<L|ETAP> Model for an Adaptive Tutoring System

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ABSTRACT
Nowadays the interest to the adaptive intelligent eLearning systems increases. There are different kind of adaptations one to the content, other to the learning process or to the assessment and so on. The crucial moment for the learner motivation's is to catch their needs and possibilities and then to act, i.e. the respond from the system.. The intelligent *tutor* (system agent(s)) has to decide the most appropriate path through the content based on the collected information for learner as: learning style, learner track through the topics, learner grades and offer further steps. The intelligent agent – tutor keeps all data for every single learner, analyse them and offers next learner's actions on the system. This paper presents a constructive model based on the learning style of the learners and their ability and how it could be implement in an intelligent eLeaning system. It should be used for self-study in formal and informal education as well as for representing the digitalized cultural and historical heritage for educational purposes.

Categories and Subject Descriptors
H.1.2 [**Models and Principles**]: User/Machine Systems – *Human factors, Human information processing*

General Terms
Design, Human Factors

Keywords
Intelligent tutoring system, e-learning, constructive model

1. INTRODUCTION: THE EVOLUTION OF E-LEARNING SYSTEMS IN SHORT
Last 30 years are time for creation of the Information Society. The education is on new stage implementing Information and Communication Technologies in it. The human ambitions for resemblance the web-based educational systems to the face-to-face education is the goal of this paper. There are different definitions of the Intelligent Tutoring System (ITS) some of them

- ITSs are computer software systems that **seek to mimic the methods and dialog of natural human tutors**, to generate instructional interactions in real time and on demand, as required by individual students.'

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- An intelligent tutoring system is educational software containing an **artificial intelligence component**.
- ITSs are computer-based learning systems which **attempt to adapt to the needs of learners**.'

The essence of the ITS is the humanization of the learning process [1]. The modelling and constructing of the ITSs is the hot topic in nowadays research. Computer Based Instruction and Training via e-learning platforms are the predecessors of ITSs. The ITSs has to build a complex model of the educational process, to adapt it and to control the interactions. Usually ITSs provide individualized tutoring using four models for knowledge of: the domain, learners, teacher strategies and user interface. Creating of the ITSs is based on different artificial intelligence algorithms and computational architectures as: Bayesian Networks [2], Markov Models [3], Neural Networks, Higher-Order Semantic Spaces [4, 5], Fuzzy Control Systems [6, 7], Production Rules Systems, Generative Grammars [8, 9], Non-Linear Dynamical Systems, External Representation [10], Concept Maps [11], Path Guidance [12], Agents Based [13, 14], Ontology Based [15, 16, 17, 18], Data Mining [19, 20, 21, 22], and etc.

2. CHANGE OF THE WAY OF LEARNING
The school is no longer the sole and the most attractive source of information and knowledge. Quick access to unlimited sources of information is widely available due to modern technologies. The traditional concept of literacy has been gradually extended to a multimedia literacy referring to students' abilities to read, write, and communicate with digitally encoded materials - text, graphics, still and moving images, animation, sounds.

The way the people learn is changed as well. The existence of non-formal learning that is not provided by an education or training institution has been widely recognised. This type of learning does not typically lead to an official certification.

Having in mind the characteristics of non-formal learning, as well as the requirements of the ICT driven educational reform, a model of Adaptive Tutoring System has been developed. The personalized support of learners has been identified as among the most important functions of the system since the learning takes place in an open and dynamic learning environment.

Nevertheless of changed way of people learning the learning style is different for the people.

Last few years the design of learning systems is the very important part of developed web technologies.

To find the most appropriate model for the learners and to make them closer to them arose and the adaptive learning systems. They

use knowledge representation and domain models, consider the student knowledge as a means for providing adaptivity [23]. The overview identifies five main features used for maintaining adaptivity:

- student goals,
- student knowledge and familiarity with the domain,
- student qualification (how quickly he or she acquires knowledge),
- experience in the hyperspace and
- personal preferences.

3. <L|ETAP> Model

In the previous work [24, 25] the author went deep in student knowledge- the most important student characteristic in the majority of the current adaptive systems.

The presented constructive research model deals with the learning style, student knowledge, the domain of knowledge, the learner interaction with the learning system (time on the ITS and type of activities) and the intelligent tutor. The ITS is adapted to the learner style, the achieved learning results- learner ability and the way of access to the learning materials. The ITS introduces and responds the appropriate materials to the learner - a thorough answer and kind of material. The intelligent tutor (system agent(s)) has to makes decision on each learner action and the collected learner's data.

The ITS model consists five elements set <L|ETAP> for the identification of learner where:

- L – **L**earning style,
- E – an **E**valuation vector –for learner assessment during the educational process,
- T – learner **T**ime spend on the system,
- A – the learner interaction with the system – type of **A**ctions,
- P – control **P**oints for learning process.

The Intelligent Tutoring System consists of few modules: Admin, Expert, Domain, Learner, Assessment, Learning Style and Learner Interface as it is shown on figure 1.

The Expert module includes pedagogical perspectives and lessons planner – connected to the Domain module (the concept map approach in combination with ontology is used in domain module). The Learning Style module is based on the Homey and Mumford's model

The learner bahviour on the system is described with these five elements where the learning style L could be identifying on each student interaction with the system. The time T spent on one action A and evaluation E on the control point return the style L. On the other hand the system keeps information for the learner way through the learning materials.

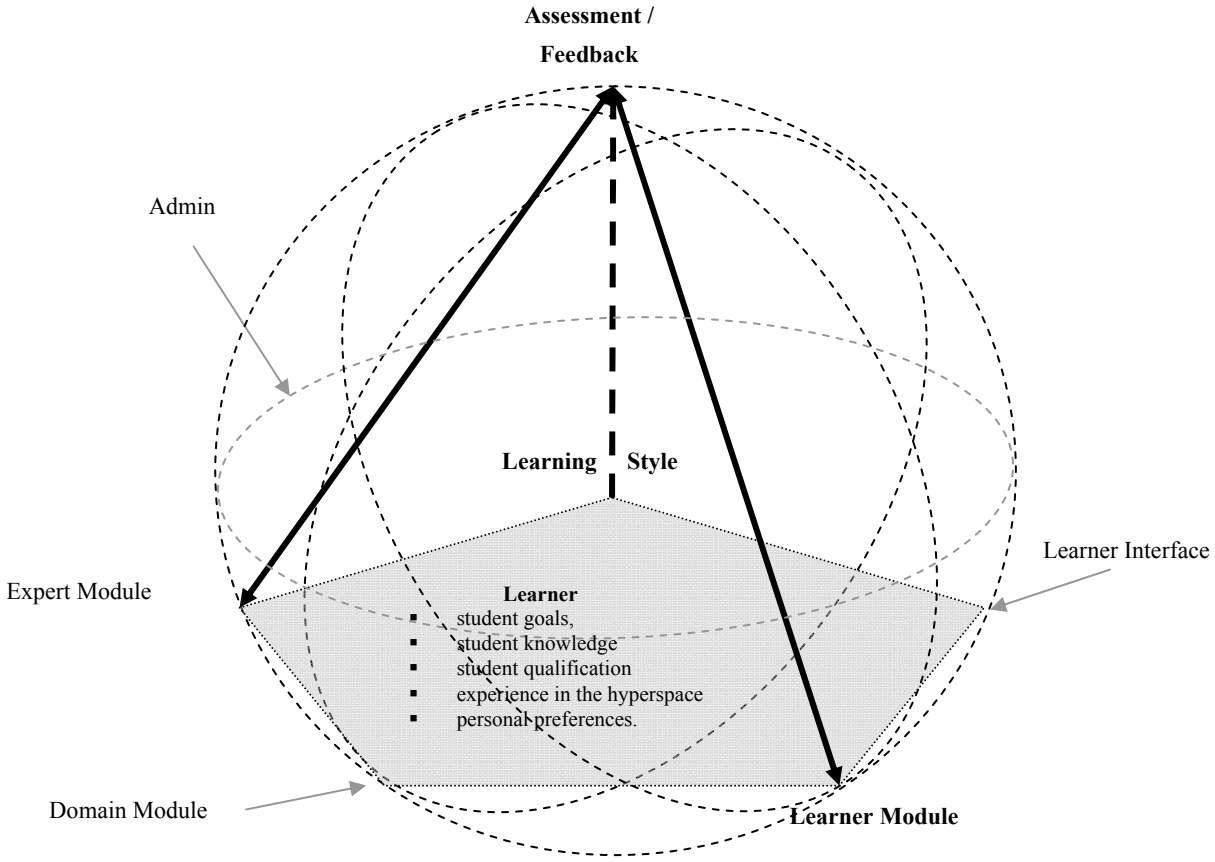

Figure 1: <L|ETAP> intelligent tutoring system.

The definition of set <L|ETAP> describes the learner from different point of view. It gives an approximation to the intelligent tutoring system for further learner actions on the system. It will improve the possibility for knowing the learner. This user profile constructive model is an attempt at comprise all learner characteristics as knowledge and as human factor.

The visualization of the module is like a sphere. The expert module, learner module, domain, learning style and learning interface are angels of one pentagram - the circumference from each angle answers for one of the modules. The Assessment module observes the learner behavior on the systems supported by the expert. The modeled intelligent system assures appropriate and ease of use learning materials and environment for each learner. It is prerequisite for effective learning.

The technology pawns the repository structured by topics, learning styles and difficulties as well as the assessment pool. The main problem could be in front of content providers to develop appropriate learning material to fill in.

Knowing of students' ability and learning style is a premise for students' engagement and involvement in mastering of knowledge and skills. This type of systems is very suitable for self-learning and distance education. The learner could be monitored at each moment by set <L|ETAP>.

4. TOOL SUPPORT FOR <L|ETAP>

4.1 Learning Style

Learning styles are various approaches or ways of learning. They involve educating methods, particular to an individual, that are presumed to allow that individual to learn best. Most people prefer an identifiable method of interacting with, taking in, and processing stimuli or information. Based on this concept, the idea of individualized "learning styles" originated in the 1970s, and acquired "enormous popularity".

Proponents say that teachers should assess the learning styles of their students and adapt their classroom methods to best fit each student's learning style, which is called the 'meshing hypothesis.

The basis and efficacy for these proposals are extensively criticized. Although children and adults express personal preferences, there is no evidence that identifying a student's learning style produces better outcomes, and there is significant evidence that the widespread "meshing hypothesis" (that a student will learn best if taught in a method deemed appropriate for the student's learning style) is invalid. Allegedly well-designed studies "flatly contradict the popular meshing hypothesis". One of it is of Honey and Mumford [26]. They distinguished four learning styles. It is one qualification and never appears in pure form:

- **Reflector** - prefers to learn from activities that allow them to watch, think, and review what has happened.
- **Theorist** - prefers to think problems through in a step-by-step manner.
- **Pragmatist** - prefers to apply new learning to actual practice to see if they work.
- **Activist** - prefers the challenges of new experiences, involvement with others, assimilations and role-playing.

Honey and Mumford have been developed tests for identifying the learning styles. The learning is more effective when the learners use appropriate (for their learning style) resources and actions and they can apply what they know in the efficient way. The implementation of the possibilities for style recognition into the tutoring systems will support the learners and give the flexibility to the learners.

4.2 Computer Adaptive Tests

Computer Adaptive Tests (CAT) base on the Item Respond Theory for identification of student ability under the knowledge domain in each step of the process. CAT successively selects questions so as to maximize the precision of the exam based on what is known about the examinee from previous questions. From the examinee's perspective, the difficulty of the exam seems to tailor itself to his or her level of ability.

The psychometric technology that allows equitable scores to be computed across different sets of items is item response theory (IRT). IRT is also the preferred methodology for selecting optimal items which are typically selected on the basis of information rather than difficulty, per se.

The learning system control points are the tests for self-evaluation not only for the different topics and with additional items describing the learner ability and motivation. One possibility for these tests is to be constructed the Computer Adaptive Test (CAT) based on Item Response Theory, [27]. The constructive research identify that the results from the CAT better describe the user comparing the fixed tests. The use of CAT presumes the well structured metadata for describing the test items and the tool for developing and pool for store the items according Thissen, & Mislevy [28]

The basic computer-adaptive testing method is an iterative algorithm with the following steps:

1. The pool of available items is searched for the optimal item, based on the current estimate of the examinee's ability
2. The chosen item is presented to the examinee, who then answers it correctly or incorrectly
3. The ability estimate is updated, based upon all prior answers
4. Steps 1–3 are repeated until a termination criterion is met

Nothing is known about the examinee prior to the administration of the first item, so the algorithm is generally started by selecting an item of medium, or medium-easy, difficulty as the first item.

As a result of adaptive administration, different examinees receive quite different tests [29].

4.3 Intelligent Agents

Intelligent Agents serve the Learner and Tutor module. They

- **keep tracks of the learner**
- **interaction user between user and system**
- **tutor's emotions return the feedback**

4.4 Concept Map

A concept map is a way of representing relationships between ideas, images, or words in the same way that a sentence diagram represents the grammar of a sentence, a road map represents the locations of highways and towns, and a circuit diagram represents the workings of an electrical appliance. In a concept map, each word or phrase is connected to another and linked back to the original idea, word or phrase. Concept maps are a way to develop logical thinking and study skills by revealing connections and helping students see how individual ideas form a larger whole.

Concept Maps ensure the categorization into the domain module. They in combination with Artificial Neural Networks are in used for knowledge representation and organization and Knowledge map as self-training and adjustable tool.

4.5 Bayesian Network

Bayesian network [2] or belief network model or directed acyclic graphical model is a probabilistic graphical model (a type of statistical model) that represents a set of random variables and their conditional dependencies via a directed acyclic graph. the Bayesian networks could be support the analysis of the data for huge about of learner and return visualized feedback to the tutor and administration.

5. CONCLUSION

The presented constructive research model deals with the learning style, student knowledge, the domain of knowledge, the learner interaction with the learning system (time on the ITS and type of activities) and the intelligent tutor. The ITS is adapted to the learner style, the achieved learning results- learner ability and the way of access to the learning materials. The ITS introduces and responds the appropriate materials to the learner - a thorough answer and kind of material. The intelligent tutor (system agent(s)) has to makes decision on each learner action and the collected learner's data.

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7. REFERENCES

[1] Samuelis L,*Notes on the Components for Intelligent Tutoring Systems*, Acta Polytechnica Hungarica Vol. 4, No. 2, 2007

[2] Butz,C.J. Hua, S., Maguire, R.B. (2004) *A Web-based Bayesian Intelligent Tutoring System for Computer Programming*, IEEE Xplore, 20–24 Sept. 2004, pp 159–165

[3] Ueno, M. & Okamoto T, *Online MDL-Markov analysis of a dischussion process in CSCL*, 6th Int. Conference in Advanced Learning Technologies (ICALT 06)

[4] Hansen, T.K. (2006) *Computer Assisted Pronunciation Training: The four 'K's of feedback*, Current Developments in Technology-Assisted Education, © FORMATEX 2006

[5] Schwitter, R. and Islamm Md T (2003), *S-Tutor: A Speech-based Tutoring System*, 11th Int. Conference of Artificial Intelligence in Education, AIED 2003

[6] Lombardi, M.M. (2007) *Authentic Learning for the 21st Century: An Overview*, ELI Paper 1: 2007 May 2007, EDUCAUSE

[7] Suraweera, P., Mitrovic A.and Martin, B. *A Knowledge Acquisition System for Constraint-based Intelligent Tutoring* Systems

[8] Contreras, W.F., Galindo, E.G., Caballero E.M., and Caballero, G.M. (2006) *An Intelligent Tutoring System for a Virtual E-learning Center*, Current Developments in Technology-Assisted Education, © FORMATEX 2006

[9] Salgueiro, F., Costa, G., Cataldi, Z., Lage, F., Martínez, R.G. (2005) *Redefinition of Basic Modules of an Intelligent Tutoring System: The Tutor Module*, Proceedings VII Workshop Argentine Computer Science Reaserchers. pp. 444–448, 2005

[10] Williams, B., *The Role of External Representations in Intelligent System authoring: Supporting localised decision complex and evolving global context*, AI-ED 2001 Workshop, External Representations in AIED: Multiple Forms and Multiple Roles, San Antonio, Texas, Sunday 20th May 2001

[11] Martins,W, Cortez, J.P., Nalini, L.E.G. Gomes, V.M. *The Use of Conceptual Maps in a Hybrid Intelligent Tutoring System*

[12] Hong, C-M., Chen, C-M ,Chang, M-H, and Chen, S-C (2007) *Intelligent Web-based Tutoring System with Personalized Learning Path Guidance*, Seventh IEEE International Conference on Advanced Learning Technologies (ICALT 2007)

[13] Hospers, M., Kroezen, E. Nijholt, A. den Akker R.& Heylen, D. (2003) *Developing a Generic Agent-based Intelligent Tutoring System*, Proceedings of the The 3rd IEEE International Conference on Advanced Learning Technologies (ICALT'03)

[14] Gulz, A.and Haake, M. (2006) *Virtual pedagogical agents – design guidelines regarding visual appearance and pedagogical roles,* Current Developments in Technology-Assisted Education, © FORMATEX 2006

[15] Day, M.-Y., Lu, C-H., Yang, J.-T.D. Chiou, G.-F., Ong, C.-S., Hsu, W.-L., *Designing an Ontology-based Intelligent Tutoring Agent with Instant Messaging*

[16] Lu, C.-H., Wu, S.-H., Tu L., Hsu, W.-L. (2004) *The Design of An Intelligent Tutoring System Based on the Ontology of Procedural Knowledge*, Proceedings of the IEEE International Conference on Advanced Learning Technologies (ICALT'04), 2004, Volume 00, pp: 525–529

[17] Oguejiofor, E., Kicinger, R., Popovici, E., Arciszewski, T. and De Jong, K. (2004) *Intellignet tutoring systems: an ontology-based approach,* International Journal of IT in Architecture, Engineering and Construction, Vol 2, Issue 2/ May 2004, Millpress

[18] Passier, H. (2004) *Ontology based feedback generation in design-oriented eLearning systems*, IADIS e-Society 2004 Conference

[19] Nkambou, R. (2006) *Towards Affective Intelligent Tutoring System*, G. Rebolledo-Mendez, E. Martinez-Miron (Eds): Workshop on Motivational and Affective Issues in ITS. 8th International Conference on ITS 2006, pp 5–12, 2006.

[20] Romero C.and Ventura, S. (2007) *Educational data mining: A survey from 1995 to 2005*, Expert Systems with Applications Volume 33, Issue 1, July 2007, pp 135–146

[21] Romero, C., Ventura S. (2006) editors, *Data Mining in E-Learning, WITpress Southampton*, Boston, 2006

[22] Attia, S.S., Mahdi, H.M.K., Mohammad, H.K. (2004) *Data Mining in Intelligent Tutoring Systems Using Rough Sets*, 2004 IEEE

[23] Brusilovsky, P. Kobsa, A. and Vassileva, J. (1998), *Adaptive Educational Hypermedia*. Kluwer Academic Publishers.

[24] Kovatcheva E., Okamoto T. (2008) *The Framework and Prospective Design for Web-Based Intelligent Tutoring System*, Proceedings of the Sixth IASTED International Conference on Web-based Education, Innsbruck, Austria, March 2008

[25] Kovatcheva E., Nikolov R., Okamoto T (2010) *The User Profile Constructive Model for a Web-Based Intelligent Tutoring System* In proceedings of ICERI2010 Conference, 15–17 November 2010, Madrid, Spain, pp 004204–004210, ISBN: 978-84-614-2439-9

[26] Honey, P. and Mumford, A. (2000) *The Learning Styles Questionnaire. Maidenhead: Peter Honey Publications*

[27] Weiss, D. J. (2004), *Computerized Adaptive Testing for Effective and Efficient Measurement in Counseling and Education, Measurement and Evaluation in Counseling and Development*, July 2004, Volume 37

[28] Thissen, D., & Mislevy, R.J. (2000). Testing Algorithms. In Wainer, H. (Ed.) Computerized Adaptive Testing: A Primer. Mahwah, NJ: Lawrence Erlbaum Associates.

[29] Green, B.F. (2000). *System design and operation*. In Wainer, H. (Ed.) Computerized Adaptive Testing: A Primer. Mahwah, NJ: Lawrence Erlbaum Associates