User Profiling in Intelligent Tutoring Systems Based on Myers-Briggs Personality Types

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Abstract—**This paper is the result of research continuance on adaptive user profiling, based on learning predispositions. As the psychometric conditions appear to play a crucial role in the tutoring systems, there emerges a need of constructing efficient instruments, that would help to improve the effectiveness of electronic teaching. It particularly concerns user profiling, grounded on the premises derived from individual personality characteristics. Considering users' preferences, stemmed from personality types, as qualities that make them differ from one another, there comes along the necessity of different tutoring method applying. In our approach we use Myers-Briggs Type Indicator (MBTI) as the basis for the development of the novel, preferences-oriented instruments, suitable for implementation in tutoring programs. MBTI has been adapted to the learning environment and complemented with the predisposition matrix instrument, to create user archetypes for intelligent profiling in tutoring systems.**

Index Terms—**intelligent tutoring systems, knowledge-based systems, Myers-Briggs Type Indicator (MBTI®), user profiling, human-computer interaction.**

I. INTRODUCTION

Functionality and effectiveness of the tutoring systems have become more and more important nowadays, with particular attention to the user's role. Recent advances in electronic teaching have been usually the result of focusing on the instruction program itself, rather than addressing the issues of knowledge absorption and usage. Although there are many research studies concerning adaptation of system performance to the user's needs, there is still an evident lack of such solutions implemented in practice. A possible reason for this may be the complexity of psychological background, which makes it very difficult to characterize the human factor in an explicit, unequivocal way.

The ability to learn stems from psychological conditions, which are different for each user. The process of knowledge acquisition depends on personal predispositions for learning. It determines the necessity of taking individual approach to tutoring programs application.

Therefore, there is high importance for treating every user individually, according to the innate abilities. The tutoring system should be able to provide the whole apparatus for implementing and executing instruction programs, and expending processes of learning and teaching, both at the same time, accordingly with the user's needs. The process of learning can be defined as the combination of cognitive and psychical processes for information assimilation. Tutoring or teaching should be perceived as the process of providing particular knowledge, and then coordinating and supervising the process of learning [5].

In this paper tutoring systems are being discussed as the continuation of the previous work, concerning adaptive, predisposition-based, intelligent user profiling. The proposed knowledge-based system contains the profile base and has the ability to adapt tutoring program to the user's individual conditions, to which learning determinants has been defined. There are three factors that determine the process of learning: memory, understanding, and the content association. In that approach, learning domain is composed of the basic elements of every information system (IS): data, information and the context of information [5].

In our study, we have put emphasis on the predispositions determining the process of learning. This approach can be used in the tutoring systems to create a suitable user profile, which the instruction program ought to be then adapted to. However, user profiling, based only on the predispositions for learning, is not complete. It focuses only on how the system uses its abilities to deal with knowledge absorbing by adapting the data and information representation. User's personality, derived from the temperament, is therefore the other important field of the profiling process. In order to make the tutoring program more effective, form of the courses needs to be adapted to peculiar user preferences.

For the best adaptation, it is not sufficient to only apply the tutoring program, which is the answer to the user's innate predispositions of learning. What is crucial is to provide the frame of the whole interaction with the tutoring system, that would increase the efficiency of teaching and make the user employ the system fully and with good attitude towards it.

The main contribution of this paper is the proposal of a tool that facilitates the quantification of the user's psychological conditions and provides the guidelines for the way tutoring programs should be conducted. That includes, but is not limited to, the user's immanent learning predispositions, based on the cognition and preferences related to particular personality types. Those are the two primary factors that determine the effectiveness of the learning process.

II. USER PROFILING IN TUTORING SYSTEMS

A. User role in tutoring systems

User profiling is not a new issue, but, in practice, it usually provides an increase in comfort level through the possibility of personalizing the tutoring or self-scoring part. Nowadays, there appears a tendency to focus on the psychological facets

of users' characteristics, with the goal to provide tutoring programs more adaptable to their needs.

Moreover, it is crucial that the tutoring system is designed not only for delivering knowledge, but to play the role of a teacher. Good teachers give all of their attention to properly fit program and tutoring methods to the individual student. Therefore, it becomes evident, that the effective tutoring system must do the same for each individual user. The more effort for adapting system's functionality to the particular user it provides, the more effective the tutoring program would be. Psychological conditions impose the proposition, that users do differ [1], and that standpoint is crucial in both, learning and teaching processes.

All the differences between individuals emerge from the process of knowledge acquisition and are highly related to its epistemological foundation, especially to the perception of reality. It leads us to two main processes of experiencing reality: cognition and perception. Perceiving the outer world is the first reaction with objective reality that ensues directly from contemplating it and results in gaining the subjective knowledge about the world.

The subject of our interest is the area of human-computer interaction, as the field of generating user profile and giving best adaptation of tutoring program to the individual needs.

B. HCI in tutoring systems

User profiling is the basis for proper interaction between the user and the tutoring system. In the conception presented in this paper, two system layers have been marked off:
1) Representation layer; including basic elements of IS and learning domain (data, information, and context), and the computation processes;
2) Application layer; including interface components for communication with the user (responsible for providing tutoring programs and coordinating learning course) and computation processes, shared with the previous layer.

Tutoring system layers are the machine-side of interaction. On the human side, there are two processes of interaction, derived from the epistemological foundation: cognition and perception. Those are the two main processes of experiencing reality. They determine how the information delivered by the system is perceived, according to the cognitive conditions. The user, guided by the learning determinants (memorizing, understanding and the content association), operates in the field of interface without any thorough insight into the methodology of processing. Intelligent system diagnoses the type of user, creates the corresponding profile, and adapts all the required functionality for the optimal effectiveness.

User-centric approach implies the need for focusing on the user in the first place. Therefore, interface in such systems should be created dynamically, as a continuous process of adaptation to changeable preferences of the user. Traditional customization, based on color settings, backgrounds, themes, and other features and widgets, is not sufficient for the best adaptation to the user's needs. Peculiarity of the tutoring system determines a special communication with the user, which is crucially important. To achieve a decent level of interaction, one has to appeal to the psychological and pedagogical aspects, because it is highly required in the teaching and learning process.

Concluding the premise that users do differ significantly, one has to assume that the general issue of user profiling is the process of creating individual profile for each user, driven by psychological conditions.

C. Predispositions-oriented tutoring

In this article, the predispositions for learning represent a natural complement to the personality types. However, there is a strong relation between predispositions and preferences. The predisposition matrix, defined as the primary abilities to assimilate information, corresponds with representation layer of the tutoring system. That implies the emphasis put on the data and information representation, which are displayed on the interface level.

Predisposition-based instruments for tutoring correspond with general learning determinants (that are included in the matrix of the predisposition-based methods for tutoring programs) [5]. *Memorizing* determines two levels of teaching methods, realized through such instruments as frequency of providing information and time unit. It can be combination of both: high or low repetition, with short and intensive training or long and extensive learning. The other determinant – *understanding*, leads to analytical or synthetic representation, that stands for deductive and inductive tutoring methods. And the last one is *content of information*. Its methods are based on the MENSA indicators for intelligence type measuring, which are represented by the following instruments:
1) Perceptiveness – visualization methods,
2) Language – using keywords and word relations,
3) Logic – causal-result relationship,
4) Numbers – formula representation.

Tutoring, which is based on the predisposition instruments, uses all the dimensions to create a suitable tutoring program for each of the user predisposition set. Apart from the information representation for knowledge delivery, there is an importance of organizing functionality and tutoring program schedules, that derive from the personal preferences.

Anyhow, users do not always have the awareness of what works for them the best, especially when the problem of choice is complex. Therefore, just as with the predispositions issue, the system executes personality type examination and adapts the course to individual preferences.

III. USER'S PREFERENCES BASED ON MYERS-BRIGGS PERSONALITY TYPES

A. Myers-Briggs Type Indicator

One of the most popular methods for defining personality type is the Myers-Briggs Type Indicator (MBTI). It is based on Carl Jung's works, exposing how does the temperament affect human's behavior in action. It has been supplemented with fourth dimension, concerning the way of dealing with environment.

Myers-Briggs' model describes mental functions, based on four criteria [3], [4]:
− attitude towards outer world – the direction of energy,
− processing (perceiving) information,
− making decisions (in Jung's work called 'judging') – how is the information transformed into useful output,
− organizing life,
that represent dichotomies on bipolar scales.

According to the specified criteria, they constitute the opposing preferences:
- **E**xtraversion – **I**ntroversion,
- **S**ensing – i**N**tuition,
- **T**hinking – **F**eeling,
- **J**udging – **P**erception,

denoted by the following pairs of letters: E–I, S–N, T–F, J–P. Personality type is the combination of all four criteria. Therefore, there are 16 different types of selected functions, represented by the set of preferred states (table 1). MBTI authors imply, that preferences for personality type are similar to the hands usage. Every human uses both of them, but one is more comfortable and efficient than the other.

The indicator for type measurement is based on the simple questionnaire test, which provides characteristics for those preferences. There are no good or bad answers, what is often underlined in the instruction. That helps to prevent a person being examined from trying to 'pass the test right'. The result illustrates what is the primary preference in each area.

TABLE 1: CHARACTERISTICS OF THE MBTI TYPES

MBTI characteristics	Type description
Extraversion (E)	Dealing with situations and facts from outer world
Introversion (I)	Dealing with ideas, thoughts, information, explanations, beliefs, and reflections
Sensing (S)	Dealing with facts, known things, information fit in with the direct here-and-now experience, i.e. clear, tangible data
Intuition (N)	Dealing with ideas, the unknown; generating new imaginative possibilities or more abstract, conceptual, and speculative information
Thinking (T)	Deciding on the basis of objective logic, using analytical and detached approach; emphasizing on tasks and results to be accomplished
Feeling (F)	Respecting values and personal beliefs, visceral-oriented, empathetic
Judging (J)	Stable and organized; managing the outer life, focusing on completing, organizing, and planning
Perception (P)	Maintaining flexibility, dealing with problems as they arise, rather experiencing the outer world than managing it

We can also group those four preferences into two mental categories: orientation and processing. Orientation includes energy direction and dealing with life. Processing concerns information processing and decision making. Each type defines how does an individual behave and deal with the reality. It has also its transmission into learning environment.

B. Personality types in learning environment

Each personality type has different potential for learning. As we have personality types distinguished, we can now describe the guidelines for tutoring methods (table 2 and 3). Those preferences determine the differences between each individual in the field of abilities for learning. What is crucial in that case is how different types affect the tutoring process.

Wide interest in the practical use of that tool had caused varieties of modifications. But essentially all of them focus on those four dimensions with the same characteristics of types. There is a number of MBTI application in learning environment, but mostly concerning just rules and guidelines for teaching, encompassing each of 16 personality types. One of the instruments is commercial solution called *Paragon Learning Style Inventory* (PLSI) [7]. It is a 48-question test, designed on the basis of MBTI as the self-scoring method.

TABLE 2: TUTORING GUIDELINES FOR THE MBTI-BASED ORIENTATION MENTAL CATEGORIES

Dimensions	MBTI characteristics	Tutoring guidelines
Concentration and attention	Extraversion (E)	Practical learning based on examples, group learning; avoiding tiresome tasks; providing variety; expressions
	Introversion (I)	Observation-oriented, thorough work; detailed, individual, analytical tasks
Dealing with tasks	Judging (J)	Well-organized, routine elements; clear schedule and consequence, rather than decision making and problem solving
	Perception (P)	Problem analyzing, adaptation to new situations, non-routine tasks

TABLE 3: TUTORING GUIDELINES FOR THE MBTI-BASED PROCESSING MENTAL CATEGORIES

Dimensions	MBTI characteristics	Tutoring guidelines
Perceiving and information processing	Sensing (S)	Dealing with facts and clear, tangible data; using known things; practical approach oriented on procedures and order (step-by-step methods); connection with real, actual situations and scenarios
	Intuition (N)	Dealing with abstract ideas and imaginative problems; providing general in nature, creative, non-routine tasks; evoking strong impulses
Problem solving and decision making	Thinking (T)	Providing clear, concrete information and rational premises; focusing on problematic cases and expecting logical solutions
	Feeling (F)	Providing self-contribution, amplifying positive attitude; accordance with values, avoidance of criticism

The problem of this and similar measuring instruments is that they use, like in this case, only 12 vague test questions for each dimension. It is insufficient for precise defining what type exactly it represents. Moreover, the number of questions for each section is even, and therefore, in case of equal score for both preferences, it becomes impossible to indicate the concrete type. Furthermore, it makes it much harder to define teaching methods for such an individual.

It leads us to the conclusion, that the PLSI or other similar instruments are more like guidelines for teachers, managers, etc., on how to deal with approximately defined personality type, which does not have any impact on the measurable increase of learning efficiency.

C. Preferences-oriented tutoring methods

Usage of the MBTI for defining types is mostly applied to the traditional management. In the field of electronic tutoring it is hardly impossible to use descriptive classifications. Moreover, there is no place for interpersonal and intuitive actions. The system is designed to replace the manager and identify the personality type automatically. Therefore, there is a need for specified, objective, and quantitative methods.

Originally, within the confines of the tutoring guidelines, it happens that some preferences are closer to one of the characteristics, and some to the opposite one. It is rather usual that one person is both thinking and feeling at the same time.

However, it depends on the sort of situation or task to do. Therefore, for providing more detailed survey, the scales (E–I, J–P, S–N, T–F) have been divided into the inner learning-teaching dimensions, accordingly to the tutoring guidelines (table 4).

Left column provides *orientation category* scales (E–I and J–P). It determines the frame of tutoring program. On the right side there is the sub-matrix of *processing category* scales (S–N and T–F). It shows the perspective how do tasks, problems, and exercises need to be presented to particular student. It is more precise instrument for measuring user's preferences for tutoring process. It might occur that Extravert type prefers to learn alone, but considers situation from outer world, which is dedicated to Introvert type.

TABLE 4: MATRIX OF PREFERENCE-ORIENTED TUTORING METHODS (BASED ON MYERS-BRIGGS PERSONALITY TYPES)

Task presentation / Program frame – tutoring organization		(S–N) Sensing – Intuition	(T–F) Thinking – Feeling
(E–I) Extravert – Introvert	empirical – reasoning varied – thorough group – individual	facts – ideas	logic – principles
		practical – imaginative	solution – attitude
(J–P) Judging – Perceiving	scheduled – adaptive result – method decision – analysis	detailed – general	prescriptive – descriptive
		step-by-step – creative	calculation – contribution

Preference-oriented tutoring method matrix (table 4) is much more the operational approach, than defining strict personality type. It presents more types, greater variety and complexity of the problem.

IV. PERSONALITY-DRIVEN INTELLIGENT TUTORING SYSTEM

A. User profiling based on psychometrics

Distinguishing (in the field of tutoring systems) the aspects of preferences and predispositions follows Rene Descartes' division of reality into two areas: *res cogitans* (from Latin – the mind; internal world of human being) and *res extensa* (Lat. – everything beyond the mind; the outer world).

Learning predispositions corresponds with internal, brain processing area. However, the external area concerns the personality types, that affect actions driven by the particular preferences. User model is a conceptual set of characteristics built of both aspects: predispositions and preferences. User profiling involves creating dynamically the profile, that is dedicated to the tutoring system. Interaction, subsequently, ought to be adapted to that profile.

In our conception, user profiling is executed in two stages. First one concerns the user archetype identifying, and then, creating factual profile that is used by the system for tutoring program adaptation (fig. 1).

Personality-based preferences are differentiated as the processing and orientation categories. The processing preferences with predispositions are the basis for the user archetype. First two elements determine user archetype, which is enriched by the third one with the full user profile.
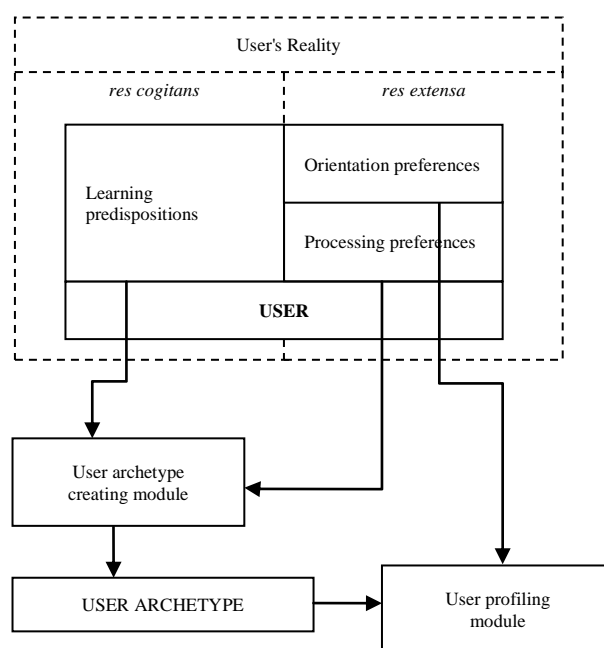

Fig. 1. Conceptual schema of user profiling in tutoring systems

There are some different methods of user profiling. One is the user archetypes classification, and the other is the interaction user-system analyzing, that, to a large extent, involves particularly orientation preferences.

Having a closer look at the profiling process, one can observe that the predispositions correspond with the data and information representation. In the next step, the preferences from the processing category provide the way of displaying the tasks, and those, from orientation category, lead to the highest level of generalization: tutoring program organizing.

B. Preference-directed user archetype

Archetype is the real foundation of user profiling and the introductory pattern of the innate characteristics. It is used for creating the profile, applied in tutoring system for instruction program adaptation, and is built of the predispositions for learning and preferences, based on mental processing.

The orientation part of preferences is connected with the tutoring program itself, and, therefore, not included into the archetype, but adapted in the final user profiling.

Combination of both instruments for defining learning predispositions and preferences allows to build the model of the user. In that depiction, predispositions are the passive side of the user-learner. They exemplify the perspective of the original qualities, concerning the way of data representation, in accordance with individual mental processing. Preferences are the active side, providing the perspective of what do users choose in learning, which is connected with the display of tasks. The archetype model represents the idea of how does the user need to be instructed by the data and information representation and, as the next step, by delivering the form of task presentation through the system display (table 5).

It is important to remember, that the qualities that concern predispositions evolve in time. It is caused by brain training. Preferences based on personality types also change in time. However, it is not an evolution, but more likely a redefinition of user preferences.

TABLE 5: USER ARCHETYPE MODEL FOR TUTORING SYSTEM

Learning determinants	Learning quality indicator	Measurement description
PREDISPOSITIONS		
MEMORY	high / low repetition	exclusive assign
	short, intensive / long, extensive training	
CONTENT	visualization	by percentage
	language: keywords, word relations	
	logic: causal-result relationship	
	formula representation	
UNDERSTANDING	analytics: deduction	
	synthetics: induction	
PREFERENCES		
INFORMATION PROCESSING	facts / ideas	exclusive assign
	practical / imaginative	
	detailed / general	
	step-by-step / creative	
PROBLEM SOLVING	logic / principles	
	solution / attitude	
	prescriptive / descriptive	
	calculation / contribution	

C. Tutoring program building

Teaching program is another important issue of the user profiling process for tutoring system. The whole user type identification and profiling would be useless if there was no particular emphasis put on the way of knowledge delivering.

Fig. 2. Process of generating and adapting the tutoring program

Tutoring program is not just a content-related resource, consisting of information and practices, that user needs to absorb. In this depiction it is intelligent, object-oriented tool, that should provide detailed adaptation to the user's needs.

Fig. 2 presents the general diagram of tutoring program adaptation to the user. The sequence of user profiling is as following: first, creating archetype and keeping in archetype base, and then, profiling for particular program organizing. It can be executed through analyzing the history of interaction and comparing the scores. It is worth revising, that the predispositions evolve as the user continues the process of learning. Preferences change in time, which is determined by the changing environmental conditions. The exceptionality of presented approach to tutoring program consists in the way of the three-step adaptation.

First one is connected with the predispositions and, therefore, with the data and information representation. Predisposition-based method matrix allows the system to prepare atomically emerged information objects, that can be represented the way, that is characterized by those methods. It is the lowest level of display.

The second step concerns personality type and processing category of the preferences. The adaptation is designed for exercises, complex tasks, or problems display, which are a combination of separate, atomic information objects. The presentation of tasks is ordered by reference to the general facts, displayed in the descriptive way.

The third step is not affiliated with the user archetype, but exact profiling. It is the most changeable part of the profile. It concerns using the orientation category of preferences for the tutoring program organizing. Therefore, the system needs to update constantly the user preferences by preliminary or periodical testing and interaction analyzing.

Only intelligent tutoring system is able to provide those kinds of mechanisms, which allow creating expertise on the user and invoking processes of adaptation, based on system self-learning. It is also indispensable for the knowledge base representation [2]. Moreover, all of those actions concern strictly the human-computer interaction in the tutoring system [6].

D. Psychometrics in HCI of intelligent tutoring system

Considering the psychological background, there appears the new issue in the field of user-system interaction. There is a reflection on the HCI framework and its functionality in intelligent tutoring system, based on specified aspects of user predispositions and preferences. As it was mentioned in the previous part, there are two layers of the system, that concern human-computer interaction: representation and application.

Preference-oriented user profiling corresponds with the application layer, that focuses mainly on functionality of the application. Predisposition-based profiling is dedicated to the representation layer, which includes data, information, and context computing. Both areas of user profiling are delivered to the interface level, which provides final display to the user.

The interaction between the user and the system is based on two interaction processes: perception and cognition, that correspond strictly with the predisposition and preference attributes (fig. 3).
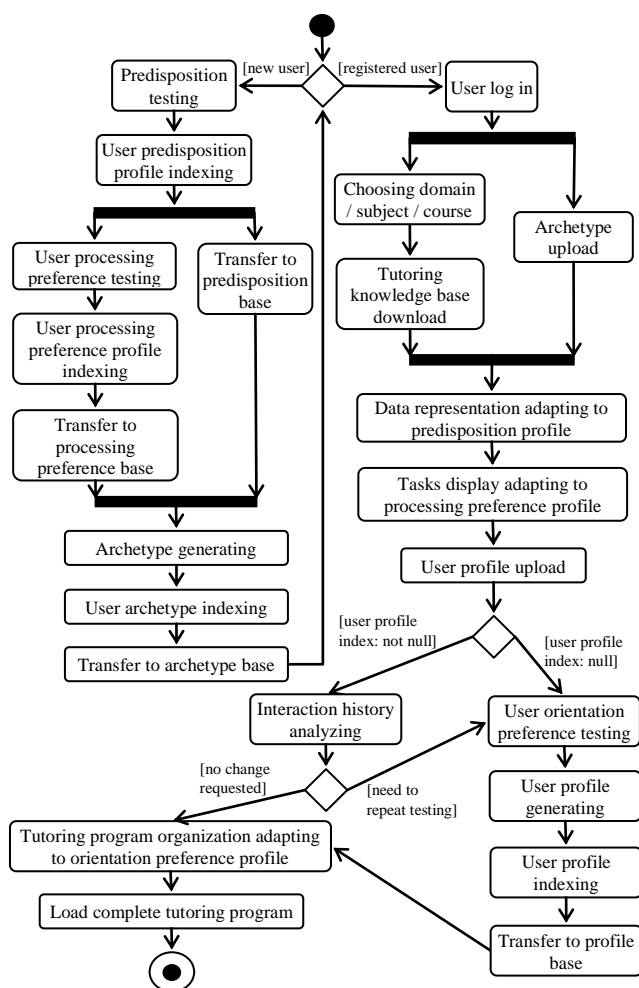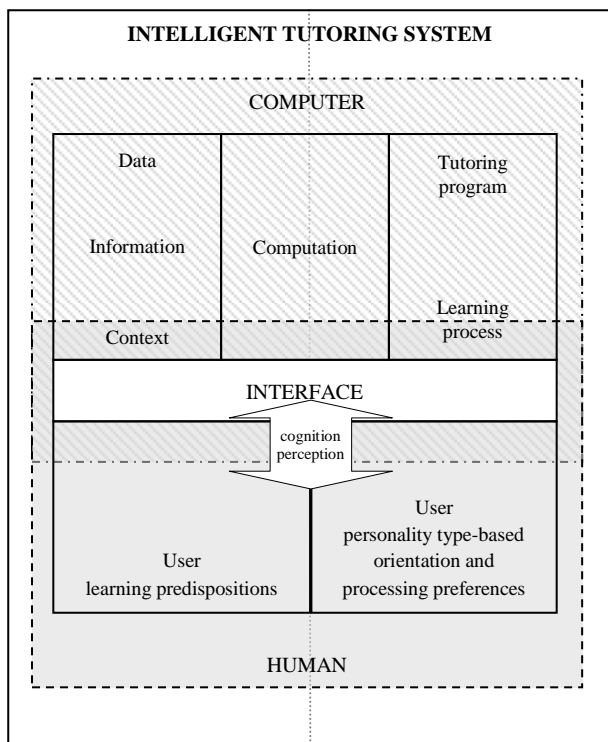
Fig.3. Psychometric model of HCI in intelligent tutoring systems

The other quality of interaction with the user in intelligent tutoring system is that the learning predispositions are the passive attributes. It is because the user does not have any direct influence on the modification process. The system, which adapts to those predisposition indicators, is in this scenario the active side. In case of preferences, user actively uses functionality of the system.

V. DISCUSSION

In our previous study we proposed a predisposition-based approach to adaptive user profiling. What became clear was that to fully address the problem, the other, complementary factor should also be taken into account: user's individual preferences. The appropriate deployment of psychometric instruments and general accordance with user's individual psychological predispositions can solve many, but obviously not all, of the issues related to the tutoring system dynamic adaptation to the user.

Users are not able to describe own personality type by themselves. Perceiving reality is extremely subjective, and, moreover, a lot of personality surveys are inaccurate. Hence our proposition of the novel instrument, which is based on the behavioral testing methods with the completed apparatus of the user type identification and detailed tutoring process adaptation to each of psychometric attributes.

There is a possibility that the user may demand additional representation, special program coordination, or even whole tutoring frame modification. In that case the system would 'remember' the last requesting history and, if it was a single or sparse event, might cause no changes. However, if the behavior is permanent or frequent, the user's profile would be modified or some functions would be added.

VI. CONCLUSION

Intelligent tutoring systems can be considered from many different engineering perspectives. In this paper we address only selected aspects, directly relevant to the user profiling process. One of them is definition of the user archetype, which is based on predispositions and preferences indicators. The archetype is the psychometric base for further creation of the user profile and generating of the tutoring program.

The solution provides flexibility for the tutoring program, which is object-oriented and the information is atomically divided for delivering different representation, accordingly to the user archetype guidelines.

However, in our opinion, the psychological aspects play in this case the crucial role. One should also not overlook the fact that the correctness of the type definition procedure considerably influences efficiency of the teaching process, which should be adapted to the individual user profile.

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