacher who provides comments, advice, and explanations and evaluates the students in traditional learning environments. In general, the feedback in e-learning occurs not only in the assessment process, but can be provided to a student during navigation through learning materials, communication and collaboration with other students, in the process of work with personal information and managing the courses (planning, enrolling, completing), etc. Even the alerts and reminders that often appear in the e-learning system can be considered as feedback. However, in this paper we focus on analysis of feedback that the user receives during the assessment in an e-learning application.

According to [13] the feedback mechanisms that are used by students have changed with the advances and growth of web-based learning systems. Bischoff [3] argued that students need regular feedback in order to know how their performance was evaluated, and how they can improve it, and also how their grades are calculated. The effective elements of online teaching include frequent and consistent online feedback, diplomatic online feedback, and evaluative online feedback [3]. It was suggested in [13] that feedback in a web-based learning system should have the following qualities: (i) prompt, timely, and thorough online feedback; (ii) ongoing formative feedback about online group discussions; (iii) ongoing summative feedback about grades; (iv) constructive, supportive, and substantive online feedback; (v) specific, objective, and individual online feedback; and, (vi) consistent online feedback.

The following problems with feedback design in e-learning systems can be outlined: (i) feedback representation (what should be included into feedback and what kind of structure should it have); (ii) time of feedback presentation (either immediate or delayed feedback); (iii) distraction of students from the learning by feedback.
In [16] we argued that the problems of feedback listed above could be partially solved by adaptation of feedback to the tasks and to the characteristics of an individual user or the group of users. In [10] the authors also emphasized the necessity of feedback personalization in e-learning systems and proposed adaptive feedback framework.

In this paper we distinguish between feedback adaptation in e-learning systems from the perspective of individual and/or group adaptation. Individual adaptation means that feedback is adapted to each student and his/her individual (combination of) characteristics. For example, the individual characteristics could include the user’s knowledge of the subject being studied (knowledge of the main concepts, formulas, etc) and the number of mistakes the user makes during the testing. The time and the way of feedback presentation could be personalized to these individual characteristics. For example, if the user has started to make some mistakes more often the system can present the feedback more often and include more detailed explanations in the feedback (compared to the feedback given to a user who only occasionally makes a mistake). The information that is presented in the feedback can be also personalized by relating to concepts that are already mastered by the user.

Group adaptation supposes that the system adapts the feedback to common characteristics of a group of users. For example, they can be grouped according to their learning style. Immediate feedback could be presented in a brief form for active users, while detailed elaborated feedback could be presented to reflective learners. Another example of the group adaptation of feedback is personalization of the feedback to students who have passed the same courses before. The feedback could include references to the previous course (if the student has passed it) or the detailed explanation (in the case the material might be unknown to the user as s/he has not taken the course).

The current paper analyzes what and how can be adapted in feedback of an e-learning system at the individual and group levels. The rest of the paper is organized as follows. In Section 2 we analyze the specific aspects of feedback personalization to the individual users in e-learning systems. Section 3 discusses the issue of the group adaptation of feedback. Section 4 summarizes the differences between individual and group personalization of feedback in e-learning system. In Section 5 we describe recently completed experiments. In one experiment we used feedback to multiple-choice tests in the Moodle learning system, and in another experiment we are analyzing the suitability of different types of feedback for field-dependent and field-independent users, using the AHA! system [7]. We briefly conclude with the summary of the paper and outline the directions of the further work in Section 6.

2 Individual Feedback Adaptation in e-learning System

In this section we discuss individual feedback adaptation in e-learning systems, by analyzing the following main questions: (1) to which individual characteristics of the user (learner model parameters) feedback can be adapted, (2) how those learner model characteristics could be acquired by the system, (3) what can be adapted to the individual users in the feedback of e-learning systems?

Adaptation to the user’s individual characteristics is traditionally organized on the basis of a user model [11, 2]. A user model determines the user’s goals, tasks, beliefs, and characteristics, which are important for adaptation [11]. In the adaptive e-learning systems a user model is traditionally called student or learner model (or profile).

According to Brusilovsky [4] a hypermedia application can be adapted to the following characteristics of the user: knowledge, goals, background and experience, preferences, interests, individual traits and environment. Besides the parameters, which are traditionally included into the user (learner) model that are listed above, the following groups of individual user characteristics could be important for the adaptation of e-learning systems: personal data (including demographic characteristics such age, data, culture); psychological, cognitive and physiological parameters such as user’s attention (simple and complex reaction time), memory (verbal working memory, long-term memory), cognitive abilities (spatial arrangement, etc.), user’s internality/externality, cognitive and learning styles, and personal decision abilities. Recent investigations of these features have shown that the cognitive characteristics have an appreciable impact on hypermedia
and web-systems adaptation (for example, [6]). However, we defer their discussion to the next section as cognitive styles, as well as user preferences, lead to a stereotypical form of adaptation that we could consider a form of group adaptation.

We will try to outline the characteristics that can be important for individual feedback adaptation in e-learning system:

**1) Personal data**

Personal data typically includes parameters such as age, gender, etc. that lead to grouping users and performing stereotype adaptation. The only real individual use of personal data is to give a “personal touch” to the application, for instance by including the user’s name in the feedback. (Example: “Sorry, this answer is incorrect, Paul. You should revisit…”)

**2) Knowledge**

Of course the user’s answers to a test provide information about the user’s knowledge, but individual feedback adaptation means that other parts of the user’s knowledge play a role in the feedback the learner receives. The feedback to a (wrong) answer can be more informative when it refers to knowledge the learner already has, perhaps about related topics. We plan to perform an experiment to verify the usefulness of this type of adaptation.

**3) Interaction Parameters**

For the purposes of feedback adaptation the following interaction parameters, grouped according the taxonomy suggested in [15], can be taken into consideration: (i) knowledge data (discussed above); (ii) chronometric data (time spent viewing pages with learning materials, time spent for passing the question in the tests and the total time spent on the assignment, the time of idle intervals); (iii) try data (the number of attempts to pass the tests or assignment, the number of times needed to give the correct answer for the certain question); and, (iv) navigation data (visited links and pages, number of visits, the frequency that specific selections have been made).

The way and form of feedback presentation can be adapted to the listed characteristics. For example, feedback could be presented more frequently for the users who have started to make more mistakes, and feedback can be delayed to slow down students who are answering too quickly and sloppily.

The user’s features which are important for individual feedback adaptation can be collected in several ways depending on the nature of the e-learning system. First, they can be collected using separate tasks (for example, small test to evaluate the user’s primary knowledge and interaction skills) or they can be derived from the performance of the user in the actual e-learning task. Secondly, the system can use some general “prototypical” or stereotype user profile or previous information of the user’s performance as a starting point and after that obtain more accurate information about the user and gradually move from stereotypical feedback to more individually personalized feedback.

True individual feedback based on an individual’s evolving characteristics like knowledge, chronometric, try and navigation data requires a tight coupling of the part of the adaptive system that provides learning material and the part that provides feedback. We are planning an experiment using a small extension to the AHA! system [7] to apply the same form of content adaptation (using conditionally included fragments) to feedback as it is done in a course text.

### 3 Personalization of Feedback to a Group of Users or a Stereotype

Adaptation to a group of users is traditionally performed on the basis of a group (or stereotype) model. The main purpose of stereotype modeling is to model a group of users in order to adapt to them as a group of users, not as individuals. This approach has been proven to be very useful for application areas in which a quick but not necessarily completely accurate assessment of the user’s background knowledge is required. It is one of the first mechanisms that have been used in adaptation of recommender systems [14].

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1 Sometimes in the literature it is possible to find another meaning of the group user modeling and group personalization: group modeling is used for the collaborative environments in which group members must work together to reach joint decisions or, in entertainment settings, in which media are enjoyed simultaneously by a group of users. So the system is adapted to the group of users who are performing the collaborative task together.
According to Lock [12] stereotype and group modeling are not synonymous. The user is considered to belong to a single group in group modeling adaptive systems, whereas in stereotype-based modeling applications a user belongs to multiple groups [12]. In this paper we are analyzing the group adaptation in the context where the user is assigned to one or several groups and the adaptation is performed according the characteristics of those groups (and thus we do not emphasize the difference between group and stereotype adaptation). For example, we can have in the system the following two group (stereotype) models: (i) the first one characterizes the user’s knowledge $Kn$ by the courses s/he has already passed and classifies the user into the several groups ($A$ – students that have passed course $A$, $B$ – students that have passed course $B$, $C$ – students that have passed both courses $A$ and $B$); (ii) the second one defines the user cognitive style according to the Field Dependent/Field Independent Scale (FD/FI) [18].

Thus the student who has passed the course $B$ and has field independent cognitive style could be assigned to the two groups $Ui\{B, FI\}$. The adaptation should be organized according to those two groups. Typically the different partitionings in groups lead to independent (or orthogonal) kinds of adaptation. Having taken course $A$ previously can be taken into account to choose between explanations, whereas adaptation to FD/FI learning styles can be done independently from that (by changing recommended navigation paths for instance). In case there are conflicts the system should have a weighting scheme, where the priority of adaptation should be given to the each of the stereotype models.

In this section we will analyze the possibilities of feedback adaptation in e-learning systems to group user models by answering to the questions, similar to the questions from Section 3: (1) according to which characteristics could the students be grouped for adaptation of feedback in e-learning system, and (2) what can be adapted to a group model in feedback of e-learning systems?

We suggest that the users should be divided to the stereotype groups according long-term characteristics (characteristics that do not frequently change). (Shorter-term, more detailed and individual changes in characteristics lead to individual adaptation, not group adaptation.) The following groups of parameters or “what can be adapted to” can be outlined:

1) Personal data (Demographical Characteristics)

Personal data include parameters that are relatively stable, such as the user’s age, gender, time zone, language and cultural properties. They lead to a clearly defined partitioning of the whole user population. Age is important in the e-learning applications, to adapt differently to small children, grade school, high school or adults. For example, an e-learning system can be used in a school, where for the smallest children feedback should include entertainment and motivational components. Informational aspects of feedback are more important for the elder student. Audio feedback could only annoy and distract the elder students, while it could be quite positive for the young children, especially if they do not have enough reading skills. The gender of the user can influence to the adaptation process as males and females differ in terms of navigation support, attitudes, information seeking strategies and media preferences [1, 8].

2) Professional

Among the professional characteristics of the user the following are especially important for the feedback adaptation: the user’s skills and experience (mainly in interaction with the e-learning system: familiarity with its structure, ease of navigation within it) and the user’s background (his/her knowledge of the subject that s/he is studying and of related subjects). Novice users should receive the maximal guidance and support via feedback while this is not required for expert users. Professional experience can also be used: when the user has a certain job for a considerable time this also leads to experience, perhaps equivalent to having taken certain courses although the courses do not appear in the user’s learning history.

3) Psychological and cognitive

The following characteristics that are important for the feedback adaptation can be outlined among this group: (i) the user’s attention (reaction time, types of errors, and omitted contents). The feedback as well as its timing could be adapted to the changes in the user’s attention and help the user to focus on the task. (Like with age, reaction times and errors can be “partitioned” so as to obtain a few “groups” of users rather than considering all individual values.); (ii) the user’s memory (verbal, visual memory); (iii) the user’s cognitive abilities (intelligence, educational level, verbal or spatial skills, etc. as estimates of these abilities); and (iv) the user’s cognitive and learning styles. The knowledge of the learning styles allows
determining the best learning strategies that can be used for the certain user. Thus, the feedback could be presented in the way that facilitates the learning.

4) Physiological
   This group of characteristics could include personal abilities/disabilities. For the feedback vision and hearing characteristics of the user could be particularly important. The system could provide audio feedback for visually impaired users and vice versa – verbal and visual feedback for hearing impaired students.

5) Environment
   As e-learning applications become ubiquitous, adaptation of feedback to environmental settings should be provided to the users. The system can adapt feedback to the user’s access platform. For example, student can use mobile phone to pass the test in the e-learning system and receive the feedback that can be presented by phone. The network connection (bandwidth limitation) should be also taken into consideration.

6) User Preferences
   This group of characteristics includes the parameters that characterize the user’s personal preferences, interests, goals, habits and mood. Users may prefer some links or parts of the pages over others and this can influence the adaptation of the feedback in e-learning. For example, the user can prefer to receive feedback in a pop-up window.

   It is unlikely that feedback adaptation systems will be developed in the near future that can take all the above mentioned characteristics into account. We have to be realistic, especially considering that the feedback to answers on tests as part of a course is a relatively small part of the entire interaction between the learner and the system. So instead of looking at all these possible parameters that influence the adaptation we can look at the taxonomy for what can be adapted, as suggested in [16]. The feedback in e-learning systems can vary according to its complexity (no-feedback, knowledge-of-response, knowledge-of-correct-response, answer until correct, elaborated), form of presentation (textual, visual, audio, video), user’s progress within a task (immediate, continuous, summative), function (confirmation, informing, correcting the user, explaining, evaluating, motivating, rewarding the user, and attracting his/her attention) and time of presentation (immediate and delayed).

In the next section we analyze the advantages and disadvantages of individual versus group personalization of feedback in e-learning systems and suggest our answer to the question, in which situations it is better to use individual personalization and in which situations it is better to adapt feedback to group model in e-learning system.

4 Individual vs. Group Personalization of Feedback

The main difference between individual and group personalization of feedback is in the way the user modeling and user identification are organized as well as what parameters are included into the model. Individual adaptation is performed on the basis of a detailed individual model of the user, while group personalization is performed on the basis of group (or stereotype) models to which the user is assigned according to the value of one or several parameters. This is the traditional explanation of the differences between individual and group user modeling [14]. It is also important to emphasize that the group adaptation is relatively easy to implement when based on long-term user models, when there is no need to track changes of characteristics in the short-term (i.e. potentially rapidly changing characteristics). On the contrary, since the short-term user models include many parameters that may change even during the same interaction session, it is unrealistic to think that these parameters will change in a similar way with different individuals and therefore, the tracking of such changes at a group level is hardly possible and needs to be implemented at the individual level. The problem of tracking and handling changes in user models may become even more severe when hidden (not directly observable) contexts change over time.

In Table 1 we summarize the most obvious advantages and disadvantages of the individual and group personalization of feedback in e-learning systems. From the table it is clear that the purely individual or purely group-based approaches both have shortcomings. However, a combined approach is possible that combines the advantages of both approaches: the group (stereotype) model can be used to classify new users and set initial values of the user model, whereas the
individual user model could be used while the user interacts with the system to correct and enlarge
the information about the user that can be used in adaptation. The user model could include both
short-term (for individual adaptation) and long-term characteristics (for group adaptation). The
truly individual adaptation could become sufficiently unobtrusive that it does not hinder users
discussing their experience with the e-learning application.

Table 1. Individual vs. Group Feedback Adaptation

<table>
<thead>
<tr>
<th></th>
<th>Individual</th>
<th>Group</th>
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<tbody>
<tr>
<td>Proc</td>
<td>– The user can receive the feedback that more exactly corresponds to her/his individual characteristics.</td>
<td>– The implementation of group adaptation is easier than supporting the individual adaptation (especially dynamic adaptation to the changes of the user characteristics).</td>
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<tr>
<td></td>
<td>– The feedback can be dynamically adapted to the changes of the user individual characteristics and performance (attention, number of mistakes, etc.).</td>
<td>– The users will more probably receive the same feedback and could refer to it during the discussions.</td>
</tr>
<tr>
<td>Cons</td>
<td>– Difficulty of implementation as the system should observe the changes of the interaction parameters and support the dynamic adaptation to these changes.</td>
<td>– The mistakes in initial assignment of the user to the certain group could lead to the problem that the user experience difficulties and interaction and the feedback is distracting the user instead of helping him/her.</td>
</tr>
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In our opinion this combined approach is the most promising for organizing the feedback adaptation in e-learning systems. This approach can allow taking into account both short-term and long-term user preferences, needs, interests and the parameters of interaction.

5 Feedback Personalization Experiments with Moodle and AHA!

In this section we will discuss a few experiments with feedback adaptation, using the Moodle e-learning system\(^2\) and using the adaptive hypermedia system AHA!\(^3\) [7]. The first experiment is finished and analyzed, the second experiment is completed and is being currently analyzed.

We have recently used Moodle for a pilot experiment that was aimed at studying the interrelations between personal learning styles and reaction to immediate and delayed feedback presentation. The main goal of the experiment was to discover whether there was a difference in the performance of the students with various learning styles (active/reflective, global/sequential, sensitive/intuitive, visual/verbal) in the tests, where brief and detailed immediate feedback were presented. The learning styles of the users were acquired using the index of learning styles test that allows to determine the learning style (LS) according to the Felder-Silverman\(^{\text{a}}\) model [9]. Two performance parameters were evaluated: the score of the user on the test and the time used for completing the test.

In this paper we are presenting several outputs of the experiment that can illustrate the stereotype feedback adaptation (see [17] for more results). The following main tendencies were discovered with respect to the active/reflective LS and brief/elaborated immediate feedback: (i) active learners performed better (with the higher score and less time) on average in the test where brief immediate feedback was presented; (ii) the performance of the reflective learners was better in the test with detailed immediate feedback; (iii) the users that were balanced between active and reflective LS performed better in the tests where brief immediate feedback was presented; and, (iv) the users with the tendency to active LS have shown the same score in the tests with brief and detailed immediate feedback.

Although the obtained results are not statistically significant due to the limited number of the participants of the experiment (12 students participated in the pilot experiment), they allow to conclude that the users could be assigned to the three stereotype groups according to their active/reflective learning style. The immediate feedback should be adapted in the following way:

\(^2\) http://www.moodle.org
\(^3\) http://aha.win.tue.nl\(/\)
brief immediate feedback should be presented to the active learners and the learners who are well balanced between active and reflective LS, while detailed (elaborated) immediate feedback should be presented to the students with reflective LS.

In the experiment with the AHA! system the possibilities of adaptation of the elaborated immediate feedback to field dependent/field independent cognitive styles [18] were analyzed. The students (that have taken the ‘Adaptive Hypermedia’ course at Eindhoven University of Technology) answered to 4 tests (of 10 questions each) on the course materials in AHA! system.

In the first two tests the presentation of immediate feedback alternated in the questions: the direct elaborated (detailed) feedback was provided to the even questions and the ‘pointing to elaborate’ feedback was presented after submission of the answers to the odd questions. The direct elaborate feedback included the detailed explanations of the answers (why the answer was correct or incorrect) and information about the correct variant of the answer. The ‘pointing to elaborate’ feedback was used to present a brief explanation of the answer together with a hyperlink to the original explanation (on slides of the presentation, where the corresponding material was discussed). The users also answered to the question about their preference of direct elaborated vs. ‘pointing elaborated’ feedback after passing the test.

In the second two tests the presentation of delayed (after all questions) feedback alternated in the same way: either direct elaborated feedback or ‘pointing to elaborate’ feedback was presented. The users were provided with the feedback only after they had answered all 10 questions of the test. The preferences of the users were also assessed by the additional question.

Field dependent users require additional reinforcements [18] and need reducing complexity of navigation. The original hypothesis for our experiment was that the field independent users would prefer and have better performance with the direct elaborated feedback, while the ‘pointing elaborated’ feedback is better for field dependent students (as it provides the context they need more strongly). We are currently gathering the final data and will analyze the results before the workshop. The responses of 15 students (7 FI users, 3 with the tendency to FI, 3 mixed FD/FI and 2 with the tendency to FD cognitive style) have already been analyzed. Most of the students preferred direct elaborated immediate feedback. However two FI users, one student whose cognitive style was balanced between FD and FI and one student with the bias to be FD preferred to have feedback with the hyperlinks (‘pointing’ elaborated feedback). In the tests where delayed elaborated feedback was presented three of seven FI students preferred the feedback with hyperlinks to the slides instead of direct elaborated feedback, while the students, whose cognitive styles were balanced between FD and FI and the student with the bias to be FD preferred to have direct elaborated feedback.

Thus, the obtained results did not demonstrate the strong relations between user’s cognitive styles and their preferences of direct or ‘pointing’ elaborated feedback: whether the feedback is immediate or delayed seems to influence the result. Further experimental research on the interrelations between the personal LS and the adaptable feedback parameters such as presentation of direct elaborated and ‘pointing’ elaborated immediate and delayed feedback is needed. The differences found thus far are small enough to indicate that a larger experiment is necessary in order to come up with truly convincing results.

6 Discussion and Further Work

Feedback that is provided to the user by the system is an integral part of e-learning. Feedback adaptation seems to be a promising aspect of the e-learning systems personalization. In this paper we have analyzed personalization of feedback from the perspective of individual and group adaptation. We discussed what characteristics are important for the individual and group adaptation. We overviewed the main parameters of the feedback that could be adapted to the user (group) model characteristics. The differences between individual and group feedback adaptation were underlined. We considered the combined group and individual feedback adaptation to be perspective for the implementation in e-learning system.

In our paper we proposed a number of hypotheses about the interrelation between the user (group) model characteristics and adaptable parameters of the feedback. Those hypotheses are based on the existing knowledge about the characteristics and the results of several pilot experiments. For further research an experimental study of the interrelations between the user
model characteristics and the adaptable feedback parameters is necessary. It is important to investigate what user characteristics have an influence to the adaptable feedback parameters and how do they affect interaction and learning process. The experiments should allow obtaining knowledge about the interrelations between user model characteristics and adaptable parameters of feedback that could be used by an adaptation engine of an e-learning system.

In the meantime we continue the experimental research of feedback adaptation to the user (group) model in AHA! and Moodle. In the future we are planning an experiment on individual feedback adaptation and the combined (group and individual) personalization using a small extension to the AHA! system.

We hope that the paper will attract the attention of the research community to the problem of the feedback personalization and will be helpful in further studies and implementation of individual and group personalization of feedback in e-learning systems.

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