

Mobility in the information society: a holistic model

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Abstract. Ukraine's National Strategy for Education Development aims to align its education system with global standards and sustainable development goals. One of the key objectives is to integrate higher education with European norms, offer diverse educational models, and meet information and communication needs. The European Commission supports this integration process by fostering initiatives such as the Bologna process, mobility, and cooperation with programs like Erasmus+. Mobility, enabled by information and communication technologies, is essential for building the European educational and scientific space. This paper explores the different aspects of mobility, such as geographic, social, professional, academic, learning, software, hardware, and technological mobility. It investigates how they relate to each other within socio-pedagogical and technical systems, highlighting their importance for the information society. Using historical and contemporary perspectives, the paper develops a holistic model of mobility in the information society. Future research directions include the dynamic evolution of mobility within higher education systems, its sociocultural implications, and its intersection with technological innovations and state-political transformations. Furthermore, the phenomenon of mobility in technological and pedagogical systems, driven by the spread of mobile information and communication technologies, deserves more attention.

Keywords: mobility, virtual mobility, geographical mobility, social mobility, professional mobility, academic mobility, learning mobility, software portability, technological mobility, mobile communications information society, holistic model

1. Introduction

The National Strategy for Education Development in Ukraine [47] outlines the restructuring of the Ukrainian education system. This restructuring is necessary for its integration into the European and global educational environment, and the shift towards a post-industrial civilization, which is expected to guarantee Ukraine's sustainable development in the first half of the 21st century. The enhancement of the Ukrainian education system's structure includes aligning the structure and content of higher education with European standards, introducing diverse models for organizing education, and addressing the educational information

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and communication needs of those involved in the educational process. This is based on forecasting trends in innovative development within the education system, utilizing the findings of comparative pedagogical research.

The European Commission is working towards modernizing national higher education systems in several ways. These include:

1. Developing national strategies for higher education development, with the goal of increasing the number of university graduates, enhancing their competitiveness, providing students with opportunities for mobile learning within the European Higher Education Area (EHEA), and strengthening the “knowledge triangle” (the links between learning, science, and production) [38].
2. Actively supporting the Bologna process, which aims to unite the EHEA and the European scientific area – the foundations of the knowledge society – by improving the quality of the higher education system, promoting the mobility of students, teachers, and education leaders, and ensuring lifelong learning [19].
3. Exchanging experiences in modernizing higher education across different countries.
4. Supporting the Erasmus+ student mobility program.
5. Cooperating with international programs for modernizing higher education, particularly Erasmus Mundus – which aims to improve the quality of higher education through global academic mobility and cooperation.
6. Conducting European studies in promising areas of education development.

An examination of the areas of support for higher education and the reports of the European Commission [18] reveals that mobility is a crucial factor in building the European educational and scientific space. This is because the education system’s primary focus on the individual is to provide opportunities for receiving education of any type and level, at any time, and in any location for all members of society [49]. The advancement of information and communication technologies (ICT) has facilitated the emergence and growth of innovative technologies for distance, electronic, blended, and mobile learning. These cutting-edge technologies embody the key features of the EHEA development, including mobility for all participants in education, continuity of education, lifelong learning, personalized education, a research-based approach to education, innovation, and a social constructivist approach to organizing education.

The experience of reforming the European higher education system demonstrates that improving the quality of education requires the integration of innovative technologies and teaching tools. The incorporation of mobile learning into Ukraine’s higher education system is crucial for modernization and integration into the EHEA. Ukraine, being geographically and historically European, is focused on embracing common European values and educational standards in political, economic, social, and spiritual domains. Although Ukraine is not a member of the European Union as of 2023, it maintains close cooperation with its governing bodies across all sectors, particularly in the fields of science and education.

Lokshyna [35, p. 5] notes that identify trends is the leading direction of research in the context of strengthening the prognostic function of comparative pedagogy. BFUG Working Group Mobility [9] define the concept of mobility (study, academic, geographical, professional, etc.) as a backbone for the EHEA. The application of the mobility concept to the learning process gave rise to the concept of mobile learning.

Despite the existence of comprehensive studies on the current state and prospects for mobile learning development in the European Union countries [15] and the world [55], there is still a need for systematic research on various aspects of mobile learning in higher education systems. Some of the areas that require further research include:

1. Forms of organization, methods, and means of students' mobile learning in higher education systems of the European Union countries.
2. General and specific aspects of the implementation of students' mobile learning in higher education systems of the European Union countries.
3. Prospects for the development of students' mobile learning in higher education systems of the European Union countries.
4. Use of the European experience of students' mobile learning in the higher education system of Ukraine.

The comparative analysis of the evolution of higher education systems in the European Union countries and Ukraine has revealed the following contradictions:

1. There is a contradiction between the necessity to ensure comprehensive student learning mobility within the higher education system and the actual implementation of its individual components.
2. A discrepancy exists between the potential of students' mobile learning within the higher education system and its psychological and pedagogical support.
3. There is a conflict between the current state of scientific comparative studies of students' mobile learning experiences gathered abroad, especially in European Union countries, and the requirement for its scientific comprehension and effective application in Ukraine.

The article aims to address the unresolved issue of how various forms of mobility – including real, virtual, geographical, social, professional, academic, educational, software, hardware, and technological mobility – interact within socio-pedagogical and technical systems. This interaction is particularly relevant in the context of mobile communications and the information society. Therefore, the article has two primary *objectives*: 1) to provide a theoretical justification for the interrelationships among different types of mobility in socio-pedagogical and technical systems; and 2) to propose a holistic model of mobility in the information society.

2. Findings

In its broadest sense, mobility refers to the ability or willingness to move and change. The term “mobility” is derived from the Latin word “mobilitas” and was introduced into the major European languages no later than the end of the 15th century [1, p. 238-239]. According to Oxford Reference, mobility can refer to the movement of people from one location to another, known as geographical mobility, or from one social, economic, or occupational group to another, known as social mobility. It can also refer to the ability to move joints or the ability to move around at home and in public, such as going out to shop or visiting friends and neighbors [37]. The relationship between “mobility” and “flexibility” is also evident in the origins of the Latin word “mobilitas”: the Old English word “mobyll” and the Anglo-French word “moble” both

evolved into “movēre” (modern English “to move”). In the languages of the European Union, “mobile” is translated as “mobile” (English, Italian, Slovenian, Finnish, French), “mobil” (Danish, German, Romanian), “mobilní” (Czech, Swedish), “mobilný” (Slovak), “mobiilne” (Estonian), “mobilan” (Croatian), “mobiel” (Dutch), “mobbli” (Maltese), “mobils” (Latvian), “mobilus” (Lithuanian), “móvel” (Portuguese), “móvil” (Spanish), “mozgó” (Hungarian), “hareketli” (Turkish), “soghluaiste” (Irish), “κίνητός” (Greek), “mobile” (Bulgarian), and “ruchomy” (Polish).

Mobility, a contemporary interdisciplinary paradigm in social and humanities sciences, investigates the movement of people, ideas, and objects, along with the repercussions of these movements. As Sheller [51] points out, a novel approach to studying mobility has emerged in social and humanities sciences over the past decade: an all-encompassing examination of the collaborative movement of people, objects, and information. This approach explores the balance between mobility and stability, the conditions for “completing movement” (transitioning to a stable state) within the “society-space” dimension, and the interplay between micro-influences and macrostructural changes in social and technical systems.

While the concept of mobility has a long history and its core meaning is well-established, the world is changing more rapidly and in more complex ways than ever before at the start of the 21st century. This has brought about new challenges, such as forced and uneven mobility, environmental limitations, and climate change, which can result in unforeseeable risks. Efforts to mitigate these risks have given rise to a general notion of the need to balance meeting contemporary human needs with safeguarding the interests of future generations, including their right to a safe and healthy environment – sustainable development [2]. Implementing this concept leads to a reduction in unwanted mobility, such as the movement of waste [54].

Urry [59], the founder of mobile sociology, aims to analyze the real and virtual mobility of people in order to meet their needs and minimize risks. Mobile sociology examines how global networks and flows alter social structures [25, 29]. Sheller [51] contends that many regions of the world are on the brink of significant changes in their existing socio-technical systems as a result of mobility and communication. Computer networks and other information and communication technologies facilitate globalization, the expansion of the international labor market, and the increase of various forms of individual mobility within the information society.

Urry identifies five primary directions for implementing mobility, which he refers to as “channels”. These include transport for people’s mobility (1st channel), the postal system and freight transport for the mobility of objects (2nd channel), cable systems such as telephone, television and computer (3rd channel), terrestrial wireless systems for transmitting sound, images and information (4th channel), and satellite and extraterrestrial systems (5th channel). The concept of a “channel” was first introduced in Dewey’s “Democracy and Education”: “We will see a mobile society saturated with distribution channels happening anywhere, only when its members are educated, and adaptive” [14] – in this Dewey saw the democratic ideal. During Dewey’s time, these communication channels were migration flows (Urry’s first channel), transatlantic mail (the second channel), telegraph (the third channel), and radio communications (the fourth channel). “Not only is social life identical with communication, but all communication (and therefore all real social life) is educational. To become a subject of communication, it is necessary to expand and change your experience” [14]. Dewey perceived communication not just as the sending and receiving of messages (the informational aspect), but also as the exchange of experiences (the educational aspect). According to Dewey, communication is the

primary educational process. The idea of education as a liberal exchange of experiences has led to philosophical and methodological questions that take on new significance in the era of mobility: mobile connectivity in society and space is amplified with the use of mobile devices and smart learning environments.

A person's mobility can be influenced by various factors, including their agility, the availability of specialized tools and vehicles, job opportunities, and more. In the context of mobile technologies, mobility refers to the ability of a device to access information, communication, and other features while the user is on the move.

Mobile sociology intersects with several fields of study, including globalization, communications, tourism, demography, anthropology, migration, border studies, cultural geography, and transport geography.

In demography and anthropology, population mobility is measured by the movement of individuals within a specific population. In contrast to demographic mobility, geographic mobility is not confined to a particular area. The concept of *geographic mobility* (figure 1) emerged at the beginning of the 20th century. Interestingly, the first recorded mention of it was in a 1909 "Report on the Desirability of Establishing an Employment Bureau in the City of New York", where it was discussed in the context of geographic labor mobility [13, p. 49].

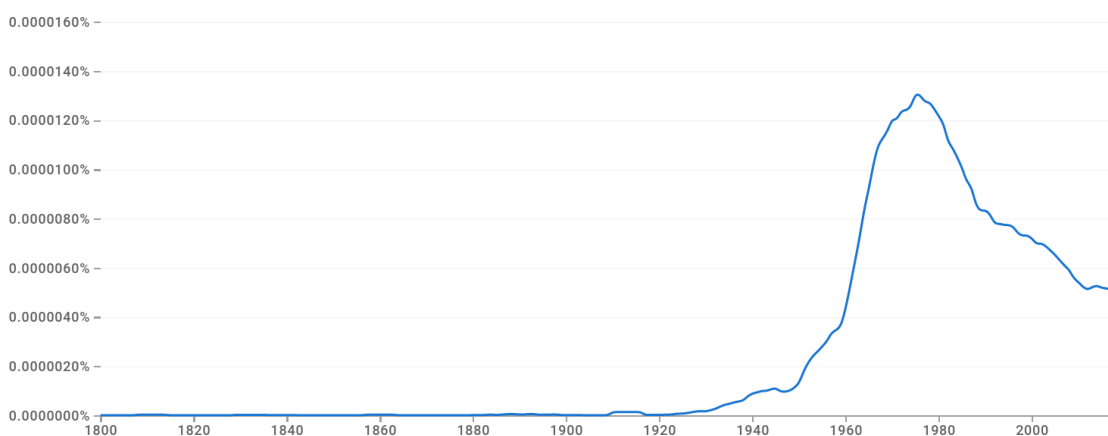


Figure 1: Geographic mobility in English corpus [21].

In sociology, the concept of mobility is often equated with *social mobility*, which denotes the capacity of individuals in a society to transition among various social strata and economic clusters, a phenomenon also known as economic mobility [24]. Social mobility can be linked with geographical movement (geographical mobility), cultural exchange (a facet of mobility from an anthropological perspective), and information mediation. The latter two elements form the foundation of the network-oriented approach to learning.

The notion of social mobility (figure 2) was first presented in the second volume of Alexander von Humboldt's work, "Cosmos" (1847). It was described as one of the three attributes of the "Roman national spirit": "social mobility, publicity, and the maintenance of individuality—the main supports of free institutions for the furtherance of intellectual development" [23, p. xvi]. Following Vannini [61], Sheller [51, p. 3] posits that "social mobility and infrastructures of

human, technological and informational mobility were as crucial to the existence of ancient imperial cities, seafaring empires of early modernity and 19th-century industrializing cities as of the modern megacities today”.

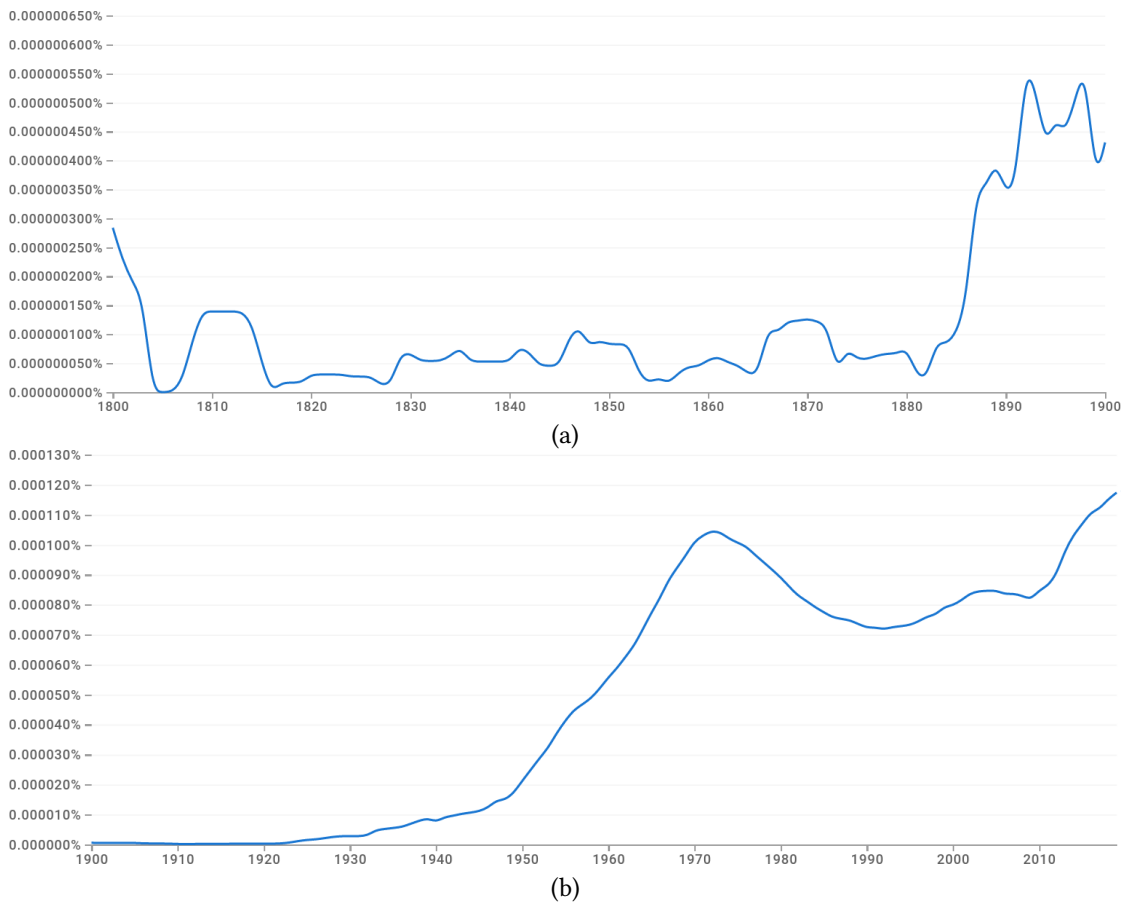


Figure 2: Social mobility in English-language sources of the XIX (a) and XX centuries (b) [21].

In contrast to the conventional sociological examination of social mobility, mobility as an emerging transdisciplinary research field addresses the spatial mobility of people and objects, the circulation of messages, images, capital, and more. It also investigates the physical means of movement, such as infrastructure, vehicles, and software that facilitate movement and communication. This approach merges the purely “social” issues of sociology (inequality, power, hierarchy) with the “spatial” issues of geography (territory, boundaries, scale) and the “cultural” issues of anthropology and media studies (discourses, representations, schema). Moreover, movement can be not only actual (geographical mobility or physical movement of objects) but also conceptual (imaginary journeys, virtual tours, etc.), allowing individuals to lead a more “mobile life” despite physical (material, social, etc.) constraints. Given the pivotal role of communication in learning, such mobility forms the foundation for structuring virtual (electronic) learning. For instance, the Second Life virtual reality system is effectively utilized for educational purposes [34].

An individual might possess a significant level of virtual mobility through mobile communications, eliminating the necessity for physical movement. This is evident in remote work scenarios that offer a high degree of professional, social, and economic mobility. Conversely, the same individual could exhibit extensive geographical mobility but lack the ability to alter personal choices and competencies. This is typically seen in itinerant work situations characterized by low levels of professional, social, and economic mobility.

Professional mobility, also known as career mobility or job mobility, refers to the movement of employees across different roles. This could involve moving to another position or occupation, gaining different responsibilities within their current role, or even moving down into a position with less responsibility.

Professional mobility, as defined by Anishchenko [3], is a form of social mobility that involves the process of workers changing jobs. The concept of *professional mobility* (figure 3) for school teachers was first introduced in a 1913 bulletin by the US Bureau of Education: “Teachers tend to become local fixtures. Reasonable mobility in the profession is highly desirable, as well as reasonable stability. Without mobility there are sure to be many square pegs in round holes, and vice versa” [52, p. 82].

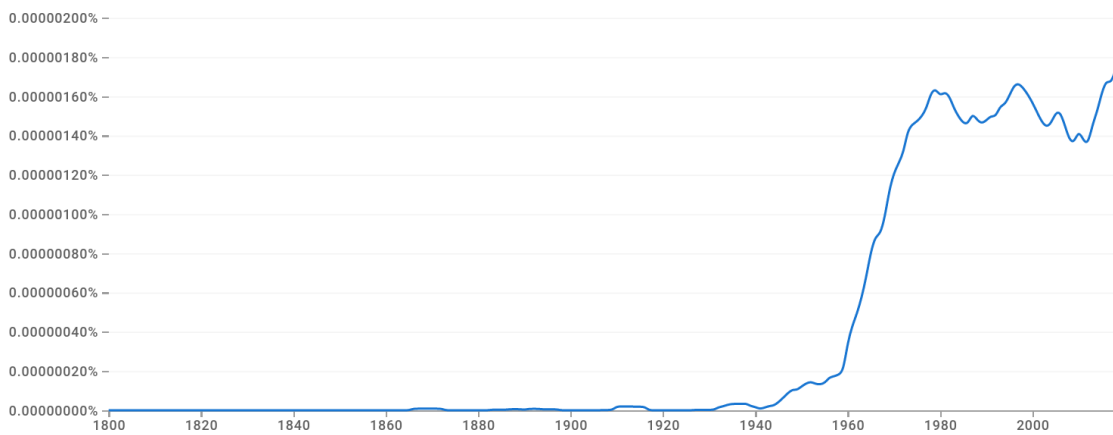


Figure 3: Professional mobility in English corpus [21].

Kugel [32] identified three primary factors influencing the professional mobility of scientists: intra-scientific (the logic of scientific research), psychological (changes in scientific interests), and praxeological (practical usefulness of research) [32, p. 96]. However, he noted that mobility involving a drastic change in the field of activity, such as transitioning from science to business, is the least effective.

Sushentseva [53] views the professional mobility of a skilled worker as a necessary quality for success in modern society. This quality is manifested in work and enables self-determination and self-realization in life and profession through the development of key competencies and qualifications. It also reflects an individual’s desire to change not only themselves but also their professional field and living environment [53, p. 158].

Shah and Burke [50], considering the promotion of the mobility of skilled workers, argue that in order to solve the problem of imbalance in the distribution of skilled workers within the

country, it is necessary to unify the recognition of their qualifications in all regions. Internal migration is more likely to succeed if it is supported by comprehensive information not only about the labor market, but also about other services such as education, health care and housing. Large differences in housing costs across regions can reduce labor mobility [50, p. 326].

Lachtman [33, p. 542] emphasizes that education serves as the cornerstone of social mobility and is a measure of a meritocratic society. The mobility inherent in education is a key feature of a cohesive educational environment, which is the goal of the Bologna process. This is evident in the principles of the Magna Charta Universitatum [44], which includes the principle of mobility, interpreted in its widest sense as the mobility of knowledge.

This principle is realized through *academic mobility*, which allows students and teachers to move between various educational institutions within and beyond their home country (figure 4). This concept was initially closely tied to social and professional mobility. For instance, Davis and Dollard [12] examined it in 1940 in relation to the personal development of African American youth in the cities of the American South [12, p. 57].

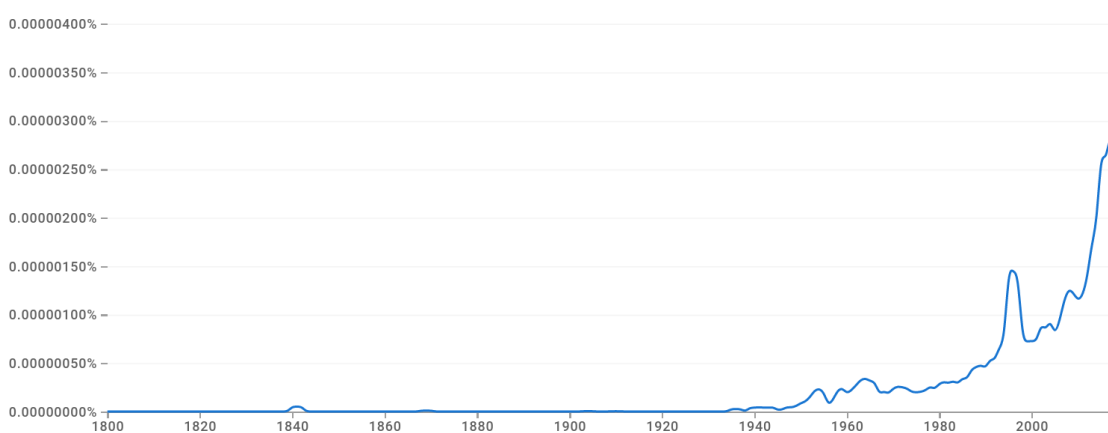


Figure 4: Academic mobility in English corpus [21].

Ko [30, p. 209] presents the idea of *student mobility* as the capacity of students to pursue studies or employment in different nations after graduating from university. The researcher highlights that a significant outcome of globalization is the enhanced mobility of students, university applicants, and graduates. Individuals with high mobility can study (be academically mobile), work (be geographically and professionally mobile), collaborate, and compete globally. This leads to an increasing necessity to establish international norms and standards for comparing and recognizing academic qualifications from various countries. Furthermore, in light of the shift towards lifelong learning, there is a growing need for international standardization of distance learning, training, retraining, advanced training, and so on.

The establishment and expansion of branches of higher education institutions beyond national borders contribute to academic mobility. This leads to the mobility of providers of educational services, educational projects, curricula, and materials, among others. These can be public or private, non-profit or commercial, local or foreign, institutions or corporations. The emergence of new partnerships is a response to the increasing demand for access to higher education and foreign academic qualifications.

Knight [28] highlights two significant trends in the evolution of academic mobility. The first trend is a transition from student mobility to mobility programs and providers. While the number of students pursuing education abroad continues to rise, there is now a greater emphasis on delivering foreign academic courses and programs to students in their home country. The second trend is a shift in focus from development cooperation to commercial trade [28, p. 510].

Knight [27, p. 383] refers to the new mobility programs:

- franchise – an arrangement whereby a provider in the source country allows a provider from another country to deliver their course/programs/services;
- twinning – a type of transnational education in which a student studies part of the time at a local university, and part of the time in foreign institutions associated with a local university;
- double/joint degree – a type of education in which providers in different countries cooperate, allowing students to take credits from each provider in order to gain qualifications from each of them;
- articulation – a type of education based on an agreement between providers located in different countries, permit students to gain credit for courses/programs offered/delivered by collaborating providers;
- validation – arrangements between providers in different countries allowing the provider in the host country to award the qualification of the provider in the source country;
- virtual/distance – arrangements where providers deliver courses/program to students in different countries through distance and online modes.

Mobility providers can be described as the physical or virtual movement of an educational institution (organization, enterprise) across national borders in order to provide educational services to students from other countries. Unlike mobility programs, mobility providers do not require students to physically move. Credits and qualifications are assigned by a foreign provider (foreign, local, own) or an affiliated local partner. The main types of mobility providers are [27, p. 385]:

- branch campus – a foreign provider establishes its own branch in another country, providing its courses and programs to students of another country and awarding its own qualification;
- independent institution – a foreign provider (university, company or alliance/network) creates an autonomous institution in another country that does not have a parent provider in the country, offers courses/programs and awards qualifications;
- acquisition/merger – a foreign provider buys part or 100% of a local university;
- study center/teaching site – a foreign provider organizes a training center in another country (collaborating with local providers or independent of them) to support students in mastering their courses/programs;
- affiliation/networks – various types of public and private, traditional and new, local and foreign providers collaborating through innovative types of partnerships to create networks/institutions to deliver courses and programs to local and international students in a traditional or remote way;

- virtual university – a provider that provides educational services to students in different countries through distance education using predominantly Internet technologies, usually without the support of face-to-face learning.

The future of international mobility is expected to combine physical and digital experiences to reach a wider range of students. *Virtual student mobility* is defined by Sabzalieva, Mutize and Yerovi [48] as “a form of mobility that uses information and communication technologies to facilitate cross-border and/or inter-institutional academic, cultural, and experiential exchanges and collaboration” [48, p. 6]. This could increase access to international education, harnessing technology for good and reducing higher education’s environmental footprint.

Van der Wende [60] underscores the importance of virtual mobility programs and virtual universities in today’s higher education landscape. These platforms serve as the foundation for virtual student mobility, leveraging new ICTs, primarily the Internet and mobile learning environments. E-learning not only facilitates global access to higher education but also fosters pedagogical innovation and reduces educational costs. In the current scenario, virtual universities and blended learning models pose a significant challenge to traditional universities and face-to-face learning methods [36].

Avveduto [6, p. 286] describes the *mobility of PhD students and scientists* as a multifaceted phenomenon. This mobility can be seen from various perspectives: as a political issue related to the drain or influx of human resources (“brain drain”), as a problem of equitable distribution of human resources across different development levels in various regions, or as a matter of migration policy.

Human resources play a crucial role in socio-economic development, and investments in their education and effective utilization are deemed essential for societal and economic prosperity.

In this scenario, the internationalization of education and science emerges as key contributors to the development of an optimal workforce. This workforce, primarily composed of graduate students and scientists engaged in scientific and technological research, benefits from mobility as an efficient means for knowledge and technology dissemination and integration.

The distinction between mobility and migration often blurs for highly skilled professionals. Avveduto [6] argues that in a globalized society, it is not accurate to equate the mobility of graduate students and scientists with a desire to flee their home country. Instead, it should be perceived as the free movement of individuals and ideas, rather than a “brain drain”.

The inherent nature of research activity necessitates competition, collaboration, and interaction with other scientists. The Magna Charta Universitatum’s fourth principle [43], which initiated the Bologna process in 1988, states: “A university is the trustee of the European humanist tradition. Its constant care is to attain universal knowledge, to fulfill the vocation it transcends geographical and political frontiers and affirms the vital need for different cultures to know and influence each other”.

To realize this objective, effective methods that align with current conditions are necessary: “Universities – particularly in Europe – regard the mutual exchange of information and documentation, and frequent joint projects for the advancements of learning, as essential to the steady progress of knowledge. Therefore, as in the earliest years of their history, they encourage mobility among teachers and students; furthermore, they consider a general policy of equivalent status, titles, examinations (without prejudice to national diplomas) and the award

of scholarships essential to the fulfilment of their mission in the conditions prevailing today” [43].

European universities hold a pivotal role in fostering academic mobility. Each university implements its own strategies and programs for higher and postgraduate education, offering members of the academic community with high qualifications various forms of mobility: from short-term visits to year-round temporary employment. The challenge lies in determining the optimal proportion of mobility in a career, an educational institution, or a country. If this proportion is exceeded or falls short of its optimal value, issues may arise. However, an excess of mobility tends to cause fewer problems than its absence.

According to OECD and European Commission [45], Canada, Australia, New Zealand, Germany, the United Kingdom, and the United States are the top destinations for immigrants worldwide. Several significant events have shaped migration patterns and policies, including the COVID-19 pandemic, Afghanistan’s fall to the Taliban, and Russia’s aggressive war against Ukraine, which led to the largest refugee crisis in Europe since World War II. Countries like the UK, Germany, and France are witnessing a unique phenomenon where substantial emigration is occurring alongside even more significant immigration. This trend underscores the extremely high mobility of highly educated professionals.

Indeed, there isn’t a universal tool that can ascertain the ideal extent of mobility. Nonetheless, evaluating the pros and cons of mobility can aid in achieving an appropriate equilibrium. The advantages of a mobile, highly skilled workforce, collaboration, and gaining experience in a foreign environment are quite evident at the individual, institutional, or national level. These present clear and positive opportunities. The risks are primarily associated with the failure to fully leverage the positive aspects of this experience or a shift in the nature of mobility – transitioning from a temporary phase to a state of perpetual mobility.

The mobility of scientists and graduate students as a phenomenon has its roots in the Middle Ages. The earliest instances of such mobility can be traced back to university students, also known as *clerici vagantes* (traveling scholars, alumni, and even professors). They leveraged the opportunity to travel within and beyond their countries to attend the best universities, each renowned for its unique specialization. For instance, the University of Bologna was the first law school in medieval Europe, while the University of Paris was known for its faculties of liberal arts, canon law, medicine, and theology. Mobility is about seeking the best opportunities for work and learning, experiencing new thought processes, comparing different cultures and ideas, and understanding what’s happening beyond one’s intellectual environment.

In the modern era, the mobility of highly skilled personnel takes various forms and intensities. It began in the mid-19th century and expanded in the early 20th century when science and scientific careers reached a significant level. An increasing number of elite migrants, including professionals and scientists, have left their home countries to establish new ventures or engage in cultural and scientific activities in companies, research laboratories, and universities that are crucial for various countries and industries. Migration surged due to several factors, including political or racial persecution before and during World War II. For instance, many scientists were compelled to migrate from Europe to the US during this period. In this context, the term “brain drain” is more apt than mobility. It’s worth noting that currently, among the member countries of the Organization for Economic Cooperation and Development (OECD), the United States and Canada are the most appealing destinations for scientists.

The survey of scientists from the European Union countries conducted in 2003 [6, p. 290] showed that the biggest mobility factors were career growth (88% of respondents), employer reputation (74%), access to advanced technologies (73%), research and development funding (70%), professional network (68%), work/entrepreneurship opportunities (56%), salary (54%), adventure (49%), education (46%).

An analysis conducted by the OECD in 2013 identified three main factors that contribute to the mobility of scientists and graduate students: academic factors (migration – 43.9%, return – 27.5%), work and employment-related factors (migration – 30.9%, return – 23.6%), and family or personal reasons (migration – 15%, return – 20.6%) [5, p. 40]. In European Union countries, academic factors had the greatest influence on the departure of scientists and graduate students from Portugal (64.1%), Spain (54.1%), and Malta (46.6%). Scientists and graduate students most often returned to Bulgaria (58.7%), Portugal (39.1%), and Hungary (39.0%).

The term “brain drain” is used to describe a situation where there are more departures than returns. The term was first used in its modern sense in the late 1950s and was mentioned in a Royal Society report in 1963 to describe the departure of British scientists from their home country [16]. This term is used to describe the large number of talented individuals who feel compelled to leave their home country in search of better conditions for their scientific work. Auriol, Misu and Freeman [5, p. 29] noted that the level of satisfaction with salaries and benefits is generally low in most countries. Other factors such as workplace environment, degree of independence, intellectual stimulation, level of responsibility, societal usefulness, and job security also contribute to the average level of satisfaction.

Appelt et al. [4] find that mobility flows are statistically related to policy-related variables such as bilateral and unilateral travel visa restrictions and to changing economic and research conditions. Scholars shows that convergence between countries is associated with increased mobility towards the countries that are catching up, at least in relative terms [4, p. 22].

In the 2020s, the factors that influence the international mobility of research scientists have evolved. According to Netz, Hampel and Aman [40], there are eight dimensions of a scientist's career that are influenced by international mobility. These dimensions can be divided into two categories: mediators and effects.

Mediators include:

- 1) international networks: mobility can broaden a scientist's network, which has a robustly positive effect;
- 2) scientific knowledge: mobility can enhance a scientist's scientific knowledge;
- 3) research infrastructures and funds: scientists who have been internationally mobile often have better access to research infrastructures and funds;
- 4) symbolic capital: international mobility can contribute to the accumulation of symbolic capital;
- 5) competences and personality: international mobility can contribute to the development of competences and personality;

Effects include:

- 6) scientific productivity: most studies find positive effects of international mobility on scientists' productivity, but some also find no or negative effects;

- 7) scientific impact: the impact of scientists' work is often positively influenced by international mobility;
- 8) occupational situation: international mobility generally has a positive impact on scientists' occupational situation.

The decision for graduate students and researchers to be mobile is largely a personal one, often seen as a valuable opportunity to gain international work experience by both students and faculty. However, this can be encouraged by state and interstate programs and agreements that aim to facilitate researcher exchange. Currently, increased mobility is viewed as an indicator of a robust and innovative higher education and science system. The European Commission's Green Paper on the European Research Area (ERA) suggests that both governments and institutions should promote the national and international mobility of graduate students and scientists. This is seen as a crucial element of the ERA, an association comprising academia, business, and citizens with the following characteristics [56]:

- an adequate flow of competent researchers with high levels of mobility between institutions, disciplines, sectors and countries;
- world-class research infrastructures, integrated, networked and accessible to research teams from across Europe and the world through new generations of electronic communications infrastructures;
- excellent research institutions engaged in effective public-private cooperation and partnerships through "virtual research communities";
- effective knowledge-sharing, notably between public research, industry and the general public;
- well-coordinated research programmes and priorities;
- a wide opening to the world, with special emphasis on neighbouring countries and a strong commitment to addressing global challenges with Europe's partners.

During their research programs, graduate students may find it necessary to visit overseas universities and laboratories to gather data or conduct experiments that are not possible in their home country. However, their most significant accomplishments are tied to the personal, cultural, and scientific growth they experience in diverse scientific and learning environments.

The primary advantage of scientists' mobility is the chance to work in a highly skilled environment where they can produce high-quality results and have unrestricted access to resources and scientific equipment. On the other hand, the downsides of mobility include bureaucratic hurdles and challenges in securing a work permit and a residence visa. To address this, the EU has established specific rules to ease the entry of foreign researchers wishing to conduct scientific research within its borders. For instance, the European Parliament and Council of the European Union introduced Directive 2016/801 on May 21, 2016 [20]. This directive outlines the conditions for entry and residence of third-country nationals for purposes such as research, studies, training, voluntary service, pupil exchange schemes, educational projects, and au pairing. It serves to regulate the process of issuing special scientific visas.

One of the obstacles to the mobility of graduate students and young scientists is the potential loss of job opportunities in their home country or city. These individuals often choose to

remain at their local university, despite it being potentially less prestigious and offering fewer opportunities for personal growth. The issue of “brain drain” remains unresolved, particularly in developing countries where the reintegration of talented researchers after gaining international experience poses a significant challenge. However, when a mobile scientist returns home, their country benefits from their new knowledge, experience, and managerial skills, thereby enhancing its competitiveness. Research by Beine, Docquier and Rapoport [8] has shown that doubling the migration rate of highly skilled workers can lead to a 5% increase in gross capital investment per capita among the local population.

The emergence of *learning mobility* (figure 5) originated from the development of teaching methods and tools for individuals with special needs ([11, p. 186], [41]). For instance, students with visual impairments typically receive learning mobility services that enable them to navigate safely and systematically within university environments, homes, and communities. This is achieved through the use of sensory information such as sound, temperature, and vibration to establish, support, or restore orientation and related concepts, methods, and tools [42, p. 836]. Today, learning mobility is primarily perceived as short-term academic mobility.

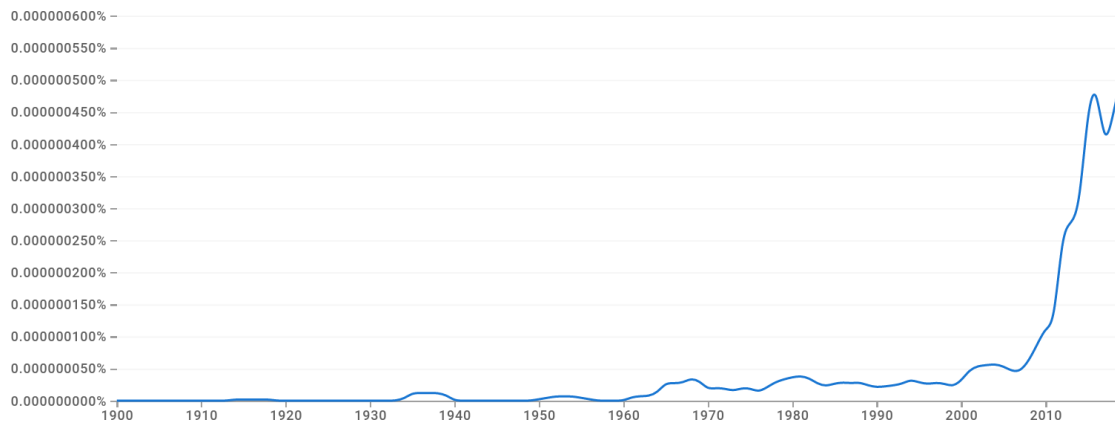


Figure 5: Learning mobility in English corpus [21].

Studying the complexity of objects and processes related to mobility necessitates a systematic approach. According to Urry [58], “all systems are dynamic ... Such powerful systems in the contemporary world are simultaneously economic, physical, technological, political and social” [58, p. 263] – after all, “technologies are always to be seen as embedded within forms of economic, social and political life” [58, p. 264]. Connections in such systems are strengthened “through software, cybernetic architecture and a more general networked character of life” [58, p. 263]. While the theory of complexity emphasizes self-organization, synergy, and self-development of systems, mobility studies primarily focus on systems controlled by humans. These include interactions with space, objects, and other individuals, often facilitated by intermediaries or within hybrid communities. Pedagogical systems also fall within this scope, where mobility is relevant to managing educational activities.

The interconnections between the primary forms of mobility, namely real and virtual, within socio-pedagogical systems are depicted in figure 6.

The dimensions of mobility in mobile communication systems, which include spatial, material,

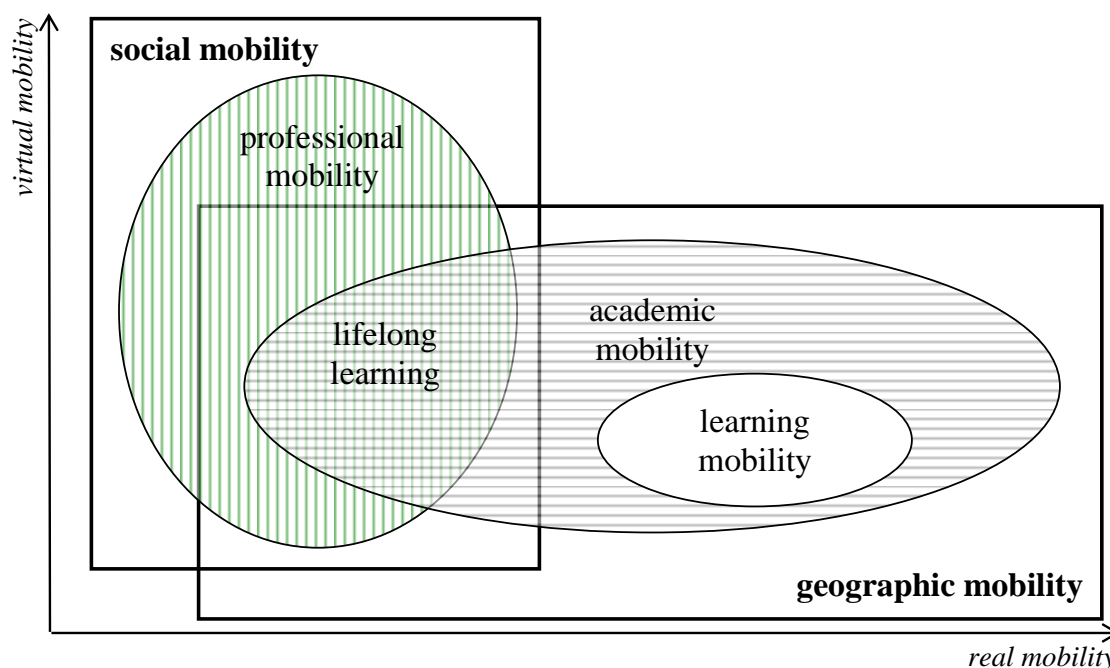


Figure 6: Relationships of mobility types in socio-pedagogical systems.

and temporal aspects, are transforming our current reality and paving the way for new forms of urban existence such as “network urbanism”, “network place”, and “network locality” [22]. Communication of non-mobile and mobile systems is provided through fixed platforms (transmitters, roads, stations, satellite terminals, airports, docks, factories) that provide geographical, labor, economic mobility.

New mobile environments are converting urban spaces into technospaces and media spaces. This transformation opens up new possibilities for individuals to navigate in public spaces (through augmented reality) and artificial environments (via virtual reality), leading to the emergence of new forms of social interaction. A prime example of this technological shift is the cloud-based mobile WebAR [39]. In terms of new research areas concerning mobility, bifurcation processes in complex systems, mobile social networks, mobile environments, and information and communication technologies have been identified [51, p. 8].

Khomenko [26] in 1998 pointed out that in recent decades “the focus has shifted ... to the mobility of a software product as a measure of unification and extension of its life, the possibility of using subsequent generations of computers” [26, p. 395].

Software portability, as described by Petrushin [46, p. 328], is a key characteristic that allows software to be easily transferred from one type of computer to another with minimal effort. This attribute is particularly significant in the development of mobile learning software. The concept of *application software package mobility* refers to the capability of moving it from one operating environment to another. This form of mobility is deemed as a critical feature of application software packages, especially in the realm of computer-assisted learning technology. It simplifies the processes of replication and maintenance, and also makes training easier as there’s no need

for retraining when the technical foundation of the computer training technology changes [7, p. 329].

Software mobility encompasses both software portability and application software package mobility. It allows for the transfer of programs between different operating systems and hardware platforms, making it a universal property.

From figure 7, it can be seen that software portability attracted the most attention of researchers in 1985–1990: it was at this time that the conceptual foundations of modern mobile operating systems and mobile technology tools were laid.

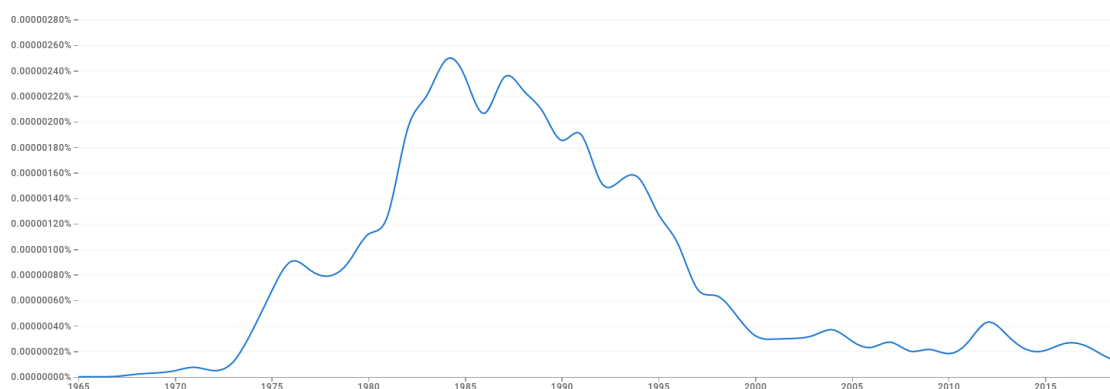


Figure 7: Software portability in English corpus [21].

The first systematic presentation of the concept of software portability was carried out by Brown [10], who defined it as follows: “A program or programming system is called portable if the effort required to move it into a new environment is much less than the effort that would be required to reprogram it for the new environment” [10, p. 80]. According to Brown [10], software portability is crucial when there’s a need to switch computer systems, as it helps avoid the loss of programs that have required significant effort to develop. The author suggests that high-level languages, including problem-oriented ones, are key to ensuring software mobility. They categorize software into four classes based on portability: small procedures are the easiest to port, followed by large subsystems, compilers, and finally, operating systems which are the most challenging to port.

Therefore, utilizing the same operating system across various hardware types results in a high degree of software portability. Linux is a prime example of this, offering extensive software portability and compatibility with a wide range of hardware platforms, from personal computers and servers to embedded systems in devices such as routers and smart TVs.

Software mobility is further enhanced by the use of mobile translators. A notable instance of this is the Java Virtual Machine (JVM), which, despite not being an operating system, is renowned for its “write once, run anywhere” approach.

Docker also exemplifies this concept. It’s a platform that employs OS-level virtualization to deliver software in packages known as containers, further promoting software portability.

Petrushin [46, p. 328] outlines the following indicators as characteristics of software mobility: 1) initial cost; 2) transfer cost; 3) transfer limitation; 4) inefficiency. Each index is calculated as a percentage, comparing the expenditure on mobile software to that of traditional software.

These characteristics can be extrapolated to other forms of mobility, such as academic mobility:

1. The initial cost indicator encompasses expenses related to standardizing the grading scale and credit transfer based on ECTS, aligning curricula and teaching methodologies with ECTS requirements, creating a National Qualifications Framework, and providing information support for academic mobility.
2. The transfer cost indicator includes expenses associated with implementing academic mobility in new educational institutions or those participating in a new mobility program.
3. The transfer limitation indicator is determined by the percentage of educational institutions (or fields of study, components of educational systems, etc.) where this type of mobility is not applicable.
4. The inefficiency indicator measures the average inefficiency of implementing the mobile system compared to the traditional one.

Hardware mobility, also known as “equipment portability”, refers to the ability to move hardware devices in space, provided that the benefits derived from such movement outweigh the costs of facilitating it. If we focus on the *outcome* of the movement, a hardware device is considered mobile if the one-time transfer costs are offset by the benefits of its continuous use in a new location. This outcome-oriented approach to defining hardware mobility aligns with geographic mobility.

If we focus on the *process* of movement, a hardware device is deemed mobile if the costs of its movement are compensated by the advantages of its use during the movement process. The process-oriented approach to defining hardware mobility is currently more prevalent. Therefore, it’s advisable to characterize hardware mobility as the ratio of device usage time during movement to total movement time. This ratio will be higher for portable, low-power, and ergonomic hardware devices that can be used more frequently and easily during transit.

In this process-oriented view, *mobile computing* is seen as a human-machine interface where the computer is expected to be portable during use. Mobile communications, mobile hardware, and mobile software are essential for enabling a mobile computing.

As shown in figure 8, interest in mobile hardware, which emerged in the late 1950s, has been steadily increasing since 1980.

The concept of “mobile hardware” has been interpreted differently over time. In the initial period (roughly until 1970), it was primarily associated with movable objects used in human activities, such as vehicles and mobile equipment. In the subsequent period, as depicted in figure 9, “mobile hardware” was primarily understood as a mobile computing device.

UNESCO [31, p. 7] broadly defines a mobile device as a digital tool that is easily portable and typically owned and controlled by an individual rather than an institution. It has the capability to access the internet, possesses multimedia functionalities, and can facilitate a multitude of tasks, especially those related to communication. Another defining characteristic of mobile technology is its ubiquity.

Mobile communications, as defined by Urry [57], are considered the fourth and fifth channels for implementing mobility. It’s worth noting that currently, not all wireless communication technologies (such as laser communication, quantum teleportation, etc.) can be utilized in mobile computing devices.

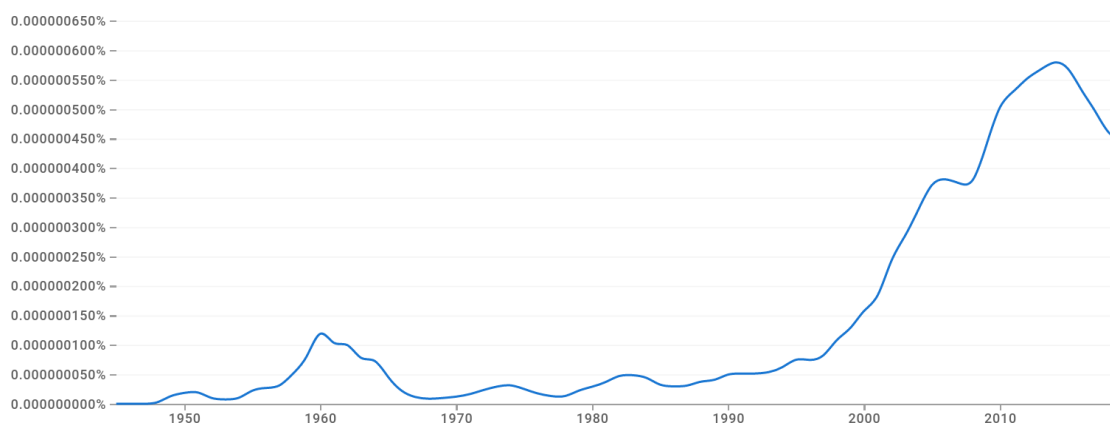


Figure 8: Mobile hardware in English corpus [21].

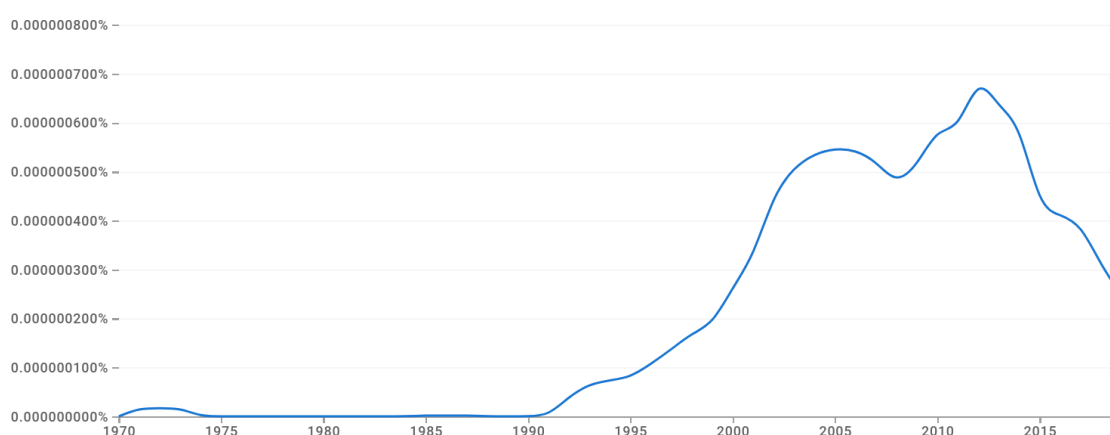


Figure 9: Mobile computing devices in English corpus [21].

The term “mobile computing” encompasses the technologies required for individuals to access data and software through the network from any location. We further define this as *technological mobility*. This term also signifies the convergence of two primary directions of mobility – real (physical device mobility) and virtual (software and data mobility as virtual objects).

The relationship between types of mobility in technical systems in the “real – virtual” dimensions is depicted in figure 10. Software mobility is more closely related to the virtual dimension (transferring programs between different types of operating systems and hardware platforms), but it also partially overlaps with the real dimension (moving programs between different devices). In contrast, hardware mobility is more about the real dimension (the movement of hardware in space) than the virtual one. Mobile communications involve the transmission of virtual objects (in the broadest sense – information) in real space (wireless communication channels).

Mobile hardware is at the intersection of hardware mobility and mobile communications; mobile software – at the intersection of software mobility and mobile communications; mobile

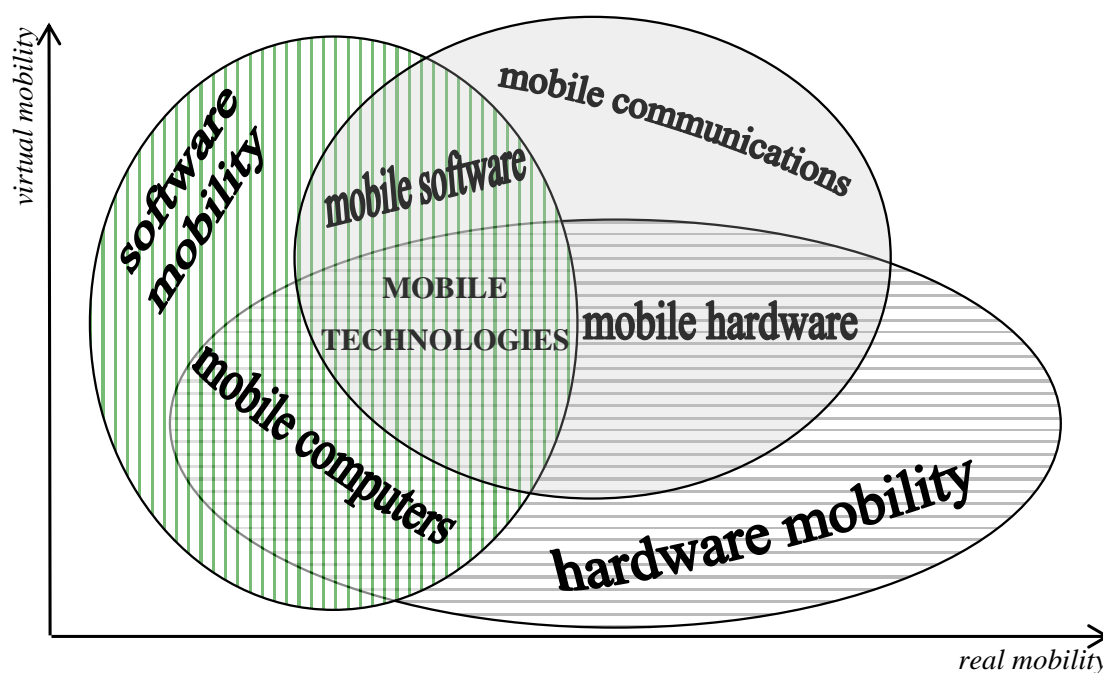


Figure 10: The relationship of mobility types in technical systems.

computers – at the intersection of software and hardware mobility. Mobile technologies are at the intersection of all types of mobility in technical systems.

The synthesis of the genesis results and the analysis of mobility measurements have enabled the construction of a holistic model of mobility in the information society, as shown in figure 11. This model has three dimensions: one real and two virtual.

The real dimension is shared by socio-pedagogical and technical systems as it involves the study of the movement of people (geographical mobility of students, scientists, and other scholars and managers) and objects (mobility of ICT hardware) in space. The first virtual dimension aligns with the social mobility of individuals, while the second virtual dimension corresponds to the informational mobility of ideas.

As per the proposed model, the real and virtual dimensions of mobility in socio-pedagogical systems form the foundation of a mobile society, characterized by members who are geographically and socially mobile. The real and virtual dimensions of mobility in technical systems underpin technological mobility. The combination of both virtual dimensions constitutes the information society, where, according to the definition by the Commission of the European Communities, information and communication technologies become the basis of human activity [17, p. 92].

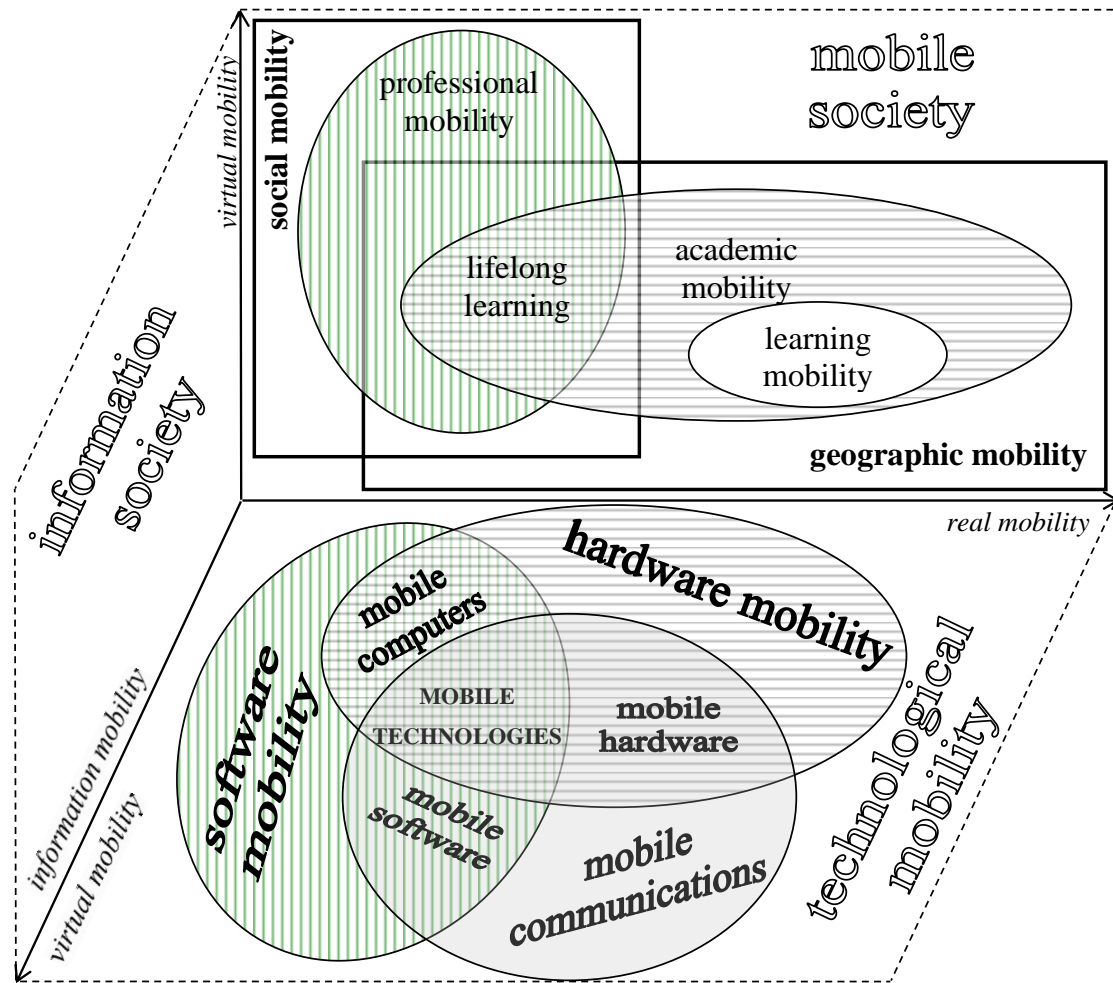


Figure 11: Holistic model of mobility in the information society.

3. Conclusions and prospects for further research

The examination of primary sources on the subject of mobility has enabled the identification of key stages in the evolution of the mobility concept within scientific discourse. It has also facilitated the recognition of various types of mobility within socio-pedagogical and technical systems, and the proposition of a holistic model of mobility in the information society.

Mobility is viewed as a contemporary interdisciplinary paradigm in social sciences and humanities, investigating the movement of people, ideas, and objects, along with the repercussions of these movements. Within this paradigm, types of mobility such as geographic, social, professional, academic, learning, software, hardware, technological, as well as real and virtual mobility are identified. It is demonstrated that research in mobile learning should consider the systemic nature of the mobility concept and not be confined to its individual types.

An analysis of the relationships between types of mobility in socio-pedagogical and technical

systems has allowed for the construction of a holistic model of mobility in the information society. This model comprises three dimensions: one real and two virtual. The real dimension is shared by socio-pedagogical and technical systems due to its focus on studying the movement of people and objects in space. The first virtual dimension aligns with social mobility of individuals, while the second corresponds to informational mobility of ideas. The real and virtual dimensions of mobility in socio-pedagogical systems form the foundation of a mobile society with geographically and socially mobile members. The real and virtual dimensions in technical systems underpin technological mobility. The combination of both virtual dimensions constitutes an information society where information and communication technologies form the basis for human activities.

In line with the proposed model, key directions for future research include:

- 1) Investigating trends in the evolution of mobility within higher education systems as a socio-cultural phenomenon that is constantly evolving and interlinked with technological advancements, state-political transformations, and developments in social and pedagogical sciences.
- 2) Studying the phenomenon of mobility in technological and pedagogical systems due to the proliferation of mobile information and communication technologies.

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