SELECTED EXAMPLES OF THE EXPERT SYSTEMS FOR THE TEX-SYS

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Abstract. In this paper we present several expert systems developed for teaching and training of chemical engineering students, and we briefly describe intelligent tutoring system TEx-Sys interface, where developed expert systems are employed. Selected expert systems are *Thermal comfort*, *Process modelling and control* and *Transducers characteristics*, among the many developed to enhance transfer of knowledge and skills to future chemical engineers.

Keywords. expert systems, intelligent tutoring systems, knowledge base, knowledge engineering, chemical engineering, measurement, process modelling, process control, thermal comfort

1. TEx-Sys - The interface of expert systems

Intelligent tutoring system Tutor-Expert System (TEx-Sys) (Stankov, 1997, Stankov & Božičević, 1997) has been imagined as a knowledge-processing engine, in which knowledge from certain domain is incorporated in the expert system. Basic functionalities of this evolving idea and developed computer system now-days are: development of knowledge basis, development of learning materials from knowledge basis, transfer of knowledge to students, student testing and evaluation of gained knowledge. Participants in this process are experts in certain knowledge domains – developers of knowledge basis, teachers that create learning material (courseware), and students. We have acted as knowledge engineers, and intensively communicated with experts and written sources to create knowledge bases to support expert systems that will serve students of chemical engineering as a help in their studying and learning.

Developed expert systems are presented to students of chemical engineering in Distributed version of Tutor-Expert System or DTEx-Sys (Rosić, 2000), which offers its functionalities to students by means of World Wide Web, Figure 1.

To the top of the student interface window there is a graphical presentation of semantic network, a list of nodes and links that serves as a menu for navigating through knowledge base. The hypertext that describes the selected node and multimedia associated with that node are placed beneath this navigation menu, so that student can learn about the specific idiom presented by selected node, and at the same time, be able to see the connections to the other nodes in the knowledge base. The DTEx-Sys engine automatically generates this interface, and it uses knowledge from a certain knowledge base created in *Developer module* of TEx-Sys by an expert or knowledge engineer.

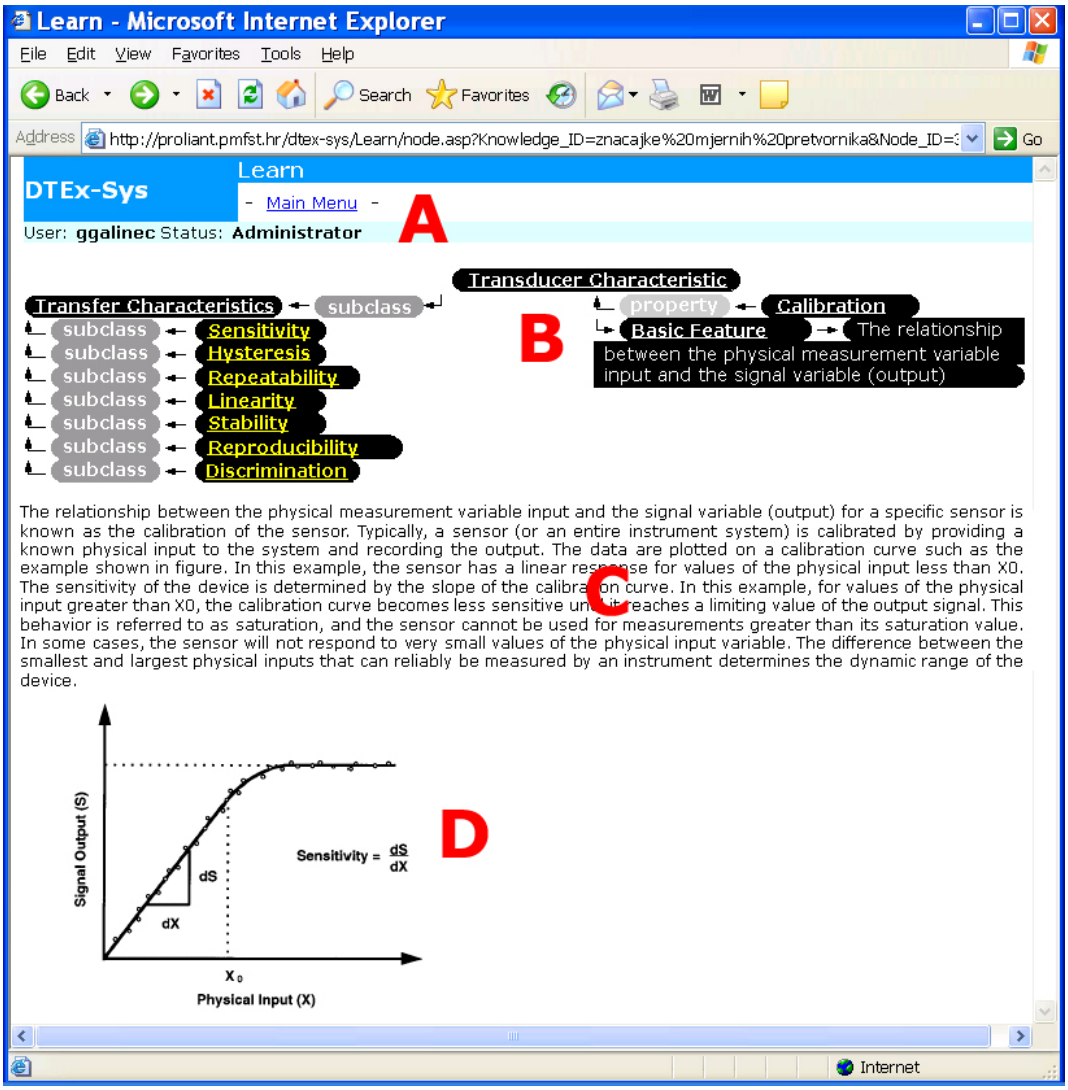

Figure 1. Knowledge representation within student interface of DTEx-Sys
A – Main Menu, B – Knowledge base navigation menu, C – Hypertext, D – Multimedia

In TEx-Sys knowledge is organized in form of a semantic network with frames (Stankov & Božičević, 1997). Semantic networks are a simple way of representing the relationships between entities and concepts, and they consist of nodes that present knowledge domain objects, and links that show relations among these objects. Semantic networks also employ other semantic entities and relations: properties and frames, properties' inheritance with inference engine, and hypermedia (multimedia and hypertext) that enriches semantic structure of knowledge base. Hypermedia is associated with the knowledge domain objects (nodes in the knowledge base), and can have following structural attributes: textual description with hypertext, icon, picture, slide, animation, sound, URL addresses or even executable file. TEx-Sys uses following links for relations between nodes: IS_A, SUBCLASS, A_KIND_OF, INSTANCE, PART_OF, PROPERTY. Besides these default link types, knowledge base developer has possibility to create links that could better describe relations between nodes. Finally, knowledge domain objects in TEx-Sys can have frames. Using frames developer can increase the power of knowledge representation method. A frame is usually assigned to an object, which can then have an arbitrary number of slots, i.e. an attribute set (Slot) and their value (Filler).

2. Selected expert systems

In their preparation for work with DTEx-Sys, students should previously gain understanding of knowledge formalization with semantic networks, i.e. domain knowledge decomposition principles. They must also learn about semantic types used in TEx-Sys and basics of DTEx-Sys program modules usage.

Students' learning process begins with logon to the DTEx-Sys system, after which they can access knowledge-consisted within certain knowledge base. After learning, they are pointed to knowledge testing and evaluation modules, where they can see the achieved results and recommendations for future work. Students can access this expert system again at any time or within previously determined period of time if student knowledge is to be tested.

After having worked with DTEx-Sys, students are invited to fill out a questionnaire about their impressions and the usefulness of the expert systems.

2. 1. Thermal comfort

The expert system for *Thermal comfort* was created by synergy of knowledge from thermodynamics, physiology, ergonomics, biometrology, architecture and chemical engineering in order to describe somewhat illusive concept of person's sense and satisfaction with thermal properties of living and/or working areas. Furthermore, it quantifies influences from variables such as air temperature and humidity, and explains derivation of thermal comfort equation. Knowledge consisted in this expert system helps students in comprehension of this complex field of science, and can serve as a base for practical applications; for instance, in design of heating and ventilation systems or in design of clothes, with emphasis on human content with parameters of the surroundings. Figure 2 presents part of a Thermal comfort knowledge base.

2.2. Process modelling and control

Expert system for *Process modelling and control* was developed with intention to help students understand cybernetic conception of system and adopt system thinking approach. Isomorphic model of the system, described in the expert system knowledge base, serves as a base for modelling technical, biological or even social processes. Emphasis is given to technical processes, and students can gain knowledge necessary for the development of their mathematical models as well as for the design of process control systems. Solved examples of different process models furthermore help students understand systems approach, modelling basics and control principles.

2.3. Transducers characteristics

The expert system *Transducers characteristics* contains knowledge from the field of measurement. It has been developed in order to help students understand problems involved in calibration, testing and usage of measurement devices (transducers). Students are guided trough transducer calibration, process of transducer characteristics determination, with emphasis on reduction of measurement errors and measurement traceability.

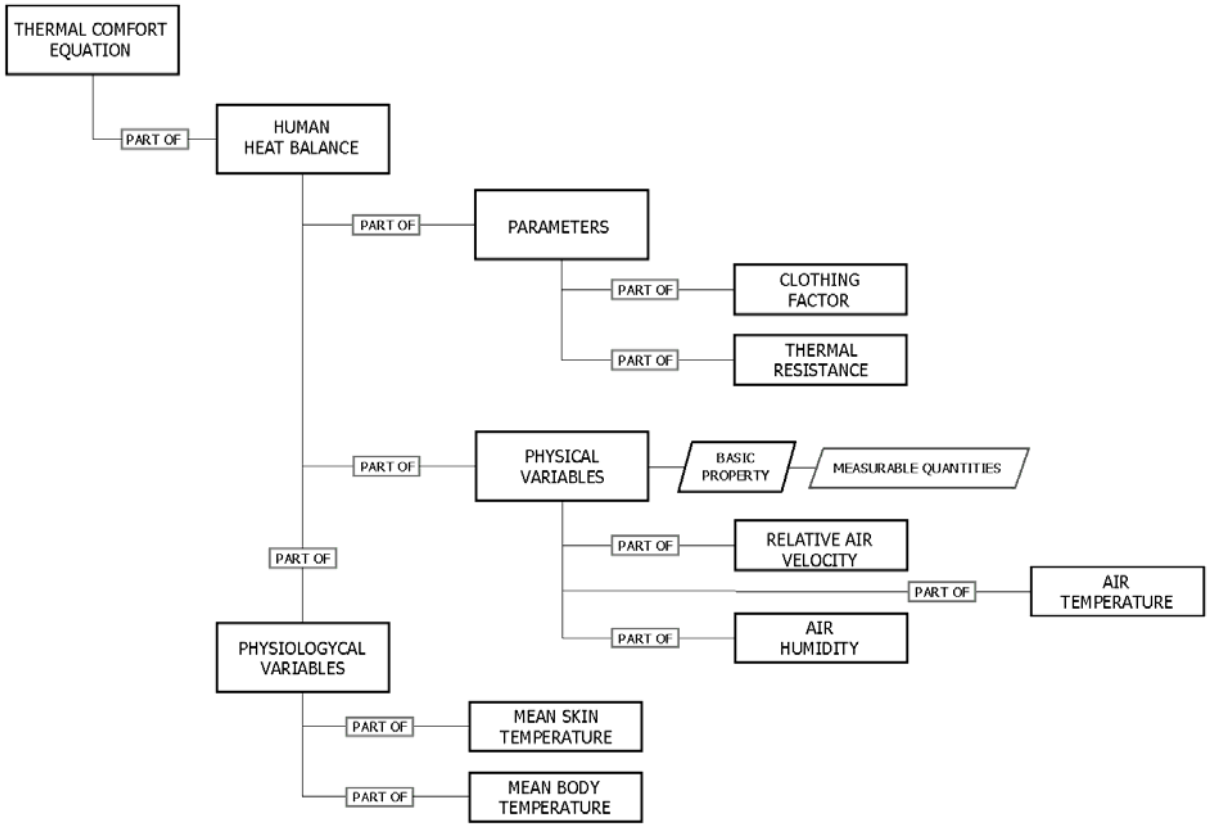

Figure 2. Graphical presentation of the knowledge base *Thermal comfort*.

3. Conclusion

Presented expert systems are applied in teaching of chemical engineering students at the Faculty of Chemical Engineering and Technology, University of Zagreb, Croatia. Three courses are supported: Measurements and Automatic Process Control (6^{th} semester), Mathematical Modelling (7^{th} semester) and Chemical Engineering Laboratory (7^{th} and 8^{th} semester). Preliminary results of testing 35 students of 6^{th} semester show excellent results; more than 77% students achieved maximum (A) grade, while the rest achieved B grade.

After having worked with DTEx-Sys, students filled out a questionnaire about their impressions and usefulness of the expert systems. They expressed very positive opinions of the conception of tutoring systems, emphasizing possibilities to take a lecture at any given time and place, multimedia surroundings and usefulness of quizzes for testing their knowledge during learning. Students' remarks and observations present good base for further enhancement of expert systems.

A greater variety of knowledge is incorporated and the tutoring system is coping better with the learning of subject matter across the full range of academic domains.

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5. Acknowledgments

The authors would like to thank Prof. Juraj Božičević, Ph. D. and Alojz Caharija, Ph. D. who actively contributed to the work with advice, counsel and criticisms. Especially, we wish to thanks former students Damir Bukovec, Marko Ukrainczyk and Neven Ukrainczyk for co-operation and help to understand student experiences and impressions.

Development of presented expert systems was supported by the Ministry of Science, Education and Sports of the Republic of Croatia.