SOME ASPECTS IN THE DESIGN AND DEVELOPMENT OF LEARNING APPLICATIONS FOR ENGINEERING SPECIALTIES

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ABSTRACT. The impact of information and communication technologies has permanently reformed many of the traditional training methods. The changes imposed by the Fourth Industrial Revolution, define new standards and approaches for a high-quality training of engineers. These changes require a transition from technologically-supported to technology-based teaching in lecture rooms and laboratories. The selection of engineers to work with sophisticated automated systems and CNC machines requires relevant competencies for a given specialty. The paper presents some aspects of training students of engineering specialties based on information and communication technologies. The new highly-interactive generation has imposed the creation of a new didactic tool for the purposes of the learning process. One possible solution to this problem is the development of WEB-based teaching application which supports the visual thinking of the new learner generation.

Keywords: education, engineering teaching, curriculum, ICT approaches

НЯКОИ АСПЕКТИ ПРИ ПРОЕКТИРАНЕТО И РАЗРАБОТКАТА НА ОБУЧАВАЩИ ПРИЛОЖЕНИЯ ЗА ОБУЧЕНИЕТО ПО ИНЖЕНЕРНИ СПЕЦИАЛНОСТИ

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РЕЗЮМЕ. Въздействието на информационните и комуникационни технологии трайно преформатира много от похватите на традиционното обучение. Промените наложени от Четвъртата индустриална революция, дефинирала нови стандарти и подходи, целящи качествена подготовка на инженерни кадри, налагат преход от технологично подкрепено към технологично базирано преподаване в лекционните зали и лабораториите. Подборът на инженерен състав за работа със сложните автоматизирани системи и машини с програмно управление поставя условието те да притежават съответните компетенции за дадена специалност. В настоящия доклад се разглеждат някои аспекти на обучението на студенти от инженерните специалности, основаващи се на информационните и комуникационни технологии. Формираното високоинтерактивно поколение налага създаването на нов дидактически инструментариум при изграждането на учебен процес. Един от вариантите за решение на този проблем е разработеното УЕБ-базирано обучаващо приложение, съобразено с визуалното мислене на новото поколение обучаеми.

Ключови думи: обучение, инженерно обучение, учебна програма, ИТ приложения

Introduction

The Fourth Industrial Revolution imposes new standards and approaches aimed at the preparation of engineering specialists (Bedolla, 2017) at a level which ensures adequate and competitive production. The ultra-high degree of systems integration and automation in the modern design and manufacturing stages, as part of the life cycle of new products, requires the selection of engineers with relevant competences for automated design (Panayotov, 2016) and work with complex computer controlled machines. Therefore, students' preparation in the field of technical disciplines should respond to the new trends in the manufacturing sphere in order to achieve a higher degree of balance between market needs and the quality of engineering specialties (Kalev, 2019). This balance could be achieved by focusing on the transformation (building) of methods, forms and didactic tools in the training. The paper discusses some aspects in the process of the design, development, and deployment of WEB-based learning applications for learning purposes.

Accepted terms

For reasons of technological accuracy, the following terms will be adopted and used in this paper:

• *digital*, rather than electronic, which is used in other publications;

• *basic types* of data which are a particular primary digital type of data having common generic properties, specific to that type, that can be used in learning content and could be visual, audial, textual, and user defined;

• *learning content* is any logically structured content that can be used for learning or training and is digitally represented by the *basic* types of data;

• *learning resource* is an object through which access to learning content is provided and which can be identified by a unified resource identifier (URI) and localised under a unified resource locator (URL);

• *interactivity* is a set of interactions based on provided programming functionality between the user and the learning application during the learning process;

• *efficiency* is seen as the process of application of learning tools and methods to achieving certain goal;

• *effectiveness is the ratio of the set goals and the goals achieved by using learning tools and methods.*

Prerequisites

The dynamic impact of information and communication technologies on a vast number of human activities has formed a new model of perception of the world around us. The so called digital generation has been replaced by a Highly Interactive Generation (HIG), which exists in high-tech environment and transforms its nature into a virtual one. This HIG accomplishes the predominant part of its needs through various types of technological devices and rightly raises questions about the approaches and didactic tools in the learning process in which it is a participant. On the other hand, there is a learning process in which a wide range of information tools is applied (Mihaylov, 2010a; Mohamad, 2015), but this process lacks attributes and teaching tools adequate to the perception model of learners and could not lead to increased quality in teaching. It is necessary to take into account that the lack of motivation in HIG learners has a negative impact on the learning process results (Mihaylov, 2010a).

Aspects of web-based applications

The main aspects in the development of WEB-based learning applications can be divided into two main groups:

• *technological (hardware and software);*

• *pedagogical*.

The leading prerequisite for the development of the application is the pedagogical goal, and the technological tools and approaches should ensure the achievement of the stated goal. The integral unity of these aspects defines the framework of the development process. There are models developed for research purposes which are relevant to the subject matter of the discipline (Mihaylov, 2016). However, the major difference, between the regular non-educational software and the software product with the characteristics of a learning application, is defined by the following aspects:

• *pedagogical goals;*

• *didactic model;*

• *implementing high interactivity.*

In the process of developing the application, there are constant factors that have a significant impact on the end product and which determine its application in the learning process. These factors establish a direct dependence of the application and operation of the product on the pedagogical goals, the didactic model and the functional high interactivity.

The use of the learning application should lead to the achievement of set pedagogical goals with measurable results. The developed learning application should provide considerable freedom of interaction between the application users and the learning resource. This is a key aspect and it is defined by the characteristics of the Highly Interactive Generation of learners, which means that one of the criteria for the effectiveness of a learning application should be the high degree of measurable interactivity of the learning content (Atanasov, 2019).

In this paper, a set of conditional average interactivity of a total high-tech environment I_{avrg} is allowed and a formalisation of a learning application model is presented:

$$\left(G \cap D\right) \cap I \Rightarrow E\,, \tag{1}$$

where:

G – *pedagogical goals*;

D – *didactic model of the learner*;

I – *application interactivity*;

E – *efficacy of the learning process.*

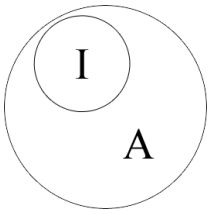

Fig. 1. The structured relation of the subset of interactivity *I* and the set of all pedagogical interactions *A*

In the presented model (***GΛD***) is the pedagogical component and ***I*** is the technological component. The structured relation of the subset of interactivity ***I*** and the set of all pedagogical interactions ***A*** are outlined (Fig. 1).

This means that any interactivity of a given learning application should be pedagogically coherent with the teacher's interactions. In order for the learning application to be effective, the following conditions are required:

$$I \neq \varnothing \tag{2}$$

$$I \subseteq I_{avrg} \tag{3}$$

$$f\left(E\right) \Rightarrow \sum_{i=1}^{I_{avrg}} I_i \tag{4}$$

There are several conclusions from (4):

- *higher interactivity determines higher efficiency*;
- *the interactivity of a given learning application should be no less than the conditional average interactivity of a total high-tech environment of a learner.*

The aspects which follow are presented in the context of the learning process of the main phases of development of the learning application.

Analysis of the requirements

From a software perspective, WEB based learning applications are software products developed on a programming language in a specific integrated development environment to achieve certain pedagogical goals, following a didactic model.

These requirements can be divided into the following three groups:

- *functional requirements - requirements to the software system;*
- *non-functional requirements - emotions, motivation, etc.;*
- *pedagogical requirements - pedagogical goals and didactical model.*

The formulation of the requirements is based on the perspective of hypermedia learning systems. A Web based learning app in an optimal case should:

1) have functionality based on a didactical model (content-logical and methodological structure),

providing a programming mechanism for realisation of the main pedagogical processes;
2) integrate a learner model;
3) provide access to the application and resources through authentication;
4) provide an adequate in form and scope mechanism for content visualisation;
5) provide opportunities for learning resources with rich interactive content;
6) offer access to additional learning resources, directly or indirectly related to the specific subject matter;
7) offer support and compatibility with widespread platforms;
8) include handbooks, manuals, and instructions;
9) provide a mechanism for monitoring the results by the teacher;
10) be built on a client/server model;
11) have a built-in database;
12) provide a mechanism for dynamic management of the learning content by the teacher;
13) provide a mechanism for managing user registrations of the application by the teacher;
14) contain a user panel;
15) contain an administrative panel;
16) provide options for settings related to various display device resolutions;
17) provide deployment capabilities to a local machine.

Choice of technologies

In developing the learning application and in view of the limited resources, the team chose to build a prototype application model by applying the iterative approach (Sommerville, 2011). The choice of the prototype approach is justified by a clearer review of the partial functionalities built to date and their compliance with the set requirements in the initial development phase for short time intervals. These activities are part of a step-by-step verification of the core system behaviour whose set of functionalities are subject to procedures described in an accepted verification methodology that is beyond the scope of this paper. The development of the learning application ends up after the achievement of the requirements which have been targeted and reaches the last phase – its implementation. Based on the engineering aspect of the application, key criteria such as visual perception, multitasking and hypermedia (Mynbayeva, 2017) are formed. The choice of technology for development of the learning application is based on research related to the processing of perceived information from certain brain regions, which determines that in the engineering disciplines the domain of the concepts and the domain of the processes predetermine the information to be visualised (Huang, 2013) including parallel visualisation of each of its text parts.

Programming tools

These tools are an important element in the system development process, and their choice is based on the provided functionalities, possible product implementation fields, a set of development tools, operational file compatibility, and other indicators that directly affect the system development process. The accepted methodology for the design and development of WEB based learning application, predetermine the environment and means for the development of: user part; administrative part; database.

The key reasons for the choice are the following prerequisites for the visual perception and thinking of the students in the engineering disciplines:

- *ability to create and edit 2D images*;
- *interoperable file compatibility*;
- *creating visual effects and animation, editing the sound environment, processing data streams and minimising the set of external applications to create visual or audio accessories;*
- *opportunities to create own components;*
- *real-time testing capabilities;*
- *a wide range of error detection capabilities in the code base;*
- *overall perspective of software development, graphic and sound layout;*
- *multiplatform independence;*
- *extensive documentation, handbooks, manuals and instructions;*
- *the presence of a wide community of developers in Internet forums.*

In order to meet the requirements, it is necessary to ensure: high degree of interactivity; Web base; extensive support by client agents (browsers); accessibility at any time and from anywhere; multimodality to perceptions.

The development team has created its toolbox in two directions – design and development. Designing a tool for system modelling using UML layouts and graphics and animation tools has been selected and focused on the programming language JavaScript and HTML5 and CSS3 structured WEB content.

Design and development

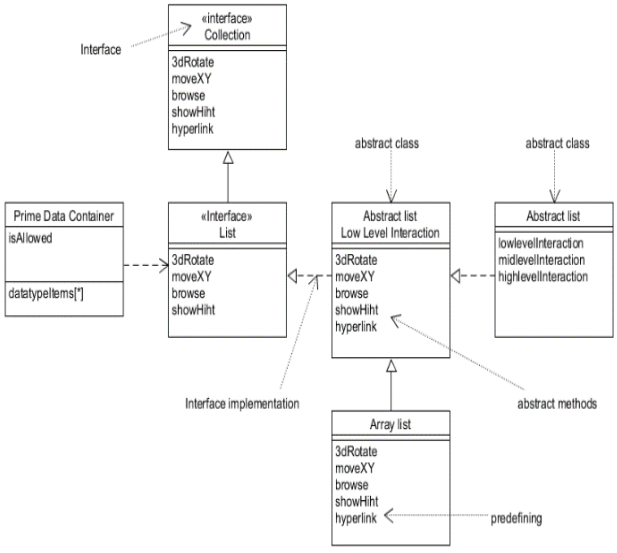

Fig. 2. Interface and abstract class of low-level interactivity

The development process is based on the synthesis of models and their implementation. According to the principles of object-oriented modelling, a system model should be synthesised representing the types of objects and their static relationships. The functional model of the application provides information about the logical procedural determination of its components from a user perspective.

Fig.2 presents the interface and abstract class of low-level interactivity of the data type object via UML class diagrams.

After the system has been modelled, the steps of code writing, testing procedures, verification and deployment have to be done. The development team of the WEB based learning app for the specific engineering specialty, taking into consideration the described in this article aspects, has achieved the desired functionality. In the steps that follow the developed learning app is to be tested in real educational environment, i.e., in the real process of learning.

Conclusion

The development of learning applications is a complex set of interrelated activities, actions and steps that are subordinate to the objectives that find their adequate reflection in the requirements analysis. As noted above, the development process has its specific features closely related to a target group with certain social and psychological characteristics – the Highly Interactive Generation. On the other hand, the developed software product should be based on certain principles that would define it as a learning tool in the hands of the teacher – a pedagogical aim, didactic model and student model. The aspects discussed above should be taken into account in a development of a learning application, which in turn would increase the efficiency of the learning process, the motivation and the interest of the learners in class.

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