Development of 3D Atlas of Metalworking Equipment

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Abstract. The paper is dedicated to solving the problem of developing innovative educational systems able to train personnel of complex and dangerous manufacturing industries (such as in metallurgy) to control the process not only under regular conditions, but in emergency and pre-emergency situations as well. At that, such educational systems shall transform training of future and current engineers into a professional activity, model both subject matter and social content of their professional labor. Key characteristics of a 3D atlas of equipment as an educational system are given, as it provides immersion of trainees into professional environment. Requirements for such systems are defined (functional, information, software and technical). Stages of development of a 3D atlas of equipment as an automated system are given, allowing one to get closer to yet another problem that of IT specialist training so that they are able to design, implement and deploy such systems.

1. Introduction
The timeliness of this paper is determined with the following positions. Firstly, analysis of previous works [1-3, 4-6] allowed one to create a map of modern trends in the development of engineering education: remoteness of engineering specialists training centers from real operating companies; creation of an educational process oriented to integration with industry, at universities and at professional development facilities alike; modeling of subject matter and social content of professional labor; development and implementation of new principles on which the integrative system of engineering education is built, with immersion of students into professional environment. Secondly, production of metalworks is constantly linked to high returns and smooth operation of equipment. Personnel, knowing configuration and principles of operation of the process plant may maintain it operational and avoid emergencies in the workplace. That is why it is important to maintain the level of training and qualification of personnel at a decent level corresponding to the modern requirements of operation. Thirdly, multimedia teaching systems are the technology supplying the basis to make it possible to solve the above mentioned problems.

The Korporativnye Sistemy Plyus company has been in the software market since 2002. Activities of the company are based on designing and implementing information systems using modern solutions in application and data base development. By now, about 50 typical multimedia teaching systems (TS) have been developed. The main purpose of a TS is training and development of practical skills of technical personnel, as well as preparing the personnel to intelligent on-line decision-making. Automated teaching system (ATS) 3D Atlas of Equipment is a relatively new direction in developing teaching systems in this company. The main feature of this software is: the 3D Atlas of Equipment is a system that shows generalized design of a process plant, vividly demonstrating variations in separate units, common types of equipment, their differences, advantages and disadvantages. At concrete enterprises, e.g., metal fabricators, some units...
may be provided with additional devices and instruments, which is reflected in additional models and differs one atlas of equipment from another. At that, creation of a 3D Atlas of Equipment for a given type of enterprise proceeds by connecting a new set of models.

The purpose of this work is to present an image and limits of the project to create a 3D atlas of metalworking equipment as a teaching system of a new innovative type. To succeed in this, it is necessary and sufficient: to show the key characteristics of the 3D atlas of equipment as a teaching system; to determine requirements posed to such types of systems and; to briefly present main stages of creating such a system.

The practical significance of this work lies in a possibility to efficiently train and assess performance of young specialists and students in industrial job training. The ATS 3D Atlas of Metalworking Equipment facilitates learning the design of the principal process equipment without a need to visit industrial sites, which will allow one to improve training of young specialists and in the future to avoid emergencies caused by abuse of equipment.

2. Materials and methods

The methodology of this study is based upon the key provisions of theory and practice of development of different automated teaching systems, as well as organization of the training process using one of them – namely, a multimedia teaching system [3].

Initial development of the ATS 3D Atlas of Equipment was conducted with the metalworking equipment taken as an example, hence there is the title "3D Atlas of Metalworking Equipment". The development process of the ATS was organized basing on the stages and phases of automatic system development, documenting regulations and after-sales management as given in the GOST 34 set of standards (GOST 34.601-90, GOST 34.602-89, GOST 34.603-90).

It is important to notice, that such a sequence of works was performed only once. Development of the atlas for a new type of equipment involves developing 3D models for different units and their connection and linking. This paper reflects principles, methods and technologies of design and FEED stages of the works on the Automatic System (AS). Besides, the work used tools of structural and process approaches (SADT and ARIS) to analysis and design of AS: Erwin Community Edition, Ramus Educational, WhiteStar UML, MS Visio, etc.. All this is aggregated in the table 1.

| Stage                        | Deliverables                                                                 | Tools/technologies                                      |
|------------------------------|------------------------------------------------------------------------------|---------------------------------------------------------|
| FEED                         |                                                                              | Ramus Educational, MS Visio, desktop applications, project management systems |
| Putting together the requirements to the AS | A presentation on the project goal and tasks, schedule and scope of works, time limits approved with the customer |                                                                                  |
| Concept Design               | A business-model of the solution being developed (a document on the image and limits of the project, a document on variants of application) | MS Visio, WhiteStar UML, desktop applications, systems |
| Technical Assignment         | Technical directions for development of an AS                               | desktop applications, systems                           |
| Design                       | Description of automated functions, description of data support, description of system algorithm, physical model of the system data, implemented system application | CA Erwin Community Edition, DMBS Firebird, DBMS Microsoft SQL Server, desktop applications, specialized development platforms |
3. Main part

After analysis of existing typical teaching systems (TSs), a set of requirements was formulated: the system shall include a module for storage and processing of information; the system shall provide possibility for user registration and storage of user accounts in a data base (DB); the system shall provide possibility to delimit access rights and organize a certain security policy; the system shall provide continuous operation, processing of user queries, stability against faults, the system shall provide assessment of student knowledge on the basis of an embedded assessment system; the system shall be convenient and easy to use; the system shall provide an interesting and fascinating learning process.

Let us compare characteristic of a typical TS and those of a ATS «3D Atlas of Metalworking Equipment»: 1) presence of all four training units (Unit Design, Control Panel, Process, Emergencies) is a feature of a typical TS and is not implemented in the 3D Atlas of Equipment; 2) user registration and delimitation of access rights – a feature of both types; 3) assessment of user knowledge – a feature of both types; 4) storing learning results – a feature of both types; 5) formation of detailed reports from the results of training – a feature of a typical TS, not implemented in the 3D Atlas of Equipment; 6) compact nature of the system – a feature of the 3D Atlas of Equipment, not implemented in a typical TS; 7) possibility of local operation without deployment and operation of a server – a feature of the 3D Atlas of Equipment, not implemented in a typical TS; 8) easy-to-comprehend learning – a feature of the 3D Atlas of Equipment, not implemented in a typical TS; 9) simple post-sale maintenance – a feature of the 3D Atlas of Equipment, not implemented in a typical TS; 10) the program does not require installation of additional software – a feature of the 3D Atlas of Equipment, not implemented in a typical TS; 11) minimal hardware requirements – a feature of the 3D Atlas of Equipment, not implemented in a typical TS.

From the analysis it is evident, that the ATS 3D Atlas of Metalworking Equipment meets almost all the criteria selected, unlike a typical TS.

Thus, the image of the solution may be represented as: ATS is a compact teaching system which is not developed for a concrete customer and thus free to distribute. The main idea in development of the 3D Atlas of Equipment: the system shall allow one to study the structure of process equipment by means of 3D models, provide possibility for detailed study of different units and mechanisms, provide additional information on the equipment (description, specifications, principles of operation in an animated form). An advantageous difference of the system from other TSs is in possibility of its easy further development by means of development and linking of relevant sets of 3D models and changes to the assessment system. Depending on a selected unit (mechanism), which the user undergo testing of knowledge for, the system presents names of elements of the unit (mechanism), while the user shall point to the corresponding elements of the 3D model. At that, the system stores details of both questions and answers. Thus, it is easy to register gaps in knowledge, organize error correction and re-taking of the test for better results.

The process of development of the teaching systems proceeds in accordance with the stages and divisions of GOST 34.601-90 with some adaptation (Table 1). Each stage brings the developer closer to implementation of the requirements in the design assignment. Let us show some of them.

Functional requirements: registration of users in the system, provision of a demo mode teaching by studying 3D models of a process plant design; provision of an assessment of knowledge of the students in the testing mode; providing storage of and access to the testing results; formation of consolidated reports for training (only in the network-enabled version); delimiting system information assess rights.

Main types of data support: 1) incoming and outgoing documents and methods for their design: corporate
templates of design assignments, action plan, remarks, instruction, guidelines and drawings for development of 3D models; 2) content and a method to build screen forms for entry of primary information, as well as forms for screen output of results. ATS 3D Atlas of Equipment provides the following forms: user registration and authorization; main system screen; training and testing of knowledge of equipment; statistics from the training results; browsing of the training results; system references (only in the network-enabled version); reporting of training and administration (only in the network-enabled version).

A key requirement for the ATS 3D Atlas of Metalworking Equipment software is a necessity to use Firebird as a target DBMS, supporting the client-server architecture. Software Requirements: general software (OS Windows XP/7; application development environment Borland Delphi 7; 3D model development environment «3ds Max»; DBMS Microsoft SQL Server; DMBS Firebird; compilers; interpreters; 2) specialized software (graphics engine AOSGraf.dll; project runtime software MTSShell.exe).

4. Conclusion
Supplementing the current data base of the teaching systems like «3D Atlas of Metalworking Equipment» allowed Korporativnye Sistemy Plyus to achieve its business goals [2], as well as to get closer to solution of the specified problems in the development of the engineering education.

Thus, by developing and implementing 3D Atlas of Metalworking Equipment in accordance with the given work sequence, Korporativnye Sistemy Plyus attained reduction of the following indicators: development efforts by a factor of 3-4 (in comparison to a typical TS) by means of implementing only a single Equipment Design unit and use of common existing software components; lead time by a factor of 3-4 in comparison to a typical TS; product cost in comparison to a typical TS, approximately 5-6 fold. This allowed one not only to extend the portfolio of solutions, but to expand the client base by attracting universities, secondary specialized educational institutions, commercial training organizations which can now afford such system.

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