Emergence and development stages of informatics in Azerbaijan

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ARTICLE INFO

ABSTRACT

The article highlights the results of studies on the emergence history and formation of informatics in Azerbaijan, and chronologically interprets the development stages of informatics. It comparatively analyzes the evolution of the fields of informatics, computer science and information and communication technology in Azerbaijan during the Soviet Union period and independence years based on archival documents. Studies are conducted on the activities of the Azerbaijani scientists who played a significant role in the emergence and development of informatics in Azerbaijan, and their central scientific achievements are presented. The measures implemented for the establishment of the national network infrastructure of the Internet in Azerbaijan and the manufacture of national products in the field of ICT are reviewed. Computer generations in Azerbaijan, state policy in the field of informatics, measures implemented for the development and application of modern technologies, personnel training in this field, leading scientific schools, higher educational institutions, as well as the provision of information sovereignty in Azerbaijan and the implementation of the IV Industrial Revolution are explored, some statistical indicators on the development of information technology are presented. The main goal of conducting the research is to comprehensively examine the history of the establishment and development of informatics in Azerbaijan, to obtain complete scientific knowledge about the role of informatics in the development of society and the country.

1. Introduction

Informatics, one of the main components of the scientific knowledge system, has a great strategic importance in terms of the establishment of the global information society. Informatics determines the development, competitiveness, quality of life of the population and national security of a country in science, education, economy and socio-cultural fields. Informatics as a discipline shapes people's ability to think logically and creatively, and develops algorithmic thinking. From this point of view, there is growing interest in the problem of clarifying the position of informatics in the system of sciences, its fundamental bases, as well as its historical-philosophical, scientific-methodological and socio-cultural aspects.

Today, many countries focus on the development of this field in connection with the expansion of the application of informatics in socio-economic processes. Ensuring information security, application of intelligent systems to separate fields, training of scientific personnel and specialists with different profiles in the field of informatics is necessary for shaping a new information culture of the society.

The term informatics (French: "Informatique") was first used by the French in 1960. This term, coined from the combination of the words information and automation, is adapted to the term "Computer science" in many countries (Karimov, Habibullayev, Ibrahimzade, 2011).

Informatics as a discipline began to be taught at the end of the 70s of the 20th century. The

formation of this discipline was stimulated by the emergence of personal computers. Informatics is a branch of science related to mathematics and cybernetics (Calalli, 2017). Cybernetics is also called the "higher" branch of computer science (Karimov, Sardarov, 2019).

Cybernetics is the science of controlling complex dynamic systems. It studies the controlled systems (Abbasov, Aliyev, 2010)

Contrary to cybernetics, computer science as a branch of science deals with the collection, storage, processing and transmission of data. From the point of view of fundamental science, the exclusive function of informatics is the examination of information transformation processes (Calalli, 2017).

The development of informatics in Azerbaijan originates from the 50s of the last century, and it has passed a long way and has become one of the important fields of science that promotes the progress of society (Abbasov, Aliyev, 2010).

Currently, interest in the history of science is growing all over the world. Because the 20th century distinguished for the most important scientific discoveries, technical progress, and the successful results of outstanding scientists and engineers.

In modern era, the teaching of the discipline "Informatics" in secondary general education schools is in the concern of every state. To succeed in competition with each other, many countries aim to train highly qualified personnel who can apply information technologies in all spheres of society, and to this end, they are constantly developing their educational programs.

This article highlights the results of historical research on the emergence and formation of informatics in Azerbaijan. It explores the emergence and development of the Internet in Azerbaijan, the establishment of the information society, the implementations for the development of ICT in the years of independence, and the measures taken in the field of electronic government. Furthermore, it examines comparatively analyzes the state policies in the field of information technology in Azerbaijan, statistical indicators of ICT development, decrees and orders signed by the head of state in the relevant field.

2. Related works

Many have been conducted so far on the emergence and development stages of informatics, the impact of information technologies on various sectors, science, education, culture, economy and the progress of society as a whole all over the world.

In the 40s of the 20th century, American scientists C.F. Neumann, G. Goldstein and A. Beris provided the basic working principles of modern computers. (Haigh, Priestley, Crispin, 2014). Those principles were implemented in 1946 in the USA with the creation of a universal computer called ENIAC (Electronic Numerical Integrator and Computer). It is the very date referred as the date of creation of modern computer technology. Since that time, computer equipment and technology began to rapidly develop.

The first microprocessor (MP) in the US was created in 1971 by Intel company. MPs were used to construct the corresponding control devices. Besides, microcomputers and supersystems were created based on MP. One of the most important events in computer history, the creation and widespread use of personal computers is directly related to the microprocessor revolution. With this spread, the stage of universal computerization began. The first microcomputer was created in the USA in 1975 (Altair 8800) (Eckert, 1980).

Computer science in the Union of Soviet Socialist Republics (USSR) has developed since the late 1940s. Following the Second World War, the development of digital computers began in the USSR. In 1950, the first seminar on programming was held at the Academy of Sciences of the USSR under the leadership of the well-known mathematician Lazar Lusternik. In 1952, the Department of Computational Mathematics was established at Moscow State University. In 1953, the Department of Programming at the Mathematical Institute of the AS of the USSR began to operate (Prokhorov, 1999).

Research and development of computers in Japan began in the 1940s. However, the production of commercial computers in the country began 10 years following the same process in the United States, since then the computer industry has become a rapidly growing industry in Japan. At the end of 1976, 39,000 computers were already installed in Japan. This was the second world indicator following the United States. In Japan, the discipline "Basics of Informatics and Computer Engineering" was included in the school curriculum in 1984 (Fridlund, 1993).

3. Formation of computer science in Azerbaijan

The emergence of informatics in the Union of Soviet Socialist Republics (USSR) dates back to the 30s of the 20th century, and its formation and development as an independent field of science dates back to the 1950s (Azerbaijan Soviet Encyclopedia, 1980).

In early 50s, the Academy of Sciences of the Azerbaijan SSR (AS AzSSR) was first to start the research on Electronic Computing Machines (ECM) in Azerbaijan. The Electromodeling laboratory established under the Oil expedition in AS SSR, built specialized grid structure models on the analog machine "EM-8". Their aimed to solve the problems of modeling processes in oil layers, to explore the theory of percolation and efficient development of oil fields. In 1956, this laboratory was attached to the Institute of Physics and Mathematics of the AS AzSSR, and continued its activity as the Computing Center.

The Computing Center operated as an independent organization from 1960, and in 1965, the Institute of Cybernetics was established on its basis. This center has been successful in scientific and applied implementations in various fields in the republic, and has given a great impetus to the development of the field of informatics and cybernetics in Azerbaijan. Following the establishment of the first Computing center at the Academy, many higher schools, ministries, and factories of the republic began the creation of computing centers in (Minutes of the meeting of the Presidium of the Academy of Sciences of the Azerbaijan USSR, 1960).

In 1955-58, supervised by Yunis Mahmudov, a test sample of the "LEM-1" universal small-scale digital computing machine was first created in the USSR. Later, the projects "LEM-2" and "LEM-4" machines were developed (Abbasov, Aliyev, 2010).

"Ural-1" machines were first introduced to Azerbaijan in 1959 and utilized in 1960.

In 1960, a group of young specialists - Telman Aliyev, Ajdar Amirov, Elshad Gasimov, Firangiz Aliyeva - went sent on a long-term mission to Ulyanovsk in order to get acquainted with the general-purpose Large Electronic Computing Machines created in the USSR - LECM (Большая электронно-счётная машина, БЕСМ). They closely participated in the assembly, tuning and testing of the machine intended for Azerbaijan at the factory where the "BEHM-2" (LECM-2) machine was manufactured.

BEHM-6 (LECM-6) computing machines, produced in the mid-1960s, were the first Soviet supercomputers based on the element base of the second generation - transistors, and defined the prospects for the development of general-purpose computers (Azerbaijan Soviet Encyclopedia, 1980). BEHM-6 made it possible to create a republican automated management system (RAMS) in Azerbaijan, and at the same time opened wide perspectives for the automated solution of various issues.

The Unified Electronic Computer System - UECS (Единая система электронный вычислительных машин, ЕС-ЕВМ) from the Soviet computer series was actively used in the Soviet countries from 1971 to 1990. This device was intended for use in computer networks, automated control systems and computing centers and provided solutions to a wide range of scientific, technical, and economic problems in various systems (Electronic computing machine, 2020).

In the 1980s and 1990s, the Soviet republics, used CM ЭВМ ("Система малых" электронная вычислительная машина – Small Electronic Computing Machines, SECM), EC-1840 computing machines, and IBM/XT, AT, Pentium, etc. in the 1990s.

On the initiative of the great leader Heydar Aliyev, the fields of information technologies, communication, electronics industry, space research were formed in the republic, and serious measures were taken. In 1974, Heydar Aliyev appealed to the Council of Ministers of the USSR regarding the establishment of the Center for the Research of Natural Resources using space technology under the AAS. By the decision of the Political Bureau of the Central Committee of the Communist Party of Azerbaijan dated August 21, 1974, the South-East Center ("Kaspi" Scientific Center) for the study of natural resources using space technology was established in Baku. In 1981, Science-Production Union for the Space Research (SPU SR) was established on the basis of the "Kaspi" Scientific Center, under the Academy of Sciences (The establishment of the National Aerospace Agency, 2023).

In the 1970s, fundamental scientific research was conducted in cybernetics, computer networks, automatic systems in the oil and gas industry, signal processing, optimal control, fuzzy logic, artificial intelligence and other relevant scientific fields for the development of informatics in Azerbaijan.

These studies carried out by well-known scientists and intellectuals of Azerbaijan have led to great achievements in many fields. In the 1970s and 1980s, Ismayil Ibrahimov, a well-known scientist and academician in the field of informatics, was the chairman of the national economy management commission with the application of economic-mathematical methods and ECM, and founded the computerization of the national economy in Azerbaijan. Scientist implemented complex applied works to increase the efficiency of production of oil refining industry of Azerbaijan (Academician Ismayil Ibrahimov, 2006).

Professor Tofig Aliyev has conducted important studies related to the theoretical and applied problems of informatics and the automation of production based on them. Moreover, the scientist had a special role in the theoretical and applied development of the information-measurement technique.

Academician Jalal Allahverdiyev is one of the invaluable scientists in the development of cybernetics and informatics science in Azerbaijan. Under his supervision, BESM-6 (LECM-6), the most powerful electronic computing machine of that time, was installed in the Special Design Bureau of the Institute of Cybernetics. Additionally, for the first time in Azerbaijan, the examination process for issuing driving licenses was automated (Abbasov, Aliyev, 2010).

Academician Telman Aliyev had imperative contributions to the formation of the entire machine park, starting with "BESM-2" (LECM-6) electronic computing machines. He has proposed the theoretical basis for ensuring the adequacy of diagnostic, recognition, forecasting, and mathematical modeling issues for real technological processes such as stationarity, normal distribution law, etc (Abbasov, Aliyev, 2010). Besides, he was an organizer of the "Digital Electronic Computing Machines" laboratory established in 1958-1960, which played a decisive role in the development of informatics in Azerbaijan and was the second (after Ukraine) among the Soviet republics, and managed that laboratory until 1976 (Academician Telman Aliyev, 2022).

Prominent scientist, corresponding member of ANAS, professor Asgar Abdullayev was closely involved in the training of highly qualified personnel in the field of automation of the oil and gas industry and automatic management theory in Azerbaijan. Moreover, A.Abdullayev has accomplished a number of achievements in the creation and wide application of automated control systems for complex automation of oil fields in Azerbaijan. The scientific school founded by the scientist gained a great reputation both in the Soviet Union and abroad (Asgar Abdullayev, 2007).

In 1971, the Department of Automated Control Systems (ACS) was established under the Institute of Cybernetics to build and apply automated control systems in the national economy, to carry out experimental, pilot-project and design works (The establishment of the Department of Automated Control Systems, 1971). The department functioned as an institution of the institute and performed many scientific and applied works. In 1982, the ACS department became an independent organization in the Azerbaijan Academy of Sciences. RACS was established in 1982 and their coordination was organized at the republic level (Establishment of the Republic Automated Management Systems, 1982). In 1997, the name and status of the AAS ACS department changed and the Information-Telecommunication Scientific Center (ITSC) was established on its basis. ITSC achieved important results in solving scientific and technical issues, such as providing security of computer networks, expert systems, information, etc., a large part of which were applied in practice.

In 2002, the Institute of Information Technology was established on the basis of the Information and Telecommunications Scientific Center (Structural changes in the Azerbaijan National Academy of Sciences, 2002). In a short period of time, the institute was distinguished by its efficient activity and engaged in scientific research on modern problems of ICT. It founded the basis for exploring information technologies, as well as scientific-theoretical problems of the information society, and its new scientific structural divisions and centers began to operate. Today, the Institute of Information Technology has created all types of opportunities for the organization of high level scientific and innovative activities. The institute conducts effective scientific research in the field of ICT, and implements important projects for the development of society. Organization of scientific activity in accordance with the global challenges using the possibilities of advnced technologies, acceleration of integration into the international world and training of professional personnel are the main tasks facing the research institution.

The institute primarily focuses on the scientific

research that includes the national and strategic interests of Azerbaijan, priority fields of science and the challenges of the IV Industrial Revolution. The institute conducts fundamental researches and achieves important results on various relevant scientific problems as theoretical foundations of e-government, cloud technologies, artificial intelligence technologies, e-demography, e-medicine, Big Data, Text Mining, cyber security problems in the Internet and cyber-physical systems, Science 4.0, Industry 4.0, Internet of Things, etc.

4. Personnel training in the field of informatics

During the Soviet period, separate higher education institutions in the republic were engaged in the training of specialists in informatics. Since the 1950s, the high schools of Azerbaijan began to organize new faculties and specializations in informatics.

In the 1960s, scientific journals, for example, "Научно-техническая информация" (Scientific Technical Information) and "Информатика" (Informatics), periodical collections, fundamental scientific research works, textbooks, etc. were published in the field of informatics (Azerbaijan Soviet Encyclopedia, 1980).

In the 1960s, the Faculty of "Automatics and Computing" was established at the Azerbaijan Polytechnic Institute (present Azerbaijan Technical University). The faculty realized staff training on computing machines, complexes, systems and networks, as well as computer software and automatic systems (Abbasov, Aliyev, 2010). The university developed the control systems of robots and automatic manipulators, their mechanics and improved the automated production technology, and built a number of modern elements on the basis of new principles of automation (Azerbaijan National Encyclopedia, "Azerbaijan" volume, 2007).

In 1961, the Azerbaijan Oil and Chemical Institute named after M. Azizbayov (present Azerbaijan State Oil and Industry University) organized the "Automation of Production Processes" faculty and established the "Electrical Measurements and Computing Techniques" and "Automatics and Telemechanics" departments under the faculty.

Azerbaijan State University (present Baku State University, BSU) was one of the higher education institutions distinguished in the field of informatics during the Soviet era. Since 1961, staff training has been started in the Department of "Computational Mathematics" of the Faculty of Mechanics and Mathematics of the Azerbaijan State University. In 1972, the "Applied Mathematics" faculty was established at the university. The "ECM and programming" department was established under the faculty, this department has achieved great achievements in personnel training in the field of informatics. In 2000, the "Informatics" department was established in the "Applied mathematics and cybernetics" faculty of BSU to ensure the wide application of information technologies in the educational process of the university.

In the 1970s, highly qualified personnel were required for the rapid development of Azerbaijan. Besides, there was a great need to ensure the progress of fundamental science in research institutes. Given this, guided by the National Leader Heydar Aliyev, as in all fields, students who excelled in their studies in informatics were sent to the most prestigious universities of the USSR. Most of the graduates continued their studies at postgraduate and doctoral levels and returned to the republic. They began to work in higher schools, the Academy of Sciences and field institutes, and were involved in building scientific schools with a solid foundation. Young, talented personnel were sent to different scientific centers located in Moscow, Leningrad, Kiev, Novosibirsk, Kuybyshev, etc. In the 1970s and 1980s, sending talented young people to various prestigious soviet higher education institutions made it possible for the republic to take a leading position in terms of educated personnel (State Program for the Education of Azerbaijani Youth in Foreign Countries, 2007). The scientific and technical potential shaped in those years has founded the progress of independent Azerbaijan in the future.

In 1975, the Azerbaijan Institute of Constructor Engineers (present Azerbaijan University of Architecture and Construction) established the "Computational technique and automation of production processes" chair. In those years, the Institute also had a Computing Center. The opening of the computing center created a great opportunity for teaching and conducting high quality research.

Since 1997, undergraduate and master's training in the specialty "Automated design systems" has been initiated at the Oil Academy. At present, the "Information technologies and management"

faculty of the university is performing training in automation and management of energy, oil-gas and petrochemical fields.

In 2001, the Azerbaijan University of Architecture and Construction established the "Information technologies and systems" and "Computing techniques and software" departments on the basis of the "Computing technique and automation of production processes" chair.

Unquestionably, successful youth policy in independent Azerbaijan was founded by Heydar Aliyev. The great leader paid special attention to young people during his entire career, and highly appreciated the growth of highly intelligent, broad-minded young people.

Today, almost all secondary and higher educational institutions of Azerbaijan greatly focus on the teaching of informatics and related sciences. The state of Azerbaijan is interested in strengthening relations with developed foreign countries, given the increase of scientific potential and its further improvement in quality. The number of specialists sent to leading scientific centers of Europe, America and Asia is increasing every year.

5. Manufacture of national products in the field of ICT

In the 70s of the 20th century, the great leader Heydar Aliyev made important decisions regarding the strengthening of the industrial potential of Azerbaijan, as well as the expansion of science-intensive fields.

In the 1980s, integrated microcircuits, semiconductor devices, ECMs were produced by the enterprises of countries such as Hungary, Germany, Poland, Romania, Czechoslovakia, and Bulgaria, which were under the impact of the Soviet Union. Following the Russian Federation, Belarus and Ukraine, Azerbaijan occupied one of the leading positions in the electronics industry in the USSR.

Scientific and industrial associations and factories created in the 70s are a manifestation of this. These enterprises were established in Baku and in various cities of the republic. In those years, "Ulduz", "Nord", ECM science and production unions, "Bullur", "Azon", "Peyk", etc. factories have been established. "Registr", "Tellur", "Kibernetika", "Kristal" "Biotex", "Mikroelektronika" and other etc. special constructor bureaus have started to operate under the research institutes. Such innovative

enterprises also operated in Nakhchivan, Ganja, Mingachevir, Sumgayit and other cities (Abbasov, 2014).

After the second return of Heydar Aliyev to the head of the country, the first foreign investments in the field of ICT in Azerbaijan began. "Bakcell", the first mobile network in Azerbaijan, was established in 1994. In 1996, the company "Azercell" began to operate (Mammadov, Gozalov, Mammadov, 2012)

Focusing on the development of this field, President Ilham Aliyev paid special attention to the development of the non-oil sector, the expansion of the application of innovations in the field of economy, and the strengthening of the role of the ICT sector in the country's development, starting from the first days of his leadership (Abbasov, 2014).

In 2004, President Ilham Aliyev signed a decree on the abolition of the Ministry of Communications and the establishment of the Ministry of Communications and Information Technologies (Ministry of Digital Development and Transport) on its basis (The establishment of the Ministry of Communications and Information Technologies of the Republic of Azerbaijan, 2004). This Decree was one of the most important steps in terms of the development of the communication and ICT sphere, as well as the expansion of citizens' free use of modern technologies (Date of establishment of the Ministry of Communications and Information Technologies, 2020).

In 2005, on the initiative of the Ministry of Communications and Information Technologies (Ministry of Digital Development and Transport), the first enterprise producing computers with the conveyor method in the South Caucasus - the KÜR plant started to function (Azerbaijan National Encyclopedia, 2007). The plant located in Mingachevir was equipped with the latest world standards equipment. The plant produced computer equipment for business and government offices, general education schools, including personal computers under the KUR trademark.

The company "Ultra" ("Ultra Technologies"), which started operating in Azerbaijan in 1999, has an ISO 9001:2000 certificate. Currently, this company is an official partner of well-known IT companies such as "IBM", "Cisco", "HP". The company aims to deliver high-quality IT services, to train qualified personnel to contribute to the proper organization and sustainable development of business using ICT, as well as to the development of modern technologies in our

country.

Since 2004, NEXUS personal computers and servers have been produced in Azerbaijan (Abbasov, Aliyev, 2010).

6. Formation of information communication technologies infrastructure in Azerbaijan

The events took place in the country at the beginning of the 90s of the last century had affected the development of information and communication technologies (ICT) and led to the weakening of this field. The explosion of the power block of Azerbaijan's state television on January 19, 1990, led to the information blockade of the country. The complicated political situation arisen in those years and the lack of national ICT infrastructure in Azerbaijan made the country's voice disregarded in the world.

After the collapse of the Soviet Union, the unstable situation in the country, the economic slowdown, as in all spheres, had a negative impact on the development of the ICT sector.

Commercial Internet services were first provided in Azerbaijan in 1996 by "Intrans" company. Later, "Azerin", "Azevrotel" and other companies were also established and started to provide Internet service. Overall, the development of the Internet in the country was mainly realized by the private sector. Presently, access to international Internet highways is provided by "Delta Telecom" LLC and "AzerTelecom".

Starting from the 90s, ICT companies emerged in Azerbaijan. "Azerbaijan Electronics" (AZEL) company was established in 1991. Others included SINAM, R.I.S.K. company, BestComp Group, "Ultra" company, etc.

In 1992, the National Aerospace Agency under the President of the Republic of Azerbaijan (NAA) was established by the Decree of the President of the Republic of Azerbaijan in order to implement the state policy on space research and to ensure the use of space research for the progress of the economy (The establishment of the National Aerospace Agency of Azerbaijan, 1992).

At the beginning of the 21st century, many decisive steps were taken for the development of ICT in Azerbaijan, and to accelerate the development of the country by expanding the use of information technologies, in 2003, Great Leader Heydar Aliyev signed the "National Strategy for Information and Communication Technologies in

sake of the Development of the Republic of Azerbaijan (2003-2012))". This historical document declared Azerbaijan's special attention to the field of ICT to our society and the whole world. ICT policy in Azerbaijan is based on this global strategy (National Strategy on Information and Communication Technologies for the Development of the Republic of Azerbaijan, 2003). This document defined the formation of the legal foundations of the information society, the development of the knowledge market, the establishment of the electronic government, the elimination of the "digital diversity" in the country, the integration of the country into the global information space and other important tasks.

Since the end of the 90s, the widespread use of satellite systems has enabled the establishment of more reliable communication systems and the creation of digital television and radio broadcasting systems around the world. In the early 2000s, the increase in demand for satellite resources further accelerated the use of ICT in this sphere (The establishment of the National Aerospace Agency of Azerbaijan, 1992).

Today, ICT has become one of the main factors driving the state and society forward. Therefore, as in other countries, ensuring the upward development of this sphere in Azerbaijan is one of the state priorities.

The development of ICT in Azerbaijan is characterized by the daily expansion of the use of the Internet network, the strengthening of the technical capabilities of mobile phone communication and other new types of services, radio and television broadcasting, and the organization of free competition conditions in the information technology market.

Today, a strong communication infrastructure has been shaped in Azerbaijan. The establishment of the information society in Azerbaijan, as well as the measures taken for the wide application of ICT, have positively affected the development of the communication sector. The consequences of development are reflected in various international and local statistical indicators.

In 2013, the first Azerbaijani telecommunication satellite "Azerspace-1" was launched into orbit. The launch of Azersky, a remote Earth observation satellite, in 2014, and Azerspace-2, a telecommunication satellite, in 2018 were important achievements. These satellite projects aimed to support the national security of the country, to conduct scientific research, as well as to increase the reputation of the country being involved in

international space projects (Nabibekova, Dashdamirova, 2021).

The development dynamics of the information society and information technologies in Azerbaijan, the successful international cooperation established in the relevant field, the formation of an innovative economy based on high technologies, as well as the steps taken by the government for the development of ICT, guarantee the country to achieve greater achievements in the field of ICT in the near future.

The "National Strategy for the Development of the Information Society in the Republic of Azerbaijan for 2014-2020" specified important tasks related to the development of Azerbaijan's economy due to the expansion of non-oil export areas before the relevant government institutions.

The "Strategic Roadmap for the development of telecommunications and information technologies in the Republic of Azerbaijan" signed by the president Ilham Aliyev in 2016s envisaged to create new mechanisms to expand the application of innovations in various fields. Following this document, important measures were taken for the faster integration of Azerbaijan into the global electronic space and the development of ICT in general (Strategic Roadmap for the development of telecommunications and information technologies in the Republic of Azerbaijan, 2016).

The mobile and fixed network infrastructure in Azerbaijan is developing in accordance with the changes taking place in the field of ICT around the world. Even in 2011, the mobile network usage rate in Azerbaijan reached 100% (Azerbaijan telecom sector, 2023).

The number of fixed line telephones in apartments was 730.8 in 2000, while in 2021, this number reached 1,377.2. The number of mobile phone subscribers was 10,817.1. The number of computers with the Internet connection was 40252.0 in 2017, whereas this figure amounted for 53484.0 in 2021 (Telecommunications and Post in Azerbaijan, 2022).

Within the framework of the "Electronic Azerbaijan" State Program (2010-2012), the capacity of the landline telephone network in Azerbaijan increased by 45 percent. In 24 cities and districts of the country, telephone networks have been fully electronic, and their technical capabilities expanded (State Program for the development of communication and information technologies in the Republic of Azerbaijan, 2010). Fig.1 shows the statistics of the ICT development index in different years in Azerbaijan.
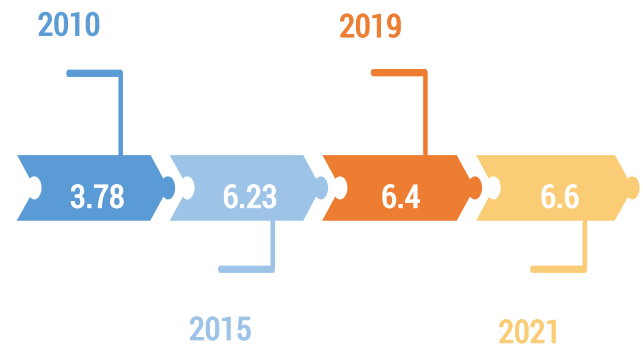

Fig. 1. ICT development index in Azerbaijan

As a result of particular attention to the development of ICT and the state policy implemented in this field, the report of the World Economic Forum held in Davos in 2008, ranked Azerbaijan the first among the CIS countries in terms of the ICT development. The report of the World Economic Forum stated the 70 percent of the Azerbaijani population to be the internet users.

There is political pluralism in Azerbaijan, i.e., the free activity of the press, including the Internet and other information media, is ensured, ICT sovereignty established.

The report "Information society in Azerbaijan" presented by the State Statistics Committee of the Republic of Azerbaijan estimates the number of Internet users per 100 people to be 79 in 2017, and which reached 87in 2021.

Azerbaijan was ranked 167th among 224 countries in the 2020-2021 by the "Cable" organization. According to this list, the average speed achieved in Azerbaijan was 6.6 Mbit/s.

7. National network infrastructure of the Internet

The establishment of the Internet, a part of the ICT infrastructure in Azerbaijan, is related to the establishment of the Azerbaijani node of the "European Academic & Research Network" (EARN) organization at the Institute of Information Technology.

In 1991, the Azerbaijani branch of the e-mail service was established by joining the international "Sovam Teleport" network. This service is provided to scientific institutions of ANAS, as well as to ensure many state enterprises to benefit from the services of international computer networks as "EARN", "BITNET", "İASNET", "Sovam teleport", etc.

In 1991, the first Azerbaijani node of the

AzScienceNet network was established, connecting the local networks of the Institute of Information Technology and the building of the Presidium of ANAS.

In 1994, supported by Turkey and the "British Petroleum" company, the Department of Automated Control Systems created an Internet hub for the first time in the republic in the main building of the Azerbaijan Academy of Sciences. Consequently, a communication channel was established between the Internet center of the Middle East Technical University via the "Turksat" artificial satellite and access to the Internet was ensured.

In 1996, a decision was made regarding the expansion of the infrastructure of the Azerbaijani part of the INTERNET and EUROMATH international computer networks, the mass application of electronic services based on network technology, and the further related scientific and technical works (Decision of the Presidium of the Azerbaijan Academy of Sciences of FRTEB, 1996).

The second Azerbaijani node of AzScienceNet began to operate in 1995. The first website in Azerbaijan www.ab.az was created in the same year at the Institute of Information Technology of ANAS and located on the servers of the AzScienceNet network. In 2003, according to the decision taken at the meeting of the Presidium of ANAS, the www.ab.az site was developed based on the new requirements and renamed to www.science.az portal (The first website of Azerbaijan – www.science.az, 2015). In 2003, Azerbaijan joined the NATO project "Virtual Silk Road", which improved the Internet access of Azerbaijan's higher schools and scientific institutions through the "Turksat" network (Alakbarov, 2016).

On May 15, 2003, the Institute of Information Technology of ANAS hosted the opening ceremony of the NATO project Virtual Silk Road. In 2004-2007, the project "Development of Internet access and infrastructure for the research, education and development of civil society" played a great role in providing Internet access to schools (Nabibekova, Dashdamirova, 2021).

In 2016, the integration of the country's science into the international world accelerated with the joining of the AzScienceNet network of the Institute of Information Technology of ANAS to the GEANT Association, a huge electronic infrastructure serving all scientific and educational institutions across Europe. Currently,

the AzScienceNet network, as a national operator, cooperates in delivering projects and services provided by the GEANT Association to the scientific and educational community of Azerbaijan (Fataliyev, 2016).

Network providers have played a distinct role in the development of information technologies in Azerbaijan. "Delta Telecom" operating in the information technology and telecommunications market since 2000 is one of the leading operators in the Caucasus region.

Nowadays, "Delta Telecom" operates 24 hours a day to provide solutions and improve the quality of services for government structures, corporate customers, banks and private enterprises, as well as all Internet Service Providers (ISPs) in Azerbaijan (About the date of establishment of "Delta telecom", 2022).

AzerTelecom LLC network provider is one of the dynamically developing telecommunications operators in Azerbaijan. The company has been operating since 2008 and is a licensed backbone internet operator connecting Azerbaijan to the international network with an appropriate (The date of establishment of "Aztelecom" company, 2022).

The first service providers in Azerbaijan are "Aztelekomnet", "İntraNS" LLC, "AB SkyBell", ADANET" JSC, "Avirtel", "Bakinternet", "Azcom" JV, "Azərin" JV, "Ultel" LLC, "Ultra", etc.

The number of Internet users in Azerbaijan is increasing every year. Figure 2 illustrates the dynamics of the number of Internet users per 100 people in Azerbaijan for 2017-2021.
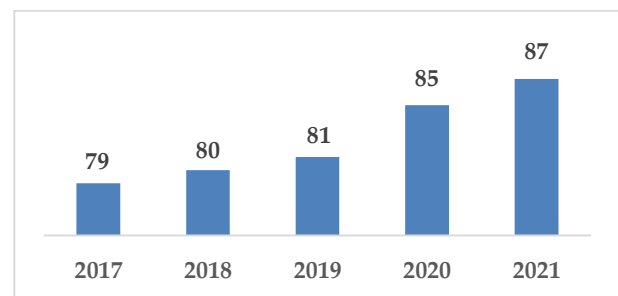

Fig. 2. Dynamics of the number of Internet users per 100 people in 2017-2021

8. Informatization of government agencies

In the 1960s, only the public sector operated in the USSR. In the Soviet countries, there was no information about the knowledge society,

electrotechnical industry, electronic state and other relevant scientific trends.

In the 60s and 70s of the 20th century, specialized enterprises, that is Computing Centers began to be built to solve complex and laborious issues through ECM.

The foundation of the first computing center in Azerbaijan's production enterprises was laid at the New Baku Oil Refinery. The Information Computing Center of "Azerenergy" has been operating since 1972. In 1973, the Information Computing Center was established in the Ministry of Oil Refining of AR.

One of the first tasks performed at the Republican Information and Computing Center (RICC) of the Ministry of Health was the creation of an automated monitoring system for patients in the intensive care unit of the Republican Clinical Hospital named after Academician Mirgasimov.

In 1962, the idea of All-Union Automated System for Information Collection and Processing (Общегосударственная автомитазированная система учёта и обработка и информация) appeared, the author of which was Viktor Mikhailovich Glushkov, a prominent Soviet mathematician and cybernetic. This plan called for the creation of a national computer network to be controlled remotely based on existing and new telephone lines. This control system was supposed to cover all factories and production enterprises as a part of the planned economy (Rustamov, 2012).

Since 1965, extensive work has been started on the creation of Automated Control Systems (ACS) for industrial enterprises and technological processes, serving various stages of production organization. In the Azerbaijan USSR, ACS was used in oil extraction, oil separation and refining, chemical industry, construction, transport, communication, medical organizations and enterprises. For example the ACS of the Azameft Union, its oil extraction enterprises, the Ministry of Petroleum and Petrochemicals of Azerbaijan, and the New Baku Refinery (Abbasov, Aliyev, 2010).

In the 70s of the 20th century, extensive work on building a system for automating the control of the national economy on the former USSR scale began. These works were performed as the Republic Automated Control Systems (Azerbaijan National Encyclopedia, 2007).

In the late 1970s, ACSE, the automated control system of the enterprise was created in the former USSR. Automated Control systems or ACS is a set of organizational complexes ensuring rational management of a complex object or process

(Rustamov, 2012). The mentioned control systems performed the function of informatization of state bodies during the Soviet era.

In the 2000s, to accelerate the country's development, it was essential to improve the education system, train intellectual personnel, and expand non-oil export areas. This made it necessary to provide the citizens of Azerbaijan with education in prestigious universities of the world. To this end, in 2007, to form a competitive economic system, the State Program was approved, which envisaged young people to study in the prestigious educational institutions of the world in the required specialties in priority areas (Program for the Education of Azerbaijani Youth in Foreign Countries in 2007). According to this State Program, dozens of young people studying or working in the field of ICT were sent to prestigious scientific centers and higher education institutions of the world. The number of highly qualified personnel in the country increased significantly as those young people gained knowledge and experience in foreign countries and returned to Azerbaijan.

In 2008, the president Ilham Aliyev adopted the State Program on informatization of the education system in the Republic of Azerbaijan. The program was mainly intended to create a uniform educational environment by expanding the application of ICT in Azerbaijan ensuring conditions for each person to get high-quality education (Decree of the President of the Republic of Azerbaijan, 2008).

By the relevant presidential Decree, 2013 was declared the "Year of Information and Communication Technolog" in the Republic of Azerbaijan. The Decree specified the work on launching Azerbaijan's artificial telecommunication satellite into orbit with the participation of the world's leading experts on the creation of the space industry, which will enable the rapid progress of science and technology. This allowed for more complete and efficient use of the potential of modern technologies (Decree of the President of the Republic of Azerbaijan, 2013). The volume of incomes obtained in the ICT sector increased, consistent work was done for the application of ICT in various spheres and the increase of the population's knowledge of information technologies.

Today, all opportunities for the development of ICT, integration into the international world and expansion of foreign scientific relations have been created in Azerbaijan. Currently, Azerbaijani scientists are conducting research in the field of

ICT in accordance with the requirements of world science and meeting modern challenges. Scientists and specialists working at the Institute of Information Technology, in turn, supervised by the General Director of this research institution, academician Rasim Alguliyev, are making significant achievements in priority areas such as Big Data, the Internet of Things, cyber security, electronic government, electronic medicine, cloud technologies.

As the State Statistics Committee reports, Azerbaijan ranks 65th among 176 countries in the world with 6.20 points according to the "ICT development index" calculated by the International Telecommunication Union, and 56th among 182 countries with 86.0 points according to the specific weight of Internet users in the total population.

The Development Concept "Azerbaijan 2020: vision of the future" defined the establishment of a competitive economy based on knowledge and innovations and information technologies in the country as a specific task (Abbasov, 2014). Moreover, in 2014, on the basis of the relevant provisions of the development concept, the National Strategy for the formation of the information society by 2020 was formed.

For the implementation of the strategic line defined in the National Strategy, the "State Program for the Development of Communication and Information Technologies in the Republic of Azerbaijan for 2005-2008 (Electronic Azerbaijan)" approved by Decree No. 1055 of the President of the Republic of Azerbaijan Ilham Aliyev dated October 21, 2005, has been completed. This program was an advanced activity concept that provided for the organizational, technical, legal and personnel modernization of the communication and ICT sphere, enabling the wide application of ICT in all spheres of society (State Program (Electronic Azerbaijan), 2005).

E-service refers to the electronic organization of services in various fields, systematized by the application of ICT, without losing time, but ensuring transparency (Yusifov, Gurbanli, 2018). As a result of the implementations performed for the realization of the "Electronic Azerbaijan" State Program, the normative-legal base in the relevant field has been developed, the telecommunication infrastructure has been reconstructed based on modern requirements, and the use of the services provided by the population with the application of ICT has increased significantly. Consistent measures have been taken to create a transparent environment in the ICT market, developing the private sector, and increasing the production of electronic devices and software products (Abbasov, 2009).

High potential personnel training in the field of ICT has always been in the focus of the state, and necessary work has been implemented for this. To meet the demand for highly qualified personnel in the country, the "State Program for the education of Azerbaijani youth in foreign countries in 2007-2015" was approved by the Order of the President of the Republic of Azerbaijan No. 2090 dated April 16, 2007 (Scientific and technical achievements in the field of cybernetics and informatics, 2012). This program envisages the creation of a single system for the organization of the education of the Azerbaijani youth abroad.

On November 4, 2008, the head of state signed the Decree on "Creation of the space industry in Azerbaijan and launching telecommunication satellites into orbit" (Decision of the Presidium of the Academy of Sciences of the Azerbaijan USSR, 1971). The Decree specifies adopted state programs and implemented measures for the development of the non-oil sector in the country opening wide prospects for the development of the economy and new industries.

In connection with the execution of above decree, in 2009, the State Program for the creation and development of the space industry in Azerbaijan was approved. On May 3, 2010, "Azerkosmos" Open Joint Stock Company was established by the relevant Decree of the President Ilham Aliyev (About the establishment of the National Aerospace Agency, 2023).

The continuous development of the ICT field has led to the elimination of information inequality in Azerbaijan, and its positioning as developed countries in the sphere of information technologies.

One of the main principles of the implementation of the National Strategy for the development of information society in Azerbaijan for 2014-2020 was to support the development of ICT industry in the country. The strategy envisages stimulation of production of competitive ICT products, science-efficient technologies, and development of free competition conditions in this sphere (On the approval of the "National Strategy for the development of the information society in the Republic of Azerbaijan, 2014).

The 2022 report of the "E-Government Development Index" offered by the UN classified the states into 4 groups as "highest", "high", "medium" and "low". Azerbaijan was ranked 23rd

among 73 countries being referred to the high group. Among 193 countries of the world, it was ranked 83rd by the "E-Government Development Index".

As Fig. 3 illustrates, Azerbaijan is also among the landlocked developing countries with the highest EGDI (e-government development index) values (United Nations e-government survey, 2022).
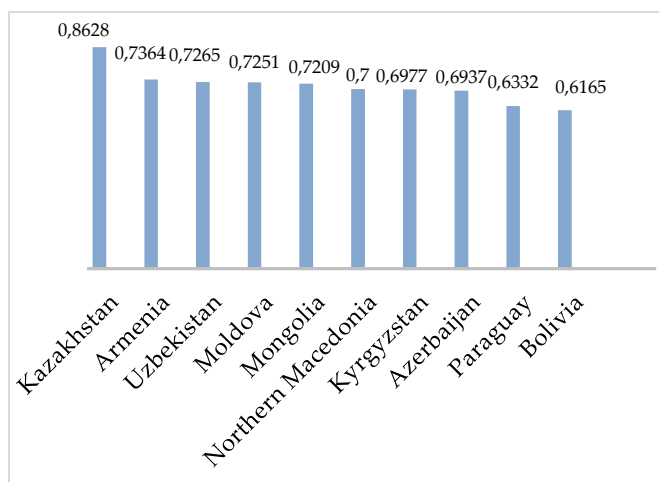

Fig. 3. Landlocked developing countries with the highest e-government development index

9. Industry 4.0 and Azerbaijan

In recent years, new realities and challenges are emerging all over the world due to the impact of the Fourth Industrial Revolution. Due to the application of the Internet of Things and cyber-physical systems to all spheres as military, economy, agriculture, transport infrastructure, etc., humanity is transitioning to a new stage of development.

In modern times, artificial intelligence technologies are one of the main trends of the Fourth Industrial Revolution. These technologies are also widely used in Azerbaijan, new realities are emerging in the labor market being affected by the digital changes. As a result of the state policy in the field of development and wide application of ICT, researches on the challenges of the Fourth Industrial Revolution are being conducted in Azerbaijan.

In 2020, under the leadership of Commander-in-Chief Ilham Aliyev, the Azerbaijani army liberated the occupied lands of Karabakh from the enemy within 44 days. Following that, the studies on the monitoring of the environmental disaster caused by the Armenians in the Karabakh region, the comparative analysis of the land and water resources, the pre-occupation and the current state

of agriculture, and their effective use became relevant, and specific tasks were set before the scientists in this field.

According to the order of the President of the Republic of Azerbaijan Mr. Ilham Aliyev, the construction of modern infrastructure, the organization of various economic fields, the creation of smart cities and villages have been started in Karabakh region.

With the special initiative and attention of President Ilham Aliyev, Azerbaijan is becoming a regional center for the Fourth Industrial Revolution. On January 6, 2021, the president signed a decree on the creation of the public legal entity "Analysis and Coordination Center of the Fourth Industrial Revolution" under the Ministry of Economy of the Republic of Azerbaijan. New priorities have been determined in order to achieve important achievements of Azerbaijani science in the field of Industry 4.0 and artificial intelligence (Decree of the President of the Republic of Azerbaijan, 2021).

The Decree of the President of the Republic of Azerbaijan on the development of the concept of "Smart City" and "Smart Village" dated April 19, 2021 states that the effective use of modern technologies accelerates the socio-economic development of the state and shapes a new labor market (Decree of the President of the Republic of Azerbaijan, 2021).

Today, the advanced technologies which are the trends of the Fourth Industrial Revolution, that is the Internet of Things, artificial intelligence, big data, cloud technologies, etc. forms the basis of the "smart city".

The studies show that due to the declaration of information technology as a priority area in Azerbaijan and its penetration into all spheres of social and political life, the demand for appropriately qualified IT specialists in both IT and other fields has increased, and this process will further intensify. The availability of highly qualified personnel is one of the main factors in the development of the IT sphere (Mammadova, Jabrayilova, 2010).

According to the Decree on the approval of the State Program for the education of Azerbaijani youth abroad in 2007-2015, the annual number of Azerbaijani youths sent to study abroad at all education levels was supposed to reach 1000 people in 2015 (Decree of the President of the Republic of Azerbaijan, 2007). It is within the framework of this State Program many young people were sent to well-known foreign

universities to study in the field of ICT, and gained advanced knowledge and experience (Mammadova, Jabrayilova, 2010).

In modern times, Azerbaijan also focusses on the field of artificial intelligence. The specific tasks set by the head of state Ilham Aliyev for the state institutions regarding the application of artificial intelligence and the development of the Fourth Industrial Revolution, the decrees and orders he has adopted prove once again that this field of science is supported at the state level in Azerbaijan.

Azerbaijani scientists have recently achieved important results by conducting fundamental research on artificial intelligence topics such as artificial neural networks, fuzzy logic and control, machine learning, expert systems.

As a continuation of the measures implemented in the relevant field, Azerbaijan decided to realize complex measures in the field of "Electronic Government" in, ensure the transition to "digital government", organize the operation of information systems based on modern requirements, and apply "cloud" technology to freely use these opportunities for citizens

The Decree of the President of the Republic of Azerbaijan signed in 2019 on the creation of the "Government cloud" (G-cloud) and measures in the field of providing "cloud" services, specifies very important measures as the improvement of management with the wide application of "cloud" technology, reduction of costs, reliable and stable infrastructure of state information systems placement, free use of state information resources, etc. (Decree of the President of the Republic of Azerbaijan 2019) The creation of the government cloud enables the establishment of a safer and more stable ICT infrastructure in the country and the efficient exploitation of the information resources of state institutions through it (Yusifov, Farajova, 2021).

10. Conclusion

Studies proved that the formation of the field of informatics in Azerbaijan had gone through a long, complex and honorable path, ICT had become the leading force of global socio-economic development in Azerbaijan, as in all countries of the world. Many scientists and engineers of Azerbaijan made great contributions to the creation of the first electronic computing machines and software in our country, and to the formation and development of computer science. Today, relevant state programs and orders in the field of ICT are adopted in our country, researches are

conducted in priority scientific trends, and important achievements are made. Consistent measures are taken for the intellectualization of the information society and the application of artificial intelligence technologies, one of the main trends of the Fourth Industrial Revolution. The results of the research conducted by Azerbaijani scientists in the relevant field are published in the world's prestigious, high impact factor journals. Studying the history of informatics in our country, its formation, organization and development stages is an integral part of studying the history of our science. The achievements in the field of ICT in Azerbaijan, the implemented measures, as well as the growing interest in the history of informatics all over the world, made it necessary to conduct fundamental researches in this field in our country as well.

References

Abbasov A., Aliyev T., "Organization of informatics in Azerbaijan", "Letterpress" Publishing House (2010), 172. (in Azerbaijani)

Azerbaijan Soviet Encyclopedia, (1980), 4, 480. (in Azerbaijani)

About the establishment of the Institute of Cybernetics - https://science.gov.az/az/institutes/860

Academician Ismayil Ibrahimov, Bibliography, "Information Technologies" Publishing House, (2006), 145. (in Azerbaijani)

Academician Telman Aliyev, Noise Technology and control systems. "Elm" Publishing House, (2022), 228. (in Azerbaijani)

Asgar Abdullayev, "Elm" Publishing House. Baku - 2007. 160 (in Azerbaijani)

Alakbarov R.G. (2016). "Azsciencenet science-computer network: development stages, Internet services and prospects", Problems of Information Society, 12-22 (in English)

Azerbaijan National Encyclopedia, "Azerbaijan" volume. "Azerbaijan National Encyclopedia" Scientific Center. Baku - 2007, 884. (in Azerbaijani)

About the establishment of the National Aerospace Agency of the Ministry of Defense Industry of the Republic of Azerbaijan - https://nasa.az/tariximiz/

Abbasov. A.M. (2014). "Founder of innovative development of Azerbaijan", "Azerbaijan" newspaper, April 16 (in Azerbaijani)

Abbasov. A.M. (2014). "ICT sector development at a new stage", "Azerbaijan" newspaper, December 6 (in Azerbaijani)

Azerbaijan telecom sector experiences tepid growth as investment in infrastructure lags other countries, https://www.budde.com.au/Research/Azerbaijan-Telecoms-Mobile-and-Broadband-Statistics-and-Analyses

About the date of establishment of "Delta telecom" company, ttps://www.delta-telecom.net/Biz_kimik-az.html

Abbasov. E.A. (2009). "Electronic Azerbaijan" State Program has been successfully implemented" (in Azerbaijani)

About the date of establishment of "Aztelecom" company, https://www.azertelecom.az/az/whoweare/

Calalli. I., Explanatory dictionary of informatics terms (2017). 995 (in Azerbaijani)

Decision No. 152 of the Azerbaijan USSR Council of Ministers on the establishment of the Republic Automated Management Systems, March 18, 1982.

Decree of the President of the Republic of Azerbaijan on the establishment of the National Aerospace Agency of Azerbaijan, February 21, 1992.

Decision of the Cabinet of Ministers of the Republic of Azerbaijan "On structural changes in the Azerbaijan National Academy of Sciences", May 21, 2002.

Decree of the President of the Republic of Azerbaijan on the approval of the "State Program for the Education of Azerbaijani Youth in Foreign Countries in 2007-2015" - https://e-qanun.az/framework/13001

Decree of the President of the Republic of Azerbaijan "On the establishment of the Ministry of Communications and Information Technologies of the Republic of Azerbaijan". Baku, February 20, 2004.

Date of establishment of the Ministry of Communications and Information Technologies – https://mincom.gov.az/az/view/pages/3/

Decision of the Presidium of the Academy of Sciences of the Azerbaijan USSR dated June 18, 1971 "On the establishment of the Department of Automated Control Systems (AIS) under the Institute of Cybernetics"

Decree of the President of the Republic of Azerbaijan on the approval of the "National Strategy on Information and Communication Technologies for the Development of the Republic of Azerbaijan (2003-2012)", https://e-ganun.az/framework/1969

Decree of the President of the Republic of Azerbaijan on the approval of the "State Program for informatization of the education system in the Republic of Azerbaijan in 2008-2012", https://edu.gov.az/az/esas-senedler/133

Decree of the President of the Republic of Azerbaijan on the establishment of the public legal entity "Analysis and Coordination Center of the Fourth Industrial Revolution" under the Ministry of Economy of the Republic of Azerbaijan, 2021, https://e-qanun.az/framework/46604

Decree of the President of the Republic of Azerbaijan on declaring 2013 as the "Year of Information and Communication Technologies" in the Republic of Azerbaijan - https://president.az/az/articles/view/7073

Decision of the Presidium of the Azerbaijan Academy of Sciences on the results of scientific and scientific organizational activity of FRTEB, (1996).

Decree of the President of the Republic of Azerbaijan on the development of the concept of "Smart City" and "Smart Village", (2021), https://president.az/az/articles/view/51179

"Decree of the President of the Republic of Azerbaijan on measures in the field of creation of the government cloud (G-cloud) and provision of "cloud" services, June 3, 2019, https://e-qanun.az/framework/42560

Eckert J. P. (1980). A History of Computing in the Twentieth Century. Academic Press. 539 p. https://doi.org/10.1016/B978-0-12-491650-0.50038-1. (in English)

Electronic computing machine EC-1036 – https://www.computer-museum.ru/histussr/21.htm (in Russian)

Fridlund. M. (1993). The Teaching of History of Technology in Japan: A Survey in 1990. Working paper. Department of History of Science and Technology, 93(7), 44. (in English)

Fataliyev T.K. (2016). On issues of ensuring the security of electronic science, Problems of Information society, 56-62. (in Azerbaijani)

Haigh. T., Priestley, Mark, R. Crispin. (2014). Engineering "The Miracle of the ENIAC", Implementing the Modern Code Paradigm. IEEE Annals of the History of Computing, 36(2), 41-59. doi: 10.1109/MAHC.2014.15 (in English)

Karimov. S.G., Habibullayev. S.B., Ibrahimzade T.I., "Informatics", (2011), 434. (in Azerbaijani)

Karimov. S., Sardarov. Y., Theoretical foundations of computer science. Press of ADNA. Baku - 2019, 290. (in Azerbaijani)

Minutes of the meeting of the Presidium of the Academy of Sciences of the Azerbaijan USSR "On the establishment of an independent Computing Center within the AzUSSR Academy of Sciences", June 3, 1960. (in Azerbaijani)

Mammadov. I.A., Gozalov. E.B., Mammadov. A.A., Wireless communication technologies. "Education" Publishing House. Baku-2012, 624. (in Azerbaijani)

Mammadova M.H., Jabrayilova Z.Q., Training of specialists in information technologies field, "Problems of Information Society", (2010), 1, 23-31 (in Azerbaijani)

Nabibekova Ch. G., Dashdamirova G.K., Formation of information society in Azerbaijan: contemporary state and problems, Information society, (2021). 93-98. https://doi.org/10.52605/16059921_2022_02_93 (in Russian)

On the approval of the "National Strategy for the development of the information society in the Republic of Azerbaijan for 2014-2020", https://e-ganun.az/framework/27456

Protocol of the meeting of the Presidium of the Academy of Sciences of the Azerbaijan

Prokhorov. S.P. (1999). Computers in Russia: science, education, and industry. IEEE Annals of the History of Computing, 21 (3), 4-15. Doi: 10.1109/85.778978. (in English)

Rustamov. G. A., "Automatic regulation theory". "Science and Education Publishing House, (2012), 752. (in Azerbaijani)

Scientific and technical achievements in the field of cybernetics and informatics during the years of independence of the Republic of Azerbaijan (1991-2011), (2012), 240 (in Azerbaijani)

State Program for the Development of Communication and Information Technologies in the Republic of Azerbaijan for 2005-2008 (Electronic Azerbaijan), https://e-qanun.az/framework/10778

Strategic Roadmap for the development of telecommunications and information technologies in the Republic of Azerbaijan, December 6, 2016, https://e-qanun.az/framework/41516

State Program for the development of communication and information technologies in the Republic of Azerbaijan for 2010-2012 (Electronic Azerbaijan), https://e-qanun.az/framework/19936

"Telecommunications and Post in Azerbaijan" statistical collection, https://www.stat.gov.az/

"The first website of Azerbaijan - www.science.az celebrated its 20th anniversary", https://science.gov.az/az/news/open/2930

United Nations e-government survey 2022, "The Future of Digital Government", https://desapublications.un.org/sites/default/files/publications/2022-09/Web%20version%20E-Government%202022.pdf

Yusifov F.F., Gurbanli A.E. (2018). "Services evaluation criteria in electronic government: The Azerbaijan case", Problems of Information Society, 76-83. doi: 10.25045/jpis.v09.i2.08. (in English)

Yusifov F.F., Farajova A.C. (2021). "Personal data protection in e-government: the concept of "Data embassy", Problems of Information Society, 119-130. doi: 10.25045/jpis.v12.i2.09 (in English)