UNIVERSITÄT DES SAARLANDES
FACHRICHTUNG INFORMATIK
D–66123 SAARBRÜCKEN
GERMANY
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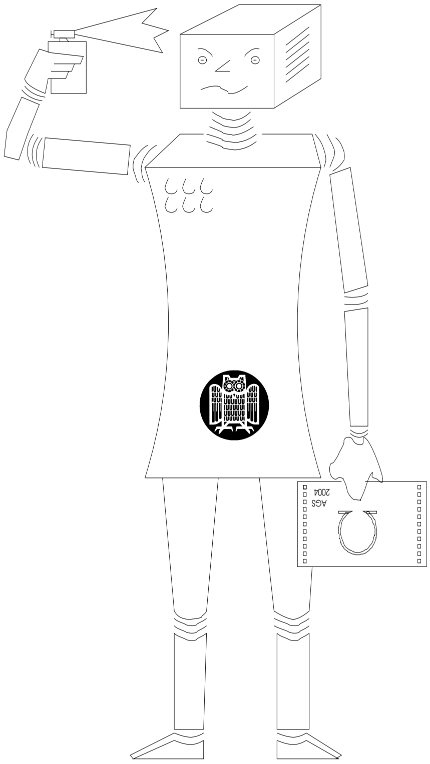

Gender-Biased Adaptations in Educational Adaptive Hypermedia

Erica Melis, Carsten Ullrich
FR Informatik, Saarland Univ.
melis@dfki.de,cullrich@dfki.de

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Editor of SEKI series:
Claus-Peter Wirth
FR Informatik, Universität des Saarlandes, D–66123 Saarbrücken, Germany
E-mail: `cp@ags.uni-sb.de`
WWW: `http://www.ags.uni-sb.de/~cp/welcome.html`

Gender-Biased Adaptations in Educational Adaptive Hypermedia

Erica Melis, Carsten Ullrich
FR Informatik, Saarland Univ.
melis@dfki.de,cullrich@dfki.de

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Abstract

Studies show that there is a statistically significant gender difference regarding computer usage. For instance, a majority of female users expect less success from an interaction with a computer and are more likely to blame themselves in case something goes wrong. As a result, women considerably less often use a computer as a tool than men do. Now, if women do not use a computer as much as men do, they will not profit as much from the advantages of computational systems as they potentially could. That's why this paper reviews work about the causes of this problem, investigates an extended model, and develops possible preventions and reactions to it. Appropriate adaptivity cannot, however, be based on mere gender information which represents a bias only and may imply cliches and discrimination. Adapting a system solely depending on the sex of the user could have the effect all users – men and women – will feel discriminated by facing a system that embodies a cliche. We think that an adaptive system with an appropriate user model can help to avoid a cliche-based treatment: the sex of a student is only used to initialize the user model and as soon as more detailed information about the aptitudes of the user is gained from his/her interaction, the initial values of the user model are refined. Moreover, the user should be in control about the behavior of the system at any time.

1 Introduction

Studies (for instance, [15, 6, 7]) show that there is a statistically relevant gender difference in computer usage. Generally speaking, female students have a significantly lower self-esteem with respect to their abilities in handling computers than males do; they expect less success from an interaction with a computer, and are more likely to blame themselves in case something goes wrong. As a result, women considerably less often use a computer as a tool than men do.

In this paper we address the question of what are the causes of this problem and what can be done about it. We are aware that this topic is a delicate one, the danger of talking about clichés and even discrimination is imminent. Most importantly, one has to keep in mind that these findings represent tendencies only rather than one-to-one mappings.

The tendencies do, however, point at profound problems. The fact that female users use computer less often, at least in Germany and the UK, is alarming for society since a majority of women may not profit as much as they potentially could from the advantages that, e.g., an e-learning system offers as compared to traditional classroom learning.

We are aware that simply adapting a system depending on the sex of its user can have unintended effects. For instance, imagine a hypothetical e-learning system that provides female users with a pink and male users with a blue background. In this case, female as well as male users may feel discriminated facing a system that embodies a cliché. With a more subtle adaptation a discrimination might not be as striking. For instance, what if a persona, a virtual guide, on the initial login provides exclusively female users with a tour through the features of a system? The underlying idea, to ease the interactions with the system, is motivated by good intentions. Still, its realization remains questionable as long as it is oriented on stereotypes only.

This paper starts with a summary of a study [6] that derives a model of the mental factors that influence computer usage. Then, we discuss and refine that model and make it the basis of a Bayesian Net student model. Since we have web-based learning applications in mind, we also look at learning situations and how they are influenced by gender-biased aptitudes. This also holds for the adaptations that are supposed to help learning. These and other adaptations are described in Section 4. Finally, we investigate how adaptivity can help to avoid clichés and discrimination.

2 Empirical Evidences of Gender Differences in Computer Usage

Numerous studies investigate the differences between male and female attitudes towards using a computer as a tool. In the following, we will concentrate on a study by Dickhäuser and Stiensmeier-Pelster. We selected this study because in addition to describing the symptoms (e.g., less women use a computer), it provides a model of the mental factors that influence the computer usage. In this section, we will not comment on the model, although some aspects seem disputable (e.g., why the usage of a computer is not directly correlated with computer choice).

2.1 Model of Mental Factors for Computer Usage

In [6], Dickhäuser and Stiensmeier-Pelster describe a study in which they investigate the causes of gender differences in computer usage. 100 male and 100 females students were recruited in the computer center of University of Bielefeld, Germany, and asked to complete a questionnaire in which the subjects had to visualize computer-related success- and failure-scenarios.

From the collected data, the model in Figure 1 was derived. It describes the internal factors and variables that influence the choice of an individual whether to use a computer. The model was derived by a path analysis that, strictly speaking, describes correlational data, only. However, it provides *estimates* of the magnitude and significance of causal connections.

In the model, *attribution index* stands for the causes people attribute their successful or unsuccessful experiences to (personal incapability vs. external computer failure). This index influences peoples individual judgment of their ability of working with a computer, the *self-concept of abil-*

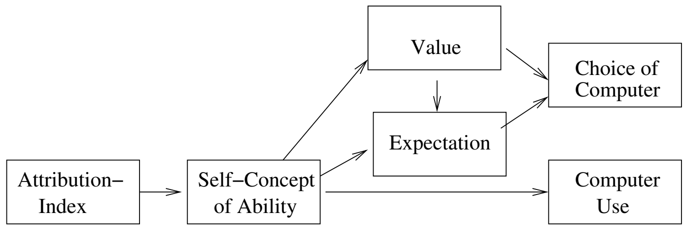

Figure 1: Model of Mental Factors for Computer Usage from [6]

ity. The attribution failure bias of females is also known from other empirical studies not directly related to computers and, presumably, for many female readers from self-inspection.

The self-concept of ability determines the frequency of their *computer use* to some extend; it additionally effects *value* (the individual perception of value of computer work in a specific situation) and the *expectation* of using a computer, which is also influenced by value. Value and expectation determine whether a person chooses to use a computer in a specific situation (*choice of computer*).

This model can explain the behavior of both, male and female subjects. The values of some of the variables, e.g., whether subjects feel confident or not, differ significantly between average male and female students. Interestingly (and in contrast to other studies, e.g., [18]), the study did not show gender differences with respect to the assigned value and potential choice of computers. This means that female students assigned the same benefits to computer usage as male students and, in principle, would use a computer as frequently. This implies that female users need not to be convinced of the advantages of the computer as a tool, but that there are other factors that need to be addressed in order to make them choose a computer more often. These factors and additional differences that come into play are described in the following.

2.2 Gender Differences in Computer Work

The empirical study in [6] as well as other studies identified the following biases of female users of computers as opposed to males. Females tend to

- attribute the cause of unsuccessful experiences to themselves more often than male subjects: in case an interaction did not lead to the expected result even though the cause may have been a software error, confusing menus, or features that were complicated and unintuitive to use, female subject attributed the cause of failure to themselves. In contrast, male subjects more often blame the software or the programmer.

- have a lower judgment of their computer-specific capabilites than male subjects: this observation is not restrained to computers. Several studies ([4, 10]) report that female subjects tend to under-estimate their technological competencies. Conversely, male subjects are likely to show the opposite behavior. They tend to exhibit an disproportionate positive view on their technical skills.

- expect less success as a consequence of the failure attribution and the lower self-judgment. When asked to visualize computer scenarios such as using a word processor, females envisage the interaction not to lead to a successful outcome more often than male subjects.

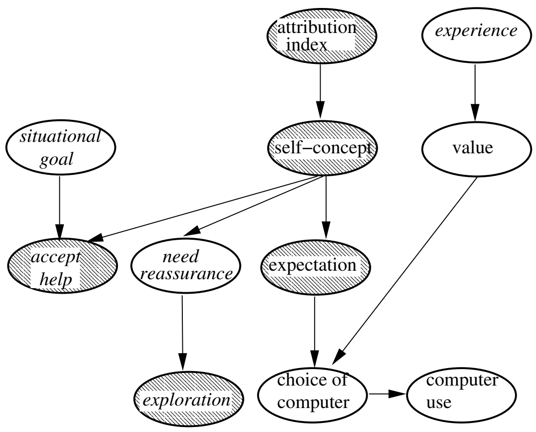

Figure 2: Bayesian Net Student Model

- use computers less intensively. Compared to the male subjects, female subjects work with computer software less often. This observation was also confirmed in other studies (e.g., [10]).

2.3 Additional Findings in e-Learning

In learning, additional gender-specific factors come into play. Female students are biased to accept (and possibly seek) help, whereas males rather tend to work independently. This difference may be a consequence of the self-concepts but it may also be influenced by other variables or even be an independent variable. For instance, this help-behavior may be influenced by whether the (situational) goal is performance-biased or learning-biased. In turn, this situational goal may be influenced by the competitiveness attitude of the individual person. For this attitude it is known that typically males behave more competitive at least in groups of males and that performance is more important to them than communication, learning, etc.

Now, research on self-explanation [11] suggests that some of the positive effects of self-explanation in learning should be attributed to the situational goal because the goal of self-explanation is understanding rather than the usual (competitive) performance in problem solving. We conclude that the learning-bias of female students provides an advantage over the performance-bias of male students in certain learning situations and for the overall goal of learning. Certainly, these statements represent tendencies and no exclusive characteristics of men or women.

3 Extended Student Model

According to the discussion in Section 2.3, we modify and extend the model from Figure 1. Added nodes are marked in italic fonts.

The structure of this model provides the basis for a Bayesian Net student model whose nodes represent probability variables and whose arrows represent conditional dependencies of variables. The dashed nodes have potentially gender-biased values.

The extended model contains additional variables because it represents mental factors relevant for education adaptive hypermedia. Note that some new variables are behavioral rather than mental characteristics (as it was in Figure 1), e.g., *accept help*. The value of those probabilities can be diagnosed from behavioral symptoms when working with a learning system as opposed to mental characteristics that are diagnosed from questionnaires.

In the following section, we provide a list of suggestions targeting those variables of the extended model (marked by a dark background in the figure) that can be directly influenced.

4 Consequences for Educational Adaptive Hypermedia

If we consider the finding that both gender see the same potential benefits in computer usage, the question arises what can adaptive educational hypermedia do to foster computer usage and learning attitudes without getting stuck in clichés. This topic investigated next with a focus on domain-independent suggestions.

4.1 Influencing the Failure Attribution Bias

Failure attribution bias can hurt females's learning because of too little motivation. It can harm males's learning because of a wrong interpretation of the failure causes, if they are due to an individual misconception. Therefore, we investigate possibilities of how to prevent a wrong interpretation of the cause of an unsuccessful experience in case of a system's failure as well as a mis-interpretation of an individual mistake as the system's fault.

In case of a system error it should clearly be specified that it is not the user who is to blame. This has to be announced as soon as possible, preferably before a system failure can possibly occur. A paragraph in the introduction to the system can address this topic and depict it iconically. Additionally, pro-active help should be provided, i.e., a short, assuring explanation of what may happen and what to do in case of system failure. Such an explanation could be a message "If the program runs into a problem, don't worry. You will be automatically transfered to a page that will tell you what to do". The text makes clear that the system rather than the user is the cause of the problem. Furthermore, it assures the user that she/he will be taken care of and provides guidance on how to proceed. In reaction to a system error, the system should provide a message that indicates that a failure did occur, the person to contact (or even better that the responsible person was automatically contacted), the way of contact (email, chat, hot-line), and an explanation of what the user should do when (e.g., "Please try again in 10 minutes"). In case the error is non recoverable, the message should indicate that the user will be contacted as soon as the system is usable again.

In e-learning, a user may experience unsuccessful exercises due to her/his lack of own capability or own misconception. The literature (e.g., [5]) provides valuable instructions for feedback in case the user made an incorrect problem step or is unable to solve a given problem. In particular, the feedback needs to support the problem solving process by offering guidance on how to solve the problem successfully. Additionally, the feedback has to prevent a mis-interpretation of an individual mistake as the system's fault. This is especially important if interactive tools are used for exercises. In this case, the feedback should prevent a student to think that he/she not able to solve a problem because of bugs in the tool. Therefore, in addition to stating that a solution step is not applicable in the current situation, feedback can provide a link to a list of applicable commands.

4.2 Preventing an Inadequate Judgment of Computer-Specific Capabilites

Generally, user interfaces should be designed to keep things simple, avoid to overload a system with features, and keep menus clearly structured (see [12]). By the same token, it is essential that all system messages, menus, etc., use a non-technical jargon. Few things de-motivate more than incomprehensive techno-babble which, potentially, is harming females's judgment of own capabilities more than males's.

Special emphasis should be put on first-time users of a system. On the one hand, a user should not be overloaded by the features of a system. On the other hand, he or she should still catch a glimpse on the possible interactions that the systems offers in addition to those the user is familiar with from previous experience from non-adaptive hypermedia. The field of Intelligent User Interfaces offers some remedies such as gradually (adaptively) adding features to menus (see, e.g., [3]).

Additionally, an introduction or a guided tour through the system should explain the list of features a system offers. Every menu item and feature should be explained in a help menu.

One of the consequences of a low judgment of computer-specific capabilites is a reluctance vis-à-vis exploring and using all features of a system. This is why a system should support and encourage a user's curiosity. After some sessions, when the user logs in again, the system should provide a list of the features not yet used, accompanied by an explanation why they are useful and an invitation to use them (i.e., a direct link). When a feature is used, the system may immediately provide positive feedback together with an explanatory link to similar features that were not yet used. A message such as "In addition to changing the language setting as you just did, you can change the values that represent your mastery level. Click here to give it a try." can help to lower the fear of exploring. The links can be annotated using techniques of adaptive navigation support.

We are not aware of studies that investigate the question whether and how to prevent an over-estimation of one's technical capabilites. We assume that in the long run over-estimation will lead to the same problems as well.

4.3 Raising the Expectation of Success Adaptively

A low expectation of success is a severe hindrance for using a tool or a software and in addition, negative experiences will be perceived more highly. One way to raise the expectation of an successful interaction consists in making these interactions explicit. By emphasizing successful experiences, the student has a chance to become aware of them. For instance, exploring a hitherto unused feature can count as an successful experience on which the system provides feedback, either immediately or at the end of a session. This feedback should consist of a list of the features used for the first time and an invitation for feedback whether they think the feature is useful or how it can be improved.

It is equally important to emphasize successful interactions that occur during the learning process. For feedback during problem solving, we refer the reader to [5]. With respect to the user's performance in a session, on logout time the system should provide a list of accomplishments in learning that were achieved during the session. This could consist of a list of solved exercises, read topics, etc. [16] describes an easily implementable solution that uses the amount of learning materials read by the student in a certain amount of time. It additionally supports learners in acquiring learning management skills by comparing this data to previously set learning goals.

4.4 How to Scaffold Help-Seeking Adaptively

Users need to be supported in using help correctly. Some users request too much help [1], other users are not much inclined to use help at all although it would improve learning or performance. Therefore, a system needs to specially support users to notice the help opportunity and to use it the way they benefit most of it. Gräsel's experiments show that offering help is not enough but a special visual focus has to be put on the help as well [8]. In case a learner ignores visual highlighting of help, a help menu can open automatically. This will be interpreted as obtrusive by most users, therefore the help messages has to make explicit the reason why a help menu was offered, i.e., by listing the actions of the user that the system used for diagnosing the need for help.

4.5 Influencing the Situational Goal of a Session

Certain instructional items (such as worked examples with a request to self-explain) can focus the learner on understanding and reasoning, and stimulate such goals different from pure performance goals. Such items can be introduced adaptively into hypermedia generated by such systems as ACTIVEMATH [9].

5 The Escape Route from Cliché

In the previous section we described features an e-learning environment may offer in order to address gender-specific differences in computer usage and learning attitudes. A simplistic implementation would ask the user for his sex and adapt the menus, layout, feedback, etc. correspondingly using adaptive hypermedia techniques such as adaptive content selection, adaptive navigation support, and adaptive presentation. The problem with this one-time-adaptation approach is that users are faced with a system that incorporates a cliché and therefore, possibly scares off all users not exactly matching a prototype.

Using the sex of a user as a basis for adaptation has one definite advantage: it is easy to collect the information. However imprecise a differentiation on this basis may be, statistics show that this single information can provide information about an individual user that holds with a certain degree of probability. Over time and ideally, an e-learning system identifies the user's aptitudes, cognitive style, capabilities, and other individual characteristics and adapts accordingly.

Therefore, the sex of a user can initialize certain values in the user model, for instance, in the model of Figure 2, the initial empirically average values. But then, user modeling continues rather than stopping at the level of averages and stereotypes. Individual differences of some characteristics can be assessed by monitoring the actions of a user (e.g., [13]). This information can be used to further refine the user model and to make the transition from the stereotype to the individual.

On way of assessing the individual attitudes consists in interactive choice of features on an individual basis. Each adaption should be accompanied by a possibility to confirm or disallows further application. This requires the user to control the adaptations in the first place. If the feature is rejected, a short notice should state that the feature was not displayed and that there is the option to display it. Additionally, all settings should be accessible in a configuration panel. The decision of the user which feature to employ updates the user model as well.

6 Related Work and Conclusion

Work in adaptive hypermedia addresses various aspects of users. It ranges from adapting to the learner's knowledge (e.g., [17]), his/her learning style (e.g., [2]) or learning goals (e.g., [9]). We do not know of work in adaptive hypermedia focused on gender-specific differences.

The literature about gender studies in general is abundant. For a comprehensive overview see Tannen [14]. She describes a cultural approach to gender differences and provides a theoretical framework with a focus on discourse analysis.

A fundamental debate on gender-differences is beyond the scope of this article. Instead, we followed a pragmatic approach. Based on empirical data we extended a model that provides a detailed explanation of internal factors underlying these tendencies. We proposed adaptive features that can help to fight relevant attitudes that are counter-productive for learning and potentially harmful consequences for males and females.

We argued that adaptive systems which adapt to an adjustable user model are more appropriate than a one-shot adaption to the gender. Even if the sex of a user is used to initialize a user model which in turn influences the adaptivity of the system, an analysis of the interaction of user and system lead to more detailed knowledge about the aptitudes of the user and give rise to a modified adaptivity.

In addition to the automated adaptation, the user should be able to control the behavior of the system at any time. In case an adaption is not wished, the user should be able to disable it and vice versa. This way, the user can express his/her individuality and is not faced with a system that confronts him or her with a fixed cliché.

There are many ways that a learner is unique. We argued that one should not stop at the level of gender but rather recognize more specific variables. Adaptive hypermedia offers the potential to do so.

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