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INSTITUTO POLITÉCNICO DE BRAGANÇA
Escola Superior de Tecnologia e Gestão

# Evaluation of Information Systems Curriculum in Portugal and Russia: IPB and KubSAU

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Final Report

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# Abstract


The importance of Information Technology (IT) and Information Systems (IS) to organizations and the need for skilled professionals in the field is one of the most important challenges to universities. With the technological and organizational changes, IS education has been under continued adaptation, and higher education institutions have several difficulties in keeping the bachelor degrees curriculum updated.

Several international organizations (ACM, AIS, BCS, IFIP, etc.) proposed for the last 40 years several curriculum guidelines, which are important to redesign the curriculum for survival in the current economic environment.

The main purpose of this work is to compare Portuguese and Russian bachelor degrees with several standard curriculum on Information Systems proposed by recognized international organizations.

The results obtained show the differences that exist between international curriculum guidelines and the bachelor degrees, and give us a perspective of the adequacy of the Portuguese and Russian curricula to the current requirements.

# Foreword

I would like to express my deep gratitude to the Polytechnic Institute of Bragança (IPB) and the professors for the education and support. During the training, I received a lot of new knowledge and experience in the field of Information Systems, which, of course, will help me in my future professional activities.

I express my deep gratitude to my supervisor, Mr. João Paulo Pereira, for valuable comments and assistance in writing the work.

I also thank the IPB staff, mainly Mr. Jose Eduardo Fernandes, for their support, kindness and priceless advice.

Thank you!

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# List of Abbreviations

IPB – Polytechnic Institute of Bragança

IS – Information Systems

IT – Information Technology

KubSAU – Kuban State Agrarian University

AIS – Association for information system

ACM – Association for computing machinery

AITP – Association of Information Technology Professionals

BCS – British Computer Society

IFIP – International Federation for Information Processing

IEEE – Institute of Electrical and Electronics Engineers

EI – Economic Informatics

MISRC – The Research Center Management Information Systems

ICIS – International Conference on Information Systems

WKWI – Vissenschaftliche Commission on fur Wirtschaftsinformatik

CRM – Customize Relationship Management

HRM – Human Resource Management

ERP – Enterprise Resource Planning

ITSM – IT Service Management

KPI – Key Performance Indicator

IFRS – International Financial Reporting Standards

FOSTAS – Fund for Support of System Design, Standardization and Project Management

CT – Computational technologies

ABM – Anti-Ballistic Missile

MAWS – Missile Attack Warning System

CE – Computer Engineering

# 1. Introduction

## 1.1 Context and motivation

With the development of information technologies (IT) and the explosive expansion in use of IT by organizations, Information System (IS) education has been under continued adaption. In a field like IS that is rapidly changing, it is important for institutions offering undergraduate programs in IS to periodically evaluate their curriculum and make necessary modifications to meet the demand and requirements of industry [1].

Important is the quality of graduates of information systems and the curriculum of information systems. Then, the proper education of information systems graduates is becoming more critical and designing a consistent IS curriculum is a challenging yet necessary process for all educational institutions [2].

The work of IS curricula task groups began in the early 1970s and has continued for the past 40 years. The Association for Computing Machinery (ACM) has been a major organizer for these task groups including the first efforts in the 1970s. Other organizations, including AIS (Association for Information Systems), AITP (formerly DPMA), BCS (British Computer Society) and IFIP (International Federation for Information Processing), have aided model curriculum development [3].

The convergence of national education systems within the European Union and in a wider area - in all European countries - is an important milestone in the global development of higher education in the 21st century. The official date for the beginning of the process of rapprochement and harmonization of higher education systems in Europe with the aim of creating a single European space for higher education is considered June 19, 1999, when their governments signed the Bologna Declaration. Russia joined the Bologna Process in September 2003 at the Berlin meeting of European education ministers. Because of joining the Bologna process, educational systems in most European countries are currently in the process of reform. Prior to higher education institutions, the task is not to unify, but to harmonize educational programs ("tweaking" them based on similar basic principles). Academic models of graduates and qualifications needed by the market and society should play an important role in the reform process along with specific tasks that are solved by academic community. In this regard, a methodology is needed to describe the level of the education received in terms of competencies and learning outcomes [3] [4].

## 1.2 Main objectives

The aim of the thesis is to analyze the educational programs of the IPB and KubSAU, analyze their compliance with current recommendations from educational associations, draw conclusions about the compliance of the IPB and KubSAU educational programs with new requirements. In the work, we define the following questions:

a) Compare Portuguese and Russian bachelor degrees with several standard curriculums on Information Systems proposed by recognized international organizations;

b) Show the differences that exist between international curriculum guidelines and the bachelor degrees (IPB and KubSAU);

c) Understand the adequacy of the Portuguese and Russian curricula to the current requirements;

d) Propose suggestions and orientations to improve both curricula.

## 1.3 Methodology

The methodology to study the curriculum of Information Systems in Portugal and Russia is based on the analysis of the curricula of these higher education institutions and their comparison with recommendations from international associations of Information Systems and Technologies. In accordance with the goal, we define the following steps:

1. Analyze the leading recommendations on educational programs in the field of information systems.
2. Analyze the relevance of educational programs to current recommendations.
3. Construct graphs reflecting the position of the university's bachelor degrees programs in relation to the recommended programs.
4. Based on the results of the graphs, evaluate the relevance of bachelor degrees programs to new requirements.
5. Based on the results of the analysis, we define proposals to improve the information systems programs quality in IPB and KubSAU.

In the process of analyzing the curricula of the selected educational institutions, we form the basis of subjects and the main subjects of the disciplines. At this stage, we can conduct a comparative analysis of training programs.

The next step is to compare the results with the recommendations from international educational organizations that are involved in curriculum development and accreditation. In the course of this analysis, we evaluate the quality of the curricula available at the university, with the curricula proposed by the associations (Figure 1).

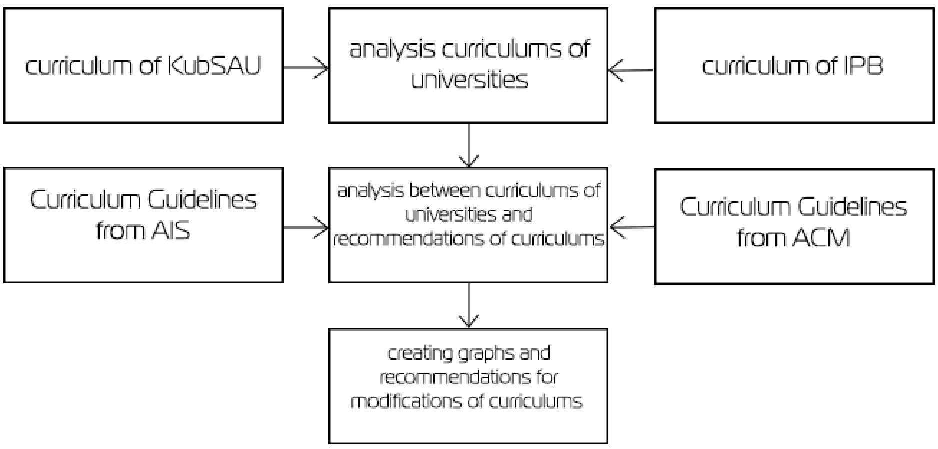


Figure 1. Methodology for the Evaluation of Information Systems Curriculum in Portugal and Russia

As a result, we get the percentage of the curriculum's compliance. We can analyze which curriculum is more in line with the recommendations. We will identify which disciplines are absent or do not fully comply with the recommendations. Thanks to this, we have an opportunity to make many recommendations for the modification of curricula, for their greater compliance with modern standards.

## 1.4 Structure of the work

The structure of the work is fully in line with the methodology plan, supplemented only with reference information on the objects of work.

The first chapter describes the context and relevance of this work, the chosen methodology and, in fact, the structure itself.

In the second chapter, we describe the main concepts about Information Systems, Information Technologies, their role in the modern organizations and the importance of the educational program in all this.

The third chapter describes the history of several international associations that proposes curriculum guidelines, the reasons for their emergence, the stages of development. Examples of the main players in this field are given and, most importantly, the international organizations chosen by us to develop recommendations for curricula, describing their structure, importance and why they were chosen.

The fourth chapter contains a description of the research methodology. It contains a comparative analysis, the main recommendations for the analyzed curricula.

The fifth chapter contains the main conclusions and possible ways of continuing work.

# 2. Information System field

The field of study called information systems encompasses a variety of topics including systems analysis and design, computer networking, information security, database management and decision support systems.

Some authors make a clear distinction between information systems, computer systems, and business processes. Information systems typically include an ICT component but are not purely concerned with ICT, focusing instead on the end use of information technology. Information systems are also different from business processes. Information systems help to control the performance of business processes.

## 2.1 Information systems

*"Information Technologies are currently in the state of either a new revolution, or counter-revolution. There is a transition from the introduction of accounting systems to optimization systems with clear business performance metrics. The old systems, of course, will not go anywhere, but the focus will leave them."* Nikolay Mikhailovsky, General Director of NTR Lab [5].

What is an information system? The answer to this question seems trivial. The Russian Federal Law says that "the information system is a collection of information contained in databases and providing information technology and technical means for processing it".

The definition is very general, as it is supposed to be in the law. You can see the definition in the classic book "Glossary for the Information Society". There, the information system is determined, following MR. Kogalovsky as a system that provides "support for a dynamic information model of some part of the real world to meet the information needs of users" [6].

In addition, a very general definition with its merits and demerits. Perhaps the understanding of what people usually imagine by the words "information system" is the easiest way to get by simply typing this phrase into the search string. This is the first picture that Google gives to this question (Figure 2).

Figure 2. Typical representation of information systems. [5]

The picture is more than familiar. Such information systems are everywhere.

At the bottom of the picture (Figure 3) are the accounting systems: CRM, HRM, ERP, ITSM. At the top, he takes out systems that provide the interface of accounting systems with the end user. Everything is logical [7].

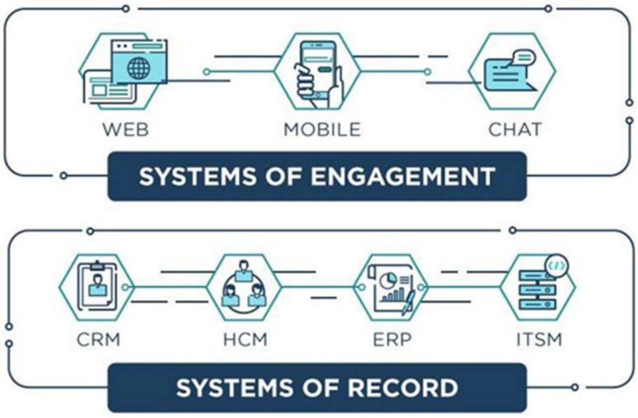


Figure 3. Presentation of information systems from Jerry Chen.

Let's look at information systems on the one hand - the requirements imposed on them. Here is a typical list of requirements for a system of accounting type (financial management automation), see Table 1.

Table 1. The typical list of requirements for a system of accounting type [8].

| Strategic model | Budgeting, KPI | Accounting, reporting |
|---|---|---|
| 1. Control of model versions.<br>2. "Sliding" planning<br>3. Modeling "if, then"<br>4. Planning "from what has been achieved"<br>5. Accounting data on accounting / management accounting data<br>6. Calculation of financial results | 1. Consolidation<br>2. Planning "from what has been achieved"<br>3. Accounting for the fact according to accounting records<br>4. Calculation of financial results<br>5. The ability to differentiate the access rights to the objects of the system<br>6. Ability to import / export data<br>7. The ability to monitor the execution of the budgeting schedule<br>8. System of approvals and approvals | 1. Preparation of accounting and tax reporting<br>2. Updating the database in accordance with tax laws<br>3. Maintaining a sufficient number of management analysts.<br>4. Use of the parallel chart of accounts for management reporting under IFRS. |

Thus, the requirements for such a system are expressed in the list of functions / capabilities of the system. The system is evaluated by the readiness in it of such opportunities and, possibly, the convenience of their use. The question of how effectively these opportunities are used remains for brackets and is determined by the quality of the implementation of the system in the organization - as well as the effectiveness of the system itself.

### 2.1.1 Information systems yesterday

The first information systems appeared in the 50's. Over the years, they were designed to process invoices and payroll, but were implemented on electromechanical accounting machines. This led to a certain reduction in costs and time for the preparation of paper documents.

In the 60's there was a change in attitude towards information systems. The information obtained from them became applicable for periodic reporting on many parameters. This day organizations needed computer equipment for a wide range of purposes, capable of serving many functions, and not only processing accounts and counting wages, as it was before.

In the 70's information systems are beginning to be widely used as a means of management control, supporting and accelerating the decision-making process.

In the 80's the concept of using information systems is changing again. They became a strategic source of information and are used at all levels of organization of any profile. Information systems of this period, providing timely information, help the organization succeed in its activities, create new products and services, find new sales markets, provide very worthy partners, organize production at a low price and much more [9].

The processes ensuring the operation of an information system of any purpose can be conditionally represented in the form of a scheme consisting of blocks [10]:

1. input of information from external or internal sources;
2. processing input information and presenting it in a convenient form;
3. output of information for presentation to consumers or transfer to another system;
4. feedback is information processed by people of this organization to correct input information.

The information system is defined by the following properties:

1. any information system can be analyzed, built and managed based on general principles of building systems;
2. the information system is dynamic and evolving;
3. when building an information system, it is necessary to use a systematic approach;
4. the output of the information system is information based on which decisions are made;
5. the information system should be perceived as a human-computer system for processing information.

### 2.1.2 Information systems tomorrow

If we look at the Gartner's curves of the hype about new technologies (at the time of this writing the most recent was the version of 2016), we will see that 9 of the 35 technologies on the curve of 2016 (Figure 4), and 8 of the 35 technologies on the curve of 2015 (Figure 5) have an important common feature, which is the most important feature of the technology, such as, for example, the Automated Vehicles, Machine Learning, Cognitive Expert Advisors, Smart Robots, IoT platforms, Commercial UAVs, Affective Computing, Personal Analytics and General Purpose Machine Intelligence, being applied in the information system [11] [12].


Figure 4. Gartner's Hype Cycle for Emerging Technologies 2016 [11].

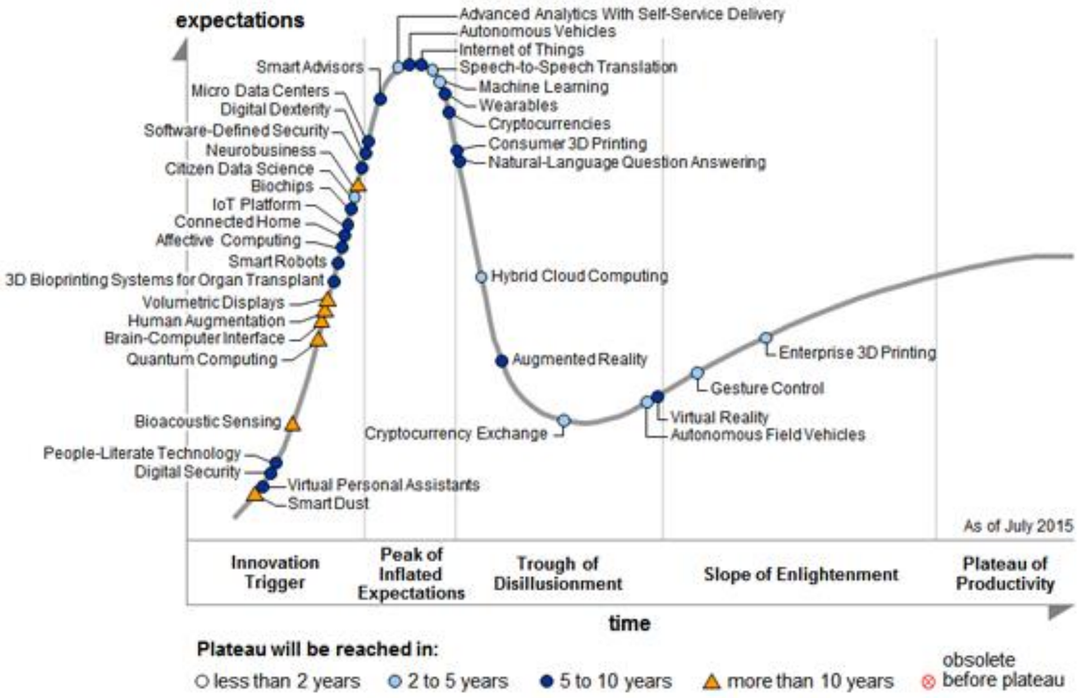


Figure 5. Gartner's Hype Cycle for Emerging Technologies 2015 [12].

Let's illustrate this based on machine learning, for example, crossss.ru is a service of personalized recommendations for online stores. The purpose of introducing such a service by an online store is to increase its profit per visitor (subject to a fixed marketing strategy). Optimization of this indicator requires knowledge of the profit for each product, including, depending on the volume (in the case of a large retailer, this means the inclusion of data on category management). Such data is often confidential and external services are not transferred. Therefore, these services usually optimize one of the proxy functions of the profit per visitor - turnover per visitor or conversion.

Thus, the client for choosing an information system of this kind does not compare the list of functions of the two information systems, but their A / B test with respect to one of the objective functions, Figure 6 [13].

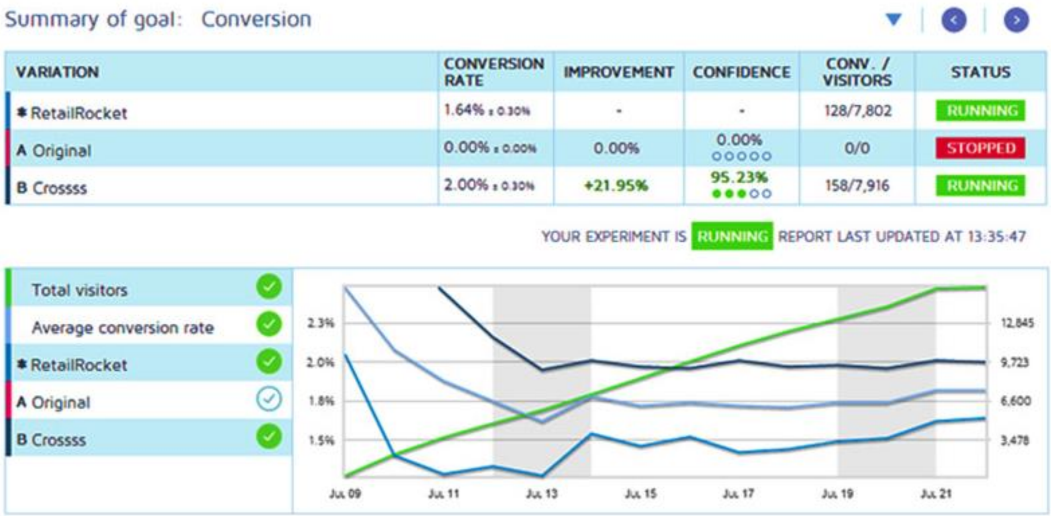


Figure 6. A / B test with respect to one of the objective functions in crossss.ru [13]

The system that statistically shows the best result, and should be used.

Thus, we can notice that the technologies are developing spirally and the essence of the information systems of the new class is not in the fashion words (deep machine learning, Internet of things, etc.) but in the fact that each such system has a small amount of measurable in terms Business results of optimization of certain processes.

If we talk about development in a spiral a little more detailed, then we can say that in terms of obtaining data, information systems evolved:

1. From a small amount of continuous / noisy data specially prepared for the system by external devices (for example, radar data);
2. To discrete data input by people;
3. And again, to continuous data, in huge quantities collected from sources of the general kind.

In terms of the objectives of the information system:

1. From decision making;
2. To informing;
3. And again, to autonomous decision-making without human participation and on the scales of volumes and velocities that are inaccessible to man.

In terms of ways to assess the effectiveness of the system:

1. From explicit performance criteria based on statistical inferences;
2. To implicit performance criteria;
3. And again, to explicit, statistically significant efficacy criteria.

As Gregory Tsiperman noted in the discussion of the speech at the FOSTAS mini-conference, this can be seeming like a confirmation of the law of negation denial:

1. At the first stage of CE (Computer Engineering) development, when computing tools were expensive and could not have wide distribution, it made sense to apply them only in the most critical cases where a person could not cope. This is a real-time system, which includes dispatching systems, incl. And air defense systems. To use means CE in registration systems was madness, unless, in systems of the government.
2. The development of CE means and their cheaper, the emergence of mini- and personal computers made it possible to use computers for accounting systems. Hence the migration of concepts: information management systems have moved to accounting and transactional and analytical systems that have dominated and usurped the name of information systems, pushing complex stochastic systems into a special niche.
3. Finally, the further development of CE has opened access to systems based on Big Data / the Internet of things and their like, in which probabilistic methods play a key role.

Note that because of the previous revolution, the old school of information systems lost its position as a world leader. During the new revolution, there is a small and somewhat illusive, but a chance to restore this position. Therefore, one must be very attentive to changes in the trends of information systems and change the educational programs for them in time, otherwise we will receive specialists who are not ready to perform modern tasks, coz we must track to gain competitive advantage [14].

## 2.2 Information Technology

The role of information technology (IT) in the society is constantly increasing, more and more enterprises are using IT to improve management efficiency and competitiveness in the market. In the middle of the last century, computer technologies in business were used mainly by large manufacturing companies to calculate the optimal loading of workshop equipment and planning supplies using MRP systems (Material Requirements Planning Systems). It was the time of development of corporate computing centers, whose leaders became the first IT managers. Few of the ordinary employees of enterprises were directly involved in the work of the information system , data to which the operators of the computer center contributed. A separate contribution to the development of information technology has been made by industries that require fast and accurate work with big data. For example, the development of information technology for the space program.

At the end of the last century, information technologies became more widely used, and they began to be used not only in solving production planning problems, but also to automate the activities of most of the company's services (financial, commercial, personnel), facilitated by the rapid development of corporate network technologies and the widespread use of personal Computers. The head of the IT service became one of the top managers of the enterprise, even a special abbreviation CIO (Chief Information Officer) appeared, which placed the head of the IT department on the same level as the executive (COO) or financial (CFO) director.

Nowadays, information technologies already go beyond the boundaries of enterprises, involving clients, partners, supervisory bodies and even shareholders in the exchange of information. Thanks to global communications and intelligent technologies, modern IT allows you to create completely new types of business through the extensive use of self-service tools, to create a unique environment for knowledge management and innovation. It can be said that information technologies are developing together with the economy and enterprises, corresponding to the economic era [15].

Dependence of the role of IT in the activities of an enterprise from its sectoral affiliation is the topic of this article. Information technologies can play a different role: be an auxiliary function, like economic services, help to improve the efficiency of business processes in the organization, but can become an integral part of business (for example, in finance and telecommunications). A special role will be played by information technologies in the knowledge society, when the bulk of the added value will be formed through collective intellectual and creative activity.

Human speech was the first bearer of knowledge about actions performed jointly by people. Knowledge was gradually accumulated and orally transmitted from generation to generation. The process of oral stories received the first technological support with writing on different media. First for the letter used stone, bone, clay, papyrus, silk, then - paper. The emergence of printing accelerated the rate of accumulation and dissemination of knowledge, stimulated the development of sciences.

Information technologies today are rapidly developing automated ways of processing information. For the implementation of which computers are used (including). Information technology now penetrates those areas of human activity, where it was previously impossible to participate in the machine. Let's say, in management, sometimes - in creative activity.

In addition, information technology is a set of methods, means of production and software integrated into the technological chain, ensuring the collection, storage, processing, production and dissemination of information. Information technologies are designed to reduce the complexity of using information resources and automation and to simplify complex calculations. For working with big data.

The first stage of IT development is "manual" information technology (until the second half of the 19th century). Instrumentation: pen, inkwell, ledger. The form of communication is mail. But already in the XVII century. Began to develop tools that allowed in the future to create mechanized, and then automated IT.

During this period, the English scientist C. Babbage theoretically investigated the process of performing calculations and substantiated the basics of the architecture of a computer (1830); Mathematician A. Lovelace developed the first program for the Babbage machine (1843) [16].

The second stage of IT development is "mechanical" information technology (from the end of the 19th century). Instrumentation: typewriter, telephone, phonograph. The information is transmitted with the help of improved postal communication, a search is being made for convenient means of presenting and transmitting information. At the end of the XIX century, the electricity was opened, which contributed to the invention of telegraph, telephone, radio, allowing the rapid transmission and accumulation of information in any amount. There were means of information communication, through which the transfer of information could be carried out over long distances [16].

During this period, the English mathematician George Buhl published the book "The Laws of Thinking", which was an instrument for the development and analysis of complex schemes, of which many thousands are modern computers (1854), the first telephone talks on telegraph wires (1876); Production of computer perforating machines and punched cards (1896) [17].

The third stage of IT development began in the late 1940s.

During this period, the development of automated information technologies begins; Use magnetic and optical storage media, silicon; "Electrical" information technology (40-60s of XX century) is applied. Until the late 1950's in the computer, the main element of the design was electronic lamps (the first generation), the development of ideology and programming technology was due to the achievements of American scientists [17].

Instrumentation: large computers and related software, electric typewriter, portable tape recorder, copiers.

In this period: the attention of the scientific community is represented by Z3 - a programmable computer electromechanical machine, possessing all the properties of a modern computer, created by the German engineer K. Zuse in 1941; Launched Mark I - the first American programmable computer (1944); The first electronic machine was created in the USA - ENIAC (calculator) (1946); In the USSR under the guidance of S.A. Lebedev was created by MESM - a small electronic calculating machine

(1951); In the Soviet Union, a serial production of machines began, the first of which were BESM-1 and Strela (1953); IBM introduced the first hard disk drive ("Winchester") RAMAC with a capacity of 5 MB (1956) [17].

The fourth stage of IT development is "electronic" information technology (since the early 1970s). Its tools are large computers and the automated control systems created on their basis, equipped with a wide software. The goal is the formation of a substantial part of the information.

The invention of microprocessor technology and the emergence of a personal computer (70s of the XX century) made it possible to finally switch from mechanical and electrical means of converting information to electronic ones, which led to a miniaturization of all devices and devices. Microprocessors and integrated circuits create computers, computer networks, data transmission systems.

In the 1970s and 1980s, the mini-computer is created and distributed, an interactive mode of interaction of several users is carried out.

The fifth stage of IT development is computer ("new") information technology (since the mid-1980s). Toolkit - a personal computer (PC) with many software products for various purposes. A decision support system is developing, artificial intelligence is implemented on a PC, telecommunications are used. Microprocessors are used. The goal is the content and accessibility for the general consumer of miniaturized technical means for every day, cultural and other purposes.

In the 1980's and 1990's. There is a qualitative leap in the technology of software development: the center of gravity of technological solutions is transferred to the creation of means of interaction between users and computers when creating a software product. An important place in IT is the presentation and processing of knowledge. Knowledge bases, expert systems are created. Widely distributed personal computers [18].

IT development in the 1990-2000s: Intel introduces a new processor - 32-bit 80486SX, which speeds up 27 million operations per second (1990); Apple creates the first monochrome hand-held scanner (1991); NEC releases the first CD-ROM drive at double speed (1992 g); M. Andrisen presented to the public his new web browser, called Mosaic Netscape (1994); By 1995, Microsoft software used 85% of personal computers. Windows OS is improving year by year, already having access to the global Internet [19].

At the present stage, instrumental environments and visual programming systems are being developed to create programs at the high-level level: TurboPascal, Delphi, Visual Bask, C ++ Builder, etc. Therefore, it attracts massive distributed data processing. Unique opportunities are provided by the Internet, potentially enabling the creation of the largest parallel computer to effectively use the existing network potential. It can also be viewed as a metacomputer - the largest parallel computer, consisting of many computers.

Against the backdrop of the growing needs of retail business and other structures in IT professionals, the role of quality, corresponding to modern requirements, education is growing more and more.

## 2.3 Importance of IS in organizations

Information systems have become integrated, interactive "smart" tools used in all day-to-day operations and when making decisions in large organizations. Next, we describe the process of changing the role played by them in the work of such organizations, and how this was influenced by the interaction of organizations and information technologies.

From the economic point of view, the technology of information systems can be viewed as a production factor interacting with labor and financial resources, fulfilling their functions. If the cost of information systems falls, this is reflected in labor resources, which have a historical tendency to increase. Hence, using the microeconomic model of the firm, it can be shown that information technology can reduce the number of middle managers and clerks by automating their functions.

Information technology also helps firms to control their size, as they can reduce the cost of transactions - transactions for the acquisition of goods on the market that the firm cannot produce on its own. According to the theory of transaction costs, firms and individuals try to minimize transaction costs, as well as production costs. The use of markets is expensive, as this includes the costs of finding and communicating with suppliers, monitoring the implementation of contracts, insurance, obtaining information about similar products, etc. Typically, companies are trying to reduce transaction costs, increasing their size, increasing the number of employees, as well as acquiring suppliers and distributors, as does General Motors [20].

Information technology, especially when using computer networks, can help firms reduce transaction costs, allowing the use of internal sources, rather than referring to external partners. For example, using computer communication with external suppliers, Chrysler Corporation could save significant funds by ordering more than 70% of spare parts from third-party manufacturers. In Figure 7 demonstrates that if the value of transactions decreases, the size of the firm (the number of employees) will decrease, since it is much easier to procure goods and services on the market than to produce them independently. The firm's size can remain constant or decrease, even if its revenues grow. [21]

Information technology can also lead to a reduction in management costs within the company. According to the agency theory, the firm is viewed as a connected group of contracts between individuals having their own interests, and not as a separate object that maximizes their own profit. The principal (the owner) of the enterprise hires "agents" (workers) to perform certain work. However, agents must control and manage them, because, as a rule, their own interests are more important than the interests of the owner. With the increase in the size of the firm and the expansion of its activities, the costs of managing agents also increase.

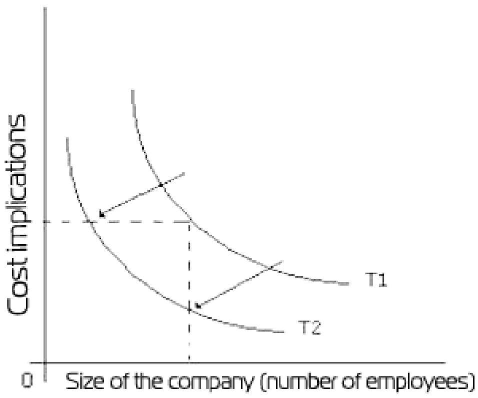


Figure 7. Theory of cost costs applied to the use of information technology in an organization. [21]

Information technology allows you to reduce agency costs by reducing the cost of obtaining and analyzing information, enabling managers to control a greater number of employees. In Figure 8 shows how by reducing overall management costs, information technology allows a company to increase its revenues by reducing the number of middle managers and dismissing some of the clerks. Previous chapters also gave several examples of how information technology increases "power" and extends the scope of small organizations, allowing them to manage a small number of employees.

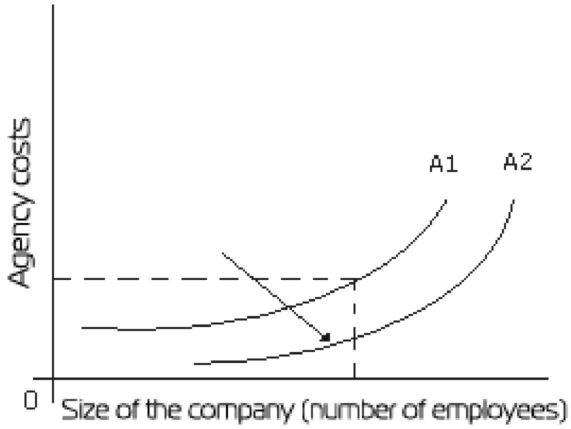


Figure 8. Agency theory applied to information technology used by the organization. [21]

Information technology can change the hierarchy of decision-making in an organization by reducing the cost of extracting and disseminating information. Information technology ensures the transfer of information from all departments directly to senior management, eliminating the need for middle managers and clerks serving them. Conversely, the necessary information can be transferred to performers who can independently make decisions in their field of activity, based on their own knowledge and experience. Some researchers even believe that computerization provides middle managers with information sufficient for making more important decisions than before, which allows an enterprise to dispense with employees who were engaged in its collection and processing.

In post-industrial societies, power structures are increasingly dependent on knowledge and awareness, rather than on the level of the position they occupy. Consequently, organizations are gradually aligned, as professionals can themselves make the necessary decisions at the local level; The decision-making process becomes decentralized with the dissemination of information and knowledge within the organization. Information technologies lead to the emergence of adhocracy and "target" structures, in which specialists are temporarily divided into groups to perform specific tasks, and then disband to continue working on other problems. Many firms can exist in the form of virtual organizations, whose activities are not limited to their geographical location. Virtual organizations use computer networks to communicate among themselves employees, exchange of assets and ideas. They can connect the firm with suppliers, customers and even competitors, helping to create and distribute new products and services, not paying attention to the traditional boundaries of the enterprise or its physical location. For example, Calyx and Corolla is a networked virtual organization that sells live flowers, delivering them directly to customers, bypassing flower shops. The firm accepts orders by phone or via the Internet, and then transfers them to gardens or greenhouses that send flowers to customers ordered by Federal Express minibus [22].

Thus, it turns out that today information systems and information technologies play a leading, irreplaceable role in the life of organizations. The role of information systems in organizations is so strong that, if lost, the activities of the entire company can stop.

## 2.4 Information Systems Professionals

Increasingly, the development of companies depends on the quality of IT work. Yes, before, many companies did not even think that in addition to the system administrator, for the smooth and precise operation of the company they might need specialists with more extensive knowledge and skills.

In most cases, the job of a system administrator in many companies is to repair computer equipment and other works that are also relevant to this area. Now, for the development and clear operation of the company, this is not enough, and only IT specialists can help in this situation.

Practically, the activities of all companies require the use of both computer equipment and special programs. Any failure in the program, or even more so the system, can completely stop the work of the whole company, and only the IT specialist can help here to return to its working condition. Clear control of the situation, a quick explanation of the cause of the failure and its elimination, are capable to renew work of the company for a short time [20].

IT professionals today can be found in all companies. Every organization that uses computers needs the support of an IT specialist. Small companies can call different services when they get into trouble, but medium and large companies usually have their own IT staff to solve their daily problems.

IT specialist helps in solving problems related to work, server, site, special programs. Also, if necessary, he can quickly restore the efficiency of computer technology and other office equipment.

As the world becomes more and more dependent on computers, the demand for IT professionals grows very quickly. Required IT knowledge will increase with time. The importance of this profession is growing every day, and accordingly the number of vacancies increases. Therefore, the quality of education in information systems is so important.

With the constant change in the technology and organizations the current programs do not deliver graduates with the skills to succeed in the IT industry.

The curriculum is the basis of the learning process. Real changes in education comes with changes in its content that teachers teach and students learn, and in the teaching methods that teachers use. Both curricula and instructions, in turn, form expectations about the types of educational outcomes that students should show up by the time they graduated from the school.

Based on the standards, the reforms were built around a set of assumptions about the curriculum and instructions embodied in the standards of content and productivity that are crucial to reform.

Accordingly, the quality of specialists graduated by a higher educational institution also depends on the content of the educational program. Therefore, it is especially important to keep the state of the educational program in accordance with modern requirements [23].

# 3. IS Curriculum Guidelines

## 3.1 Introduction

What is informatics? How to teach computer science? What are the characteristics of an IT specialist? These questions were always of concern to the scientific community. The subsequent heated discussion of the issues of teaching informatics led to the creation and implementation of state educational standards reflecting the understanding at the time of the subject of computer science and the corresponding knowledge. Efforts to standardize the teaching of computer science deserve the closest attention. The most significant project in this area, of course, is the creation and updating of the document Computing Curricula ("Recommendations for Teaching Informatics in Universities"). The first version of Computing Curricula was developed by the Special Committee for the Education of the Professional Association of Association for Computing Machinery (ACM) and was published in 1968. In the 1970s, another professional society, the IEEE Computer Society, issued a similar document [24].

Technological development of the 1950-60's was a prerequisite for the introduction of information technologies in business, as well as the emergence of academic communities engaged in research and training of specialists in this subject area. One of the first academic communities for "information management systems" (Management Information Systems) was founded by scientists from the USA and Canada.

In Germany and Austria at the same time began to form a community on "economic informatics" (WIRTSCHAFTSINFORMATIK). Despite the terminological differences, the subject of the study was general - information systems in economics. Understanding the terms "management information systems" and "economic informatics" as synonyms applied to the field of scientific research in question, we will use the name "economic informatics" (EI).

The beginning of the formation of the North American Community for EI was the creation in 1968 of the Research Center Management Information Systems (MISRC) at the School of Management of the University of Minnesota. The center was organized with financial support and direct participation of more than 20 American companies that had international fame and invested in information systems. Four years later, the Association for Computer Science ACM published a curriculum model for the EI specialty at the first stage of higher education, as well as for the same master's and doctoral programs. In 1974, Gordon Davis - the founder of MISRC - published the first and subsequently widely used in the universities textbook "Management Information Systems». To achieve high quality training of EI specialists at universities in the US and Canada, research was organized on the formation of the theoretical foundations of this new subject area and authoritative scientific journals were created to publish the results. The first such magazine, MIS Quarterly, appeared in 1977. To organize cooperation with colleagues from around the world, the North American Community for EI organized the first international conference "International Conference on Information Systems" (ICIS) in 1980 [25].

The German-speaking community for EI, which began to form around the same years as in North America, went through similar stages. The first doctoral thesis on EI was defended by the German scientist Peter Mertens in 1966. At the end of 1960 at the universities of Germany and Austria the EI departments were founded. In 1975, German-speaking professors on the EI created the scientific association "Vissenschaftliche Commission on fur Wirtschaftsinformatik" (WKWI). In 1984, Peter Mertens published the first recommendations for the preparation of students in the field of EI. The scientific journal "Wirtschaftsinformatik" was founded in 1990, and three years later WKWI established an annual conference on EI. By the 1990s, the ICIS International Conference had become a center for cooperation between academic communities. On EI from all over the world. In 1994, on the initiative of the conference participants, the International Association for Information Systems (AIS) was established [26].

## 3.2 International Information System Organizations

Given the rapid pace of technological and economic development of the IT industry, issues related to the adequacy of the content of educational programs for the professional training of IT specialists to the modern requirements of employers, as well as the timely recording of changes in the labor market context, are of paramount importance. Currently, the search for answers to these questions lies in the way of the implementation of the competence paradigm in the design and implementation of educational programs.

By the middle of the first decade, a set of documents describing model curriculum models, called curriculum standards: Computer Science 2001 (CS2001 or CCCS2001), Information Systems 2002 (IS2002), Computer Engineering 2004, was developed by a joint team of ACM, IEEE-CS, AIS and AITP specialists. (CE2004), Software Engineering 2004 (SE2004), Information Technology (IT2006), and the document Computing Curricula 2005 (CC2005), which has a common methodological purpose. In the next five years (the process of development has assumed a constant continuous character and is implemented on the principles of consortium standardization), practically all the above documents have been revised and published in new editions.

### 3.2.1 Association for Information Systems

Currently, AIS has about 4 thousand members from 99 countries, that is, it is truly an international organization. AIS member can become both an organization, for example a university, and a professional in the field of EI scientist, teacher, graduate student, business representative). The amount of the annual fee varies for different countries. For example, a Russian VBO membership in AIS will cost about $ 1000, for a domestic teacher or scientist this amount will be $ 70, for a graduate student - $ 48, and a representative of business from our country will need to pay $ 175. Members of the organization receive an exclusive right to participate in AIS conferences, privileges to participate in conferences of partner organizations, as well as free access to the resources of the electronic library. This creates broad opportunities for integration into the global professional community on EI [26].

Regional groups (AIS chapters) started to be established in 1996. Now such groups 39. Their members organize closer contacts within the group and create local services, for example, a regional bank of vacancies and data on scientists, teachers and specialists in EI.

To increase the number of services provided to the members of the association, in 2001 AIS started the creation of thematic groups (Special Interest Groups - SIGs). The first were six groups on the following topics: human-computer interaction; Automation of processes and management; Agent-oriented information systems; Cognitive research; E-business; Internet and network security. For the next 14 years, based on applications from the members of ICSB, another 31 groups were organized. Within the thematic groups, studies are carried out, training materials are developed, bulletins are published [27].

In 2009, the first student group AIS (student charter) was established at Temple University (USA). Currently, more than 70 such divisions are functioning since chairs and faculties of EI at universities of different countries. Since 2010, the Students Chapter Leadership Conference has been held annually, where students report on their achievements, meet with representatives of world business and IT companies, and participate in competitions.

AIS organizes 3 conferences annually for its members: International Conference on Information Systems (ICIS), Americas Conference on Information Systems (AMCIS) and Pacific Asia Conference on Information Systems (PACIS). ICIS is held in different countries around the world and is the largest international event for EI specialists. AMCIS is hosted by the countries of North and South America, but AIS members from other continents also come to the conference as guests. PACIS is positioned as the most significant conference on EI in the Asia-Pacific region. AIS also supports and announces on its website conferences held by regional, thematic and student groups, as well as partner organizations. Access to conference materials is organized through the AIS electronic library.

AIS publishes (independently or participates in the publication) more than 10 scientific journals. Several publications have the status of affiliated AIS journals. The thematic framework of AIS journals is presented by scientists from all over the world to publish the results of theoretical and practical research on the widest range of EI issues. Many of the AIS journals have a high scientific authority, which is confirmed by the values of citation indexes and positions in world ratings. The presence of enough rating journals on EI is very important, as in many countries around the world, the published results of the research (for example, the H-index) are the main arguments for deciding whether to conclude a contract with a scientist (teacher) or allocate a contract to him.

The "MIS Quarterly" (MISQ) already mentioned in this article is the world's first EI magazine. Subsequently, he became the official magazine of AIS.

Is one of the most prestigious international publications on EI. So, according to data for 2014, its impact factor was 5.4, and in the ratings for the H-index and the indicator SC Imago MISQ ranked second in the world among the magazines of the thematic group "Information Systems". MISQ is focused on publishing the results of theoretical research on EI. In 2002, a group of scientists, widely known in the ICU community for their practice-oriented research, organized a "sister" magazine, "MIS Quarterly Executive" (MISQe). He publishes articles on research, the results of which are ready for practical use to solve specific problems that arise during the development, implementation and operation of information systems. The target audience of MISQe are practitioners, as well as teachers and students. Articles of the journal can be effectively used in the educational process at the university for discussion at seminars on EI and related disciplines.

As a professional community, AIS has seen one of its main functions in creating the conditions for effective communication between members of the association. To implement this function, in 1999, the journal Communications of the Association for Information Systems (CAIS) was established. CAIS publishes articles on a wide range of issues, including the history of EI as a field of scientific research, approaches to the teaching of EI and related disciplines in various countries of the world.

In 2000, AIS launched the Journal of the Association for Information Systems (JAIS), which became the association's main journal for the publication of research findings of a theoretical nature. The editorial office of JAIS carefully selects articles, giving preference to innovative and interdisciplinary research. In 2014, the impact factor of this magazine was 1.8, and according to the SC Imago rating, JICE entered the Q1 group with the best indicator values among all the magazines of the thematic group "Information Systems".

Among affiliated magazines AIS one of the most authoritative is "Business & Information Systems Engineering" (BISE). This is an English-language copy of the magazine "WIRTSCHAFTSINFORMATIK", which for more than 55 years has been the main journal of the scientific community on EI of Austria, Germany and Switzerland [28].

The aim of the AIS within the framework of the project is to promote the use of information systems in a politically correct way. The goals set by the Union to achieve the goal, as stated in the official website [27]:

1. Creation and maintenance of professional identity for teachers, researchers and specialists in the field of information systems.
2. Promoting communication and interaction among its members.
3. Provide a focal point for contacts and relationships with government agencies, private and educational institutions that influence or control the type of information systems.
4. Improvement of curricula, pedagogical and other aspects of information systems of education.
5. Creating a vision for the future of the industry and the profession of information systems.
6. To create modern, technologically advanced professional societies.
7. Establishment of standards of practice, ethics and education, where necessary.
8. Include professionals from around the world.

When building the program recommendations for educational programs in information systems, the organization adheres to the following plan from Figure 9:

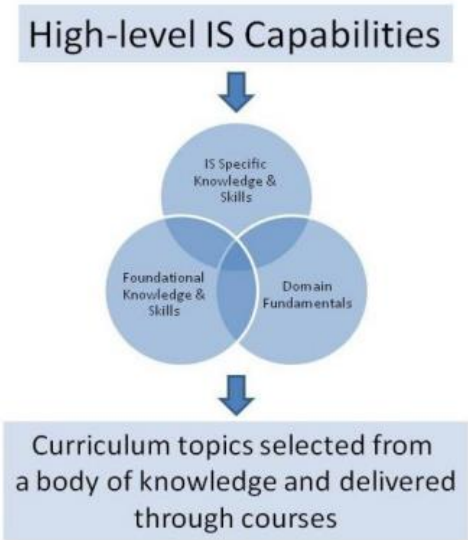


Figure 9. Overall structure of the basic concepts [27].

And gets the following structure, red marks those items that were subjected to the latest changes, Figure 10:

Structure of the IS Model Curriculum:Information Systems specific courses

| Career Track: | A | B | C | D | E | F | G | H | I | J | K | L | M | N | O | P | Q |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Core IS Courses:** | | | | | | | | | | | | | | | | | |
| Foundations of IS | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● |
| Enterprise Architecture | ○ | ● | ○ | ○ | ○ | ● | ○ | ○ | ○ | ○ | ● | ○ | ○ | ○ | ● | ○ | ○ |
| IS Strategy, Management and Acquisition | ○ | ● | ○ | ○ | ○ | ● | ○ | ○ | ● | ○ | ● | ○ | ○ | ○ | ● | ○ | ○ |
| Data and Information Management | ● | ○ | ○ | ● | ● | ○ | ○ | ● | ● | ○ | ● | ○ | ● | ○ | ○ | ○ | ○ |
| Systems Analysis & Design | ● | ● | ● | ○ | ○ | ○ | ● | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ● | ● | ● |
| IT Infrastructure | ○ | ○ | ○ | ● | ○ | ○ | ○ | ● | ● | ● | ○ | ○ | ● | ● | ○ | ○ | ○ |
| IT Project Management | ● | ○ | ○ | ○ | ○ | ● | ○ | ○ | ○ | ○ | ● | ○ | ○ | ○ | ● | ● | ● |
| | | | | | | | | | | | | | | | | | |
| **Elective IS Courses:** | | | | | | | | | | | | | | | | | |
| Application Development | ● | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ● | ● |
| Business Process Management | | ● | ● | | | ○ | ○ | ○ | | ○ | ● | | | | ○ | | |
| Collaborative Computing | | | | | | ○ | | | | | | | | ○ | | | ○ |
| Data Mining / Business Intelligence | | ● | | ● | ● | ○ | ○ | ○ | ● | | ○ | ○ | ○ | ○ | ○ | | ○ |
| Enterprise Systems | | ● | ● | ○ | ○ | ○ | ● | ● | ○ | | ● | ● | ○ | ○ | | | |
| Human-Computer Interaction | ● | | | | | ○ | ○ | | | | ○ | | | | | ● | |
| Information Search and Retrieval | | ○ | | ○ | ● | | | | | | | | ○ | | | | ● |
| IT Audit and Controls | ○ | | ● | ○ | ○ | ○ | ○ | ● | | ● | ○ | | ○ | ○ | ○ | | ○ |
| IT Security and Risk Management | ○ | | | ○ | ○ | ○ | ○ | ● | ● | ○ | ○ | | ● | ● | ○ | | ○ |
| Knowledge Management | | ● | | ○ | | ○ | ○ | | | ○ | | | | | | | |
| Social Informatics | | | | | | | | | | | | | ○ | | ○ | | |

- A = Application Developer
- B = Business Analyst
- C = Business Process Analyst
- D = Database Administrator
- E = Database Analyst
- F = e-Business Manager
- G = ERP Specialist
- H = Information Auditing and Compliance Specialist
- I = IT Architect
- J = IT Asset Manager
- K = IT Consultant
- L = IT Operations Manager
- M = IT Security and Risk Manager
- N = Network Administrator
- O = Project Manager
- P = User Interface Designer
- Q = Web Content Manager

**Key:**

● = Significant Coverage

○ = Some Coverage

Blank Cell = Not Required

Figure 10. Structure of the IS 2010 model curriculum [27].

### 3.2.2 Association of Computing Machinery

The Association of Computing Machinery (ACM), the world's largest community of teachers and professionals engaged in computer science. ACM's goal is the development of science, art and technology and IT applications through dialogue, the integration of the environment, the promotion of knowledge, the creation and promotion of ethical and professional standards.

ACM was established on September 15, 1947 in New York City, USA during a series of meetings at Columbia University. The creation of the association was a response to the progress of science. Articles and work in this area were previously associated with mathematics, electrical and other sciences [29].

Specialists need magazines and other resources to study computer science. He grew up, so did the need for such research results. During subsequent meetings at the universities of MIT and Harvard, it was decided to create a journal dealing with IT. He also defined the final form of the new name and organization. The Memorandum of Association members was formally presented in 1949.

ACM has created a digital library where its publications are available. The ACM digital library is the largest collection of computer information and has in its collection of newspapers, magazines and conferences, as well as ACM publications. Services, including forums, called "Ubiquity" and "Tech News digest" as containing the latest information about the world of IT.

### 3.2.3 Institute of Electrical and Electronics Engineers Computer society

The IEEE Computer Society was created to develop and improve the theory and practice of computer and information technology. Uniting about 100,000 members, the company is the world leader among organizations of computer professionals. Since its foundation in 1946, the computer society has become the largest technical society in the IEEE.

**Activities**

The computer society realizes its mission by organizing conferences, publications, technical committees, standards preparation groups and local student departments. It sponsors (in whole or in part) more than 140 annual conferences, symposiums and meetings on the whole range of topics of informatics. All activities are maximally decentralized and rely on the work of regional committees and subcommittees. The annual income of the company reached $ 30 million, with membership fees accounting for less than 10% of this amount. There is a special program "Distinguished Visitors Program", in which known scientists are speaking around the world with lectures on the current state of computer science and technology.

**Structure of the organization**

More than 100,000 industry representatives, academic institutions and government organizations around the world are members of the Computer Society. Volunteers from members of the community can participate in various boards, committees and working groups of the IEEE-CS. In the society, individual membership.

**Leadership**

The Executive Director, Dr. David W. Hennage, has more than 30 years of experience in management and leadership of associations in the engineering, scientific and educational fields. The President, Dr. Willis K. King, has been involved in the activities of the Computer Society for more than 20 years. Dr. King has been working at the Department of Informatics at the University of Houston since 1969. The headquarters is in Washington; Two more offices - in Brussels and Tokyo. [24]

**Main areas of work**

The work of society is extremely diverse. Anything that can help computer professionals in their work is the subject of society's activity. According to the Strategic Plan, the Computer Society must become the leading producer and supplier of information and a variety of services for professionals around the world.

**Publications**

Conference materials and training courses The IEEE computer society publishes, distributes and stores for posterity more than 20 periodicals offering readers peer-reviewed articles and research papers in all areas of computer science, including artificial intelligence, computer hardware, graphics, network technologies, information technology, software development, Multimedia and so on. Among the magazines are such popular ones as Computer, IT Professional, IEEE Internet Computing, IEEE Software, Transaction on Computing, Transaction on Software engineering. IEEE Computer Press publishes a large number of books, conference materials and training courses. Repeatedly winning various awards, Computer magazine is delivered to every member of society. Computer is a monthly publication that keeps IEEE-CS members informed of the latest technological news, trends and other issues important to professionals.

Members of the society receive free access to the following technical information:

- The magazine "Computer magazine";
- Unlimited online access to 600 Books by Safari R;
- Unlimited online access to 3000 modules of e-courses, including topics such as Java, Cisco, Microsoft, project management, security and so on;
- Free online access to books and technical articles of society.

The computer society also conducts certification of specialists in the field of information technology. A standard certification program provides six months of training and subsequent testing. Computer Society training centers conduct training and subsequent testing and issuance of certificates for more than 200 programs. [30]

In addition, there are:

1. Discounts for subscriptions to leading periodicals in your area;
2. Discounts on certification exams and a preparatory course for software development professionals;
3. Low registration fees for company-sponsored conferences;
4. Discounts on hundreds of published books and conference publications;
5. Free membership in local groups;
6. The possibility of volunteering in one of the many departments and committees of the society;
7. Reception of awards of a society.
8. Digital Library

The Digital Library of the Computer Society is a voluminous electronic collection that includes the issues of 18 periodicals of the Society (after 1988), as well as the works of more than 850 different conferences (after 1995). 68000 stored articles and works make the Digital Library a valuable research tool for professionals in any field of computer science.

**Technical committees**

Technical committees of the society are global collectives of professionals with common interests in a specific field of informatics. Members of these teams interact through electronic means of communication, meet at conferences, etc. Electronic communication means More than 30 technical committees unite the members of the Society for their professional interests. Each of the committees regularly conducts conferences and working meetings, both full-time and part-time, publishes newsletters. The size of committees varies from 500 to 10,000 members. There are four technical committees with specializations in such areas as computer architecture, operating systems, the Internet, software engineering, security, etc. Most technical committees publish and distribute free information bulletins for their members.

**Working groups on standardization**

IEEE-CS is the leader in the computer industry in the development of widely applicable, technically advanced standards. There are more than 200 working groups related to the 11 standards committees of IEEE-CS. We constantly invite members of the society to participate in the development of standards, and thousands of professionals respond to this call.

**Awards**

To encourage members of society that have achieved outstanding results, IEEE-CS sponsors an effective and prestigious awards program. These awards celebrate both technical achievements, and the service of the profession and society.

## 3.3 Model curriculum and guidelines for degree programs in IS

We have used as a comparative basis three standard curriculum on Information Systems proposed by international professional organizations. These standards are the latest available plans of recommendations from international organizations involved in the preparation of such plans and developments based on them. In our case, Curricula were used for undergraduate programs in information systems from AIS, ACM, IEEE and the work developed on their backdrop [28].

### 3.3.1 IS 2010

The Association for Computing Machinery (ACM) and Association for Information Systems (AIS) has proposed a model curriculum and guidelines for undergraduate degree programs in information systems. IS 2010 is the latest in a series of standard curriculum for a bachelor's degree in information systems (at the time of writing, version 2015 was not available for public access). It is based on the foundation formed by this early work, but this is a serious revision of the curriculum and includes several significant new characteristics. IS 2010 is the third joint project of ACM and AIS. Both organizations have a worldwide membership, and therefore IS 2010 includes elements that make it more versatile than its predecessors. IS 2010 is not directly related to the degree structure in any environment, but it contains recommendations on the main content of the curriculum that should be present everywhere, and proposals for possible optional courses and career paths based on them [28]:

Core Courses or IS Courses

- IS 2010.1 Fundamentals of Information Systems
- IS 2010.2 Data and Information Management
- IS 2010.3 Enterprise Architecture
- IS 2010.4 IS Project Management
- IS 2010.5 IT Infrastructure
- IS 2010.6 Systems Analysis and Design
- IS 2010.7 IS Strategy, Management and Acquisition

Elective Courses

- Application Development
- Business Process Management
- Enterprise Systems
- Human-Computer Interaction
- IT Audit and Controls
- Data mining / Business Intelligence
- Collaborative Computing
- Information Search & Retrieval
- Knowledge management
- Social Informatics
- IT Security and Risk Management

Figure 11 presents the beginning of a set of disciplines and topics recommended by organizations, based on which further analysis will be carried out.

The database was compiled as a result of the analysis of the recommendation program of the IS2010 curriculum. The database contains a list of disciplines and topics. In the future, on the basis of this, an analysis will be carried out of the conformity of university curricula. In this way, we will know how well the plan of recommendations has been implemented for the educational program for each subject.

| CAIS 2010 | |
|---|---|
| Disciplin | Topic |
| FOUNDATIONS OF INFORMATION SYSTEMS | Characteristics of the Digital World |
| | Information systems in organizations |
| | Globalization |
| | Valuing information systems |
| | Information systems infrastructure |
| | The Internet and WWW |
| | Business intelligence |
| | Enterprise-wide information systems |
| | Development and acquisition |
| | Information systems ethics and crime |
| DATA AND INFORMATION MANAGEMENT | Database approach |
| | Types of database management systems |
| | Basic file processing concepts |
| | Physical data storage concepts |

Figure 11. Start of base of program the IS2010

The next fundamental document is "Guidelines for Education in Business and Information Systems Engineering at Tertiary Institutions", 2017, which is based on IS 2010 and works of MSIS 2016.

### 3.3.2 BISE

Other model presents the guidelines for business education and information systems (BISE) in higher education institutions, which were developed by a working group comprising experts in the field, both from academia and from practice. The guidelines contain the results of training in undergraduate and graduate programs the key subject, social and personal skills required by BISE graduates. In addition, the relevant professional profiles, specific skills required, as well as basic and typical training content for BISE training are described. In addition, detailed recommendations are provided for the development of curriculum and by-laws of Bachelor and Master in BISE, business administration and computer science. The presented recommendations serve several purposes. Providing general guidelines for the education of BISE aims to support the personnel responsible for developing the curriculum and assist students in choosing programs and careers [31].

Next Figure shows the beginning of a database of disciplines and topics recommended in the article, because of which further analysis will be carried out (Figure 12).

The database was compiled as a result of the analysis of the recommendation program of the BISE curriculum. The database contains a list of disciplines and topics. In the future, on the basis of this, an analysis will be carried out of the conformity of university curricula. In this way, we will know how well the plan of recommendations has been implemented for the educational program for each subject.

| Disciplin | Topic | Subtopic |
|---|---|---|
| Subject and Context | | |
| | Subject matter of BISE: | overview of subdomains |
| | | relations between BISE |
| | | neighboring disciplines |
| | Types and core elements of IS in organizations and value networks | |
| | IT artifacts | |
| | Importance of BISE for organizations and economies | |
| | Digitization and globalization and their implications for BISE | |
| | IT industry: | software companies and Internet |
| | | providers (business models, markets, and management concepts), |
| | | other IT companies at a glance (including service providers). |
| | Foundations and methods of empirical and designoriented research. | |
| Economic Foundations | | |
| | Business administration foundations: | procurement, |
| | | investment and finance, |
| | | marketing, |
| | | human resources and |

Figure 12. Start of the base of program the BISE.

### 3.3.3 CS2013

ACM and the IEEE-Computer Society have a long history of sponsoring efforts to create international curriculum for undergraduate computation programs for about a decade, beginning with the publication of Curriculum 68 more than 40 years ago. This volume is the last in this series of curricula. As the field of computation has grown and diversified, it also has recommendations for curricula, and now in addition to computer science there are curricula for computer engineering, information systems, information technology and software development. These volumes are regularly updated to maintain modern and up-to-date computer programs. This volume "Computer Curriculum 2013" (CS2013) is a comprehensive edition [29].

Recommendations CS2013 include an overdetermined amount of knowledge, the result of rethinking the basics required for the curriculum in the field of computer science. It also seeks to identify samples of real courses and programs to provide specific guidance on the structure and development of curricula in various organizational contexts.

The development of curricula for computer science has always been a challenge, given the rapid development and expansion of the field of activity. The growing diversity of topics that may be relevant to education in the field of computer science, and the increasingly integrated integration of computing with other disciplines pose difficulties for these efforts. Particularly difficult is the balancing of actual growth with the need for realistic and realizable recommendations in the context of bachelor's studies. As a result, the CS2013 Steering Committee has made significant efforts to engage the wider informatics community in dialogue to better understand new opportunities and local needs, and to identify successful models of curricula, both established and new [29].

Next Figure shows the beginning of a database of disciplines and topics recommended in the work based on which further analysis will be carried out (Figure 13).

The database was compiled as a result of the analysis of the recommendation program of the CS2013 curriculum. The database contains a list of disciplines and topics. In the future, on the basis of this, an analysis will be carried out of the conformity of university curricula. In this way, we will know how well the plan of recommendations has been implemented for the educational program for each subject.

| Disciplin | Topic | Subtopic |
|---|---|---|
| Algorithms and Complexity | Basic Analysis | Differences among best, expected, and worst case behaviors of an algorithm |
| | | Asymptotic analysis of upper and expected complexity bounds |
| | | Big O notation: formal definition |
| | | Complexity classes, such as constant, logarithmic, linear, quadratic, and exponential |
| | | Empirical measurements of performance |
| | | Time and space trade-offs in algorithms |
| | | Big O notation: use |
| | | Little o, big omega and big theta notation |
| | | Recurrence relations |
| | | Analysis of iterative and recursive algorithms |
| | | Some version of a Master Theorem |
| | Algorithmic Strategies | Brute-force algorithms |
| | | Greedy algorithms |
| | | Divide-and-conquer (cross-reference SDF/Algorithms and Design/Problem-solving strategies) |
| | | Recursive backtracking |
| | | Dynamic Programming |
| | | Branch-and-bound |
| | | Heuristics |
| | | Reduction: transform-and-conquer |
| | Fundamental Data Structures and | Simple numerical algorithms, such as computing the average of a list of numbers, finding the min, max, and |

Figure 13. Start base of the program the CS2013.

# 4. Case study: IPB and KubSAU

## 4.1 Introduction

In this chapter, we will perform an analysis between KubSAU and IPB. The analysis will be carried out based on the undergraduate curricula of two universities and the programs of recommendations from international organizations that we considered earlier.

### 4.1.1 Kuban State Agrarian University - Russia

Levels of education: Specialty, bachelor's, master's, postgraduate.

Forms of study: full-time, correspondence.

Normative terms of training:

- Specialty - 5 years;
- bachelor - 4 years;
- Master's degree - 2 years.
- Postgraduate studies - 3/4 years.

Period of validity of state accreditation:

Certificate of state accreditation

Series 09A01 №0002460

Registration No. 2337 of November 8, 2016.

Valid until January 15, 2021.

Language of instruction: Russian.

The Academic Bachelor's degree program, implemented by the Kuban State Pedagogical University in the field of preparation in the field of preparation 09.03.02 "Information systems and technologies" and the profile of the preparation "Information systems and technologies", is a system of documents developed and approved by the university, taking into account the labor market requirements on the basis of Federal State Educational Standard on the appropriate direction of higher education (FGOS VO) [32].

The education program regulates the objectives, expected results, content, conditions and technologies for the implementation of the educational process, assesses the quality of the graduate's preparation in this area of training, and includes: the curriculum, the curricula of training courses, subjects, disciplines (modules) and other materials that provide. The quality of training of trainees, as well as the program of training and production practice, a calendar training schedule and methodological materials that ensure the implementation of appropriate educational technology.

The educational program has a high level of provision with educational and methodological documentation and materials. A selective analysis of the electronic library of the university showed that it presents the programs of all the declared disciplines, practices and final state attestation.

As strengths of the program, it should be noted that a sufficiently qualified faculty is involved in its implementation, as well as leading professional figures from regional enterprises. One of the advantages is the consideration of the requirements of employers in the formation of disciplines of the professional cycle.

In general, the educational program meets the requirements of the federal state educational standard, and promotes the formation of general cultural and professional competencies in the direction of preparation. 09.03.02 "Information systems and technologies" (training profile Information systems and technologies, qualification (academic degree) academic bachelor). [32]

For the subsequent study of educational programs, the curriculum of the KubSAU was analyzed (Table 2, Figure 14). M is mathematical disciplines, N is naturally disciplines, G is general disciplines, H is humanitarian disciplines.

Table 2. The list of number credits and type discipline in KubSAU.

| Course Unit | credits | type | year | semester |
|---|---|---|---|---|
| Foreign language | 4 | H | 1 | 1.2 |
| History | 3 | H | 1 | 1 |
| Economy | 3 | G | 1 | 1 |
| Foundations of legal knowledge | 3 | H | 1 | 1 |
| Philosophy | 3 | H | 1 | 2 |
| Sociology and cultural studies | 3 | H | 1 | 2 |
| Selfmanagament | 3 | H | 1 | 2 |
| Health and safety | 2 | H | 1 | 2 |
| Russian language and culture of speech | 2 | H | 1 | 2 |
| Linear Algebra and Analytic Geometry | 3 | M | 1 | 1 |
| Mathematical analysis | 3 | M | 1 | 2 |
| Theory of Probability and Mathematical Statistics | 3 | M | 1 | 2 |
| Computer science | 4 | G | 1 | 1 |
| Algorithmic and Programming | 5 | G | 1 | 1 |
| Fundamentals of mathematical logic and theory of algorithms | 4 | M | 1 | 2 |
| Physics | 3 | N | 1 | 2 |
| physical Culture and sport | 2 | N | 1 | 1 |
| Discrete Math | 4 | M | 1 | 1 |
| Elective courses in physical training and sports | 0 | N | 1 | 1 |
| Foreign language | 2 | H | 2 | 1 |
| Differential and difference equations | 2 | M | 2 | 1 |
| Algorithms and Data Structures | 4 | G | 2 | 1 |
| Physics | 3 | N | 2 | 1 |
| Computer systems | 3 | G | 2 | 2 |
| Information Technology | 4 | G | 2 | 1 |
| Database | 4 | G | 2 | 1 |
| Management | 2 | G | 2 | 2 |

| | | | | |
|---|---|---|---|---|
| Fuzzy mathematics and logic | 3 | M | 2 | 1 |
| programming technologies | 3 | G | 2 | 1 |
| Modeling of processes and systems | 4 | G | 2 | 1 |
| Microelectronics and circuitry | 4 | G | 2 | 2 |
| Data management | 5 | G | 2 | 2 |
| Decision theory | 4 | G | 2 | 2 |
| information processing technology | 4 | G | 2 | 2 |
| Elective courses in physical training and sports | 0 | N | 2 | 1 |
| Programming languages | 6 | G | 2 | 2 |
| Data description language | 6 | G | 2 | 2 |
| Electronic communication | 2 | G | 3 | 1 |
| Methods and tools for the design of information systems | 4 | G | 3 | 1 |
| The theory of information processes and systems | 5 | G | 3 | 2 |
| Information and communication systems and networks | 6 | G | 3 | 1 |
| Intelligent information systems and technologies | 5 | G | 3 | 2 |
| Ecology | 2 | N | 3 | 1 |
| microprocessors | 6 | G | 3 | 1 |
| Information systems architecture | 4 | G | 3 | 1 |
| Economics and Mathematical Methods | 4 | G | 3 | 2 |
| Elective courses in physical training and sports | 0 | N | 3 | 1 |
| Management Information Theory | 5 | G | 3 | 2 |
| Infotelecommunication transport systems | 5 | G | 3 | 2 |
| Administration in Information Systems | 3 | G | 3 | 2 |
| Quality information systems | 3 | G | 3 | 2 |
| Multimedia technology | 3 | G | 3 | 1 |
| decision support system | 3 | G | 3 | 1 |
| OS | 4 | G | 3 | 1 |
| Process Control | 4 | G | 3 | 1 |
| Development of systemic administration programs | 4 | G | 3 | 1 |
| Data mining technology | 4 | G | 3 | 1 |
| Theory and mechanisms of creation of IT and systems | 3 | G | 3 | 2 |
| Data protection | 4 | G | 4 | 2 |
| Standardization, certification and quality management IS | 5 | G | 4 | 2 |
| information management | 6 | G | 4 | 1 |
| Corporate information systems | 4 | G | 4 | 2 |
| Fundamentals of control theory | 4 | G | 4 | 2 |
| Tools of information systems | 3 | G | 4 | 1 |
| Fundamentals of inventive activity and protection of intellectual property | 3 | G | 4 | 1 |
| Administration in Information Systems | 6 | G | 4 | 1 |
| Quality information systems | 6 | G | 4 | 1 |
| Web-based engineering | 6 | G | 4 | 1 |
| telecommunication technologies | 6 | G | 4 | 1 |
| Developing cross-platform applications | 4 | G | 4 | 2 |

| | | | | |
|---|---|---|---|---|
| GIS technology | 4 | G | 4 | 2 |
| Cloud computing | 6 | G | 4 | 1 |
| Protocols and information systems interfaces | 6 | G | 4 | 1 |
| Methodical bases of research information subsystems and processes | 2 | G | 4 | 1 |

The following table shows the credits located by type. We can see that the KubSAU program contains not only general and mathematical subjects but also natural and humanitarian ones.

Table 3. The list of number credits of type discipline in KubSAU.

| Total: hours/credits | 274 |
|---|---|
| mathematical | 22 |
| naturally | 10 |
| general | 217 |
| humanitarian | 25 |

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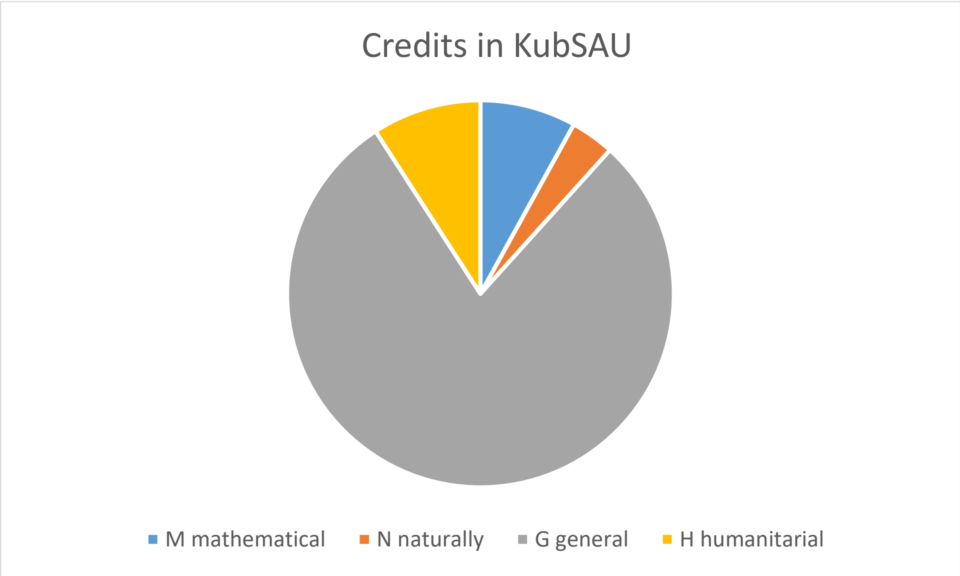


Figure 14. The graph of percentage of types disciplines in KubSAU.

### 4.1.2 Polytechnic Institute of Bragança - Portugal

General tasks of the study of the cycle

Common goals for the research cycle.

The training course is aimed at training specialists, able to perform functions related to management and business administration, management and administration of databases and applications, planning and management of IT projects, systems analysis, audit and consulting systems information, computer programming, administration and maintenance Communication networks and computer systems, web services and security of information systems [33].

General tasks of the study cycle.

Training course for postgraduate AIIS capable of: management organization, basic administration date, management of information applications, planning and management of IT projects, systems analysis, audit and consulting of information systems, computer programming and administration of maintenance of telecommunications networks, web services and information system security.

Sequence of tasks set with the mission and strategy of the organization.

The School of Technology and Management of Braganca (ESTiG) fulfills its mission of teaching and research / development in engineering and business sciences. His training proposal has made, always, the courses spread across these two main areas. With respect to training for the first cycle, then ESTiG available vacancies in the following courses: Biomedical Engineering, Civil Engineering, Renewable Energy, Electrical Engineering, Computer Engineering, Mechanical Engineering, Chemical and Biological Engineering, Accounting, Management and IT Management. Faculty of ESTiG, as well as its non-teaching staff, were consolidated around the main field of engineering and business sciences. In addition, school material resources, especially laboratory equipment, which were designed to give a qualified answer to these aspects [33].

As a result, the scientific and technological potential of the ESTiG provides important interventions at the level of the surrounding community, both in the industrial sector and in the service sectors. In the current context of the school, the degree in IT management allows:

- make use of the efforts and synergies of many teachers in the field of engineering and management, to train specialists capable of solving increasingly complex problems;
- to promote the development of interdisciplinary projects, intervening in an integrated manner, from conception to implementation / production.

Coherence of the objectives of the research cycle and the mission and strategy of the institution.

The School of Technology and Management of Bragança (ESTIG), bears its mission of training personnel and its R & D activities in the field of business and engineering. It offers a set of programs for each of these areas. Regarding the first cycle, the ESTiG determines the ACCEPTANCE place in the following research cycles: Biomedical Engineering, Civil Engineering, Renewable Energy, Electrical Engineering, Computer Engineering, Engineering, Chemical and Biological Engineering, Accounting, Management and Management. Teachers of ESTiG, as well as its non-teaching staff were united around the main fields of engineering and business science. In addition, school facilities, especially laboratory rooms were designed to give a qualified response in these parts. As a result, the scientific and technical potential of the ESTiG provides important interventions to the surrounding society, both in industry and in services-related industries [33].

In the current context of the school, the degree in the management of computer science Allows:

1. To take advantage of the synergy and efforts of many teachers in the field of technology and
2. To train management professionals capable of solving problems in a broader sense;
3. Increase the development of interdisciplinary projects, act on an integrated basis, from conception level to the level of production.

Means of disseminating goals to teachers and students involved in the study cycle.

Disclosure during research tasks begins immediately after their approval; School It produces promotional materials for all its research cycles, which contains: goals, research plan and career opportunities. The advertising material is distributed on paper and available on the web portal, the member of the ECTS Information Guide on the part of the Bank. Web version, the goals of each of them are also available. Of course.

The production and annual updating of this material includes several teachers and passes through several levels of verification / approval: responsible for courses, department coordinators, committees of course, and the pedagogical council. As a result, teachers are widely familiar, like the Course of Learning Goals [33].

For the subsequent study of educational programs, the curriculum of the IPB was analyzed (Tables 4, 5, Figure 15).

Table 4. The list of disciplines into IPB.

| Course Unit | credits | year | semestr |
|---|---|---|---|
| Linear Algebra | 6 | 1 | 1 |
| Mathematical Analysis I | 6 | 1 | 1 |
| Financial Accounting I | 6 | 1 | 1 |
| Introduction to Informatics | 6 | 1 | 1 |
| Programming I | 6 | 1 | 1 |
| Mathematical Analysis II | 6 | 1 | 2 |
| Financial Accounting II | 6 | 1 | 2 |
| Discrete Mathematics | 6 | 1 | 2 |
| Programming II | 6 | 1 | 2 |
| Information Systems | 6 | 1 | 2 |
| Databases I | 6 | 2 | 1 |
| Management Accounting | 6 | 2 | 1 |
| Statistics | 6 | 2 | 1 |
| Object Oriented Programming | 6 | 2 | 1 |
| Computing Systems | 6 | 2 | 1 |
| Algorithms and Data Structures | 6 | 2 | 2 |
| Databases II | 6 | 2 | 2 |
| Economics | 6 | 2 | 2 |
| Operational Research | 6 | 2 | 2 |
| Computer Networks | 6 | 2 | 2 |
| Software Engineering | 6 | 3 | 1 |
| Corporate Finance | 6 | 3 | 1 |
| Operating System Fundamentals | 6 | 3 | 1 |
| Multimedia | 6 | 3 | 1 |
| Final Project in Management | 6 | 3 | 1 |
| Information Systems Management | 6 | 3 | 2 |
| Application Interfaces | 6 | 3 | 2 |
| Software Engineering Laboratory | 6 | 3 | 2 |
| General Industrial Management | 6 | 3 | 2 |
| Final Project in Informatics | 6 | 3 | 2 |

The following table shows the credits located by type. As we can see IPB have a type: Computer Science, Accounting, Economy, Computer Engineering, Management, Mathematics, Project, Information systems. Most of all disciplines such as Computer Science.

Table 5. The list of number credits of type discipline in IPB.

| **Scientific Area** | | **ECTS Credits** | |
|---|---|---|---|
| | | **Required** | **Optional** |
| Computer Science | CCp | 42.0 | 0.0 |
| Accounting | Con | 18.0 | 0.0 |
| Economy | Eco | 6.0 | 0.0 |

| | | | |
|---|---|---|---|
| Computer Engineering | ECp | 18.0 | 0.0 |
| Management | Ges | 12.0 | 0.0 |
| Mathematics | Mat | 36.0 | 0.0 |
| Project | Prj | 12.0 | 0.0 |
| Information systems | SIf | 36.0 | 0.0 |
| | **Total** | 180.0 | 0.0 |

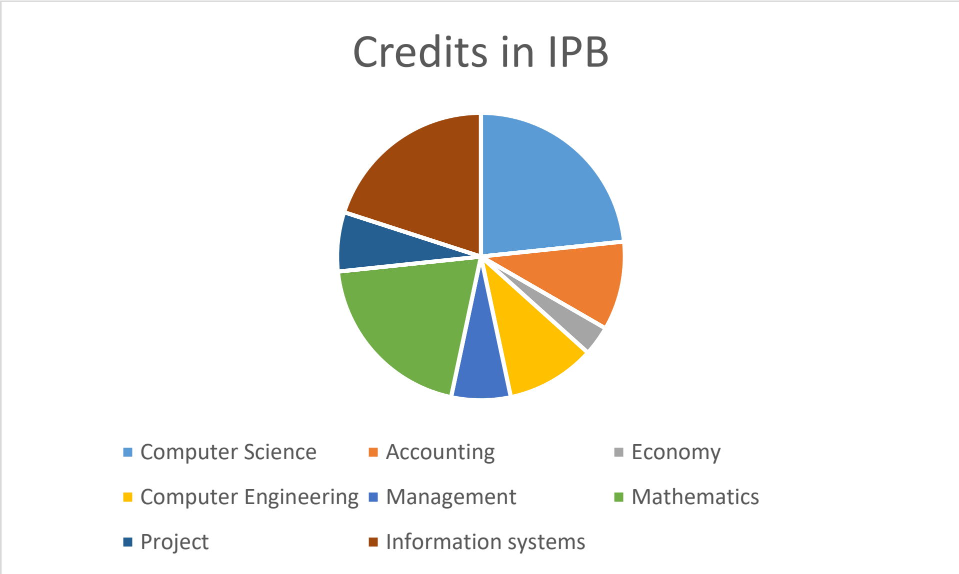


Figure 15. The graph of percentage of types disciplines.

## 4.2 Analysis and Results

The main part of the analysis is based on the analysis of the conformity of curricula of higher educational institutions with the recommendations of international organizations. The analysis should be carried out for the correspondence of disciplines and themes that are contained in the disciplines. Some plans involve sub-themes, which are analyzed in the same way. Upon completion of the analysis, a correspondence table is drawn up, where the percentage indicates how well the program of recommendations has been implemented for each subject. As a result, we will start from these results, drawing conclusions and final recommendations.

The analysis is carried out according to the procedure shown in Figure 16.

| Disciplin | Topic | Subtopic | Disciplin | Topic | Subtopic | Disciplin | Topic | Subtopic |
|---|---|---|---|---|---|---|---|---|
| Algorithms and Complexity | Basic Analysis | Differences among best, expected, and worst case behaviors of an algorithm | | x | x | | x | x |
| | | Asymptotic analysis of upper and expected complexity bounds | | | x | | | |
| | | Big O notation: formal definition | | | x | | | x |
| | | Complexity classes, such as constant, logarithmic, linear, quadratic, and exponential | | | x | | | x |
| | | Empirical measurements of performance | | | | | | x |
| | | Time and space trade-offs in algorithms | | | x | | | x |
| | | Big O notation: use | | | | | | x |
| | | Little o, big omega and big theta notation | | | | | | |
| | | Recurrence relations | | | | | | x |
| | | Analysis of iterative and recursive algorithms | | | | | | x |
| | | Some version of a Master Theorem | | | | | | |
| | Algorithmic Strategies | Brute-force algorithms | | | | | | |
| | | Greedy algorithms | | | | | | |
| | | Divide-and-conquer (cross-reference SDF/Algorithms and Design/Problem-solving strategies) | | | | | | |
| | | Recursive backtracking | | | | | | x |
| | | Dynamic Programming | | | | | | |
| | | Branch-and-bound | | | | | | x |
| | | Heuristics | | | | | | |
| | | Reduction: transform-and-conquer | | | | | | |
| | Fundamental Data Structures and Algorithms | Simple numerical algorithms, such as computing the average of a list of numbers, finding the min, max, and | | | | | | |

Figure 16. Start graph of analysis between IPB, KubSAU and CS2013

On the contrary, those who satisfy the content of the recommended program are given the sign "x". As a result, following the results of the study, we obtained the following results (Tables 6,7,8).

At this stage, we conduct a primary analysis of the correspondence of the university's educational programs to the recommended programs from international organizations. Thus, the results about analysis KubSAU program of the comparison are shown in Figures 17,18,19.

### 4.2.1 IPB/KubSAU vs IS2010

The following table shows the relevance of university curricula to the recommended plan from IS2010.

Table 6. Result of the analysis between IS2010, KubSAU and IPB

| | IS2010 disciplines | IPB | KubSAU |
|---|---|---|---|
| 1 | FOUNDATIONS OF INFORMATION SYSTEMS | 77,78% | 66,67% |
| 2 | DATA AND INFORMATION MANAGEMENT | 87,50% | 31,25% |
| 3 | ENTERPRISE ARCHITECTURE | 55,56% | 33,33% |
| 4 | IT INFRASTRUCTURE | 42,86% | 7,14% |
| 5 | IS PROJECT MANAGEMENT | 33,33% | 16,67% |
| 6 | SYSTEMS ANALYSIS & DESIGN | 46,67% | 73,33% |
| 7 | IS STRATEGY, MANAGEMENT, AND ACQUISITION | 53,33% | 0,00% |
| 8 | APPLICATION DEVELOPMENT | 80,00% | 93,33% |
| 9 | BUSINESS PROCESS MANAGEMENT | 80,00% | 40,00% |
| 10 | ENTERPRISE SYSTEMS | 15,00% | 5,00% |
| 11 | INTRODUCTION TO HUMAN-COMPUTER INTERACTION | 83,33% | 83,33% |
| 12 | IT AUDIT AND CONTROLS | 0,00% | 0,00% |
| 13 | IS INNOVATION AND NEW TECHNOLOGIES | 0,00% | 0,00% |
| 14 | IT SECURITY AND RISK MANAGEMENT | 30,00% | 30,00% |
| | Avgl | 48,95% | 34,29% |

The following graph shows the relevance of the IPB and KubSAU curriculum to the recommended educational program plan from IS2010.

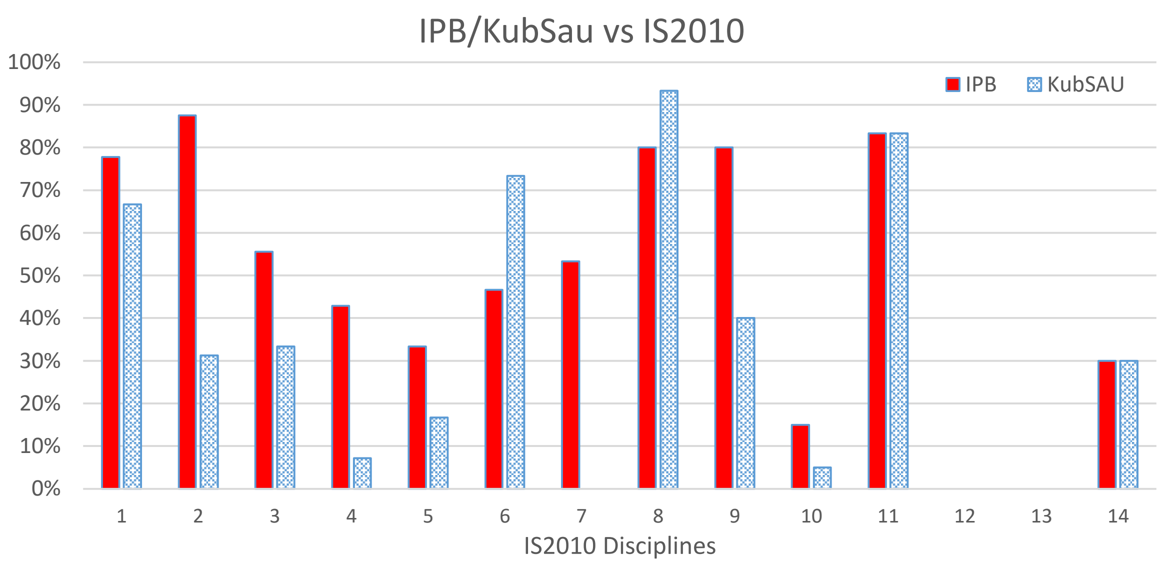

Figure 17. The result of the analysis between KubSAU, IPB and IS2010

On the following graph, you can see how both curriculum differ against the background of the recommendations for the educational program from IS2010.

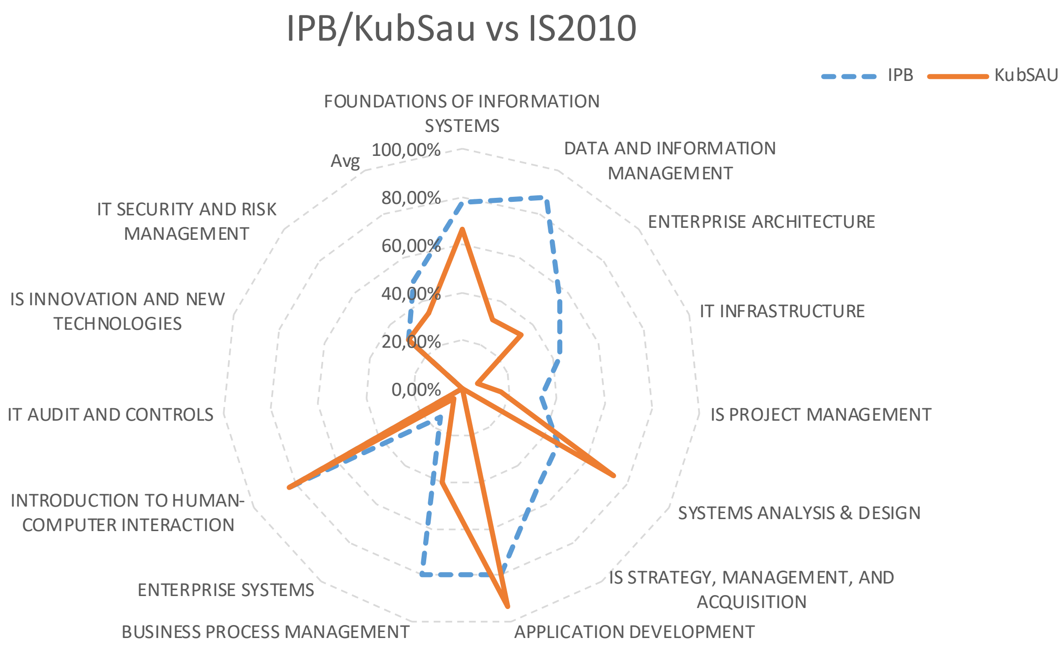


Figure 18. The result of the analysis between KubSAU, IPB and IS2010

As a result of the analysis between KubSAU, IPB and IS2010, we see that the Polytechnic Institute of Bragança is more in line with the recommendation program. IPB corresponds in general to 50%, KubSAU by 34%.

In the results, we see that subjects such as IT audit and controls and IS innovation and new technologies have not been reflected in any of the programs of higher education institutions.

Most of the recommended program corresponds to such items as: foundations of information systems, introduction to human-computer interaction. In IPB, the plan for data and information management, business process management is well executed, objects such as enterprise architecture, is strategy, management, and acquisition are well executed. In KubSAU the plan on systems analysis & design is perfectly executed.

In higher education institutions, the program of such subjects as: it infrastructure, is project management, enterprise systems, it needs security and risk management. IPB followed to consider the finalization of such items as systems analysis & design. KubSAU failed to consider the finalization of such items as data and information management, enterprise architecture, business process management. It is recommended to introduce missing subjects as separate disciplines.

### 4.2.1 IPB/KubSAU vs CS2013

The following table shows the relevance of university curricula to the recommended plan CS2013.

Table 7. Result of the analysis between CS2013, KubSAU and IPB

| | CS2013 disciplines | IPB | KubSAU |
|---|---|---|---|
| 1 | Algorithms and Complexity | 36.51% | 47.62% |
| 2 | Architecture and Organization | 32.73% | 56.36% |
| 3 | Computational Science | 15.15% | 72.73% |

| | | | |
|---|---|---|---|
| 4 | Discrete Structures | 47.50% | 72.50% |
| 5 | Graphics and Visualization | 13.85% | 24.62% |
| 6 | Human-Computer Interaction | 37.80% | 62.20% |
| 7 | Information Assurance and Security | 13.70% | 32.88% |
| 8 | Information Management | 51.04% | 44.79% |
| 9 | Intelligent Systems | 14.94% | 49.43% |
| 10 | Networking and Communication | 33.33% | 70.00% |
| 11 | Operating Systems | 45.31% | 56.25% |
| 12 | Platform-Based Development | 70.00% | 70.00% |
| 13 | Parallel and Distributed Computing | 15.22% | 26.09% |
| 14 | Programming Languages | 32.97% | 50.55% |
| 15 | Software Development Fundamentals | 78.26% | 94.35% |
| 16 | Software Engineering | 94.34% | 79.25% |
| 17 | Systems Fundamentals | 0.00% | 0.00% |
| 18 | Social Issues and Professional Practice | 0.00% | 0.00% |
| | Avg: | 35.15% | 50.53% |

The following graph shows the relevance of the IPB and KubSAU curriculum to the recommended educational program plan from CS2013.

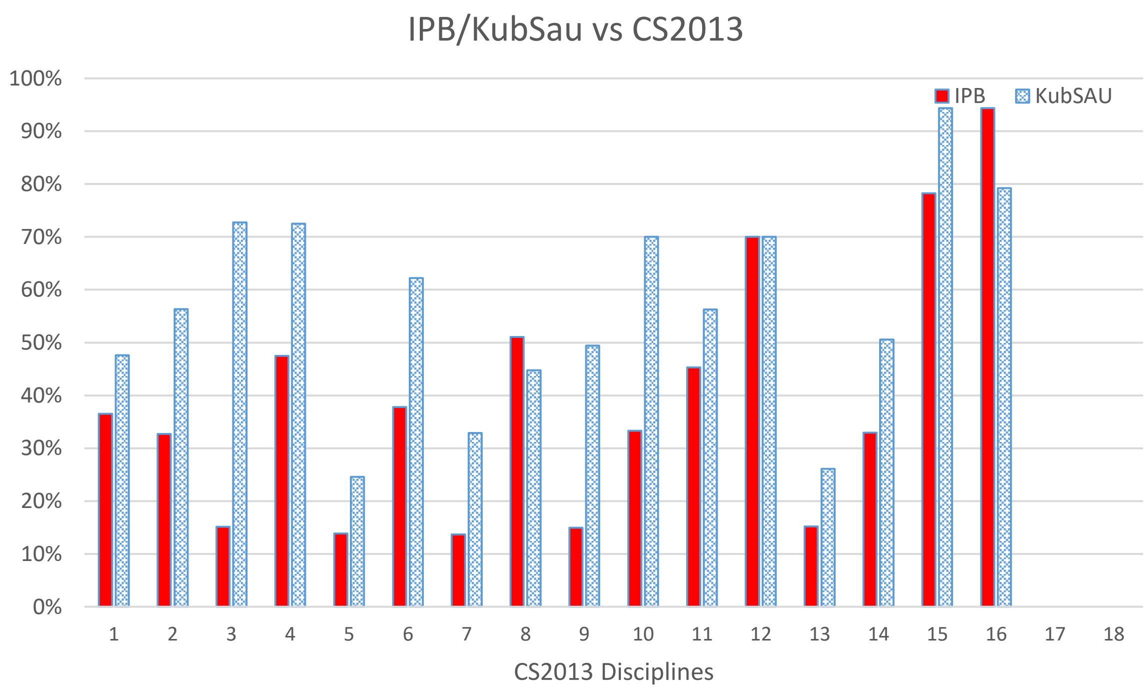


Figure 19. The result of the analysis between KubSAU, IPB and CS2013

The following graph shows the relevance of the IPB curriculum to the recommended educational program plan from CS2013.

On the next graph, you can see how the KubSAU curriculum and IPB curriculum differ against the background of the recommendations for the educational program from CS2013.

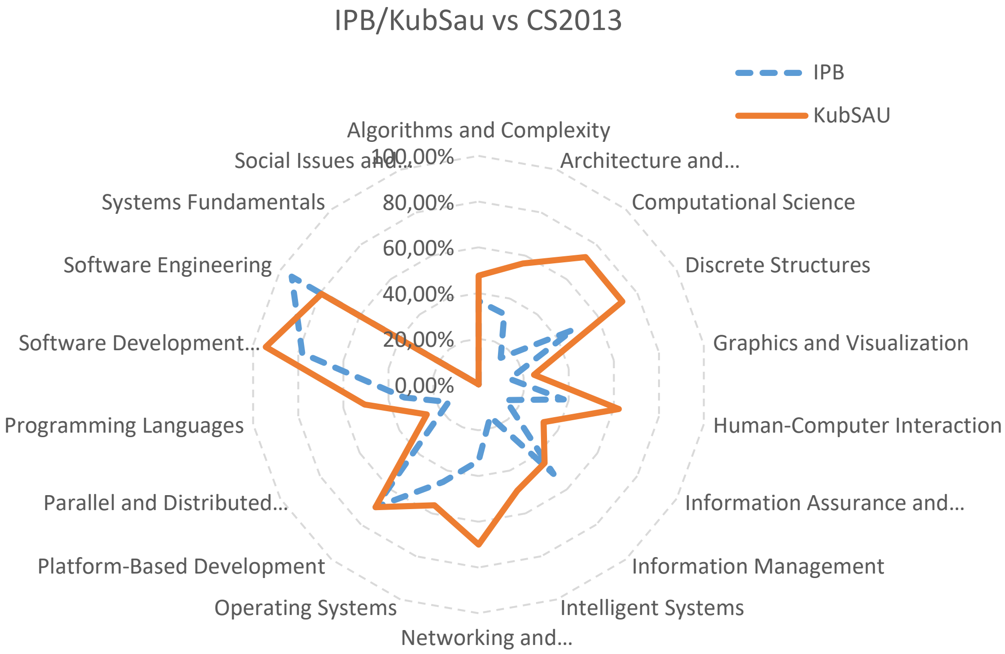


Figure 20. The result of the analysis between KubSAU, IPB and CS2013

As a result of the analysis between KubSAU, IPB and CS2013, we see that the Kuban State Agrarian University is more in line with the recommendation program.

KubSAU corresponds in general to 51%, IPB by 35%.

In the results, we see that subjects such as Systems Fundamentals and Social Issues and Professional Practice have not been reflected in any of the programs of higher education institutions.

Most of the recommended program corresponds to such items as: Platform-Based Development, Software Development Fundamentals, Software Engineering. In IPB, subjects such as Information Management, Discrete Structures are well executed. In KubSAU the programs on subjects Computational Science, Discrete Structures, Human-Computer Interaction, Networking and Communication were well executed, the plan on Algorithms and Complexity, Architecture and Organization, Operating Systems, Programming Languages, Intelligent Systems was well executed.

In higher education institutions, the programs of such subjects as: Graphics and Visualization, Information Assurance and Security, Parallel and Distributed Computing, need to be improved. IPB failed to consider the finalization of such items as Algorithms and Complexity, Architecture and Organization, Computational Science, Human-Computer Interaction, Intelligent Systems, Networking and Communication, Operating Systems, Programming Languages. KubSAU failed to consider the finalization of such items as Information Management. It is recommended to introduce missing subjects as separate disciplines.

### 4.2.1 IPB/KubSAU vs BISE

The following table shows the relevance of university curricula to the recommended plan BISE.

Table 8. Result of the analysis between BISE, KubSAU and IPB

| | University | IPB | KubSAU |
|---|---|---|---|
| 1 | Subject and Context | 54.55% | 45.45% |
| 2 | Economic Foundations | 95.00% | 75.00% |
| 3 | Foundations of Computer Science | 100.00% | 100.00% |

| | | | |
|---|---|---|---|
| 4 | Further Foundations | 25.00% | 0.00% |
| 5 | Data Management | 80.00% | 80.00% |
| 6 | Process Management | 50.00% | 25.00% |
| 7 | Information Management | 80.00% | 50.00% |
| 8 | Development and Operation of Information Systems | 75.00% | 100.00% |
| 9 | Corporate Core Systems | 57.14% | 0.00% |
| 10 | Knowledge Management and Collaborative Technologies | 55.56% | 0.00% |
| 11 | Model-Based Decision Support, Business Intelligence, and Analytics | 50.00% | 30.00% |
| 12 | Digital Transformation | 44.44% | 0.00% |
| | Total: | 63.89% | 42.12% |

The following graph shows the relevance of the IPB and KubSAU curriculum to the recommended educational program plan from BISE.

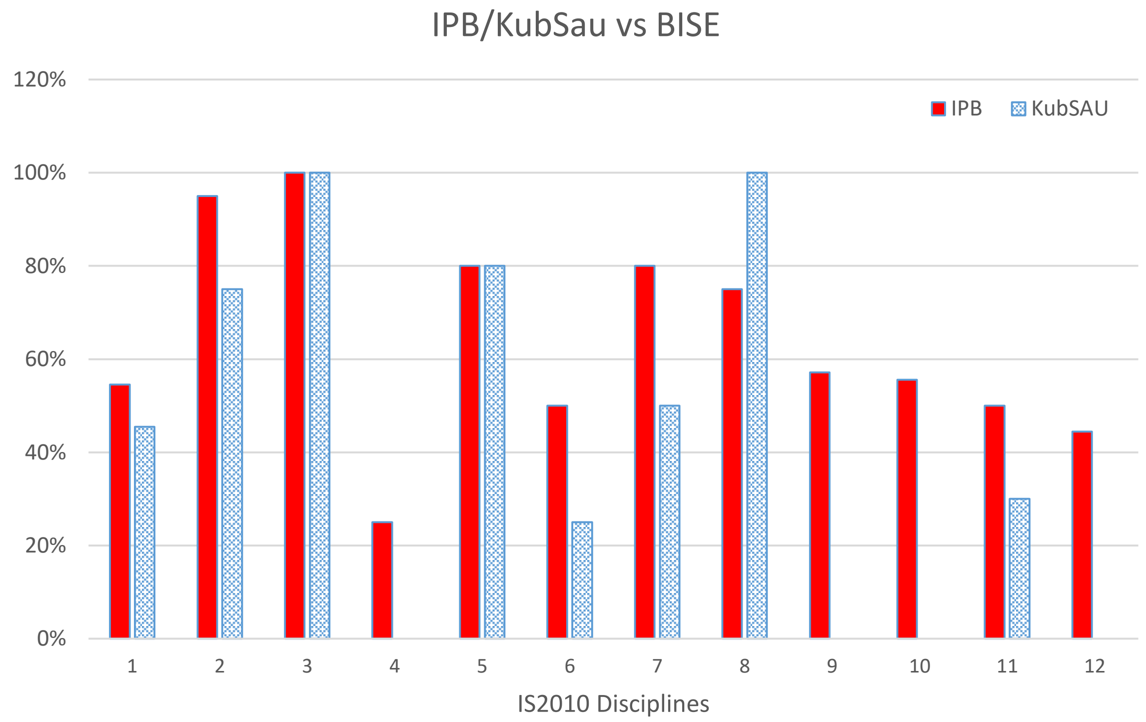


Figure 21. The result of the analysis between KubSAU, IPB and BISE

The following graph shows the relevance of the IPB curriculum to the recommended educational program plan from BISE.

On the last graph, you can see how the KubSAU curriculum and IPB curriculum differ against the background of the recommendations for the educational program from BISE.

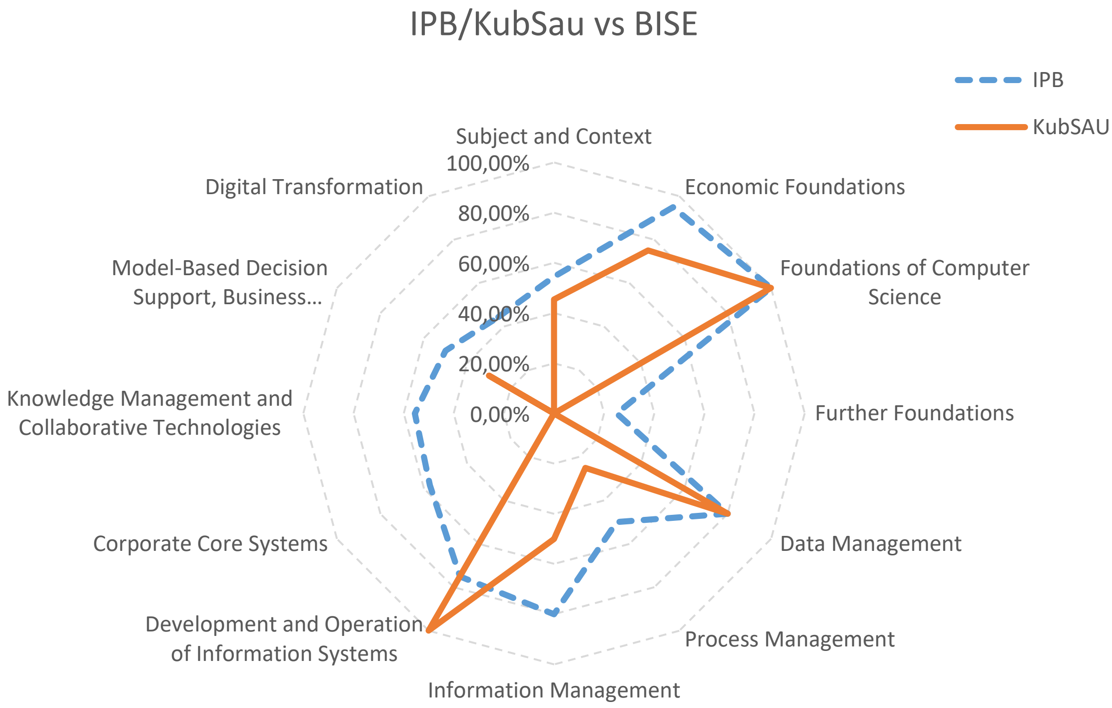


Figure 22. The result of the analysis between KubSAU, IPB and BISE

As a result of the analysis between KubSAU, IPB and BISE, we see that the Polytechnic Institute of Braganca is more in line with the recommendation program.

IPB corresponds in general to 64%, KubSAU by 42%.

In the results, we see that the discipline Foundations of Computer Science is fully consistent in each of the higher education institutions.

Also, the most recommended program corresponds to such subjects as: Economic Foundations, Data Management, Development and Operation of Information Systems. Objects such as Information Management are well executed in IPB, well-built programs of such subjects as Corporate Core Systems, Knowledge Management and Collaborative Technologies, Model-Based Decision Support, Business Intelligence, and Analytics. In KubSAU, the Information Management programs are well executed.

IPB followed to consider the finalization of such items as Further Foundations, Digital Transformation. KubSAU failed to consider the finalization of such items as Subject and Context, Process Management, Model-Based Decision Support, Business Intelligence, and Analytics. Also, KubSAU is required to enter non-existent items from the recommendation plan, which are missing at the moment: Further Foundations, Corporate Core Systems, Knowledge Management and Collaborative Technologies, Digital Transformation.

### 4.2.2 Global analysis

As a result, we do not have very good results on the outcome of the study, for the most part higher education institutions do not meet the recommended curriculum more than half. It goes without saying that these recommendations curricula are outstripped, but the more important is the relevance to them of real curricula, because students who have completed training must meet the requirements for several more years after graduation. Of course, the educational programs for teaching bachelors in the field of information systems of universities are somewhat based on the needs of the local labor market and local trends, but with the increase in labor mobility, the role of international norms in educational programs is growing more and more, and higher education institutions should rely on them.

KubSAU showed its lag in two programs of three (IS2010, BISE). Both these programs are based on the work of the Association for Information Systems. The lag in these programs explains that the educational programs at this university are built according to FGOS standards, which are more focused on the Russian market and have only recently begun integration between domestic norms and European ones. IPB has lagged behind as a result of the analysis of the recommendation program for the formation of information systems CS2013, based on the development of ACM and IEEE computer society.

It cannot be said that the educational program of a university is worse or better. As a result of the research, we see that the IPB and KubSAU educational programs follow slightly different ideas of how an undergraduate education program should be organized in information systems. But basically, they are identical and using the results of research in modernizing educational programs we can supplement existing plans by making trained bachelors readier for changes in information systems and technologies.

# 5. Conclusions and Future works

In this work, the main features of educational programs for the preparation of bachelors in the field of Information Systems at the universities of Portugal and Russia were determined. Identified features of the higher education system of Portugal and Russia.

A comparative analysis has been made between education systems in the information systems of Russia and Portugal, and the recommended plans of educational programs from international associations.

Developed a plan of recommendations for the modification of education systems in the higher educational institutions in question.

The discipline of information systems (IS) is facing greater challenges now than at any time. The university curriculum in information systems (IS) is reviewed and frequently modified in higher education institutions to reflect changes in this field. It is important to make the necessary changes to the IP curriculum to make programs challenging and better to prepare graduates for today's labor market.

The study of the curriculum shows the differences in each program (table). It is also statistically shown that these programs differ depending on the main credit courses and elective courses, regardless of accreditation.

The introduction of undemanding elements into curricula will help to improve the quality of education.

This will give students the experience and, possibly, the possibility of finding employment after the completion of the program. These classes can be an additional course of programming, computer forensics, an extended database, advanced network management or the promotion of a web page.

The result of the study can help programs move to developing a more coherent curriculum. The result of this study is useful for universities when developing or reprocessing an IP program. More detailed studies will be required to better understand the deviation disclosed in this paper.

The results can be used to modernize the curricula of Russian and Portuguese universities in the light of expanding international cooperation.

In the future, the work can be expanded as an analysis of the differences between the educational programs of information systems in Russia (FGOS), Portugal and other countries in Europe, America to identify their strengths and make recommendations for their improvement.

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# 7. Annexes

## 7.1 International Curriculum Guidelines

### 7.1.1 IS2010

Table 9. IS2010 disciplines and topis

| Discipline | Topic |
|---|---|
| FOUNDATIONS OF INFORMATION SYSTEMS | Characteristics of the Digital World |
| | Information systems in organizations |
| | Globalization |
| | Valuing information systems |
| | Information systems infrastructure |
| | The Internet and WWW |
| | Business intelligence |
| | Enterprise-wide information systems |
| | Development and acquisition |
| | Information systems ethics and crime |
| DATA AND INFORMATION MANAGEMENT | Database approach |
| | Types of database management systems |
| | Basic file processing concepts |
| | Physical data storage concepts |
| | File organization techniques |
| | Conceptual data model |
| | Logical data model |
| | Physical data model |
| | Database languages |
| | Data and database administration |
| | Transaction processing |
| | Using a database management system from an application development environmen |
| | Use of database management systems in an enterprise system context |
| | Data/information architecture |
| | Data security management |
| | Data quality management |

| | |
|---|---|
| | Business intelligence |
| ENTERPRISE ARCHITECTURE | Service oriented architecture |
| | Enterprise architecture frameworks |
| | Systems integration |
| | Enterprise resource software |
| | Monitoring and metrics for infrastructure and business processes |
| | Green computing |
| | Virtualization of storage and systems |
| | The role of open source software |
| | Risk management |
| | Business continuity |
| | Total cost of ownership and return on investment |
| | Software as a service |
| | Enterprise data models |
| | Data / information architecture and data integration |
| | Content management |
| | Audit and compliance |
| | System administration |
| | IT control and management frameworks |
| | Emerging technologies |
| IT INFRASTRUCTURE | Core computing system architecture concepts |
| | Core computing system organizing structures |
| | Core technical components of computer-based systems |
| | Role of IT infrastructure in a modern organization |
| | Operating systems |
| | Networking |
| | Organizing storage on organizational networks |
| | Data centers |
| | Securing IT infrastructure |
| | The role of IT control and service management frameworks (COBIT, ITIL, etc.) in managing theorganizational IT infrastructure398Volume 26 Article 18 |
| | Ensuring business continuity |
| | Grid computing |
| | Cloud computing, computing as a service |
| | System performance analysis and management |
| | Purchasing of IT infrastructure technologies and services |
| IS PROJECT MANAGEMENT | Introduction |
| | The Project Management Lifecycle |
| | Managing Project Teams |
| | Managing Project Communication |
| | Project Initiation and Planning |
| | Managing Project Scope |
| | Managing Project Scheduling |
| | Managing Project Resources |

| | |
|---|---|
| | Managing Project Quality |
| | Managing Project Risk |
| | Managing Project Procurement |
| | Project Execution, Control & Closure |
| | Managing Project Control & Closure |
| SYSTEMS ANALYSIS & DESIGN | Identification of opportunities for IT-enabled organizational change |
| | Business process management |
| | Analysis of business requirements |
| | Structuring of IT-based opportunities into projects |
| | Project specification |
| | Project prioritization |
| | Analysis of project feasibility |
| | Fundamentals of IS project management in the global context |
| | Using globally distributed communication and collaboration platforms |
| | Analysis and specification of system requirements |
| | Different approaches to implementing information systems to support business requirements |
| | Specifying implementation alternatives for a specific system |
| | Impact of implementation alternatives on system requirements specification |
| | Methods for comparing systems implementation approaches |
| | Organizational implementation of a new information system |
| | Different approaches to systems analysis & design: structured SDLC, unified process/UML, agile methods |
| IS STRATEGY, MANAGEMENT, AND ACQUISITION | The IS function |
| | IS strategic alignment |
| | Strategic use of information |
| | Impact of IS on organizational structure and processes |
| | IS economics |
| | IS planning |
| | Role of IS in defining and shaping competition |
| | Managing the information systems function |
| | Financing and evaluating the performance of information technology investments and operations |
| | Acquiring information technology resources and capabilities |
| | Using IS/IT governance frameworks |
| | IS risk management |
| | The core course in IS Strategy, Management and Acquisition will take a high-level approach to the management and acquisition of IS-resources within the firm. |
| | The course will deliver the student specific strategies used in firms today to help form the basis of IS strategic management. Students will apply these strategies to management issues within an IS context. |
| | Specifics on the types of strategic thinking are used in this course are left unanswered. Institutions may have certain capabilities or constraints that can be optimized to offer the best thinking for the companies that are hiring their graduates. Also, there are different regional issues that need to be addressed in order to match the trends of specific IS strategies. |
| | Using a case study methodology is highly recommended for this course as it will help the students strategically identify issues in a real-world setting. In general, it is essential that the pedagogical approaches chosen for this course will carefully consider the fact that the issues covered are at a higher level of abstraction than what the students are used to based on their practical experience in organizations. Inviting senior management practitioners to address topics such as alignment, strategic planning, and restructuring is especially useful in targeting regional needs and allowing a divers set of industry verticals. |

| | |
|---|---|
| APPLICATION DEVELOPMENT | Program design |
| | Program development lifecycle |
| | Requirements determinants and analysis |
| | Modular design |
| | Techniques for modeling program structures |
| | Programming concepts |
| | Coding |
| | Unit testing |
| | Control structures |
| | Input/Output (I/O) design |
| | Data structures |
| | Database access |
| | Development approaches |
| | Application integration |
| | Prototyping |
| | Overview and history of programming languages |
| BUSINESS PROCESS MANAGEMENT | Overview |
| | Understanding organizational processes |
| | Process assessment |
| | Process improvement |
| | Using IT for process management and improvement |
| | Organizational issues in business process management |
| ENTERPRISE SYSTEMS | Business processes and business process integration |
| | Making the case for acquiring and implementing enterprise systems |
| | Analyzing business requirements for selecting and implementing an enterprise system |
| | Selection of enterprise systems software |
| | Challenges associated with the implementation of global enterprise systems applications |
| | Organizational change and change management |
| | Strategic alignment |
| | User commitment |
| | Communications |
| | Training |
| | Job redesign |
| | Governance of processes and data |
| | Post-implementation issues |
| | Enterprise system processes |
| | Order processing |
| | Purchasing |
| | Production logistics |
| | Accounting |
| | Planning and control |
| | Human resource functions |

| | |
|---|---|
| | How enterprise systems support business |
| INTRODUCTION TO HUMAN-COMPUTER INTERACTION | Relevance of HCI |
| | Principles in HCI design |
| | User-Centered Design |
| | Special HCI Issues Related to |
| | Devices |
| | Development |
| | Evaluation Methods |
| IT AUDIT AND CONTROLS | The need for information technology audit & controls |
| | Information technology risks – Business Process and Business Continuity |
| | Auditing ethics, guidelines, and standards of the profession |
| | Undertaking an information system audit |
| | Controls over information and processes |
| | Controls Assessment |
| IS INNOVATION AND NEW TECHNOLOGIES | Globalization |
| | Conversation about the commoditization of IT |
| | Technologies that have shaped the electronic world |
| | Process of IS innovation |
| | Strategic importance of the Web as a platform |
| | Web 2.0 tools |
| | Information organization |
| | Virtual teams |
| | Economics of digital goods and services |
| | Search space |
| | Knowledge management |
| | Future trends |
| IT SECURITY AND RISK MANAGEMENT | Introduction to information security |
| | Inspection |
| | Protection |
| | Detection |
| | Reaction |
| | Reflection |
| | Risk assessment frameworks |
| | Security engineering |
| | Physical aspects |
| | Security in connected systems and networks |
| | Policy and management issues |

### 7.1.1 CS2013

Table 10. CS2013 disciplines and topics

| Disciplines | Topic | Subtopic |
|---|---|---|
| Algorithms and Complexity | Basic Analysis | Differences among best, expected, and worst case behaviors of an algorithm |

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|---|---|---|
| | | Asymptotic analysis of upper and expected complexity bounds |
| | | Big O notation: formal definition |
| | | Complexity classes, such as constant, logarithmic, linear, quadratic, and exponential |
| | | Empirical measurements of performance |
| | | Time and space trade-offs in algorithms |
| | | Big O notation: use |
| | | Little o, big omega and big theta notation |
| | | Recurrence relations |
| | | Analysis of iterative and recursive algorithms |
| | | Some version of a Master Theorem |
| | Algorithmic Strategies | Brute-force algorithms |
| | | Greedy algorithms |
| | | Divide-and-conquer (cross-reference SDF/Algorithms and Design/Problem-solving strategies) |
| | | Recursive backtracking |
| | | Dynamic Programming |
| | | Branch-and-bound |
| | | Heuristics |
| | | Reduction: transform-and-conquer |
| | Fundamental Data Structures and Algorithms | Simple numerical algorithms, such as computing the average of a list of numbers, finding the min, max, and mode in a list, approximating the square root of a number, or finding the greatest common divisor |
| | | Sequential and binary search algorithms |
| | | Worst case quadratic sorting algorithms (selection, insertion) |
| | | Worst or average case O(N log N) sorting algorithms (quicksort, heapsort, mergesort) |
| | | Hash tables, including strategies for avoiding and resolving collisions |
| | | Binary search trees: Common operations on binary search trees such as select min, max, insert, delete, iterate over tree; Common operations on binary search trees such as select min, max, insert, delete, iterate over tree |
| | | Graphs and graph algorithms: Representations of graphs (e.g., adjacency list, adjacency matrix); Depth- and breadth-first traversals. |
| | | Heaps |
| | | Graphs and graph algorithms: Shortest-path algorithms (Dijkstra's and Floyd's algorithms); Minimum spanning tree (Prim's and Kruskal's algorithms) |
| | | Pattern matching and string/text algorithms (e.g., substring matching, regular expression matching, longest common subsequence algorithms) |
| | Basic Automata Computability and Complexity | Finite-state machines |
| | | Regular expressions |
| | | The halting problem |

| | | |
|---|---|---|
| | | Context-free grammars (cross-reference PL/Syntax Analysis) |
| | | Introduction to the P and NP classes and the P vs. NP problem |
| | | Introduction to the NP-complete class and exemplary NP-complete problems (e.g., SAT, Knapsack) |
| | Advanced Computational Complexity | Review of the classes P and NP; introduce P-space and EXP |
| | | Polynomial hierarchy |
| | | NP-completeness (Cook's theorem) |
| | | Classic NP-complete problems |
| | | Reduction Techniques |
| | Advanced Automata Theory and Computability | Sets and languages o Proving languages non-regular, via the pumping lemma or alternative means o Regular languages o Review of deterministic finite automata (DFAs) o Nondeterministic finite automata (NFAs) o Equivalence of DFAs and NFAs o Review of regular expressions; their equivalence to finite automata |
| | | Context-free languages o Push-down automata (PDAs) o Relationship of PDAs and context-free grammars o Properties of context-free languages |
| | | Turing machines, or an equivalent formal model of universal computation |
| | | Nondeterministic Turing machines |
| | | Chomsky hierarchy |
| | | The Church-Turing thesis |
| | | Computability |
| | | Rice's Theorem |
| | | Examples of uncomputable functions |
| | | Examples of uncomputable functions |
| | Advanced Data Structures Algorithms and Analysis | Balanced trees (e.g., AVL trees, red-black trees, splay trees, treaps) |
| | | Graphs (e.g., topological sort, finding strongly connected components, matching) |
| | | Advanced data structures (e.g., B-trees, Fibonacci heaps) |
| | | String-based data structures and algorithms (e.g., suffix arrays, suffix trees, tries) |
| | | Network flows (e.g., max flow [Ford-Fulkerson algorithm], max flow – min cut, maximum bipartite matching) |
| | | Linear Programming (e.g., duality, simplex method, interior point algorithms) |
| | | Number-theoretic algorithms (e.g., modular arithmetic, primality testing, integer factorization) |
| | | Geometric algorithms (e.g., points, line segments, polygons. [properties, intersections], finding convex hull, spatial decomposition, collision detection, geometric search/proximity) |
| | | Randomized algorithms |
| | | Stochastic algorithms |
| | | Approximation algorithms |

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|---|---|---|
| | | Amortized analysis |
| | | Probabilistic analysis |
| | | Online algorithms and competitive analysis |
| Architecture and Organization | Digital Logic and Digital Systems | Overview and history of computer architecture |
| | | Combinational vs. sequential logic/Field programmable gate arrays as a fundamental combinational + sequential logic building block |
| | | Multiple representations/layers of interpretation (hardware is just another layer) |
| | | Computer-aided design tools that process hardware and architectural representations |
| | | Register transfer notation/Hardware Description Language (Verilog/VHDL) |
| | | Physical constraints (gate delays, fan-in, fan-out, energy/power) |
| | Machine Level Representation of Data | Bits, bytes, and words |
| | | Numeric data representation and number bases |
| | | Fixed- and floating-point systems |
| | | Signed and twos-complement representations |
| | | Representation of non-numeric data (character codes, graphical data) |
| | | Representation of records and arrays |
| | Assembly Level Machine Organization | Basic organization of the von Neumann machine |
| | | Control unit; instruction fetch, decode, and execution |
| | | Instruction sets and types (data manipulation, control, I/O) |
| | | Assembly/machine language programming |
| | | Instruction formats |
| | | Addressing modes |
| | | Subroutine call and return mechanisms (cross-reference PL/Language Translation and Execution) |
| | | I/O and interrupts |
| | | Heap vs. Static vs. Stack vs. Code segments |
| | | Shared memory multiprocessors/multicore organization |
| | | Introduction to SIMD vs. MIMD and the Flynn Taxonomy |
| | Memory System Organization and Architecture | Storage systems and their technology |
| | | Memory hierarchy: importance of temporal and spatial locality |
| | | Main memory organization and operations |
| | | Latency, cycle time, bandwidth, and interleaving |
| | | Cache memories (address mapping, block size, replacement and store policy) |
| | | Multiprocessor cache consistency/Using the memory system for inter-core synchronization/atomic memory operations |
| | | Virtual memory (page table, TLB) |
| | | Fault handling and reliability |
| | | Error coding, data compression, and data integrity (cross-reference SF/Reliability through Redundancy) |

| | | |
|---|---|---|
| | Interfacing and Communication | I/O fundamentals: handshaking, buffering, programmed I/O, interrupt-driven I/O |
| | | Interrupt structures: vectored and prioritized, interrupt acknowledgment |
| | | External storage, physical organization, and drives |
| | | Buses: bus protocols, arbitration, direct-memory access (DMA) |
| | | Introduction to networks: communications networks as another layer of remote access |
| | | Multimedia support |
| | | RAID architectures |
| | Functional Organization | Implementation of simple datapaths, including instruction pipelining, hazard detection and resolution |
| | | Control unit: hardwired realization vs. microprogrammed realization |
| | | Instruction pipelining |
| | | Introduction to instruction-level parallelism (ILP) |
| | Multiprocessing and Alternative Architectures | Power Law |
| | | Example SIMD and MIMD instruction sets and architectures |
| | | Interconnection networks (hypercube, shuffle-exchange, mesh, crossbar) |
| | | Shared multiprocessor memory systems and memory consistency |
| | | Multiprocessor cache coherence |
| | Performance Enhancements | Superscalar architecture |
| | | Branch prediction, Speculative execution, Out-of-order execution |
| | | Prefetching |
| | | Vector processors and GPUs |
| | | Hardware support for multithreading |
| | | Scalability |
| | | Alternative architectures, such as VLIW/EPIC, and Accelerators and other kinds of Special-Purpose |
| | | Processors |

### 7.1.2 BISE

Table 11. BISE disciplines and topics

| Disciplin | Topic |
|---|---|
| Subject and Context | Subject matter of BISE: |
| | Types and core elements of IS in organizations and value networks |
| | IT artifacts |
| | Importance of BISE for organizations and economies |
| | Digitization and globalization and their implications for BISE |
| | IT industry: |
| | Foundations and methods of empirical and designoriented research. |
| Economic Foundations | Business administration foundations: |
| | Business administration foundations with particular relevance to BISE |
| | Selected economic foundations: |
| Foundations of Computer Science | Mathematical foundations of computer science (including discrete structures, complexity, and computability). |

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|---|---|
| | Foundations of software engineering (including process models and development tools), in particular object-oriented modeling (e.g., Unified Modeling Language), programming and architectures of application systems. |
| | Programming with (object-oriented) programming languages (e.g., Java). |
| | Specific algorithms, data, and data structures (e.g., planning and optimization algorithms in the context of ERP systems). |
| | Design and implementation of database systems (e.g., implementation and optimization of databases and database management systems). |
| | Web engineering (e.g., technologies and applications on the Internet). |
| | Optional additional topics from applied computer science (e.g., operating systems, computer networks, and distributed systems). |
| Further Foundations | |
| | Statistics and mathematics for BISE, especially discrete mathematics, linear algebra, graph theory, combinatorics, stochastics, methods of deductive and inductive statistics, econometrics, selected aspects of logic. |
| | Behavior science foundations: organizational psychology, acceptance, group decision-making, cognitive psychology, behavioral economics, foundations from neuroscience. |
| | Business law: private law, labor law, copyright law, intellectual property law, media law, telecommunications law, each with particular emphasis on information processing (e.g., privacy, product liability and copyright protection for software, participation in automation projects, internet access), IT Compliance. |
| | Ethics and sustainability. |
| Data Management | |
| | Data models and database systems: enterprise data models, conceptual data modeling (in particular by means of entity-relationship model, semantic object model, Unified Modeling Language); logical data models and database schemas. |
| | Relational databases and database management systems: relational algebra, database languages (esp. Structured Query Language), transactions. |
| | Non-relational database systems: Not only SQL, CAP theorem, column-oriented databases, in-memory databases, data lakes, collection and storage of large and heterogeneous data sets. |
| | Data warehousing: data management (extraction, transformation, loading), multidimensional data models, Multidimensional Expressions, architectures (e.g., hub and spoke), operational data stores and data marts, Lambda architecture, distinguishing operational and analytical data models and database systems. |
| | Applications in master and metadata management, data quality management, data integration (business documents, data interfaces, especially Extensible Markup Language), repository systems, ontologies, semantic web. |
| Process Management | |
| | Strategic process management: process organization, strategic alignment, business process management lifecycle, maturity models. |
| | Enterprise modeling, e.g., with architecture of integrated information systems, semantic object model, multi-perspective enterprise modelling or comparable modeling frameworks; modeling methods, metamodeling, methods design. |
| | Process modeling, e.g., with business process model and notation, event-driven process chains or comparable modeling frameworks; complementary modeling languages for data, decisions, and rules, e.g., entity-relationship model or decision model and notation, business rule management. |
| | Process analysis and mining: descriptive vs. prescriptive process models, quantitative and qualitative process analysis, business activity monitoring, process warehouse, process simulation, process compliance and compliance management, process mining algorithms such as alpha algorithm; analysis of process models with suitable query languages (model query). |
| | Process execution and monitoring: workflow management, enterprise resource planning, web service composition, choreography/orchestration, businessprocess-management |
| | systems, event-driven business process management, process simulation at theoretical and practical levels. |
| | Process optimization and continuous improvement: models and methods of quality management, six-sigma method for error-free business processes, benchmarking. |
| | Domain-specific reference models, e.g., for industry, banking, retail, finance, tourism, and e-government. |
| Information Management | |
| | (a) Fundamental concepts: data/information/knowledge and information management, historical roots, structuring approaches from information management and its interaction with other BISE topic areas, especially the digital transformation (e.g., newer forms of division of labor and value creation, new management roles within the digital transformation). |
| | (b) Value contribution of IT: IT as a competitive factor, differentiating effect of IT. |
| | (c) IT Governance: role of IT in companies and organizations, interaction between IT and business departments, internal organization of the IT department, roles of a chief information officer, IT risk management. |
| | (d) IT strategy: formulation of an IT strategy and alignment with corporate strategy (strategic alignment), differentiation of IS strategy and IT strategy, determining the product and service portfolio to be realized by the IT department. |
| | (e) Sourcing of IT: insourcing and outsourcing, reasons, evaluation of variants, contract design (e.g., in terms of service level agreements), managing supplier relationships. |
| | (f) Software: sources, selection, implementation and management (make-or-buy decision, configuration and parameterization of standard software, process models for selection and introduction of standard software, |

| | |
|---|---|
| | management concepts (especially the cloud), software-as-a-service, on-premises use, mobile applications (apps), licensing models). |
| | (g) IT landscape: management of information and communication technology infrastructure and IT security as well as the product and service portfolio of the IT department; architecture overview, planning, integration and consolidation, operations. |
| | (h) IT controlling: controlling instruments (e.g., IT balanced scorecard), economic efficiency of IT, IT cost allocation, frameworks (e.g., CoBIT). |
| | (i) Project management: project initiation, planning and management. |
| | (j) IT compliance and legal framework of information management, e.g., data security, privacy, co-determination, contract design, copyright protection for software. |
| Development and Operation of Information Systems | |
| | (a) Problem analysis and requirements specification: use of languages for modeling business processes, operations and workflows, objects, data, and features (e.g., architecture of integrated information systems, business process model and notation, semantic object model, the Unified Modeling Language); consideration of requirements for strategic informationsystem planning and Business-IT alignment, compliance requirements, risk management. |
| | (b) Architectural design: architectural models (e.g., web architecture, service-oriented architecture, peer-topeer architectures, component-oriented architectures, client–server architectures), architectural styles (e.g., representational state transfer), enterprise architecture management, cloud computing, software-as-aservice, component interfaces, architecture development. |
| | (c) Program development and testing: development tools, languages, and libraries, development platforms (e.g., JavaEE, .NET, the Android platform, the iOS platform, Windows-platform apps, OS X apps), use of database systems and data services, reuse (e.g., patterns), test methods and strategies (testdriven development, continuous integration), modeldriven approaches, secure software development. |
| | (d) Automation: determination of degree and form of automation for information systems, design of human–computer interface (e.g., human–computer interaction, usability, accessibility). |
| | (e) System integration: integration concepts, selection of system components (full service versus best-of-breed approaches). |
| | (f) Process models for the development of information systems: V-Model XT, rational unified process, classical process models (waterfall model, prototyping, spiral model), agile approach (eXtreme programming, Scrum), process models with specific focus (e.g., business intelligence projects). |
| | (g) Operation of information systems: IT service, IT service management, cooperation agreements, service level agreements, monitoring operating conditions, reference models (e.g., IT infrastructure library), life cycle of IT systems (replacement of legacy systems and continuous renewal and development), maintenance of IT systems, ensuring information security. |
| | (h) Integration of information systems: Integration concepts, horizontal and vertical integration, integration across organizational boundaries, networking of information systems with things (smart objects) and operational resources (e.g., in the internet of things or as cyber-physical systems); integration of corporate core systems with document and workflow management systems, with social software and collaboration systems. |
| Corporate Core Systems | |
| | (a) Enterprise resource planning: function-oriented ERP modules or application systems (e.g., human resource management, accounting, finance), illustration and integration of business processes in ERP (e.g., order processing); sector-dependent and sectorindependent ERP systems. |
| | (b) Supply chain management: strategic planning of supply chains and networks, network-wide planning, management, control, and monitoring of supply chains (supply chain event/performance management), advanced planning and scheduling, supplier relationship management. |
| | (c) Customer relationship management: information technology for building and maintaining client relationships; subsystems (e.g., sales force automation, call center, customer service, collaborative and analytical customer relationship management) and integration thereof. |
| | (d) Product lifecycle management including product data management: modeling and structuring of technical and workflow-related product data; strategic planning of production, management, distribution, and use processes for product data in value chain networks for the entire product life cycle, starting with the product idea and development. |
| | (e) Economic branch-oriented information systems, especially in industry (e.g., ERP modules that deal with production planning and control, manufacturing execution systems), commerce (e.g., inventory control systems), services sector (e.g., service data management systems, yield management systems), financial sector (e.g., systems for payment, retail, inventory, and risk management); public administration (e.g., e-government). |
| | (f) e-Business and e-commerce systems, especially electronic marketplaces and auction systems, electronic stores, systems for catalog management, product configurations, order management, omnichannel commerce. |
| | (g) Management information systems: analysis of information needs and products for management tasks, providing internal and external information, issue management and early warning systems, reporting systems, monitoring systems, planning systems. |
| Knowledge Management and Collaborative Technologies | |

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| | (a) Strategy and processes: knowledge management strategy; knowledge management success; knowledge management objectives; critical success factors; performance indicators; potential benefits; intellectual capital statements; knowledge management processes (localize and collect, exchange and distribute, benefit, (further) development); (business) process support through knowledge management; process-oriented knowledge management. |
| | (b) Organization and culture: knowledge management organization; chief knowledge officer; knowledge workers; storytelling; knowledge bridge; knowledge management culture; incentive systems; motivation. |
| | (c) Digital workgroups: communication; cooperation/collaboration; coordination; computerized working group (computer-supported cooperative work); media-choice theory; awareness management; unified communication. |
| | (d) Digital communities: social media; enterprise social media; social media analytics (e.g., topic modeling, sentiment analysis, network analysis); social network sites; blogs; microblogging; wikis; forums; virtual worlds; online reviews. |
| | (e) Management of digital content: content management systems; enterprise content management; content lifecycle; document management systems; metadata management; repository systems; user-generated content. |
| | (f) Knowledge acquisition and knowledge sharing: skills management; skills lifecycle; individual and organizational learning; e-learning; learning-management systems; knowledge organization. |
| | (g) Methods of knowledge management in weakly structured data stocks: knowledge modeling and visualization (e.g., ontologies, semantic web, topic maps, taxonomies); portals and search; text mining. |
| | (h) Digital and collaborative innovation: open innovation/ideation; crowdsourcing; crowdtesting; crowdfunding. |
| | (i) Integration with information systems within and external to companies: design and emergence of information systems; omnichannel management; shadow IT; (social) customer relationship management. |
| Model-Based Decision Support, Business Intelligence, and Analytics | |
| | (a) Types of decision problems, decision support systems. |
| | (b) Data preparation: visualization of input data, aggregation and disaggregation techniques, handling missing data. |
| | (c) Mathematical-statistical models and methods of knowledge discovery in databases: e.g., forecasting, classification, clustering, regression, optimal experimental design, data mining, predictive modeling, text mining, opinion mining and sentiment analysis, process mining. |
| | (d) Models and methods of operations research: optimization and simulation models from industry, commerce, and services sectors, solution methods from linear and mixed-integer optimization, sensitivity analysis, heuristics and metaheuristics and hybrid methods, discrete simulation, Monte Carlosimulation, simulation-based optimization. |
| | (e) Models and methods of artificial intelligence and soft computing: e.g., software agents and multi-agent systems, evolutionary algorithms, machine learning methods such as artificial neural networks, fuzzy systems. |
| | (f) Modeling and usage cycle: model selection, model creation, process selection, performance evaluation of decision models/algorithms, incorporatingdynamics and stochastics into decision models (e.g., scenario management), parallelization algorithms. |
| | (g) Using results: fully automated use vs. modification by human decision makers, dealing with dynamics and stochastics (e.g., rolling planning strategies, rescheduling). |
| | (h) Cognitive science theories (e.g., cognitive-load theory, bounded-rationality theory, illusion-of-control theory), behavioral operations research, influence of emotions on decisions, human-centered management support, staff intelligence, game-based management support, collaborative business intelligence, selfservice business intelligence. |
| | (i) Presentation of results: visual analytics, guidelines for the design of reports and business graphics, geographical analysis, dashboards. |
| | (j) Technical perspective: decision architecture, e.g., entry-exit systems, method databases, integration of algorithmic kernels into existing application systems, parallelization strategies, distributed data analysis, mobile business intelligence, real-time business intelligence. |
| Digital Transformation | |
| | (a) Concept understanding, demarcation of information management, localization of phenomena and developments (sharing economy, crowdsourcing, newer forms of cooperation); relations to information economies: nature of information, information as a resource, economics of network effects, platforms, two-sided markets; access, control, and ownership; opening of resources; internal, external, shared resources; stages of the digital transformation, digitalization, and digital maturity of organizations. |
| | (b) Value chain structures: value creation and value appropriation; IT-induced changes in the horizontal and vertical value-chain structure, e.g., newer forms of division of labor and knowledge transfer between stakeholders (companies, customers, etc.); interactive value: division of tasks, transaction costs, limits; hybrid coordination forms: virtual enterprise, supply chain/supply networks; business ecosystems. |
| | (c) Business models: description approaches for business models; typical changes in the configuration of business models; incremental versus radical business model innovation; data-driven business models. |
| | (d) Changes to primary activities: customer relationship management based on customer relationship management systems; recommendation systems and their impacts; search-engine marketing, individualization in production (mass customization); product-centric innovation approaches (e.g., smart objects). |

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| | (e) Changes to secondary activities: newer forms of recruitment; newer forms of product development (customer-centric), e.g., open innovation, commonsbased peer production, user innovation; individualization in communication and marketing. |
| | (f) IT-induced changes in management, strategy, and the organization; capabilities for data collection and analysis and the implementation of data-based findings. |
| | (g) Transformation management: digitization strategies and the demarcation of IT strategy; methods for promoting change (business patterns, business model innovation); newer role models (such as chief digital officer) and their cooperation with traditional IT roles; intrapreneurship and entrepreneurship, role of incubators, company builders etc.; business IT alignment: professional, social/organizational and cultural factors and hurdles in a digital transformation; role of IT environments, interaction with IT organizations, networking and their effects, e.g., the Internet of Things, cyber-physical systems. |
| | (h) Effect of transformation on companies and industries: lifecycle model for business, specifics, and success factors for digital startups; specific developments in selected sectors (e.g., media and automotive). |
| | (i) Social implications of the digital transformation: protection of privacy, distribution and access to information, digital divide. |