Using information and communication technologies in teaching the academic discipline “Lifecycle management of information systems”

E B Zolotukhina, I V Medvedkova and S A Krasnikova

National Research Nuclear University MEPhI (Moscow Engineering Physics Institute), 31, Kashirskoe hwy, Moscow, 115409, Russia

E-mail: sakrasnikova@mephi.ru

Abstract. The results of the research on the application of information and communication technologies in teaching the discipline “Lifecycle management of information systems” in higher education institutions majoring in “Business Informatics” are presented in the article. The choice of methods, notations and modeling tools supporting the life cycle of information systems creation was carried out on the basis of peer inspections. The information for the execution of an examination was systematized in the form of passports of methods, notations and modeling tools. The package of educational materials, including interactive lectures, laboratory work, business games, independent tasks that form students’ professional competencies, was created using the selected techniques, notations and modeling tools. It is proposed to include elements of a package of training materials when teaching other engineering disciplines related to the creation of various automated systems, including information and software systems.

1. Introduction

A modern technical university is inconceivable without the use of information and communication technologies (ICT) in the educational process. Moreover, it is worth noting that in relation to specialties and areas of training in information technology (IT), we are talking about the use of these technologies both for organizing the learning process itself and for professional ICT training for future graduates. The relevance of teaching the discipline “Lifecycle management of information systems” in higher education institutions is due to the need to train qualified personnel for the digital economy.

The digital economy is an objective reality that allows finding ways of innovative development of society, increasing the efficiency of activities due to a fuller and wider use of various methods and technologies for processing digital information. The digital economy requires the widespread use of digital ICT: digital platforms and technologies, on the basis of which competencies are formed for the development of markets and sectors of the economy, a technological digital environment that creates conditions for the effective interaction of market entities and sectors of the economy and covers statutory regulation, information infrastructure, personnel and information safety [1].

Thus, the introduction of modern ICT into the educational process is an important task. When teaching the discipline “Lifecycle management of information systems” it is proposed to use modern methodologies and tools as ICT that support the full life cycle (LC) of creating automated systems (AS), including information systems (IS).
2. Problem statement
In accordance with ISO/IEC/IEEE 15288:2015 Systems and software engineering - System life cycle processes, LC of the system is the development of the system from concept to disposal. Throughout the life cycle of systems, there are a number of problems that need to be understood and solved when teaching the discipline “Lifecycle management of information systems”.

It is proposed to solve the main problems through the use of ICT (table 1), and the introduction of ICT into the educational process will allow students to acquire the competencies necessary for the successful creation and application of information systems within the professional activities of graduates.

| Problem | Information and communication technologies |
|---------|---------------------------------------------|
| The absence in most cases of a formalized description of automated business processes (BP) | Conducting interactive lectures on various BP modeling techniques and modeling notations, a business game for BP modeling, performing an independent project, conducting laboratory work on BP modeling using a visual modeling tool |
| Changing the requirements for AS throughout their life cycle | Conducting interactive lectures on requirements management, a business game to identify the requirements for AS being created using models, laboratory work on requirements modeling using a visual modeling tool |
| Complexity of AS, the need to integrate created AS | Conducting interactive lectures on the AS architecture, laboratory work on the creation of elements of the AS architecture using a visual modeling tool |
| Complexity of documentation and support in the current state of documentation for AS | Conducting interactive lectures on documenting AS, an independent task for AS documenting |
| The heterogeneity of the groups of developers of AS for the level of qualifications, use of various software and hardware platforms to create an AS | Conducting interactive lectures on various methods for creating an AS and various software and hardware platforms used, collective implementation of a project to create an AS, including planning a life cycle based on information technology standards |
| Continuous training of users in the techniques of working with AS | Conducting an interactive lecture on the creation of interactive tests, an independent task on the creation of interactive tests |

3. Research questions
In the research, the subject matter is the existing methods, notations and tools that support the life cycle of the AS throughout its entire length.

3.1. Methods that support the lifecycle of system implementation
For the research, the following methods that can support life cycle systems were selected: 1) information technology standards: ISO/IEC/IEEE 15288:2015 Systems and software engineering - System life cycle processes, ISO / IEC / IEEE 16326: 2019 Systems and software engineering - Life cycle processes - Project management, ISO/IEC/IEEE 24748-1:2018 Systems and software engineering - Life cycle management - Part 1: Guidelines for life cycle management, ISO/IEC/IEEE 12207:2017 (E) Systems and software engineering - Software life cycle processes, ISO/IEC/IEEE 29148:2018 (E) Systems and software engineering - Life cycle processes - Requirements engineering, GOST 19.102 - 77 Unified system for program documentation - Development stages, GOST 34.601 - 90 Information technology - Set of standards for automated systems - Automated systems - Stages of development; 2) methods from the leading world leaders in the development of AS and software, power supply and systems modeling: Architecture of Integrated Information Systems (ARIS) of Software AG corporation [2], Unified software development process Software Development Process [3], Rational Unified Process (RUP) of IBM corporation [4], Microsoft Solutions Framework (MSF) of Microsoft corporation [5], methods of
software application development of Oracle company [6]; 3) flexible development methods [7-11]: SCRUM, Extreme Programming (XP), KANBAN.

3.2. Modeling notation
Studying modeling notations included: 1) Unified Modeling Language (UML) [12,13]; 2) Business Process Model and Notation (BPMN) [14]; 3) ArchiMate [15]; 4) ICAM Definition (IDEF0) (ISO/IEC/IEEE 31320-1:2012 Information technology - Modeling Languages - Part 1: Syntax and Semantics for IDEF0); 5) Event-Driven Process Chain (EPC) [16].

3.3. Tools
When studying the tools, the main attention was paid to the tools related to: 1) modeling of a domain, systems and software; 2) requirements management; 3) project management related to lifecycle of systems and software. The following tools were considered: Microsoft Visio [17], Rational Software Architect [18], Sparx Systems Enterprise Architect [19], IBM Rational System Architect [20], Sybase Power Designer [21].

4. Purpose of the study
The purpose of the work was to create ICT to solve the problems presented in paragraph 2 using the selected methods, notations and tools and the introduction of ICT in the educational process of training in the field of “Business Informatics”.

5. Research methods
The choice of methods, notations, and tools for creating ICT was carried out using the creation of their passports, the analysis of these passports by individual experts and rational choice by experts based on the analysis of passports of methods, notations, tools for using them in the creation of ICT in the discipline “Lifecycle management of information systems”. Five experts participated in the research.

5.1. Passport of the methods supporting the life cycle of creating systems
The attributes of the methodology passport were determined on the basis of the recommendations presented in [22-24] and the descriptions of the methods listed in paragraph 3.1.

Methodology passport attributes include:

- Method name - full, abbreviated name is indicated.
- Availability of a formalized description of the methodology - the choice is “yes/no”.
- Supported stages of life cycle of the systems - a list of stages of life cycle of systems is indicated.
- Availability of a stage associated with the survey - the choice is “yes/no”.
- Availability of modeling notation in the description methodology - the choice is “yes/no”, if “yes” is selected, then the modeling notation is indicated.
- Availability in the methodology of recommendations for creating models of the BP of the subject area - the choice is “yes/no”, if “yes” is selected, the list of basic models is indicated.
- Availability of recommendations for creating system models in the methodology - the choice is “yes/no”, if “yes” is selected, then the list of basic models is indicated.
- Supported models of the life cycle of the system - a list of models is indicated: cascade, incremental, evolutionary, spiral, etc., or their combination.
- Support for documenting the systems being created throughout their life cycle - the choice is “yes/no”, if ”yes” is selected, the list of basic documents is indicated.
- Support of the methodology by tools - the choice is “yes/no”.

5.2. Notation passport
Notation passport attributes were defined based on [13-16].

Notation passport attributes include:
• Notation name - indicate the full, abbreviated name.
• Availability of a modeling technique that supports the notation - the choice is "yes/no" ("yes" = 1, "no" = 0), if "yes" is selected, then the method is indicated.
• Creation of domain models - the choice is "yes/no" ("yes" = 1, "no" = 0), if "yes" is selected, a list of basic models is indicated.
• Creation of system models - the choice is "yes/no" ("yes" = 1, "no" = 0), if "yes" is selected, a list of basic models is indicated.
• The full life cycle of the system is supported - the choice is "yes/no" (where "yes" = 1, "no" = 0).
• Support for decomposition of models - the choice is "yes/no" (where "yes" = 1, "no" = 0).
• Ease of perception of notation - the choice is "yes/no" (where "yes" = 1, "no" = 0).
• Availability of free versions - the choice is "yes/no" ("yes" = 1, "no" = 0).
• Cost of paid versions - one of the ranges is indicated (from 0 to 300 $ = 2, from 300 to 1000 $ = 1, from 1000 $ and more = 0).

5.3. Toolkit passport
The attributes of the toolkit passport were determined within the framework of this study and were reviewed [17-21].

Toolkit passport attributes include:

• Tool name - the tool is indicated;
• Supported notations - a list of notations and possibilities is indicated;
• Support of project management methods - the choice is "yes/no", if "yes" is selected, a list of the main project management methods is indicated;
• Support for requirements management - the choice is "yes/no";
• Testing support - the choice is "yes/no";
• Support for code generation - the choice is "yes/no";
• Database design - the choice is "yes/no";
• Simplicity of learning toolkit - the choice is "yes/no".

6. Findings
Based on the research carried out for the creation of ICT, the following methods were selected that support the creation of systems throughout their entire life cycle, notations and tools: standards - System life cycle processes (ISO / IEC / IEEE 15288: 2015), Software life cycle processes (ISO / IEC / IEEE 12207: 2017 (E)), Requirements engineering (ISO / IEC / IEEE 29148: 2018 (E)); methods - RUP, SCRUM; notations - UML; tool - Sparx Systems Enterprise Architect.

An example of an aggregated assessment associated with the choice of notation based on expert opinions is presented in table 2.

An example of an aggregate score associated with the choice of notation based on expert commentaries is presented in table 2.

Table 2. An example of an aggregate score of notation.

| Notation attributes                    | UML | BPMN | ArchiMate | IDEF0 | EPC |
|----------------------------------------|-----|------|-----------|-------|-----|
| Methodology availability               | 1   | 1    | 1         | 1     | 1   |
| Creation of domain models              | 1   | 1    | 1         | 1     | 1   |
| Creation of system models              | 1   | 1    | 1         | 1     | 1   |
| Full system lifecycle is supported     | 1   | 0    | 1         | 0     | 0   |
| Model decomposition support            | 1   | 1    | 1         | 1     | 1   |
| Simplicity of notation perception      | 1   | 1    | 0         | 0     | 0   |
| Availability of free versions          | 1   | 1    | 1         | 1     | 1   |
Cost of paid versions

| Cost of paid versions | 2 | 1 | 1 | 1 | 0 |
|-----------------------|---|---|---|---|---|
| TOTAL                 | 9 | 7 | 7 | 6 | 5 |

7. Conclusion

As a result of the studies carried out with the aim of introducing ICT in the teaching process of the discipline “Lifecycle management of information systems” in higher education institutions, the following results were obtained:

- the main problems that arise during the creation of the AS during the life cycle were identified, and the ways to solve these problems were suggested;
- templates for passports of methods, notations and toolkits were developed;
- passports of the analyzed methods, notations and toolkits were created using the developed templates;
- based on the completed passports with the use of expert commentaries, methods, notations and toolkits for introducing ICT into the educational process were selected;
- a package of training materials has been developed; this package of training materials will develop students’ competencies in the field of ICT, related to the use of modern standards and methods for creating and managing automated systems, developing procedures for managing the processes of system life cycle of enterprises;
- elements of this package of training materials can also be used in teaching other engineering disciplines related to the study of software and AS;
- graduates will be able to use the package of training materials in their professional activities in the creation and operation of AS.

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