# PREDISPOSITION-BASED INTELLIGENT TUTORING SYSTEM
## *Adaptive User Profiling in Human-Computer Interaction*

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Abstract: The aim of the article is to present the conception of the new approach to human-computer interaction in intelligent tutoring systems. Teaching supported by technology is one of the most important issues these days. The crucial problem is how to learn effectively and how to substitute the student-tutor contact. However, traditional education also does not provide individual, predisposition-oriented teaching programs. Many of the people all over the world choose electronic way of studying. Therefore, it is crucial to evolve methodology of user-adapted solutions. In this paper we present the learning predisposition-based tutoring in intelligent instruction system, with individual user profiling, based on psychological conditions.

## 1 INTRODUCTION

Following the old Chinese proverb "*Tell me, and I forget, show me, and I remember, involve me, and I understand*", one can make a clear conclusion about the importance of the appropriate education process. Traditional lectures are noticeably less effective than exemplifying and drilling, because hearing alone is not the strongest of the human senses. For efficient learning, all of the senses need to be involved.

From the learner's perspective, the process of learning can be perceived as the combination of both cognitive and psychical processes, concerned with the assimilation of information. All these processes encompass acquirement and improvement of skills and knowledge, but also attitudes and behaviours.

In this paper we define tutoring as the activity of providing knowledge and coordinating the process of learning. We focus on the category of education, as the instruction process supported by technology.

In our opinion, there is a significant issue with efficiency in learning systems. The commonly used mechanism of repetition provides means only for memorizing some sort of information. What is more important, however, is to understand the educational material thoroughly and absorb it persistently. Most of the tutoring systems available currently on the market are focused on the cognition process, leaving the psychological aspects uncovered. Combining the two facets together may yield better results.

Common pedagogical methods used in electronic teaching are dedicated mainly to the general group of students, not to the individuals. The benefits from the usage of instruction programs are therefore more like in the traditional high-numbered class groups. It means that the tutor has little time for each student and cannot deliver the required level of attention.

The technology-supported tutoring system ought to provide an instruction program for each of users individually, adapting in a dynamic way to his or her particular needs and preferences The adjustment to such kind of factors is usually realised through the use of customised interface themes, individual visual arrangements, flexible course time scheduling, and so on. Nevertheless, despite the increase in comfort, it does not make the learning process more effective.

The differences in human nature, character and individual predisposition for learning imply what sort of teaching method should be applied towards a particular human being. Leveraging the adaptation to user's needs, the predisposition-oriented approach can be more effective than the traditional tutoring.

The article discusses the conception of a new approach to intelligent tutoring systems, based on user profiling according to their individual learning predispositions. We describe a universal method for user profiling, in spite of the domain of tutoring program or performing institution. We focus on the category of education as the technology-supported instruction process from application perspective.



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# 2 INDIVIDUAL LEARNING PREDISPOSITIONS

The conception of concentrating on the student's individual learning predispositions derives from the psychological and pedagogical premises. In the traditional teaching, the tutor's acquaintance of a student plays a very important role, as it is used for choosing the best teaching method, leveraging his or her skills and learning predispositions.

The tutoring model based on the individual user predispositions can provide a real-time adjustments in the general teaching program (Warren, 2005). The advantage of such an approach is mainly in operating with the consideration of the current user's needs. Therefore, a very significant increase in the course overall effectiveness can be achieved.

## 2.1 Learning Determinants

There are three main determinants that can affect the learning process. Those are the following:

- Memory,
- Understanding,
- Content association.

Memory concerns all of the activities that require to keep in mind data and simple information. Next, understanding represents cognitive process based on the comparison between oneself interpretation of an information and its objective meaning or intention of the sender. Content association can be considered as the ability to compare the information meaning, and associate it in logical, causal-result relationship.

Figure 1 represents the mutual relations between those three main factors in learning environment.

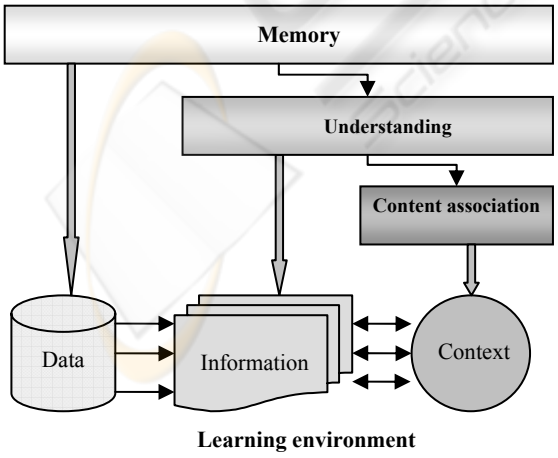


Figure 1: Memory, understanding and content association connections schema in learning environment.

There are three standard elements of information system (IS), as the domain of the learning process:

- Data,
- Information,
- Context of information.

Information is a form of structuralized data set. Context of information may be provided by a user, group, or community. Double-sided arrows between information and its context represent the continuous process of creating and using context to generate new information. Process of enriching information with context gives the base for creating knowledge.

We use 'Memory' for all three IS elements: data, information (with participation of 'Understanding' process) and context (involving of 'Understanding' and 'Content association' processes).

Those three determinants can be activated in a various ways by different individuals. It all depends on their immanent predispositions for learning.

## 2.2 Basic Predispositions for Learning

In the history of psychology science, there were two standpoints. One was gathering the followers of the theory, that the entire human is similar and has practically unlimited potential for development. The other group claimed, that individual differences between people are determined by the biological conditions, which should be treated as guidelines for upbringing and personality moulding. It implies the necessity of creating the society structure that would enable activities consistent with individual's innate abilities and predispositions (Anastasi, 1958).

Gerald M. Edelman (1972 Nobel Prize laureate) proved the theory, that there is no identical brain system, determined by different neural connection. It leads to conclusion that the brain of each individual is as unique as fingerprint. So are the predispositions for learning and the corresponding user profile.

The essential role in researches over individual differences plays the problem of reality perception. It concerns the elementary experience processes, such as: impressions, sensations and imaginations. In practice we meet number of people whose mental imagery is visual rather than auditory, or conversely.

The other factor is the process of memorizing. It includes the following types of memory: semantic, logical, visual, mechanical, associative, lexical, and many others. The typology of memory depends on the predispositions. It gives a variety of possibilities for using memory in creating instruction programs. Simultaneously, it brings the problem into teaching methods' effectiveness, because there are too many inexactly defined categories of predispositions.

The solution appeared with intelligence category as a factor responsible for the process of learning (Guilford, 1967). We can analyse the Mensa questions for measuring the intelligence quotient. There are four categories of problems that concern the perceptive, language, logical and numerical predispositions. People always have one of the abilities stronger than others. In that field we can identify the predispositions, which can be useful in the tutoring methods particularly.

## 2.3 Predisposition Matrix for Tutoring Methods

Following the statement, that every person has the individual suite of learning predispositions, we can conclude that the tutoring program, as well as its instruments, should be adapted to the needs of a potential student. There could possibly be a problem in defining unique instruction path for each student. Therefore we need to find the way how to analyse learning potential and how to create the model that would help in defining tutoring methods.

First of all, as we now have the general learning determinants, we should discern the instruments for tutoring based on predispositions. Each instrument represents the category of tutoring methods (table 1). It results from learning determinants and represents the predisposition aspect.

Table 1: Predisposition-based tutoring instruments.

| Learning determinants | Predisposition-based tutoring instruments | Instrument method |
|---|---|---|
| Memory | frequency | high repetition |
| | | low repetition |
| | time unit | short, intensive training |
| | | long, extensive training |
| Understanding | analytics | deduction |
| | synthetics | induction |
| Content | perceptiveness | visualization |
| | language | keywords, word relations |
| | logic | causal-result relationship |
| | numbers | formula representation |

Directly from the 'Memory' determinant, we can receive a frequency of the instruction program and a time unit, designed to realise each exercise, task, or problem. According to the 'Understanding' process determinant, we have two ways of brain processing: the analytic and the synthetic one. It corresponds to the following methods: deductive and inductive.

For the content, we have specified instruments based on the intelligence perception: perceptiveness, language, logic and numbers. For each instrument a different method of tutoring has been allocated: visualisation, for those who are more perceptive, keywords with the word relations, for the language intelligence, the causal-result relationship problems, for logic-guided people, and formula representation, for the so-called mathematical brains.

For the usage of the previously mentioned three main learning determinants, we have to allocate a combination of all the instruments. Table 2 presents the matrix of the predisposition-based methods in aspect of memory, understanding, and content usage.

Table 2: Matrix of the predisposition-based methods for tutoring programs.

| UNDERSTANDING | MEMORY: high repetition | MEMORY: low repetition | MEMORY: short, intensive training | MEMORY: long, extensive training |
|---|---|---|---|---|
| CONTENT: visualization | | | | |
| CONTENT: keywords, word relations | deduction | | | |
| CONTENT: causal-result relationship | | | | induction |
| CONTENT: formula representation | | | | |

Because there are 4 instrument methods for the 'Memory' determinant, 2 for the 'Understanding', and 4 for the 'Content', it gives 32 complex methods for tutoring in total. This means that e.g. for one individual there can be prepared a tutoring program, specified by the following set of methods: intensive training with high repetition of instructions, based on deductive thinking with causal-result relationship presentation of information.

# 3 USER PROFILING IN HCI TUTORING

Human-computer interaction (HCI) is nowadays one of the biggest issues in the IT development (Preece, 2002). In this paper, we perceive it mainly from the

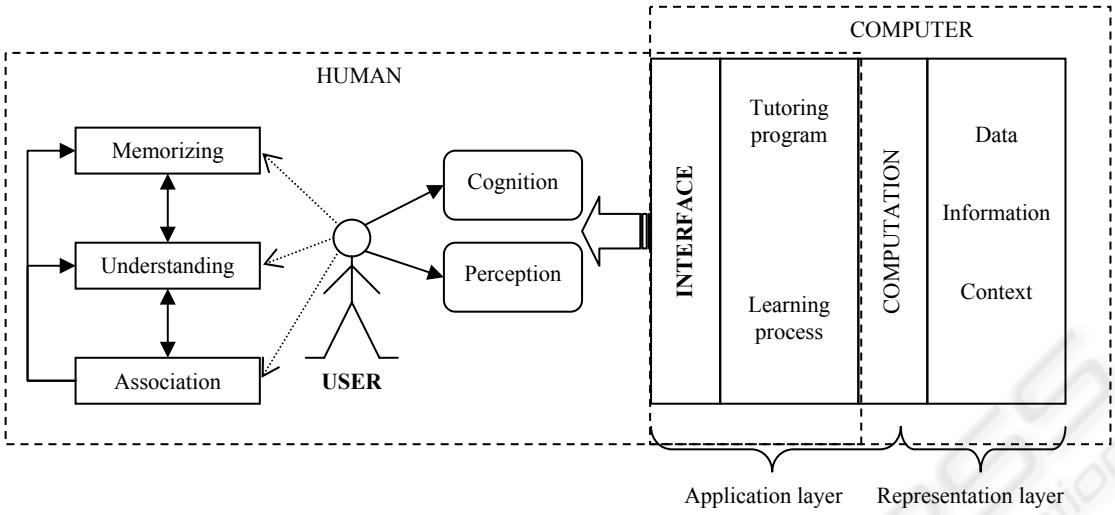


Figure 2: Conceptual model of HCI tutoring framework.

perspective of a tool, used for increasing the tutoring efficiency through the adaptation to user's needs.

Technology usage methodology is determined by the quality of the tutoring process optimization. It implies the need for adapting interaction to the user profile (Chung, 2004). The tutoring process is led by the individual program for each defined profile.

## 3.1 User Predisposition Profiling

The major problem is to generate the profile that would be the foundation of the interaction process with the computer, with respect to the individual preferences of a particular user. In the case of our intelligent tutoring system, we have to concentrate mainly on the learning predispositions.

User profiling is used for creating the individual teaching environment. It consists in identifying user preferences, such as the ability for learning. After diagnosing of the user type, all suitable instruction methods should be applied in the system. The data computation helps with recording user parameters and defining the suitable tutoring program. For the communication between the user and the system, we have the category of HCI framework.

## 3.2 HCI Tutoring Framework

The HCI framework is dedicated for tutoring. The main element is the human constituent, i.e. the user. Therefore, the HCI design should be user-centred. The user executes the learning process by himself. The computer part of the interaction process gives the instruction set and invokes human reaction. HCI tutoring framework is settled on intelligent system, which plays the role of a teacher, so it has to respond abreast of the student needs and behaviours. Figure 2 presents the HCI framework for tutoring.

On the computer side, we can see the two system layers: representation, concerning data, information and knowledge procedures used during computation, and application layer, which includes interface for communication with user and the applied instruction program. On human side, we have the user and his learning abilities. The processes on the left represent learning determinants: memorizing, understanding and association of absorbed information.

We can observe that the application layer is the common field for the human and computer activity, including interface, tutoring programs, and activated user learning. The invoked process of knowledge acquisition concerns two processes of the human brain: cognition and perception.

There appears to be the necessity of implying the concept of the individual predispositions, based on the quality of executing processes of cognition and perception, such as memorizing, understanding and associating.

## 3.3 Adaptation of HCI Tutoring in User Profiling

Adaptation consists in adjusting HCI tutoring to the user profile, accordingly to the individual learning predispositions. It means that there are significant differences between each profile on the application and the interface level.

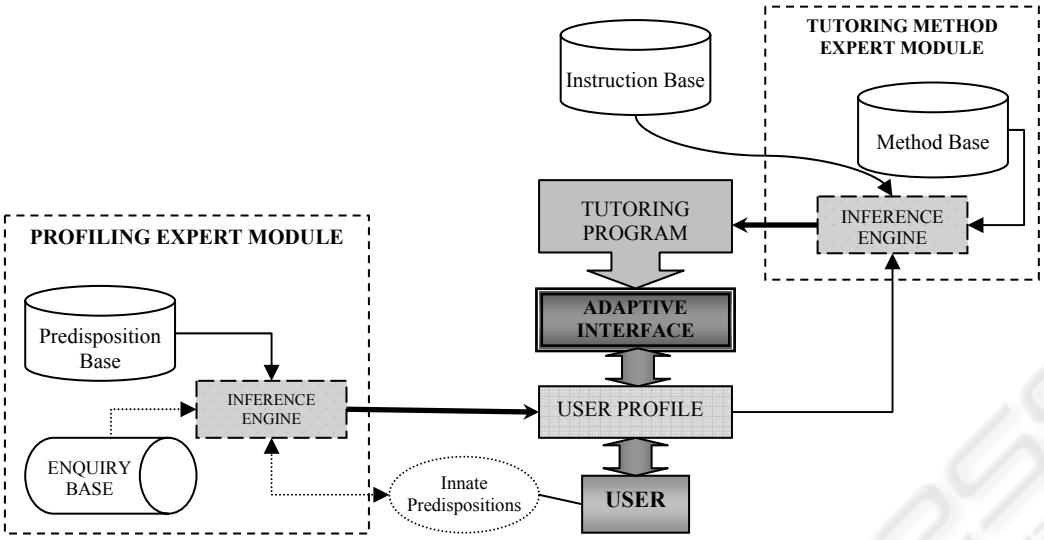


Figure3: Model of intelligent predisposition-based tutoring system.

For the tutoring process, we can use the method matrix, adequate to each single profiling. For the information presentation (content determinant) and the proceeding method (inductive or deductive), we have to follow the principles of the interface design (Wright, 2005). The time matter for memorizing depends mainly on the application execution.

The need of profiling for the individual user and adapting the tutoring process for particular abilities and preferences, induces the problem of identifying each profile and applying it into the system.

# 4 ADAPTIVE USER PROFILING IN INTELLIGENT TUTORING SYSTEM

In the adaptive approach to the user profiling in the tutoring systems, we concentrate on the aspect of the flexibility towards student, especially by using their learning predispositions to achieve best effectiveness results. The interaction process between human and computer using intelligent solutions helps with the adjusting program to the user abilities, but without the need of any psychological knowledge of their individual predispositions.

## 4.1 Premises of Intelligent Tutoring

An intelligent system application supporting fully the predisposition-based tutoring program comes up with the following elements:

- Creating tutoring program,
- User profile modelling,
- Building tutoring methodological apparatus,
- Designing interface class.

Tutoring program is the process of instruction, created accordingly to specified teaching methods. The user profile is a complex characteristic of a student, that is based on his/her individual learning predispositions. Methodology apparatus is the tool for instructing, adaptive to the user profile.

Interface is the class of the possible instruction scenarios. Each of them depends on the user profile and the dedicated tutoring program (Powers, 2006).

Intelligent system is based on the expertise due to evaluating user potential and adapting the most suitable training program.

## 4.2 Model of Intelligent Predisposition-driven Tutoring System

Model of an intelligent predisposition-based tutoring system is presented on figure 3.

In the model we have two inference engines. One is responsible for the expert subsystem, assigned to profiling, and the other for the method importing.

Profiling expert module is dedicated to acquiring predisposition pattern from the base and comparing with user predisposition, received through enquiring process. Inference engine generates the user profile, which is then used for creating the tutoring program.

Tutoring method expert subsystem is dedicated to instruction program applying. Inference engine

uses the method base and adapts collected matrix of methods to previously received user profile.

Instruction base is the collection of information that is designed for the tutoring program. Inference engine transforms tutoring data into the teaching program. Tutoring program is based on the suitable methodology adjusted to user profile and generates adaptive individual interface for the particular user.

### 4.3 Practical View on Adaptive User Profiling in Tutoring Systems

Tutoring program ought to be designed according to the object-oriented paradigm, as well as the base of instructions. It gives the opportunity to implement any data to the previously defined methods and to present it in a suitable to the user profile form.

We can also use a dynamic, content-based web environment for the predisposition-based tutoring. Every student has his or her own profile, despite the same material of knowledge to acquire.

There is also an interesting possibility of sharing different user profiles in order to compare the results and selected ways of learning. Different learning predispositions allow for comparing various kind of information presentations, that has been already learned. It might be also a good issue for knowledge sharing and exploring new areas of perception.

## 5 DISCUSSION

As the HCI concept provides a wide area of possible solutions, that ensues from many various domains of interests, we cannot treat it separately. For the best adaptation to the user, the holistic perspective should be considered with all of the HCI aspects.

Presented model does not include description of the semiotic premises for engineering process, and requires some sort of additional combining with the defined predisposition determinants. Ethnographic and language problems may appear while modelling the predisposition base, and, therefore, should be considered as a separate research issue.

The implementation difficulties for intelligent tutoring system based on user's predispositions may be caused by insufficient psychological and social expert background. The background constitutes the foundation for the adaptive user profiling as much as for technological advance and system integration.

## 6 CONCLUSIONS

Electronic teaching can achieve the advantage over the traditional methods, mainly because of the possibility to simultaneously use the different types of media. Model of intelligent predisposition-based tutoring system, presented in this paper, gives the opportunity to provide individual and user-oriented instructions with the support of the technology.

Psychological approach offers pedagogic ground, which is the crutial element in the learning process, and is being so often passed over by the electronic teaching systems designers. The authors believe that the proposed solution is universal and can be applied in almost every kind of education scenarios.

Matrix of predisposition-based tutoring methods is an illustration model, presenting our approach to the problem. The matrix can be freely extended of additional determinants or tutoring instruments. It can give more complex method apparatus that might give more accurate tutoring programs in the end.

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