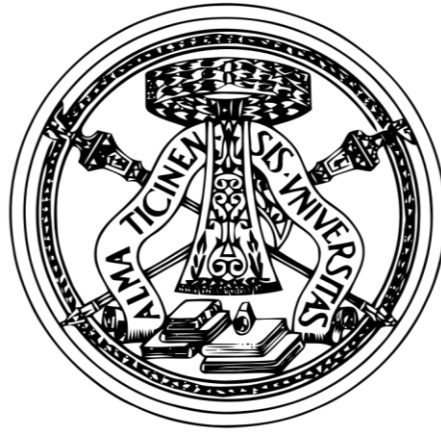




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SUSTAINABLE MANAGEMENT

«Inclusive and socially sustainable innovation: a case-example of ExoRoller»

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Table of content

List of figures and tables

Abstract

Introduction	8
1. Literature review.....	13
1.1 Concepts and essence of inclusive innovations	14
1.2. Socially sustainable innovations in assistive technologies	18
1.3. Modern means of transportation for people with disabilities: wheelchairs, exoskeletons and hybrid devices	22
2. Hypothesis development	35
3. Methodology	38
3.1. Research design and methodological approach.....	38
3.2. Data collection methods: observation, interviews and document analysis.....	40
3.4 Ethical aspects of the research.....	46
4. Results	47
4.1. General characteristics of the company LLP “MBionics”	49
4.2. Development and technical features of ExoRoller	54
4.3. Market application and first results of implementation.....	59
5. Discussion	73
5.1. Inclusiveness and accessibility of technology	73
5.2. Social sustainability and impact on users' quality of life.....	75
5.3. Unique Value Proposition and Competitive Advantages	78
5.4. Main barriers and development prospects	78
5.5. Theoretical implications for the concept of inclusive innovation	81
5.6. The significance of the study for the innovation environment of Kazakhstan	82
5.7. Comparison with international practices	85
5.8. Practical recommendations	91
Conclusion.....	96
Bibliography	99
Applications	102

List of figures and tables

Figure 1: Organizational structure of LLP “MBionics”

Figure 2: ExoRoller

Figure 3: Main components of the ExoRoller

Figure 4: Main components of the ExoRoller (2)

Figure 5: MBionics website activity by country

Table 1: Comparative overview of assistive devices

Table 2: SWOT analysis of LLP “MBionics”

Table 3: Main technical specifications of ExoRoller

Table 4: Questionnaire

Table 5: Scores on key survey questionnaire

Table 6: Results of semi-structured interview

Table 7: Main barriers and development prospects of ExoRoller

Table 8: Comparison of assistive technology development by country

Table 9: Practical recommendations for the development of inclusive innovations

Abstract

This study analyzes inclusive and socially sustainable innovations in the development of assistive technologies for people with disabilities. The relevance of this topic is driven by the global community's growing focus on social inclusion, accessible environments, and improving the quality of life of various population groups, including people with disabilities. In conditions of technological progress, particular value are solutions serving users in three directions: functional, social and economic at the same time.

Objective of this thesis is to analyze in detail process of development, implementation and usage of hybrid mobility devices taking example of ExoRoller developed by LLP “MBionics”. The device is also analyzed on accessibility aspects in terms of principles of inclusiveness and social sustainability.

The theoretical section examines key approaches to understanding inclusive innovation, their relationship with the concept of sustainable development, and the role of such technologies in implementing social policy. Special attention is given to modern types of assistive devices—wheelchairs, exoskeletons, and hybrid devices. Their functionality, advantages, and existing limitations that influence their practical application are analyzed.

The research methodology includes qualitative analysis methods such as a literature review, case study, questionnaire, interview, and observation. As part of the empirical study, I conducted a questionnaire among current ExoRoller users and semi-structured interviews with professionals involved in the project. It helped to understand the characteristics of perception of innovative solutions, identify factors that influence the decision to use such devices and determine the main obstacles to the widespread introduction of these technologies into everyday practice.

The data showed that hybrid devices have good prospects to significantly improve the mobility of users, independence and integration into society. At the same time, during the research it was revealed significant restrictions, including the device price issue, limited accessibility for many users, the requirement to adapt the existing infrastructure to new developments.

The practical value of the study is the recommendations, that are developed to create inclusive innovations, improve systems of state support and increase access to modern assistive technology.

The proposed measures may help to implement these solutions more effectively in the social and economic environment.

In general, the study shows that hybrid vehicle development is a promising field that can help make society more inclusive and improve the quality of life for disabled people.

Keywords: and inclusive innovations; socially sustainable innovations; assistive technologies; disability; accessible environment; exoskeletons; hybrid devices; mobility; social integration; innovative entrepreneurship; quality of life; ExoRoller.

Italian abstract

Il presente studio analizza le innovazioni inclusive e socialmente sostenibili nell'ambito dello sviluppo delle tecnologie assistive destinate alle persone con disabilità. La rilevanza di questo tema deriva dalla crescente attenzione della comunità internazionale verso l'inclusione sociale, la creazione di ambienti accessibili e il miglioramento della qualità della vita di diversi gruppi della popolazione, comprese le persone con disabilità. Nel contesto del progresso tecnologico, assumono particolare valore le soluzioni in grado di rispondere contemporaneamente alle esigenze degli utenti dal punto di vista funzionale, sociale ed economico.

L'obiettivo della presente tesi è analizzare in dettaglio il processo di sviluppo, implementazione e utilizzo dei dispositivi ibridi per la mobilità, prendendo come caso di studio ExoRoller, sviluppato dalla società LLP "MBionics". Il dispositivo viene inoltre analizzato dal punto di vista dell'accessibilità, in relazione ai principi di inclusività e sostenibilità sociale.

La sezione teorica esamina i principali approcci alla comprensione dell'innovazione inclusiva, il loro rapporto con il concetto di sviluppo sostenibile e il ruolo di tali tecnologie nell'attuazione delle politiche sociali. Particolare attenzione è dedicata alle moderne tipologie di dispositivi assistivi, tra cui sedie a rotelle, esoscheletri e dispositivi ibridi. Vengono analizzati la loro funzionalità, i principali vantaggi e le limitazioni esistenti che ne influenzano l'applicazione pratica.

La metodologia di ricerca comprende metodi di analisi qualitativa, tra cui la revisione della letteratura, il caso di studio, il questionario, l'intervista e l'osservazione. Nell'ambito dello studio empirico, ho somministrato un questionario tra gli attuali utilizzatori di ExoRoller e interviste semi-strutturate con i professionisti coinvolti nel progetto. Ciò ha permesso di comprendere le caratteristiche della percezione delle soluzioni innovative, individuare i fattori

che influenzano la decisione di utilizzare tali dispositivi e identificare i principali ostacoli alla loro diffusione nella pratica quotidiana.

I dati ottenuti mostrano che i dispositivi ibridi presentano buone prospettive per migliorare significativamente la mobilità degli utenti, la loro indipendenza e l'integrazione nella società. Allo stesso tempo, la ricerca ha evidenziato alcune importanti limitazioni, tra cui il costo del dispositivo, la limitata accessibilità per molti utenti e la necessità di adattare le infrastrutture esistenti alle nuove soluzioni tecnologiche.

Il valore pratico dello studio risiede nelle raccomandazioni elaborate al fine di favorire lo sviluppo delle innovazioni inclusive, migliorare i sistemi di sostegno pubblico e aumentare l'accesso alle moderne tecnologie assistive.

Le misure proposte possono contribuire a una più efficace implementazione di tali soluzioni nel contesto sociale ed economico.

Nel complesso, lo studio dimostra che lo sviluppo dei dispositivi ibridi per la mobilità rappresenta un settore promettente, in grado di contribuire alla creazione di una società più inclusiva e al miglioramento della qualità della vita delle persone con disabilità.

Parole chiave: innovazioni inclusive; innovazioni socialmente sostenibili; tecnologie assistive; disabilità; ambiente accessibile; esoscheletri; dispositivi ibridi; mobilità; integrazione sociale; imprenditorialità innovativa; qualità della vita; ExoRoller.

Introduction

In the context of globalization and rapid technological progress, there is growing attention to innovations that aim to solve social problems. Inclusive innovation has become an important framework for ensuring that processes and results of innovation are relevant and accessible for groups that can otherwise be left out of economic and social development (Foster & Heeks, 2013). In this regard, the topic of inclusive and socially sustainable innovations for people with disabilities is of special significance since the access to appropriate technologies for this group of users can affect their participation, independence, and quality of life.

Inclusive innovations are typically focused on the integration of vulnerable and underserved groups of people into the economic and social life through designing products and services that respond to their needs (Foster & Heeks, 2013). Assistive technologies play a significant role in this context as they are intended to maintain or improve an individual's functioning and mobility and independence while supporting their well-being, inclusion, and participation in society. The global scale of assistive technology is considerable, with more than 2.5 billion people in the world requiring at least one assistive product at the moment and this number expected to grow to over 3.5 billion by 2050. At the same time, there are substantial access gaps to assistive technology, particularly in low- and middle-income settings, that underscores the need for affordable, accessible, and user-oriented inclusive innovation (WHO & UNICEF, 2022).

These factors combined make the topic of assistive technology and inclusive innovation important to study. Assistive mobility solutions, such as advanced wheelchairs, exoskeletons, and other hybrid devices, are of particular relevance because mobility technologies can play a significant role not only in providing functional support but also in enabling independence and social inclusion. Examining the processes and experiences related to the use of such

technologies can potentially help to understand their opportunities as an example of inclusive and socially sustainable innovation.

This study uses ExoRoller project, created by LLP “MBionics”, as a case-example. This hybrid device combines the functions of a wheelchair, an exoskeleton-inspired support mechanism and rehabilitation trainer.

The aim of the study is to analyze ExoRoller as an inclusive and socially sustainable innovation, as well as to identify its impact on the quality of life of users and the development of an innovative environment.

To achieve this goal, the following tasks have been defined:

- to reveal the theoretical foundations of inclusive and socially sustainable innovations;
- to study modern assistive technologies;
- to develop a research methodology;
- to conduct a case analysis of the company LLP “MBionics” and the ExoRoller product;
- to assess the level of inclusiveness and social sustainability of the technology;
- to formulate practical recommendations for the development of inclusive innovations.

The research object is the innovative activity in the field of assistive technologies.

The research subject is inclusive and socially sustainable characteristics of innovative product ExoRoller.

The scientific novelty of the work is an integrated assessment of hybrid assistive technologies and their contribution to social inclusion and sustainable development. The research also identifies the role of these technologies in inclusive innovation ecosystem development in Kazakhstan.

The structure of the thesis is determined by its aim, specific research objectives. It consists of five chapters.

Chapter 1: provides a review of the relevant literature and discusses the theoretical background of inclusive and socially sustainable innovation. It considers the core principles of inclusive innovation and examines their role and relevance within the contemporary economic context. Special emphasis is placed on modern mobility solutions for individuals with disabilities, such as wheelchairs, exoskeleton systems, and hybrid assistive devices.

Chapter 2: is devoted to the development of the research hypothesis and describes the general design of the study.

Chapter 3: presents the methodological foundation of the study. This chapter includes details about the study design and gives a fuller description of methods used for data collection and analysis. Moreover, this chapter highlights methodological limitations and ethical considerations that took place during the research.

Chapter 4 is an introduction to LLP “MBionics”, a description of the technical characteristics of the ExoRoller device and an analysis of the data received during the study (analysis of possible markets of use and preliminary results of technology implementation).

Chapter 5 interprets the data in the context of inclusiveness and social sustainability of the technology, analyzes its impact on the quality of life of users, and examines competitive advantages, barriers to adoption and development prospects. It also compares international practices, presents theoretical conclusions, and offers practical recommendations, while assessing the relevance of the study for Kazakhstan’s innovation environment.

Guided by the aim and the set of objectives, the study was shaped around three research questions. While the first two are answered by referring to literature and via theoretical generalization, the third research question is empirically explored with the help of primary research data.

The first research question: “What are the main benefits and limitations of hybrid mobile devices for people with disabilities?” has been widely discussed in the scientific literature.

However, most studies approach this issue primarily from a technical or medical-rehabilitation point of view. The focus is on the functional characteristics of these devices and their impact on the physical condition of users. Reported benefits generally include better mobility, less dependence on help, better overall health, and more opportunities for social participation and inclusion.

At the same time, existing research identifies several limitations that prevent the wider adoption of such technologies. They mainly include the high production and procurement costs, the complexity of design and maintenance, and the need for environmental and infrastructure adaptation. Together, these factors significantly affect the availability of the technology and slow its wider adoption among potential users. This highlights the need for further research focused on technical characteristics and on the sociopsychological aspects of using such technologies.

The second research question: “What current trends in assistive technology development and social policy influence the spread of inclusive innovations?” is based on the observation that the success of innovative solutions in this area is determined by social, economic, and institutional factors. Current research emphasizes the growing role of government support, public-private partnerships, and a focus on user needs in technology development.

Factors such as device availability, user awareness, and trust in innovative solutions are particularly important. However, the scientific literature has paid insufficient attention to analyzing how these factors influence user adoption of new technologies and their integration into everyday life. This study examines these aspects as an essential context for further empirical analysis.

The third research question: “How can hybrid devices improve users' social integration and quality of life?” is central to the empirical portion of the study. This question needs to be tested by gathering real world data (e.g., surveys, interviews, observations).

Current research indicates that social integration of people with a disability is highly affected by their mobility and independence, which allows to feel more confident and socialize more while allowing them to be active in society and the economy. Hybrid devices have been viewed as possibly more successful than other mobility devices.

The practical value of this study is associated with its potential to be applied in new projects, public policies, and programmes for entrepreneurship support aimed at social inclusion of people. The results can be used for better design of user-centered solutions, the enhanced support and development of funding and subsidy mechanisms for assistive technologies, and the scaling of innovative products to international markets.

Literature review

The literature review highlights the important scientific approaches and concepts related to inclusive and socially sustainable innovation. Special focus is made on the topic of development of assistive technologies and hybrid mobility devices. Analysis of the reviewed scientific sources allows establishing the way the ideas concerning innovation contribution to social justice, technological accessibility and quality of life improvement for people with disabilities evolved over time.

Interest to inclusive innovation has been steadily growing over the recent decades. The current surge in this area is largely connected to global socioeconomic trends, concerns over inequality, as well as the general goal to build more accessible and socially oriented societies. Inclusive innovation is distinct from traditional innovation concepts by placing the emphasis on accessibility of technology solutions to various population groups (Foster & Heeks, 2013).

The theoretical background for this direction ties into sustainable development and social responsibility ideas. According to the concept developed by United Nations Commission on Environment and Development, economic, social and environmental dimensions are interconnected. These ideas became central to the concept of “triple bottom line”, which suggests that the innovation impact should be measured in three ways: economic efficiency, social impact and environmental friendliness (Elkington, 1997). Applied to assistive technologies, it points to a union of innovation efficiency with accessibility, safety, and value to the end user.

The other research line focuses on the assistive technology devices as tools for social integration of individuals with disabilities. Research proves that assistive devices significantly impact individual's autonomy, mobility, and involvement in society. Examples range from wheelchairs and exoskeletons to hybrid devices. Special attention has been paid to usability and ergonomic design of the devices, safety issues and user experience.

Analysis of existing studies allows claiming that efficiency of inclusive innovations is relies heavily on socioeconomic conditions and institutional support. Public policy, incentive and financing schemes, and public-private partnerships also influence on them. Very important, as a rule, is the involvement of end users in design and testing, which allows them to take into account real needs and increase the practical applicability of developed technologies. (Norman et al., 2007)

1.1 Concepts and essence of inclusive innovations

Inclusion is seen as a society in which people, regardless of their physical, cognitive, social or economic features, have equal opportunities to be fully involved in all aspects of society. In a scientific literature, inclusion is perceived as a wider development paradigm in which all barriers preventing access to education, employment, health care, transport, and other areas of life, to some groups of people are removed. This approach applies especially to disabled people who typically experience overlapping physical, institutional, and social barriers that prevent them from independently engaging in daily activities (Goodley, 2011; World Health Organization, 2022).

In socioeconomic terms, inclusion means establishing conditions that will enable members of the society to achieve their full potential and to improve their contribution to socioeconomic development. This is to accept that the diversity of the needs, backgrounds and opinions is a resource to be valued as an opportunity for innovation and social change, and not as an obstacle. In this context, inclusion is strongly linked to the concepts of equality, accessibility and non-discrimination.

Inclusion has gained significant importance as a key component of sustainable development. The United Nations Sustainable Development Goals (SDGs) highlight the need to “leave no one behind” and ensure equal access to resources, technologies and opportunities.

This approach recognizes that economic growth alone is not enough if large segments of the population are left behind. Inclusive development has become one of the central elements of strategies to reduce inequality and improve social well-being.

One of the most important practical applications of inclusive innovation is assistive technology. Assistive technology is a branch of technology that is aimed at helping people with disabilities maintain or improve their functional abilities. These include wheelchairs, prosthetic devices, hearing aids, exoskeletons, and others. Its benefits in terms of greater independence, stronger self-esteem, and increased social participation make this an area of development that truly matters. By allowing users to increase their mobility and overcome daily physical challenges assistive technologies reduce social exclusion and help create opportunities for learning, employment and social activities (Borg, et al., 2011).

Mobility for persons with disabilities is currently one of the most prominent areas of study in the intersection of medicine, engineering, rehabilitation, and social policy. “The Global Report on Assistive Technology” published by the World Health Organization and UNICEF (2022) emphasizes that the development of assistive technologies is a significant factor influencing quality of life, social integration, and the realization of human rights. Particular attention is paid to technical solutions aimed at compensating for musculoskeletal disorders and expanding independent mobility. The literature also shows their evolution from simple mechanical models to modern electric and smart systems. The introduction of electronic controls, touchscreen interfaces, and automated functions has significantly enhanced usability and functionality. However, certain limitations remain, including the inability to assume an upright position and dependence on infrastructure accessibility.

Exoskeletons, considered high-tech devices designed to support and restore human motor activity, have received particular attention in scientific research (Barnes & Mercer, 2005). Research emphasizes their interdisciplinary nature, combining advances in robotics,

biomechanics, and medical technology. The use of exoskeletons improves mobility and positively affects users' physiological condition, including better circulation, reduced risk of pressure sores, and maintenance of muscle tone. They are also widely applied in rehabilitation and are considered an effective tool for restoring motor functions after injuries and illnesses. However, their widespread use is constrained by cost, complexity, specialized training requirements, and limited independence. Due to this, exoskeletons are primarily used for clinical and rehabilitation purposes and are not meant to be used daily.

Increasing attention is being paid recently to hybrid type of mobility devices. Hybrid system development as a potential solution for developing more versatile assistive devices (Schott & Steinmueller, 2018). They give users the opportunity to transition between sitting and standing posture which enhances functionality and social involvement. Author also focuses on engineering aspects of these devices. The complexity in designing a hybrid device stems from having to combine mechanical and electronic components, controllers, as well as safety mechanisms. It is important to look at biomechanics, ergonomics and reliability during the design process of these assistive technologies. One of the key ways to make AT more effective, it's argued, is by considering individual user traits. This includes customizing control parameters, adapting ergonomic solutions, and taking into account medical indications.

International organizations, including the World Health Organization, highlight the expansion of access to assistive technologies as an important condition for sustainable development. Research shows that improved access to mobility solutions supports social integration, increases opportunities in education and employment, and helps reduce social isolation (WHO & UNICEF, 2022).

Richard Heeks views inclusive innovation as a systemic process that includes the end product, institutional, organizational, and technological dimensions. He distinguishes different

levels of inclusivity, ranging from basic access to innovations to full participation of users in the creation and dissemination of innovative solutions (Foster & Heeks, 2013).

A significant contribution to the development of the concept of inclusive innovation was made by the “Bottom of the pyramid” theory, designed by CK Prahalad and Stuart Hart. Following from this concept, the greatest opportunity for innovation resides with low-income populations that have traditionally been treated as mere welfare beneficiaries. C.K. Prahalad believes that they can also become market participants if provided with customized and accessible innovative offers. This allowed opening up of a market niche with a new business model for mass markets with low purchasing power but high demand overall (Prahalad & Hart, 2002).

An important theoretical basis for inclusive innovation is the concept of social entrepreneurship. Gregory Dees views the social entrepreneur as a change agent who uses innovative approaches to solve social problems. Within this framework, innovation is a tool for creating social value, not just economic gain. This brings inclusive innovation closer to sustainable and responsible business practices (Dees, 1998)

The theory of inclusive innovation was further developed within the concept of co-creation, developed by Prahalad C.K. and Venkat Ramaswamy. This approach involves the active participation of consumers in the development of products and services. In the context of inclusive innovation, this means involving vulnerable groups in the creation of solutions, which allows for their real needs to be taken into account and increases the effectiveness of innovation (Prahalad & Ramaswamy, 2004).

From a practical perspective, inclusive innovations are characterized by a number of key attributes. First, accessibility, which implies reduced costs and barriers to use. Second, adaptability, which takes into account the specific needs of different user groups. Third,

participation, which involves users in the development process. Fourth, scalability, which enables the innovation to expand to new markets and regions.

This study uses the concept of inclusive innovation as a theoretical framework for analyzing next-generation assistive technologies, including hybrid devices like the ExoRoller. This approach allows us to examine the mechanisms behind the development of technological solutions that address social needs, as well as assess their impact on users' quality of life and the development of the innovation environment as a whole.

1.2. Socially sustainable innovations in assistive technologies

Social innovation can be understood as the process of developing and applying new ideas, products, services, organizational approaches, and forms of collaboration that help address important social problems. Its main purpose is to respond to unmet social needs and improve the quality of life and well-being of individuals and communities. The current stage of global development is characterized by increased attention to issues of sustainability, social justice, and improving the quality of life of various population groups. Accelerating demographic changes, an increase in social inequality, urbanization trends, and technological development require innovation approaches to be reconsidered.

Socially sustainable innovation is considered as an approach to balance between the interests of business and society. While traditional innovation strategies focus on market value and potential financial gain, socially sustainable innovations solve social issues: accessibility of services for people, mobility of population, inclusion, and decrease in social inequality. The solutions should aim to provide long-term social benefits and help improve the quality of society's life as a whole (Porter & Kramer, 2011).

Geoff Mulgan describes social innovations as "...new ideas that work in meeting social goals." From this definition, we can highlight two important features. First, an innovation

should contain a certain novelty. It can be a new product or service or way of organization functioning. Second, this idea should work in practice, which means the possibility of proving that it really creates value for society through measurable changes. Julie Caulier-Grice adds that social innovations should not be seen solely as single solutions to specific problems but can shift the relationship between people, organizations, and institutions by developing new systems of collaboration and resource allocation.

Social innovation is often not created by a single organization, but rather through the cooperation of several actors. Governments, universities, businesses, nonprofit organizations and communities can all be involved in identifying needs, generating ideas, piloting potential solutions and spreading successful approaches. This collaborative aspect is what allows social innovation to integrate both technological possibilities with social awareness of problems.

Cross-sector collaboration plays a significant role when it comes to socially sustainable innovation. Michael Porter and Mark Kramer call this creating “shared value” which allows business, governments, and society to work together to solve social problems. In terms of Assistive Technology, this could mean co-working between the producers, medical institutions, government facilities, and non-profit organizations (Porter, Kramer, 2011).

This idea was one of the inspirations of Triple Bottom Line concept by John Elkington. According to this approach, organizational performance and innovation effectiveness should be assessed simultaneously across three dimensions: economic, social, and environmental. (Elkington, 1997).

An important addition to this theoretical framework is research in the field of social innovation. Geoff Mulgan and Julie Caulier-Grice defines social innovation as new approaches, ideas, products, or services aimed at meeting societal needs and changing the forms of interaction between social groups. The main feature of such innovations is directed at the fact

that they change existing practices and institutional arrangements to more effectively solve social problems (Mulgan et al., 2007).

By combining all the above approaches, we can view socially sustainable innovation as a phenomenon containing technological, social and institutional features. This is a complex process including the creation of novelties and change in patterns of interactions between participants in society and social and economic processes. Assistive technologies can also be viewed as one of the most expressive examples of socially sustainable innovation principles since they are targeted directly at creating a better life for vulnerable social groups. Assistive technology that assists people with disabilities holds a unique position within this concept. They are used with the goal of removing physical and social barriers that hinder these people from participating in public life. Such technologies provide access to mobility, educational resources, employment, and other areas of life, thereby promoting the expansion of individual capabilities and increasing independence. In this context, assistive technologies act as a means of social integration. From a sustainability perspective, the life cycle of an innovative product is an important aspect. Socially sustainable technologies must be effective at the implementation stage and ensure long-term operation, maintainability, and accessibility to service. In turn, this demands implementation of environmental sustainability principles such as recyclability and smaller environmental footprint.

Another important aspect of socially sustainable innovations concerns the effect they have on the quality of their users' lives. Capability concept approach theorized by Amartya Sen determines increase of people's capabilities as the principal indicator of development. Assistive technologies allow people to move freely, be independent, and access education and work thus contributing to the realization of this approach (Sen, 1999).

Creating socially sustainable innovations in assistive technology field is tightly connected to digital solutions implementation. Innovations in artificial intelligence, robotics,

and IoT allow the development of smart devices that are capable of learning and adjusting to specific characteristics of their users. This would allow the technologies to be more personalized and convenient in use, thus increasing their effectiveness and promoting their widespread use (Borg et al., 2011).

In the field of assistive technologies, socially sustainable innovations are particularly important, as they are directly linked to improving the quality of life of people with disabilities. According to the World Health Organization, assistive technologies include devices and systems aimed at maintaining or improving a person's functional abilities. For example, wheelchairs, hearing aids, prosthetics, exoskeletons and various digital solutions.

Universal design principles formulated by Ronald Mace are directly related to the emergence of assistive technologies. This principle states that when developing a product, it should be adapted to the greatest number of users without special adaptations. In terms of socially sustainable innovations, this means fewer barriers and greater availability of technology for different categories of the population (Mace, 1998).

One of the key drivers of socially sustainable innovation in this field is demographic change. Increasing life expectancy and the growing number of people with chronic diseases and disabilities are contributing to rising demand for assistive technologies. As noted in the Global Report on Assistive Technology, “Over 2.5 billion people need one or more assistive products.” (World Health Organization & UNICEF, 2022)

Assistive technology that combines multiple devices like ExoRoller can be classified as forms of social innovation. Hybrid devices like this attempt to take different functions and integrate them into one product with the goal of offering users increased flexibility, mobility, and participation.

Despite significant potential, the development of socially sustainable innovations in assistive technologies faces a number of barriers. These include high development and

production costs, limited access to funding, insufficient infrastructure, and a lack of standardization and regulation. Low user awareness of available technologies is an additional factor. In developing countries, including Kazakhstan, these issues are particularly pressing. The slow uptake of innovative solutions, driven by financial limitations and institutional barriers, highlights the paramount importance of support mechanisms. Government subsidy programs, local capacity-building initiatives as well as enabling innovative entrepreneurship are crucial in this context. Directions for future development of socially sustainable assistive technology innovation include a more comprehensive digitalization, focus on personalized assistive solutions and increased international cooperation. The concept of open innovation, based on cross-border and interorganizational exchange of knowledge and technologies, is also gaining importance. Overall, socially sustainable innovations in assistive technologies form an important part of the modern innovation economy, as they address pressing social issues and contribute to improving quality of life through the coordinated development of technological, economic, and institutional frameworks.

1.3. Modern means of transportation for people with disabilities: wheelchairs, exoskeletons and hybrid devices

The development of modern technologies is significantly transforming approaches to ensuring the mobility of people with disabilities. In the context of an increasingly complex social structure and increasing demands on quality of life, a person's ability to move independently is particularly essential. It largely determines their level of autonomy, independence, and participation in various spheres of life. Quality of life and participation in the economic sphere are also greatly affected by the ability of a person to move independently. The lack of physical ability to move freely may serve as a restriction preventing one from living up to their potential. Mobility issues can cause different types of exclusion and result in dependency on the aid from others. (Barnes & Mercer, 2005).

Mobility devices for disabled people can, therefore, be attributed particular social importance. The impact of these devices goes beyond providing technical means for transportation. They are a crucial component of social infrastructure that is taken into account when providing equal rights and opportunities in accordance with international and domestic regulations. Mobility devices allow you to compensate for the person's physical condition and create conditions for their fuller involvement in public life by broadening their social circles and increasing independence in day-to-day activities.

Mobility is beginning to be perceived as a complex combination of technical, social, and economic factors. This approach is due to the fact that the efficiency of a mobility device depends on many factors, including design features, availability, usability, compliance with individual needs of the user, as well as the level of development of the surrounding infrastructure. For these reasons, mobility devices are now starting to be considered as part of an inclusive system of assistance to people with disabilities along with all the conditions for their application, maintenance, and social environment.

Mobility solutions available today can be conditionally divided into three groups: traditional wheelchairs, exoskeletons, and hybrids. These categories were derived based on the evolution of technology used to approach users' mobility issues, differences in the principle of operation, autonomy level, and method of user interaction with the device itself. In addition, each group is designed for different purposes and user categories, which predetermines their functional differences and technical characteristics.

All three areas have their own features, advantages and disadvantages, development and degree of technical readiness level and availability. The choice of a solution that best meets user needs will depend on the needs of individuals, their health status, physical activity and environmental conditions; they can also be used in a complementary way. Mobility solutions in all three areas are developing synergistically – this is part of the global trend towards creating

more flexible mobile solutions that are closer to the users and their needs, focused on social inclusion.

Wheelchairs are by far the most widely used and available type of transportation option for people with musculoskeletal disabilities and have become an integral part of assistive technology. Wheelchairs allow for equal opportunity to access public services, eliminate obstacles to participating in social and economic activities, and enhance user autonomy. Wheelchairs in the current day are starting to be recognized as a tool of fundamental rights, allowing for independence of mobility, employment, and social activity.

The history of wheelchairs shows just how society's views on disability have evolved alongside technological advancement. One of the first improvements in wheelchair design was made by Stefan Farffler in 1655, when he designed self-propelled wheelchairs with a manual drive. It can be regarded as the prototype of mechanical wheelchairs because it allowed individuals to independently move around without regular assistance.

The subsequent development was gradual, mainly due to the improvement of materials and construction. A major breakthrough occurred in the 20th century, especially after the World Wars, when the growing number of people with mobility impairments accelerated the development of rehabilitation technologies and assistive devices. At that time, standardized mechanical wheelchairs entered mass production and became widely used in clinical practice. Typically, they consisted of a frame, seat, armrests, footrests, and wheels. Movement was manually controlled by spinning the large rear wheels. Wheelchairs have made great advancements in mobility however still require manual strength and stamina of the user. Mechanical wheelchairs offer users simplicity, sturdiness, and affordability. Because they are not reliant on an external power source they are advantageous to areas with limited resources or developing countries. In addition, their simple design ensures easy maintenance and long service life, which contributes to their global distribution.

Although mechanical wheelchairs remain widespread due to their simplicity and accessibility, they have a number of pronounced limitations. Firstly, this is the need for constant physical effort on the part of the user, especially during prolonged movement, climbing or overcoming uneven surfaces. In addition, it should be noted that ergonomic comfort in the design of such strollers is not enough, which causes quick fatigue when using it for a long time. Their manoeuvrability also worsens in tight spaces, which narrows down the conditions for using them in daily life. limits their ability to operate in daily life.

Developments in engineering and electrotechnical spheres led to the beginning of creating electric wheelchairs which was the important stage of rehabilitating equipment developing. The creation was basing on development of battery system and electromechanical drive. The initial development of electric models happened in the 50s – 60s of the XX century, in particular, in Canada when George Klein significantly contributed to creating the first examples of such devices and control systems for people with disorders of the musculoskeletal system. These electric wheelchairs feature rechargeable batteries and electric motors, enabling independent mobility without substantial physical effort. Control is provided by means of joysticks or alternative interfaces, which expands the possibilities of their use for people with various forms of limitations. Compared to their mechanical counterparts, such devices provide a higher level of autonomy, comfort, and functional adaptation to environmental conditions.

Electric wheelchairs today offer significantly more adaptability and enhanced functionality. They can be equipped with intelligent safety systems, including automatic braking, motion stabilization, and sensors for detecting obstacles. Special attention is paid to individual adjustment: the seat position, the angle of the backrest and the footrests are adjusted for maximum comfort and to match the physical characteristics of each user. Currently, a whole field of “smart” wheelchairs is being developed, based on digital technologies and automated control. These wheelchairs allow analyzing the surrounding space, making moving around

easier and safer for the user. Advancements in sensor systems, computing speed, and software contribute to their improvement. Models include automatic collision avoidance systems, semi-autonomous driving control, connection to mobile applications, and other smart devices. All these make using a wheelchair more comfortable and practical for the user. Alternative control methods are offered to people with limited mobility of the upper limbs: voice control or motion tracking systems.

Despite many improvements, wheelchairs still cannot overcome some of the design limitations. The most obvious one is that wheelchairs do not allow users to verticalize, which affects their physiology and restricts daily life and social activity. Wheelchair user also heavily depends on infrastructure: presence of stairs, narrow passages and lack of ramps are big limitations for wheelchair users' freedom of movement. Having the best modern model of wheelchair won't help if the city infrastructure is poor adapted to their needs.

Maintenance is also a concern, especially with electric and smart wheel chairs. The user must have access to a service center, places to charge or replace batteries, and other requirements that allow the device to function. Otherwise, operation may be difficult.

Despite their inherent limitations, wheelchairs continue to be the backbone of assistive technologies, and their development aims to further enhance convenience, functionality, and accessibility. In turn, exoskeletons are wearable robotic devices designed to restore, compensate or improve human motor functions. In modern scientific and applied literature, they are considered one of the most promising areas of assistive technology development, combining advances in biomechanics, robotics, sensor systems, and digital control. The basic idea behind an exoskeleton is to create an external mechanical structure that mimics the anatomy of the human body and interacts with it, providing support or full reproduction of movement in individuals with limited or lost motor function.

From a theoretical point of view, exoskeletons can be considered as human-machine systems in which biological and technical components are closely integrated. Exoskeleton systems operate on the principle of tight coordination between the user's actions and the device's mechanical components. This requires precise determination of the user's intentions, continuous analysis of their motor activity, as well as prompt response of control algorithms to changes in body position. Unlike traditional mechanical mobility devices, exoskeletons do not limit themselves to passive support of the user but actively participate in the movement process, acting as an external amplifying or compensating mechanism.

Exoskeletons are complex machines. They have a frame that looks like a human body, motors that move parts, and sensors that sense movement. Sensors (such as gyroscopes and accelerometers) tell the control system how a person is moving. The control system, using special programs, sometimes even with elements of artificial intelligence, decides how the motors should move. This helps the exoskeleton work together with the human smoothly and safely. It is important that the management system can adapt to each person in order to avoid mistakes and dangerous situations. Military exoskeletons are developed to increase the strength and endurance of service members. Although they have different goals, each of these devices function on the same principles of human-machine interaction.

Exoskeletons have a unique position in the rehabilitation process. Use of the devices enables patients to practice movements they would not otherwise be able to perform. This activates the nervous system and promotes regaining motor function. Exoskeletons allow forming new neural pathways, therefore making them efficient in neurorehabilitation and returning lost motor skills. A significant function of exoskeletons is to help in gaining and maintaining an upright position. Standing vertically has a multifaceted positive effect on the body: it improves blood circulation, optimizes the functioning of internal organs and reduces the likelihood of problems associated with prolonged sitting or lying down. In addition to the

physiological benefits, an upright position helps to improve psychological well-being, strengthening self-confidence, stimulating social activity and improving the overall standard of living. Hugh Herr has worked on developing both the theoretical foundations of exoskeletons as well as practical applications of them. In his work "The new bionics that let us run, climb and dance" Herr views exoskeletons as a crucial piece of equipment in the implementation of bionic systems where people and technology act as one. His hope is that they can provide research into both replenishing lost abilities and matching the mechanical design to every user's unique trait. His work examines biomechanics, human device interaction, and control algorithms that allow for the most natural user movement.

However, even though there are clear benefits that these devices can provide there are also a variety of limitations that prevent them from being fully integrated. Cost is one of the biggest drawbacks as they require complex design, expensive components, and customization for each individual user. These factors create limitations for the access people can have to the technology, especially in places where healthcare may be underfunded.

In addition, exoskeleton operation also involves pre-training of the user and operation under the supervision of specialists. Proper and efficient use of the device will require learning of motor skills and coordination with its control system. Learning takes time and qualified instructors, which also affects the spread of the exoskeleton.

Another drawback is low battery life due to the use of rechargeable batteries. This restricts the ability to use devices in everyday situations as well as requires daily charging of devices, causing inconvenience to the user. Exoskeletons need systematic maintenance, diagnostics, and setting of operational parameters. All these factors increase the overall cost of using the device. Today these devices are used in medical and rehabilitation institutions to rehabilitate patients' motor functions. In addition, active development is being given to projects

and pilot installations of exoskeletons intended to study ways to improve mobility and quality of life of people with disabilities.

Improving exoskeleton technologies is linked to increasing their affordability, reducing cost and improving ergonomics with the addition of digital solutions. Sensor systems, control algorithms and material science continue to improve allowing for the production of lighter, more comfortable, and practical devices that people can use daily outside of professional institutions

Exoskeletons as assistive technologies thus present themselves as a significant segment with wide-ranging application prospects in medicine, rehabilitation and social adaptation. Furthermore, the development of such devices as a whole shows a trend towards smart and adaptive solutions centered around humans and their quality of life. Hybrid vehicles can be considered as another segment of assistive devices, which aim to combine different technical approaches into one. One of the driving forces behind creating hybrid machines is combining different technologies into one system in order to reach an optimal trade-off between functionality, accessibility, and convenience.

Overall, hybrid mobility systems can be defined as transformable adaptive platforms. They operate in two positions: standard seated position like an ordinary wheelchair and the assisted-standing position with the implementation of exoskeleton ideas. Hybrid type mobility increases versatility and functional scope of the device.

The major advantage of this kind of system is having multiple working positions in one device. Working in a seated position, the user can efficiently navigate long distances while consuming less power. In the standing position, it becomes easier to interact with the environment, complete everyday activities, and socially interact with other people. Devices that offer such versatility can more efficiently adapt to different conditions encountered in day-to-day life.

Hybrid device is tightly linked to advances made in robotics, sensory technologies, and automatic control. Modern devices are often equipped with various types of sensors that measure parameters such as movement, pressure, tilt, user position, etc. This data is used by the control system to regulate the device's behavior and transition between modes seamlessly and safely. The collected data is being used by an on-board computer to control the device's behavior and switch between working modes safely and seamlessly.

Hybrid solutions from an engineering point of view can be described as systems consisting of several layers. The foundation is formed by the mechanical construction which allows the device to stay upright and transform from one position to another. Actuators which perform the movement of the device between two working positions. Next are the sensors which receive data on the device's state. Lastly, there's a software that coordinates all the components to work together.

As for the user's experience, hybrid devices have several important benefits. First of all, such devices provide the user with an opportunity to select a mode of use that is most suitable for the current task and conditions. Secondly, it can increase the user's independence, as it will require less support from others. Third, it can have a positive effect on the psychological state of the user, since the device will allow them to remain upright and interact with people on the same level.

This is due to the fact that such systems usually combine many functions, which allows the user to have just one device instead of buying multiple, specialized devices for each function. In theory, this could lower the total cost of mobility and rehabilitation. However, it should be mentioned that the price of a hybrid device is still quite high, which prevents them from gaining much popularity, and this type of device is not available for the majority of users.

One of the most important development directions for such systems is the merging with modern digital technologies and intelligent control algorithms. This process actively uses

methods of data analysis, adaptive control algorithms, and interaction interfaces which allow more intuitive and accurate control of the device. The use of such technologies improves ease of use, enhances safety, and expands the functional potential of equipment. In the future, the development of such systems is associated with the creation of algorithms that will be able to independently adapt the device's operating mode to individual user parameters, its current functional state, as well as external environmental conditions. This will increase the level of autonomy and make management more intelligent and flexible. However, despite the high potential of hybrid technologies, their practical implementation faces a number of significant difficulties. First, it is the high design complexity of the devices, which requires combining mechanical, electronic, and software components into a single coherent system. All elements must work synchronously and stably, since disruption of interaction even at one level can reduce the efficiency of the entire structure.

From the perspective of inclusive development, hybrid technologies occupy an important position. They support greater independence among people with disabilities and contribute to improving their overall quality of life. It can be assumed that future development will take place primarily through technical refinement, increased affordability, ergonomic enhancements and availability to a broader range of consumers, resulting in increased adoption.

Overall, hybrid mobility solutions are part of a trend in assistive technology that is becoming more flexible and human-focused. By allowing for more possibilities to participate in different activities, they strengthen the concept of independent living with no bounds defined by physical ability. A comparison of wheelchairs, exoskeletons, and hybrid devices shows clear differences in their purpose, technological complexity, and accessibility. At the same time, it highlights the main directions in which assistive technologies are evolving. Together, these categories form the basis of modern mobility support systems for individuals with disabilities

and represent different strategies for achieving independence and social inclusion. Table 1 presents a comparative overview of wheelchairs, exoskeletons, and hybrid mobility devices.

Table 1: Comparative overview of assistive devices

Criterion	Wheelchair	Exoskeleton	Hybrid mobility device
Functionality	Sitting position only	Vertical position only	Hybrid: sitting and upright position
Ease of use	Simple	Complex	Adaptive, integrated management
Technical complexity	Low to moderate	Very high	Very high
Cost	Low to moderate	High	Moderate to high
Main application areas	Daily mobility	Rehabilitation and specialized use	Daily mobility and rehabilitation
Level of autonomy	Medium (depending on type)	Intermediate/High (requires training)	High (independent control and mode transition)
Social integration	Average	High	High

A comparative analysis shows that the 3 main categories of mobility devices differ significantly in terms of functionality, technical complexity, and accessibility. The choice of a specific device type is determined by a combination of various factors. These factors include the user's health status, level of physical activity, individual characteristics, environmental conditions, and financial capabilities. As a result, a single universal solution is impossible,

which requires the development of a variety of technological approaches adapted to different life situations.

The development of accessibility and inclusivity of assistive technologies retains the status of one of the priorities in both scientific and applied fields. Comprehensive initiatives aimed at increasing equal access to mobility for people with disabilities are being implemented internationally. These initiatives are based on the development of unified standards, methodological recommendations and institutional support mechanisms aimed at removing barriers and ensuring equal opportunities for participation in social and economic life.

A comparative analysis of wheelchairs, exoskeletons, and hybrid systems demonstrates both the functional differences between them and the common vectors of technological evolution. Overall, there has been a steady shift in the industry towards more intelligent, adaptive, and user-oriented solutions that prioritize customization, ergonomics, and social integration of the end user.

Modern means of transportation for people with disabilities form an interdisciplinary field of research located at the intersection of engineering, clinical medicine, information, and computing technologies and social policy. There is a gradual transformation from isolated technical devices to integrated life support systems focused on expanding autonomy and improving the quality of life.

Broadly speaking, assistive technology builds an accessible social environment that opens up opportunities for education, career and socialization for people who need special conditions. Assistive technology is beginning to be seen not just as a medical gadget, but as an opportunity for social inclusion and human empowerment.

Contemporary methodological approaches for developing these systems follow principles of universal design, accounting for the broadest range of user characteristics. This

includes the comprehensive adaptation of interfaces, improving ergonomic performance and ensuring technological accessibility.

Promising developments, illustrate the further evolution of hybrid solutions based on the synergy of various technological platforms. They provide a combination of mobility, verticalization and parametric adaptation to the individual characteristics of the user.

In the long term, the development of this field will be determined by deepening interdisciplinary cooperation, expanding the use of intelligent control algorithms and enhancing the personalization of technical solutions. Together it will contribute to the formation of a more flexible, inclusive and technologically advanced living environment.

2. Hypothesis development

The study hypotheses are formulated on the basis of the theoretical and empirical arguments presented in the literature review. Prior research on inclusive innovation and assistive technology indicates that the value of a technological solution for the people with disabilities can be measured both by its technical performance and by its impact on such factors as mobility, independence, accessibility, social participation, and quality of life.

Assistive technologies aim to maintain or improve the individual's functioning and independence and can support participation in education, employment, and social life (WHO & UNICEF, 2022). Mobility technologies have also been the subject of research, suggesting that more advanced assistive devices increase the user's opportunities for performing daily activities more independently. In particular, there is evidence that powered exoskeletons can support the mobility and functional activity of people with severe mobility impairments (Brynjolfsson & McAfee, 2014). Hybrid mobility devices take this idea further by integrating different mobility and rehabilitation functions into a single technical solution. Therefore, the first hypothesis is formulated as follows:

Hypothesis 1: The use of hybrid mobility devices significantly improves users' mobility and independence compared to traditional assistive devices.

The effect of assistive technology can be, however, broader than its functional dimensions. The capability approach suggests that development can be understood in terms of the expansion of individuals' real opportunities to perform activities and participate in society (Sen, 1999). Assistive technologies may support this process by improving the user's independence and reducing mobility barriers. WHO and UNICEF (2022) also highlight the role of assistive technology in supporting inclusion and participation in family, community, education, and employment. Therefore, higher mobility may lead to greater social participation. This leads to the second hypothesis:

Hypothesis 2: Use of hybrid devices allows for a higher degree of social participation and involvement in public life.

While assistive technologies can have important individual and social benefits, access to these technologies is not equal. WHO and UNICEF (2022) identify affordability, availability of services, infrastructure, and access to appropriate assistive products as important challenges for the development of assistive technology. These challenges are particularly relevant for technologically complex mobility devices whose practical use also depends on the accessibility of the surrounding physical environment. Accordingly, the following hypothesis is proposed:

Hypothesis 3: The high costs of hybrid devices and limitations of infrastructure are obstacles for its spread.

In addition, the literature review also indicates that inclusive innovation is not shaped only by companies and users but also by the institutional environment. Heeks and Foster (2013) conceptualize inclusive innovation as operating on different levels and dimensions of inclusion, while the development and diffusion of socially oriented innovations can depend on the interaction between business, government, and other actors. Porter and Kramer (2011) similarly conceptualize business cooperation with society as a means of creating shared value. In the context of assistive technology, public funding and support mechanisms can reduce accessibility barriers and facilitate more widespread diffusion. Therefore:

Hypothesis 4: Government support programs and subsidies positively impact hybrid devices' accessibility.

Finally, inclusive innovation is also focused on whether the process and results of innovation address the needs of groups that are potentially or actually excluded from the benefits of innovation (Heeks & Foster, 2013). The social innovation literature similarly underscores the creation of solutions responding to unmet social needs and generating social value (Mulgan et al., 2007). When users view an assistive device not as a technological product

but as a solution that has been purposefully designed to improve their independence, inclusion, and quality of life, this social value may contribute to a more positive perception of the new technology. On this theoretical basis, the final hypothesis is proposed as:

Hypothesis 5: Perception of the device as a socially meaningful inclusive innovation increases trust towards it and willingness to use it.

As a whole, listed hypotheses combines both theoretical aspects of the project with practical implications. Their empirical testing will help evaluate the potential of hybrid mobility technologies as a means of improving the quality of life of people with disabilities and fostering a more inclusive environment. The next section will present a description of the methodological approach of the study, including the study design, methods of data collection and analysis, and the tools used to test the hypotheses.

3. Methodology

3.1. Research design and methodological approach

The choice of ExoRoller as the focal case was based on both theoretical relevance and empirical accessibility. First, ExoRoller represents a hybrid assistive mobility solution that combines several functions within a single device, making it particularly relevant for examining the principles of inclusive and socially sustainable innovation. Second, the case provides an opportunity to investigate the development of assistive technology within the context of Kazakhstan, where the availability and adoption of advanced mobility solutions remain relatively limited. Finally, direct access to the company and the ExoRoller project during the internship enabled the collection of primary data through observation, questionnaires, and interviews with users and specialists. This access made it possible to examine the technology in its real-life organizational and user context rather than relying exclusively on secondary information. Therefore, ExoRoller was selected as an information-rich case suitable for an in-depth case study analysis.

A case study design was selected because it allows an in-depth investigation of a specific contemporary phenomenon within its real-life context (Yin, 2018). This approach is particularly appropriate for the present research, since ExoRoller is examined not as an isolated technological product, but in relation to its users, the company developing it, rehabilitation practices, and the broader social environment.

The study primarily adopts a qualitative approach, as qualitative research is particularly appropriate for exploring complex phenomena, participants' experiences, and the meanings they attribute to them within a specific context (Creswell & Poth, 2018). This approach is suitable for the present research because the study aims to understand not only the functional characteristics of ExoRoller but also users' experiences and perceptions of its impact on

mobility, independence, and social inclusion. The method approach enables the research to analyse socio-technical systems, like assistive devices for persons with disabilities, and understand their user experience, satisfaction levels and social impact.

The focus of this research is on hybrid mobile devices for people with disabilities as part of an assistive technology system. The research demonstrates how such solutions affect inclusivity and sustainable development, as well as their role in increasing mobility, self-reliance and social inclusion of users. The ExoRoller device is considered as an example.

The research methodology includes several logically related stages. First, the scientific literature on assistive technologies, including wheelchairs, exoskeletons, and hybrid systems, as well as research on inclusive and sustainable innovations, is analyzed. This stage is necessary for the formation of a theoretical framework and the definition of key concepts.

Next, a comparative analysis of existing mobility solutions is carried out. Their functionality, limitations, accessibility, and usability are discussed here. This allows us to identify the main problems that justify the development of hybrid technologies.

The next stage is devoted to the analysis of the ExoRoller itself. Its design, operating principle, functionality, and usage scenarios are being studied. Special attention is paid to how the device interacts with the user and how convenient it is in everyday practice. Then an empirical hypothesis test is performed. For this purpose, user surveys, interviews with experts, observation, and analysis of existing data can be used. Questionnaires help to obtain quantitative indicators, and expert interviews provide a deeper understanding of technical and practical aspects.

Comparative and content analysis, as well as simple statistical processing of survey data, are used to process information. This allows to compare different types of devices and highlight their key features.

The work is based on a systematic approach that considers assistive technologies as a single system that includes the device, the user, and the environment. This view allows us to assess the technical side and the social impact of technology. A user-centered approach is also used, in which the real needs and experiences of the people using the device are of key importance.

The reliability of the results is ensured by using different data sources and a combination of several analysis methods, which reduces the impact of subjectivity. The main limitation of the study is the limited empirical evidence, as hybrid devices, including the ExoRoller, are at an early stage of implementation. However, the chosen case study format makes it possible to compensate for this by analyzing the specific case in more depth.

In general, the chosen methodology provides a comprehensive consideration of hybrid assistive technologies as part of modern inclusive and socially oriented innovations. The use of mixed methods, systems analysis, and case studies provides a comprehensive understanding of the research topic and assesses the potential of hybrid devices to enhance users' mobility, autonomy, and social integration.

3.2. Data collection methods: observation, interviews and document analysis

The data collection methods used in this study, were selected to address the need for a comprehensive study of the ExoRoller device, encompassing both the technical and social aspects of its operation. Given the interdisciplinary nature of the study, a qualitative data collection method is particularly important, ensuring the acquisition of in-depth, detailed, and contextually relevant information. The analysis reveals that human interaction with such devices is formed at the intersection of the functional characteristics of the technology, the individual characteristics of the user and environmental conditions.

In addition to observation and document analysis, primary data were collected through a structured questionnaire and semi-structured interviews. The questionnaire was administered exclusively to current ExoRoller users, that is, individuals who had already purchased and were actively using the device. As a result, it became possible to collect data on user experience and evaluate the real-world effectiveness of ExoRoller on mobility, independence, psychological status and social participation.

Semi-structured interviews were selected because they provide a balance between consistency across participants and flexibility to explore individual experiences in greater depth. This format was particularly appropriate for the study because participants represented different stakeholder groups and could provide different perspectives on the usability, technical characteristics, and social impact of ExoRoller (Kvale & Brinkmann, 2009).

Current ExoRoller users were identified with the assistance of MBionics during my internship at the company. MBionics authorized the collection of primary data for the purposes of this research and facilitated access to individuals who had purchased and were actively using the ExoRoller. These individuals were invited to participate voluntarily in the questionnaire and interviews. Only participants with direct experience of using the ExoRoller were included in the user group.

Interview was carried out with rehabilitation specialists and professionals who worked on the project and implemented device development. This strategy made it possible to complement users' questionnaire responses with professional perspectives on the device's functionality, usability, technical development, and practical implementation.

The survey consisted of 19 questions organised into six thematic blocks. Section one collects basic background information about respondents, including their mobility limitation category as well as whether or not they had prior experience with assistive devices. Section two queried users about ExoRoller usage patterns (how long they used it, how frequently they used

it during the day, and what functions they accessed most often). Section three addressed issues related to increased independence by asking users to rate how much ExoRoller helped them complete daily activities on their own and how much it helped them avoid needing assistance from another person. Section four queried users about issues related to the device's convenience and safety (how easy ExoRoller was to use and how useful it was for urban environments. Section five asked users about psychological aspects such as how using the device made them feel in terms of confidence, self-esteem, and emotional comfort. Section six provided users with an opportunity to give an overall assessment of ExoRoller by identifying what they felt were the greatest challenges with using ExoRoller and what benefits were most important to them.

The questionnaire consisted of various questions types. Some questions allowed respondents to pick only one option, while other questions were scaled on a five-point Likert scale from 1 being the lowest level to 5 being the highest level. Based on the question they would answer 1 as strongly disagree or very low, 2 as disagree or low, 3 as neutral or moderate, 4 as agree or high and 5 as strongly agree or very high. There are multiple choice questions, optional questions if users did not want to disclose some information, and open-ended questions for additional comments.

The questionnaire was developed based on the theoretical framework and the literature reviewed in Chapter 1. The selection of the questionnaire dimensions was particularly informed by the WHO and UNICEF (2022) framework on assistive technology, which emphasizes mobility, independence, accessibility, participation, and quality of life. The questions related to autonomy and social participation were also informed by Sen's (1999) capability approach, while the dimensions concerning accessibility and inclusion were linked to the inclusive innovation framework discussed by Heeks (2013). Based on these theoretical foundations, the questionnaire was structured to assess users' experience with ExoRoller in terms of mobility, independence, usability and safety, psychological well-being, and social participation.

The interview questions revolved around how beneficial ExoRoller was to the user. This included questions about technical aspects, functionality, quality of life when using it, barriers and opportunities of implementing it more widely.

The combination of questionnaires, interviews, observation, and document analysis made it possible to integrate standardized quantitative data with in-depth qualitative insights. This methodological triangulation enhanced the reliability of the findings and provided a comprehensive understanding of ExoRoller as an inclusive and socially sustainable innovation.

3.3 Data analysis strategy and limitations of the study

The approach to data analysis, which is used in this study is based on qualitative research logic and allows enabling of structured processing, interpretation and comparison of the empirical material obtained during observations, interviews and document analysis. Considering the interdisciplinary scope of the research, the analytical procedure is oriented toward the integration of heterogeneous data types, including behavioral observations, subjective accounts, and documentary evidence. All of this allows to create an inclusive analytical view of how the ExoRoller hybrid solution functions and how it is integrated into wider processes of inclusive and social innovation that can be considered sustainable. Method triangulation was used, meaning the study analyzed information gathered through various sources, which can increase validity of research outcomes and decrease likelihood of subjective bias.

Triangulation offers a possibility of comparing research findings as well as making sure the results of these measurements are consistent when collected through different means (observation, interview, documents). Presented analytical procedure of the study is structured as multilevel processing leading towards organizing heterogeneous empirical material into sensible and interpretable outputs. Instead of analysing observational, interview and document-

related data separately study will follow the principle of their gradual integration that allows recognizing embedded patterns, possible contradictions and dependencies within explored phenomenon.

The interview material was subjected to qualitative content analysis using a thematic coding approach. Interview data were analyzed through thematic analysis, which provides a systematic yet flexible approach to identifying, organizing, and interpreting recurring patterns within qualitative data (Braun & Clarke, 2006). The analysis involved familiarization with the interview material, initial coding, grouping related codes into broader themes, and interpreting these themes in relation to the research questions. During the initial phase of analysis, the primary material (i.e., interview transcripts) was segmented into meaning units, then encoded in an "open" manner, thus giving rise to conceptual categories. Examples of categories formed at this stage of analysis include usability experience, satisfaction degree, perceived effectiveness, functional limitations, mobility increment, effectiveness expectations, and social rehabilitation outcome. Subsequently, axial coding would reassemble these codes into larger categorical relationships. Interpretive coding will then review those categorical structures against the study goals so as to determine prevailing trends characterizing users' and experts' experience with the ExoRoller.

Secondary data from documents such as technical manuals and descriptions, scientific publications, business documents of LLP "MBionics", normative and technical documentation and industry reports were analyzed with the use of content analysis. The document analysis included several types of materials related specifically to ExoRoller: the ExoRoller product presentation, technical specifications, user instructions, information published on the official MBionics website, internal company documents related to the development and functionality of the device, and reports from ExoRoller testing. These materials were analyzed to obtain information about the device's technical characteristics, functionality, development process,

intended use, and results observed during testing. These materials were reviewed to extract necessary information about the logic of design and functioning scheme of the device, context of development and so on. Attention was drawn to the correlation between official technical characteristics of the device and characteristics observed during research to allow further verification of results and limiting ambiguity of conclusions.

Triangulation occurs through the process of comparing results. Methodological triangulation was used by comparing evidence obtained from interviews, observation, questionnaires, and document analysis. The use of multiple sources of evidence is particularly valuable in case study research because it enables findings to be cross-checked and strengthens the credibility of the interpretation (Yin, 2018). The data obtained during the observations is compared with the interview data to determine whether what users are saying corresponds to what they are actually doing. Documents served as another data source that helps to interpret results placing them into a wider context of science and technology development.

Observation was used to complement participants' self-reported experiences with direct evidence of how the device was used in practice. Observation is particularly useful in case study research because it enables the researcher to examine behaviours and interactions within their real-world context (Yin, 2018).

Validity of this type of triangulation is achieved by repeating the process of data verification, coding operations and cross-checking survey methods. One aspect of interpretation that can affect objectivity is researcher bias. It is addressed through rigorous, methodical and transparent data analysis.

Methodological triangulation was used by comparing evidence obtained from interviews, observation, questionnaires, and document analysis. The use of multiple sources of evidence is particularly valuable in case study research because it enables findings to be cross-checked and strengthens the credibility of the interpretation (Yin, 2018).

While this study is limited by sample size and qualitative data, this does not diminish the analytical power of the method. Quite the contrary, given the case-study approach taken, focusing on ExoRoller as a sociotechnical system allows prioritization of interpretation of processes over statistical generalizability. Perspectives are diversified through inclusion of users, rehabilitation specialists, and professionals to create stronger interpretation through richer data.

Interviews that produce subjective data are not considered on an individual basis. Instead, data are coded into units that can be analyzed comparatively to decrease variance and find points of semantic stability between respondents. Interview data can then be triangulated methodologically with observational and documentary data to produce more consistent findings with stronger interpretation.

3.4 Ethical aspects of the research

The ethical components of this research project are of primary importance since study participants are users of assistive devices, and data processed during the research directly relates to their personal experience with the ExoRoller (LLP “MBionics”) device. Due to the nature of the topic under study, which involves participants’ health, mobility and subjective well-being experience, particular attention needs to be paid to research ethics and scientific integrity principles.

The ethical framework underlying this study includes several interrelated principles guiding how participants are involved in the research project and how research data is collected, stored, accessed and used. Before collecting any research-related data from participants, they were provided with information about the study’s purpose, procedure, applied research methods, and potential consequences of providing their data for this research. The information was given in a way that was easy to understand and participants’ consent to be involved was

only requested once they had independently decided they wanted to participate. During all stages of the research, participants had the immediate right to stop their involvement and withdraw the provided data without explanation.

A further important principle is about maintaining confidentiality and anonymity of personal data. All pieces of information received throughout the study are treated confidentially and will not be presented in an identifiable form. Transcripts, notes from observations, and any additional documents will remain anonymous from the beginning of data processing. Any potential clues that might identify respondents were removed from outputs or future publications. This action is taken in order to protect privacy.

Nonmaleficence is another ethical principle that guided the development of this study. As this study will involve participants with disabilities, it was ensured that all data collection will not result in excessive physical activity, mental distress or other discomfort for the respondents. The entire data collection process was constructed in a way that would not contradict their medical condition or personal limitations. Individual has a right to pause or stop the interview at any time if you do not feel comfortable continuing the study.

Additionally, the researcher will treat each respondent with dignity and avoid showing bias. Throughout the interview and observation processes, the researcher will remain neutral and won't lead respondents to specific answers. The researcher will not judge respondents, pressure them to answer questions in a certain way, or exhibit biased behaviors.

Ethical responsibility also relates to the use of secondary data sources. All documentary materials utilized as part of analysis are chosen and used in compliance with academic integrity guidelines. Information from existing studies and institutional reports are not misrepresented through either incorrect citation or falsification of data. Any openly sourced materials adhere to the guidelines of academic integrity by citing properly, giving credit to authorship and

sources, and negating plagiarism. This ensures transparency of research and substantiates the scientific merit of study.

Maintaining objectivity and scientific integrity when analyzing and interpreting collected data is another crucial aspect of this component. Reporting the findings of research is completed in a way that does not falsify results through leaving data out, skewing information, or offering biased interpretation. This factor is especially important when analyzing innovative technological developments that tend to frame conclusions to match expectations or subconsciously align with received results. To prevent this issue, data is conveyed in full volume in an accessible form without significantly cropping information.

4. Results

4.1. General characteristics of the company LLP “MBionics”

LLP “MBionics” is Kazakhstan company developing assistive devices. MBionics develops engineering solutions for individuals with mobility disabilities. It works at the cross section of medicine and engineering design. Devices designed by LLP “MBionics” are aimed to aid movement, assist motor function and help increase daily life independence. Its product line includes bionic prosthetic systems, robotic exoskeletons, and hybrid mobility devices that combine different functional principles within one structure.

Founded in 2018 by engineer Maulen Bakhytbekovich, the company has developed as a small private organization with a full-cycle production model. This means that all stages of work—starting from idea generation and design development and ending with prototyping, testing, and final adjustment—are carried out within a single team. The described approach allows to consistently continue development and quickly adapt technical solutions based on test results or user needs.

One of the key directions of LLP “MBionics” is the development of next-generation assistive systems, the functions of which go beyond mobility support alone. The company is focused on technologies that compensate for physical limitations and help improve the user’s quality of social involvement. In this context, LLP “MBionics” projects such as bionic upper-limb prostheses or hybrid systems ExoRoller are developed as all-in-one solutions that unify mobility assistance, postural support and adaptation to usage conditions. A distinctive feature of the company’s work is the emphasis on personalization. Each device is developed with consideration of individual user characteristics, including body structure, medical condition, and level of physical activity. This individualized approach improves usability and ensures that technical solutions are better aligned with real-life rehabilitation and daily needs.

LLP “MBionics” cooperates with health facilities and rehabilitation centers, providing an opportunity to test the developed products under applied conditions. This is a good way of improving design decisions and matching technologies to real demands. Furthermore, the company is involved in various projects concerning inclusive development and accessibility, promoting this social initiative in Kazakhstan.

From an organizational point of view, the company is represented by a compact team of engineers, programmers, and technical specialists. The company’s limited resources do not prevent it from implementing engineering projects of considerable complexity, which is facilitated by its flexible, project-focused structure. Workflow is also arranged such that various specialists self-coordinate when completing certain development stages.

In general, LLP “MBionics” may be viewed as an innovation-driven engineering company with activity focus on development of medical rehabilitation technologies. Its mission is centered around development of assistive devices that help people with disabilities maintain mobility and participate in social life.

Organizationally, the company has a project-oriented structure typical for small high-tech companies. There are not many management levels, but the functions are distributed within the team according to type of activity.

Thus, LLP “MBionics” can be characterized as an innovation company with engineering development linked to practical social applications. Its work contributes to the advancement of assistive technologies while simultaneously addressing issues of accessibility, rehabilitation, and quality of life improvement for end users. The presented organizational structure diagram demonstrates the key management levels and interrelations between the company's units, including engineering, software, production, and administrative functions (Figure 1).

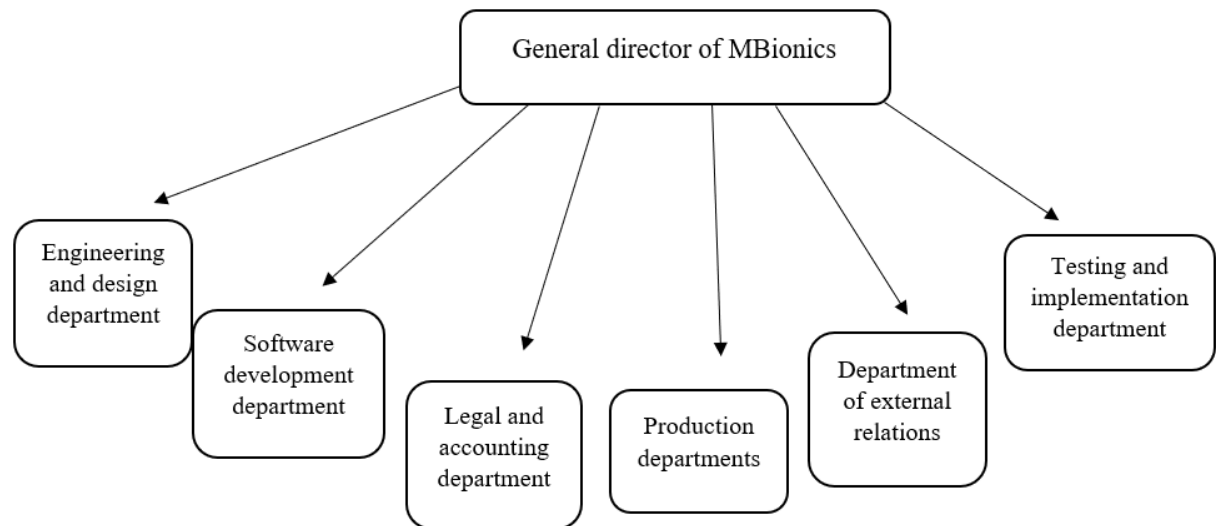


Figure 1. Organizational structure of LLP “MBionics”. Source: MBionics.kz, reproduced with permission.

The organizational management model of LLP “MBionics” is represented by a mixed model with elements of functional and project structures that fit well with the nature of assistive technology development. Specialists are grouped by functional areas of activity and also work in teams created for the development of specific products. Thus, along with professional specialization of employees of LLP “MBionics”, there is also interaction of experts in various fields in a single process.

Management of the organization is centralized at the head level and concerned with setting priorities and vector of long-term development. The coordination of activities is carried out from a single center, which unifies decisions and processes with the development strategy. At the same time, operational responsibilities are distributed across distinct development areas responsible for successive stages of the product lifecycle. These stages include conceptual design, engineering development, prototyping, testing, and implementation. Such a structure allows each stage to be addressed in a more focused and technically detailed manner while maintaining overall process coherence.

A key feature of the company's functioning is the strong reliance on a project-oriented approach. This approach allows for a high degree of organizational flexibility and facilitates swift response to changes in technical specifications and customer demands. Moreover, it allows managing iterative processes, when testing results and real operation evaluation are fed into the product improvement process. All this is especially useful when developing assistive technologies since their application can be optimized based on user characteristics and feedback received in operating conditions.

Therefore, structural organization of LLP "MBionics" can be defined as flexible-centralized since its structure allows controlling the process of any development at the strategic level while enabling the flexible distribution of tasks among specialists and quick integration of new developments. This approach allows maintaining the dynamics of sustainable development of the company and efficiently converting engineers' developments into actual assistive technology used by end consumer.

To review MBionics' activity and identify areas for development in the field of inclusive and socially sustainable innovation, a SWOT analysis was conducted. An analysis makes it possible to systematize the factors that determine the company's competitive advantages and disadvantages and show opportunities and threats that exist in the business environment. The analysis results can be used to develop strategic recommendations for strengthening the company's position in the assistive technology market and improving the effectiveness of innovative solutions, including products such as the ExoRoller, developed by MBionics (Table 2).

Table 2: SWOT analysis of LLP “MBionics”

Strengths (S)	Weaknesses (W)
1. Availability of innovative developments in the field of assistive technologies. 2. In-house engineering competencies and R&D potential. 3. Individual approach to product development. 4. Experience in the development of bionic prostheses and exoskeletons. 5. Availability of unique products (ExoRoller).	1. Limited financial resources 2. Small scale production 3. Limited brand recognition 4. Limited distribution channels
Opportunities (O)	Threats (T)
1. Growing demand for inclusive technologies. 2. State support and inclusion programs. 3. Development of the market for medical and rehabilitation technologies. 4. Opportunities for international cooperation. 5. Implementation of digital and intelligent technologies.	1. High competition from international manufacturers 2. Dependence on imported components 3. High cost of innovative developments 4. Limited purchasing power of the target audience

Another interpretation of SWOT profile of LLP “MBionics” is the summary in terms of internal and external factors determining the company’s current position.

Another interpretation of SWOT profile of LLP “MBionics” is the summary in terms of internal and external factors determining the company’s current position. In terms of internal factors, LLP “MBionics” has quite strong intellectual resources due to engineering skills and experience in developing its own prototypes of Assistive Technologies. From this point of view, focus on individual solutions for individual customers is an important asset, making these

products topical in terms of inclusion and social direction of innovations. This trend can be defined as one of LLP “MBionics” core strengths.

On the other hand, all limitations defined as LLP “MBionics” weaknesses also have internal origin. They include small amount of financial and production capacities which limits business growth and ability to produce assistive devices on mass scale. Weak brand awareness also decreases company attractiveness in the general marketplace. Smaller human resource base also increases its risk exposure, especially in terms of staff turnover. Challenges in developing stable distribution channels also limit market penetration and product diffusion.

In terms of the external environment, the company operates under conditions that simultaneously create growth potential and structural challenges. Among the opportunities, it can be highlighted an increase in the population’s demand for AT solutions – due to demographical and social trends, as well as a growing interest for inclusion-related policies. Digital transformation trends and international cooperation development also provide opportunities for upgrading technology and entering new markets.

An analysis of the relationship between the internal strengths and weaknesses of the organization and external opportunities shows that LLP “MBionics” exists in an environment with high innovation potential, however, heavily reliant on available resources and scaling challenges. At the same time, the company faces a number of threats, including intense competition, dependence on imported components, regulatory restrictions, and the limited purchasing power of its target audience.

4.2. Development and technical features of ExoRoller

ExoRoller represents a hybrid assistive mobility system designed as an integrated engineering platform that combines the functional principles of a wheelchair, a verticalization-support mechanism and a rehabilitation device. Its defining characteristic is that it allows the

operation mode of sitting and standing within the same equipment, without having to switch devices. A person can stay in standing position, take steps while on the spot for rehabilitation purpose or even walk from one place to another. Furthermore, ExoRoller is designed to both serve its purpose during rehabilitation exercises but can also be used in the long run as a daily permanent mode of transportation. With this technology, the capabilities of assistive mobility in daily life are increased while allowing for a more versatile form of support.

The main technical specifications of ExoRoller are presented in Table 3.

Table 3: Main technical specifications of ExoRoller

Parameter	Specification
User height	90-190
Maximum user weight	120 kg
Device weight	70 kg
Dimensions (L × W × H)	100 × 66 × 130-140 cm
Maximum speed	10 km/h
Battery life	Up to 6 hours
Verticalization angle	Up to 90
Intended use	Rehabilitation and everyday mobility
Target users	Individuals with musculoskeletal impairments, including cerebral palsy (CP). The device requires a sufficient level of physical condition, the ability to maintain a stable body position, and the absence of medical contraindications.



Figure 2. ExoRoller. Source: MBionics.kz, reproduced with permission.

The ExoRoller has a control panel that the user interfaces with. The interface includes power controls, activation and deactivation of the stepping function, a joystick for controlling device movement, speed adjustment buttons, a verticalization control, a battery charge indicator, and a charging connection. This allows the operator to control the basic mobility and rehabilitation features with the unit.

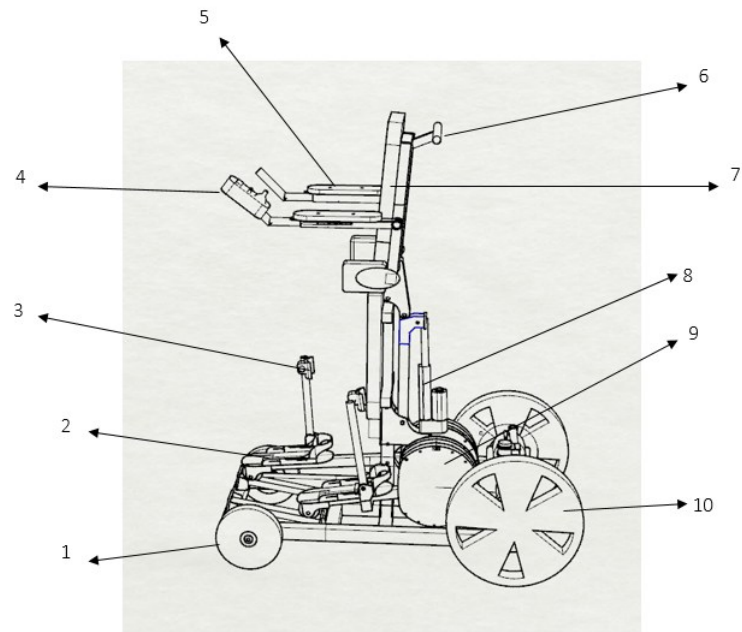


Figure 3. Main components of the ExoRoller. Source: MBionics (2025), reproduced with permission.

1. Front wheel 2. Foot support 3. Knee support 4. Joystick control 5. Armrest 6. Handrail 7. Back cushion 8. Linear motor 9. Axial motor 10 .Rear wheels

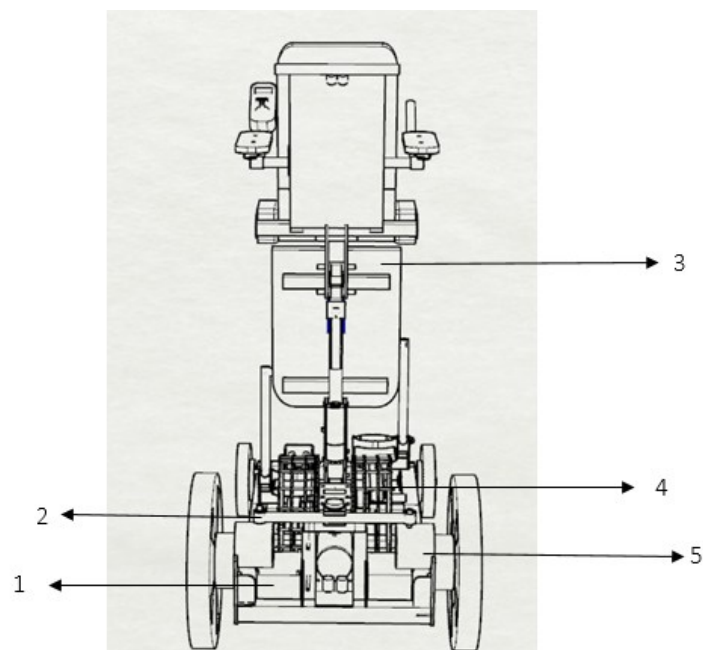


Figure 4. Main components of the ExoRoller (2). Source: MBionics (2025), reproduced with permission.

1. Battery 2. Flywheel 3. Chair 4. Motor 5. Electric drive motor

Structurally, the device follows a modular architecture in which mechanical, electronic, and software subsystems are interconnected but remain technically distinguishable for adaptation and optimization. The mechanical frame forms the structural basis of the system and is engineered to withstand variable and dynamic loads. The frame consists of lightweight yet sturdy materials. It includes advanced aluminium alloys and carbon fiber reinforced plastics. Joints between sections are designed to maintain defined motion between operational states; motion is carefully managed to maintain stability.

Mode transitions are accomplished via actuation systems. They translate power into directed force to raise or lower the apparatus as well as control its position. Actuators may vary based on the desired size and specifications. Selection usually involves torque demand, overall robustness, and safety factors. Operation is synchronized by means of an onboard computer or controller. The controller includes numerous sensors to gauge tilt angle, load, and position. Sensor data is then analyzed to produce signals that can adjust the posture of the apparatus and smooth transitions between positions. This allows the apparatus to maintain stability while changing modes or when external conditions change. It would also allow for it to adapt to changing surface elevations and user position.

Software closes the loop by tying all the electronics and mechanics together. It is tasked with keeping the modules in sync. This includes programs that allow the system to balance itself, control motion, and interface with the user. Additional logic may be implemented under special circumstances to alter how the device reacts to user inputs. For manual actuation, the user can make use of joysticks or other input devices.

Comfort is another factor that has been taken into consideration. Adjustable parts of the apparatus, such as seat height, backrest angle, and rollers, allow users to tailor the product to their own needs or medical conditions. If done properly this would allow for less user fatigue and better weight distribution. Standing up straight is also known to provide better blood-flow and reduce blood-pressure concerns from sitting too long. For instance, users can adjust the load applied to their arms. Standing up straight is also known to provide better blood-flow and reduce blood-pressure concerns from sitting too long.

Stability is also achieved by using redundant safety features. These may include but are not limited to: load sensors, automatic balancing features, cut-off switches, and 'safe zones' enforced by software. Variable constraints can also be placed on the system depending on the mode it is in. This minimizes the chance of user error leading to a dangerous state. As such, the ExoRoller utilizes a variety of systems all working in tandem. Its design combines mechanical, electronic, and software solutions, allowing for adaptation to the user and operating conditions. This fact turns such developments into a very promising direction in assistive technology development and an important step towards providing people with disabilities with greater accessibility.

4.3. Market application and first results of implementation

The appearance of hybrid types of mobility devices such as ExoRoller LLP “MBionics” is explained by the high level of interest shown by society in innovative developments in recent years. Rehabilitation market itself is specific: firstly, it represents the intersection of medicine, engineering and social sphere sectors. Secondly, as this product doesn’t belong to mass-markets, its potential audience is quite limited: people with disabilities and organizations working in the field of rehabilitation.

Pilot projects play a key role in the initial stages of implementation. These are the conditions under which the device is tested in real-world use. This allows to understand its usability in everyday use. Feedback from users and specialists is very essential: it helps identify both successful solutions and areas requiring improvement. Practical experience shows that such devices can expand human capabilities – in terms of mobility and in terms of vertical positioning, which impacts overall well-being and activity.

From the point of view of economics, such developments are usually considered niche products and relatively expensive solutions. The reasons for this include the high cost of development of such devices, complicated design, and small production volumes at the initial stage of sales. However, as production experience is gained and volumes grow, there is an opportunity to reach an acceptable level of cost optimization. Support could be provided by various programs and initiatives from the government for developing an inclusive environment and implementing innovations.

Practice with the ExoRoller shows, such a device can be used both as means of mobility and as rehabilitation equipment. Using it for rehabilitation purposes in the medical settings helps restore motor activity, develop muscle activity and coordination. The periodic transfer of the patient to an upright position with the help of ExoRoller is used to eliminate negative effects of sedentary lifestyle, which is very important during comprehensive rehabilitation.

As far as people perception was concerned, they noted that those kinds of devices allow them to have more independence in their daily activities and give them a feeling of self-confidence. Control over movement and the ability to change positions without assistance gives a feeling of independence. Also, this factor affects patients on a psychological level by expanding the possibilities of their activities and providing more opportunities to communicate with people and socialize. To assess how ExoRoller influenced emotional state of users there was conducted a questionnaire with specific questions asking how do people feel after using

such device. As a result, many of the respondents noted that they had more self-confidence, more independence, increased motivation to continue rehabilitation. Respondents also noted improvement of their emotional state.

The final sample consisted of 13 respondents who represented the main group of interest: ExoRoller users.

The full versions of the questionnaire are presented in the Table 4.

Table 4: Questionnaire

Question	Response options
Section 1. General information	
1.E-mail	Personal email
2.Name and Surname	_____
3. Type of mobility limitation	- Spinal cord injury - Cerebral palsy - Muscular dystrophy - Stroke - Other: _____ - Prefer not to say
4. How long have you been using assistive devices for mobility?	- Less than 1 year - 1–3 years - 3–5 years - More than 5 years
Section 2. Using ExoRoller	

Table 4: Questionnaire (continued)

5. How long have you been using ExoRoller?	- Less than 1 month - 1-3 months - 3-6 months - More than 6 months
6. How often do you use ExoRoller per day?	- Less than 1 hour - 1-3 hours - 3-5 hours - More than 5 hours
7. ExoRoller features do you use most regularly?	- Stroller mode - Upright mode - Both modes
Section 3. Independence assessment	
8. ExoRoller increases my mobility in daily activities.	1-5
9. ExoRoller reduces my need for assistance from others.	1-5
10. ExoRoller help me participate in my social life (meetings, travel, work)	1-5
Section 4. Convenience and safety	
11. How safe do you consider ExoRoller?	1-5
12. How convenient is ExoRoller to use?	1-5

Table 4: Questionnaire (continued)

13. How easy is it to use ExoRoller in an urban environment (streets, shops, transport)?	1-5
Section 5. Psychological well-being	
14. I feel more confident when using ExoRoller.	1-5
15. Using ExoRoller improves my self-esteem.	1-5
16. I feel emotionally comfortable while using ExoRoller.	1-5
17. I would recommend ExoRoller to other people with limited mobility.	1-5
Overall evaluation	
18. What difficulties or limitations do you experience when using ExoRoller?	- Difficulty of control - Physical fatigue - Infrastructure barriers - Maintenance requirements - Limited battery life - Discomfort during prolonged use Other: _____
19. What do you consider to be the most important advantages of the ExoRoller?	- Independence - Mobility - Social integration - Improved health Other: _____

The questionnaire was administered to current ExoRoller users and was designed to assess the device's impact on mobility, independence, convenience, safety, psychological well-being, and social participation.

The obtained data were processed through statistical aggregation methods, primarily by computing mean scores for each survey item and examining the overall distribution of responses. This allowed us to identify key trends in the perception of hybrid technologies, determine their level of social and economic acceptability, and assess the potential demand for such devices (Table 5).

Table 5: Scores on key survey questions

Question	Average score (1-5)	Interpretation
Increase in mobility in daily activities	4.6	Very strong positive impact on everyday mobility
Reduction in need for assistance from others	4.3	Significant increase in independence
Improvement in participation in social life	4.5	Strong positive effect on social inclusion
Perceived safety of ExoRoller	4.2	High level of trust in the device
Convenience of use	4.1	Positive assessment of usability
Ease of use in urban environments	3.9	Moderately high level of practicality

Table 5: Scores on key survey questions (continued)

Increase in confidence	4.5	Strong positive psychological effect
Improvement in self-esteem	4.3	Noticeable improvement in self-perception
Emotional comfort while using ExoRoller	4.4	High level of emotional well-being
Willingness to recommend ExoRoller to others	4.7	Very high overall satisfaction and acceptance

As evidenced by the survey results, there is considerable interest in hybrid assistive technology and positive expectations regarding its beneficial features. Respondents largely suggest that this kind of technology contributes to meaningful daily activity, particularly improved mobility and independence, as well as social integration overall.

Ease of use in cities had the lowest score among the main survey questions with an average of 3.9/5. This could also be viewed as a somewhat positive result, yet it may imply that users experience certain challenges while using ExoRoller outdoors in real-life conditions (uneven road surface, curbs, tight spaces, lack of access to public spaces etc.). This means that, despite general positive experiences with the device, the urban environment itself as an external factor can still impact the usability of ExoRoller in users' day-to-day lives.

Conversely, the question about willingness to recommend the device scored the highest, with an average of 4.7. This indicates a strong sense of satisfaction and general acceptance of the ExoRoller among those surveyed. Furthermore, the results confirm significant positive influence of the device on users' mobility and sense of independence, as well as confidence, self-esteem and social life.

In general, the survey confirmed the pertinence of hybrid assistive solutions like ExoRoller and highlighted their significant potential in the domain of inclusive and socially beneficial innovation.

Meanwhile, results from semi-structured interviews conducted with four participants were summarized in table form for ease of interpretation and visual emphasis on dominant trends. This form of data representation allows spotting similarities and differences between answers of different groups of respondents – staff that were involved in testing and building the device, and rehab experts who are ExoRoller’s partners. Responses were analyzed using qualitative content analysis, followed by grouping of statements into key semantic blocks, including experience using existing devices, evaluation of the ExoRoller's functionality and ergonomics, comparison with traditional devices, impact on mobility and independence, and identification of barriers and limitations to use (Table 6).

Table 6: Results of the semi-structured interview

Subject category	Key opinions of rehabilitation specialists	Main opinions of professionals involved in the testing	General conclusion
Experience in using other assistive devices	“Existing devices does not always meet users’ everyday mobility needs. Some users still need assistance with daily activities.”	“Traditional assistive devices often require significant physical effort.”	Existing tools have limitations in convenience.

Table 6: Results of the semi-structured interview (continued)

ExoRoller Functionality	Participants generally emphasized the usefulness of combining mobility and rehabilitation functions.	Professionals highlighted the functionality of the device but noted that the control system could be simplified.	ExoRoller was positively assessed functionally, while some improvements in usability were identified.
Convenience	“It is very important that the verticalization process is smooth and free of sudden movements.”	“The device can be adjusted to fit different users comfortably.”	ExoRoller provides several features that support user comfort, including controlled verticalization and individual adjustment.
Comparison with traditional means	Higher mobility potential.	A more technologically complex solution.	ExoRoller offers broader functionality than traditional mobility devices, although its use may require additional training and adaptation.

Table 6: Results of the semi-structured interview (continued)

Impact on mobility and independence	“Being able to change position and move more independently can make everyday activities easier for the user.”	Improving the efficiency of movement with proper settings.	The device helps improve the quality of life.
Barriers and limitations	“The device may not be suitable for every user, because each person has different physical abilities and needs.”	“The main challenge is the cost. The device has many technical components, which makes production more expensive.”	The main barriers include individual user limitations and the relatively high cost and complexity of the technology.

The evaluation of interview data allows to describe several general tendencies in the respondents' attitudes. Respondents who are clinicians are more focused on the rehabilitation aspects. From their point of view, it has some potential for helping patients recover, or at least remain functional in the long term. However, clinicians emphasize that it should be fully customised to each individual. Therapeutic outcome is determined by how much the system is suitable to their conditions, as well as its compatibility with their rehabilitation goals.

A slightly different perspective is taken by those who have been involved in the development and testing of the system. This is because their analysis is more technically based. In addition to the complexity of the mechanical and computer systems involved, this group also

points out that there is room for improvement in the design, control system, and stability of the prosthesis. Reliability and safety are also areas that have been pointed out as requiring work.

The most important barriers that were highlighted by all groups of respondents included the high price, the need for the training of the end-users, as well as the overall low availability of such solutions in practice. However, the general assessment of the results of the interviews suggests that there is a generally positive perception of ExoRoller, as well as an understanding of the further prospects for its development, if the existing limitations are taken into account, and the technical and functional parameters are appropriately developed.

The above-mentioned survey and interviews results are complemented with additional information about the market interest, obtained through the analysis of traffic of the official website. This allowed for an assessment of the domestic audience response to the product, as well as the extent to which the ExoRoller has managed to attract the attention of international visitors. According to website statistics, the product was viewed by users from a number of countries: Uzbekistan, Turkey, Georgia, Azerbaijan, Russia, Germany, China. Although website visits do not necessarily indicate confirmed purchase intentions, they provide useful evidence that the device is attracting attention from potential users, rehabilitation specialists, healthcare organizations, and other stakeholders outside Kazakhstan.

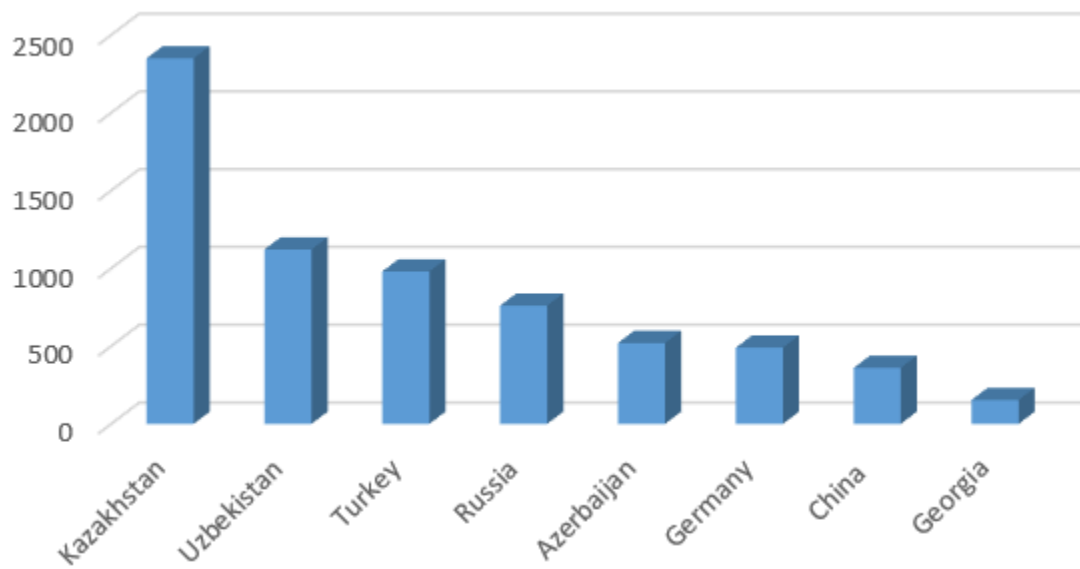


Figure 5 – MBionics website activity by country.

Source: Author's elaboration based on internal website analytics of MBionics.

The broad geographic distribution of website visitors suggests that the challenges addressed by ExoRoller are relevant in many countries. Issues such as limited mobility, reduced independence, and insufficient access to advanced rehabilitation technologies are common across different healthcare systems and social contexts. Consequently, a device that is a combination of a wheelchair, rehabilitation trainer, and verticalization system becomes interesting to a varied and international audience. Analysis of the site data shows that awareness of the ExoRoller is gradually spreading beyond the local market and reaching potential customers in both neighboring countries and more distant regions.

Especially strong interest came from countries in Central Asia, the Caucasus, and Eastern Europe, where healthcare systems may face similar challenges in terms of availability and affordability of advanced rehabilitation equipment. On the other hand, interest from Germany and China testifies to the fact that the product was also able to attract attention in larger and more developed markets, where competition is higher and users are generally more

familiar with high-tech assistive devices. This could also be taken as a sign that the concept and functionality of ExoRoller are understandable and clear to an audience with a different level of technological development and purchasing power.

Despite the international interest observed through website activity, international deliveries of ExoRoller remain limited. According to internal information provided by MBionics, one of the main challenges is the cost and complexity of international transportation due to the device's size, weight, motorized components, and electronic systems. Additional considerations include customs procedures, certification requirements, and the organization of after-sales support. Nevertheless, MBionics has already completed several international deliveries, demonstrating the practical possibility of entering foreign markets despite these barriers.

The experience of using ExoRoller in practice confirms that the main factor of efficiency is the technical feasibility of the hybrid mechanism and its adaptation to real conditions. User behavior indicates that maneuverability, the possibility of mode switching, the technical stability of the device in a variety of driving conditions have a certain significance. On the other hand, physical activity and the feeling of independence are directly linked to the convenience of the design and the logic of interaction of the human with the system.

Along with the objective parameters of operation, the subjective perception of technology is essential. Users and experts have different opinions about the potential of hybrid devices, but in most cases, they contribute to increased mobility, reduced dependence on outside help, and increased confidence in daily activities. Simultaneously, there are also negative factors associated with high cost, maintenance complexity and insufficient infrastructure adaptation.

An analysis of existing practices in the use of assistive technologies shows that traditional mobility tools, exoskeletal systems and hybrid solutions form a complementary

structure. Wheelchairs ensure a basic level of mobility and are characterized by accessibility and ease of control. Exoskeletons, on the other hand, provide support for an upright position and partial restoration of motor functions, but are still complex and costly to operate. Hybrid devices take an intermediate position, combining the advantages of both previous approaches and offering a more flexible application scenario.

Special importance is given to the trend for the integration of intelligent control systems, sensor modules and adaptive algorithms that allow the device to adapt to changes in the external environment and the user's condition. It is this that leads to the transition from mechanical means of transportation to intelligent support systems for mobility. As a result, the individualization of the use of technology increases, in which the device adapts to the physical capabilities, behavioral characteristics and living conditions of a particular person.

The social aspect of the implementation of such solutions requires special attention. The use of hybrid assistive technologies affects physical mobility, and the level of social activity, participation in educational and professional environments, as well as the degree of social inclusion.

However, the development of this area is limited by a number of factors. Economic barriers, insufficient infrastructure availability, and limited availability of high-tech solutions to a wide range of users have a significant impact. These circumstances slow down the process of mass adoption of hybrid devices, despite their high potential.

Thus, the analysis of hybrid assistive technologies allows us to consider them as an evolving class of devices located at the junction of engineering, medical and social solutions. Their further evolution is associated with increased technological adaptability, cost reduction, the development of user-oriented design and the expansion of customization options. Together, this forms a promising direction aimed at improving the quality of life and expanding the opportunities of people with limited mobility.

5. Discussion

5.1. Inclusiveness and accessibility of technology

The findings of this study suggest that ExoRoller can be considered an example of inclusive assistive innovation due to its combination of mobility, rehabilitation, and verticalization functions. The empirical findings provide two complementary perspectives: the direct experience of current ExoRoller users obtained through the questionnaire and the professional perspective of MBionics employees involved in the development and testing of the device obtained through semi-structured interviews. This combination allows the results to be interpreted from both user and professional perspectives.

The questionnaire results demonstrate generally positive perceptions of ExoRoller among its users. The highest average scores were recorded for willingness to recommend the device (4.7), improvement in daily mobility (4.6), social participation (4.5), and increased confidence (4.5). Emotional comfort was also evaluated positively, with an average score of 4.4, while independence and self-esteem both received an average score of 4.3. These findings suggest that the perceived value of ExoRoller extends beyond its basic function as a mobility device. Users associate its use not only with improved movement but also with greater autonomy, confidence, and participation in everyday and social activities.

The relationship between mobility and social participation is particularly relevant to the concept of inclusive innovation discussed in the theoretical part of this study. Improved mobility can expand opportunities to participate in everyday activities and reduce dependence on assistance from other people. In this sense, the value of assistive technology is connected not only with its technical performance but also with the opportunities it may create for users to participate more independently in society. The positive assessments of mobility, independence, and social participation observed in the questionnaire are therefore consistent

with the broader principles of inclusive and socially sustainable innovation examined in this thesis.

At the same time, the questionnaire results indicate that users' experiences are not equally positive across all dimensions. Ease of use in an urban environment has received the lowest average rating (3.9). Convenience (4.1) and safety (4.2) were also rated slightly lower than mobility and social participation. These differences are significant because they indicate that the impact of an assistive device depends on the technical solution itself, and also on the context in which it is used. The presence of infrastructure barriers, accessibility of public places, the effort required for control, maintenance, and adaptability to different environments can all affect the degree of practical benefit that the technology can provide to users.

The semi-structured interviews with MBionics employees can be used to complement these results from the user questionnaires by providing professional insight into the development and testing of ExoRoller. The employees interviewed emphasized the value of integrating several functions into one device and adapting technology to the practical needs of the users. On the other hand, the professional insights also point to challenges related to individual adjustment, user training, device control, production costs, and further technical development. These findings can help to explain the contrast between positive overall ratings of the concept and functionality of ExoRoller and its lower scores in some aspects of convenience and ease of practical use.

The combined analysis of questionnaire and interview results thus points to an important distinction between the potential value of technology and the conditions for its effective daily application. While the users' assessments show that effects on mobility, independence, social participation, and psychological well-being are evaluated positively, the professional interviews provide insight into the technical and implementation challenges that may affect these results.

Instead of being contradictory, these two perspectives thus give a more complete view of ExoRoller as an assistive product and an inclusive innovation.

In general, the empirical findings support the conclusions about the social value of ExoRoller based on its ability to integrate functional support for mobility with the promise of greater independence and participation. At the same time, the results also show that technological functionality is not the only factor that determines success in implementation. Usability, affordability, user training, individual adaptation, and the accessibility of the surrounding environment remain important factors. These findings provide the basis for the following discussion of ExoRoller's contribution to inclusive and socially sustainable innovation and the barriers affecting its wider implementation.

5.2. Social sustainability and impact on users' quality of life

ExoRoller hybrid device, developed by LLP “MBionics”, can be viewed as a tool for creating a socially sustainable environment aimed at improving the quality of life of people with disabilities. In socially sustainable innovation, the most important element is the technology’s potential for long-term positive impact on users’ social inclusion, autonomy, access to resources, and overall well-being.

Social sustainability in assistive devices depends largely on the degree of impact a specific device has on a user’s ability to participate in everyday social environments and break down social barriers. For example, in most existing wheelchairs, the logic of movement is well thought out, but at the same time, the user does not have many opportunities for equal participation in social situations. Hybrid systems such as ExoRoller provide an alternative interaction logic by allowing a person to move vertically, thereby changing the premises for perceiving the user and interacting with them. The eye-level communication allowed by the system in many cases results in a more natural, active position of its users (Bayley et al., 2020).

Functional changes are also associated with the physical well-being of users. With the help of the described changes in vertical positioning, using such devices, people also experience a change in the physiology of their body. For example, changes in position, which help keep the body in motion and alternate between sitting and vertical positioning, directly affect blood circulation and also carry a therapeutic and adaptive load that can reduce some of the consequences of being in the same position for a long time (Paleg & Livingstone, 2015). All this, in particular, also for a wide class of users with limited mobility, can be a direct comfort factor and a partial rehabilitation effect. In this context, the discussed device is not only a transport device; some of its effects go beyond the time of direct use and can be conditionally called maintenance of functional level over time.

An equally important condition for sustainability over a long period is the ability to demonstrate stable performance in real conditions and during long-term operation. A number of properties, in particular, structural durability, availability for maintenance, and the ability to upgrade technical characteristics, influence the relevance of the device. Modular construction, in the context of the ExoRoller project, is an important point, as it makes it possible to service or replace certain elements without redesigning the entire system. This contributes to the longevity of the product and the reduction of the total cost of its operation.

Psychological effects also play an important role in determining social sustainability. Devices allowing for the maintenance of an upright position also affect self-perception, since the reorientation of the user's body relative to the outside world also changes the user's spatial relationships. This can improve users' sense of self-confidence and reduce the emotional tension of having limited mobility. The opportunity to increase participation in everyday activities, in turn, supports a more active social identity, which is a very important determinant of life satisfaction.

Finally, the socially sustainable impact of advanced assistive technologies is manifested in the long term in the environmental and cultural plane. A shift in thinking towards greater accessibility is observed, which to some extent is facilitated by the introduction of new technologies into the environment. This, in turn, is projected onto urban planning and construction solutions. In the long run, this process should create a more barrier-aware environment and, therefore, a more balanced approach to social participation.

A wider layer of the socially sustainable effect of advanced assistive technologies is found in the slow change in environmental and cultural attitudes. A shift in thinking towards greater accessibility is observed, which to some extent is facilitated by the introduction of new technologies into the environment. This, in turn, is projected onto urban planning and construction solutions. In the long run, this process should create a more barrier-aware environment and, therefore, a more balanced approach to social participation.

Devices such as the ExoRoller are also a kind of drivers of interdisciplinary interaction, as their development and implementation require a coordinated approach between various specialized teams. In this regard, the areas of expertise are also closely related: engineering specialists need to coordinate their actions with the medical community and rehabilitation professionals, as well as directly with potential users. At the same time, the resulting interaction serves as a prerequisite for the formation of more integrated innovation systems. The long-term social effect is thus combined with the possibilities for technological development, and does not exist independently. An assessment of the social sustainability of the innovative ExoRoller device and its impact on users' quality of life was conducted based on the results of a survey among users. The survey was conducted to obtain quantitative and qualitative data on the dynamics of changes in key indicators reflecting mobility, social activity, and subjective perceptions of quality of life during ExoRoller use.

5.3. Unique value proposition and competitive advantages

The ExoRoller's value proposition is formed at the intersection of three key factors: increased user autonomy, improved quality of life, and expanded opportunities for social integration. The ability to independently control the device and switch between modes without assistance helps reduce dependence on others and increases the user's independence. The upright body position, in turn, improves physiological indicators and promotes more active participation in social interactions.

In terms of comparative characteristics, ExoRoller occupies an intermediate position between traditional wheelchairs and full-fledged exoskeletons. Unlike wheelchairs, it provides the opportunity to move to an upright position, which is important for both physiological activity and social engagement of the user. At the same time, compared to exoskeletal systems, the device does not require full robotic movement support, which makes it easier to operate and potentially more accessible to a wide range of users. It can therefore be said that this makes the product more versatile and can cover different use cases.

On the other hand, the technology is to be associated with a higher production price and a more complex engineering. The considered product segment would therefore have to be clearly assigned to a segment of the assistive technology market. Users in this market segment typically require fundamental mobility assistance, rehabilitation-focused features, the ability to adjust their posture, and a greater capacity to improve social integration. In the long run, the development of such a solution could thus be seen as a means to help the mobility market move in a more holistic and inclusive direction.

5.4. Main barriers and development prospects

ExoRoller hybrid device, developed by LLP “MBionics”, reveals a number of systemic barriers limiting its widespread adoption, as well as significant potential for further growth and improvement. Key barriers relate to economic, technological, institutional, and social factors,

while development prospects are determined by digitalization trends, decreasing technology costs, and growing demand for inclusive solutions (Table 7).

Table 7: Main barriers and development prospects of ExoRoller

Category	Barriers to development	Development prospects
Economic forces	High cost of development and production	Reducing costs by scaling up production
	Limited purchasing power of the target audience	Expanding funding through government programs and subsidies
Economic forces	High maintenance costs	Development of service infrastructure and optimization of services
Technological factors	Complexity of design and system integration	Improving modular architectures
	Limited battery life	Improving battery technology
	The need for high control precision	Implementation of artificial intelligence algorithms
Institutional factors	Difficulties of certification and standardization	Developing international standards for assistive technologies
	Regulatory restrictions	Harmonization of the regulatory framework

Table 7: Main barriers and development prospects of ExoRoller (continued)

Market factors	Limited sales market	Segment expansion driven by growing demand for inclusive technologies
	Low user awareness	Active promotion and information
Social factors	Insufficient accessible infrastructure	Development of a barrier-free urban environment
	Limited user adaptation	Training programs and user support
	Stereotypes and social barriers	Raising the level of inclusive culture

As with most other hybrid technologies, the primary barriers to the development and commercialization of ExoRoller are its cost and complexity, alongside more ‘institutional’ limits. These are typical barriers to early-stage technological developments and, as a result, usually require system-level, coordinated intervention rather than single-point interventions.

The sector future is generally optimistic, but this is contingent on multiple factors. A reduction in cost, production technologies improvement, digital enablement, and external support from government and international stakeholders, among others, all contribute to the environment in which these devices can become more widely accessible and diffused. Additionally, the development of inclusive infrastructure and increased public awareness of the capabilities of modern assistive technologies are playing a crucial role.

Taken together, this suggests that, provided key barriers are addressed, hybrid devices such as the ExoRoller have high potential for scalability and could play a significant role in the provision of mobility and social inclusion services for people with disabilities.

5.5. Theoretical implications for the concept of inclusive innovation

The theoretical analysis shows that inclusive innovations emerge at the intersection of numerous approaches to sustainable development, social innovation, inclusion, and human-centered design. Unlike traditional innovations, they focus on the accessibility of technologies for different population groups, including vulnerable groups.

In the sustainability discourse, such innovations are increasingly seen as solutions that do not directly but rather indirectly intervene in existing structural inequalities and make various functional and social opportunities more accessible. Their specificity lies in the fact that they are designed with user groups in mind that are often underrepresented in conventional market-driven development.

Conceptually, inclusive innovation is defined as the confluence of technological, social and institutional factors. These components do not have to be seen as distinct layers, on the contrary, they interact. On the one hand, technologies make it possible to implement solutions at the operational level. On the other hand, social needs provide a direction and an understanding of their relevance. The last element, the institutional context, supports this at the level of regulation and institutional initiatives.

This also means that such innovations cannot be understood as purely commercial products. The measure of their value is not primarily the market logic, but at the same time they are also means of changing structures of accessibility, participation and everyday conditions of life. For this reason, an evaluation is also necessary with a broader set of criteria than just economic efficiency. It also needs to include social impact and inclusiveness as an outcome

measure. A human-centered approach in which users are involved in the development of solutions plays an important role in this. This aspect is particularly important for assistive technology since there is also a need to take into account individual differences. Public policy also plays an important role in the development of inclusive innovation, as support in the form of programmes, subsidies and regulations helps to expand access to them and encourages their use.

In the context of digitalization, the relevance of inclusive innovation is increasing. The use of modern technologies makes it possible to create more flexible and personalized solutions, as well as to expand access to them through digital services. Thus, inclusive innovation is a complex phenomenon that combines technological and social aspects and aims to create a more accessible and equitable environment.

5.6. The significance of the study for the innovation environment of Kazakhstan

The empirical analysis and discussion of inclusive and socially oriented innovations are conducted on the example of the hybrid assistive technologies platform and the ExoRoller developed by the LLP “MBionics”. The obtained results contribute to the emerging innovation discourse and policy in Kazakhstan, which has been recently engaged in modernizing the national economy towards digitalization, diversification, and social awareness.

On the conceptual level, the conducted study enriches the current conceptualization of innovations in Kazakhstan by introducing an inclusive lens, while the focus on innovation used to be traditionally set on technology output and its commercial returns. The country’s innovation support has a stable institutional framework that focuses on tools for competitive economic performance, with social policies often staying apart. As far as socially inclusive innovation policy is still at its infancy globally, the analysis of inclusive and socially oriented innovation moves the conceptual boundary in this direction. This is because the attention to

user needs diversity and its accommodation in technological solutions is already being foregrounded.

On the applied level, the research results could be useful for some revisions of the policy design concerning both innovation governance and social support policies. The analysis of distinctive features of hybrid assistive technologies has allowed for the identification of possible areas for additional research or elaboration of different types of legal tools, funding schemes, or other forms of institutional support. This may be relevant against the background of the current period of technological modernization that is accompanied by the focus on social equity and accessibility.

An additional layer of relevance is associated with the development of entrepreneurial and startup activity in the field of assistive technologies. The ExoRoller case illustrates how locally developed engineering solutions can evolve within a niche that combines technological innovation with clear social demand. This points to the potential for emerging ventures to contribute to the formation of socially meaningful innovation trajectories. This could contribute to the creation of a favorable environment for the emergence of new startups in the field of assistive technologies, medical devices, and solutions for people with disabilities. In turn, the development of this segment could become a driver of innovative growth and investment in the country's economy.

A different vector of influence is the research impact on the state and development of human capital and the educational ecosystem. Inclusive innovation by definition cannot be implemented within the framework of a single discipline. This process is based on the merging of engineering and medical knowledge, information technologies and social sciences. As this process deepens, expectations about professional training gradually change: isolated specialization becomes less relevant, competencies are moving toward an integral level. The focus of attention shifts to the preparation of specialists for work in hybrid professional settings,

which also has an impact on the quality of human capital in the long run and the adaptive capacity of the national innovation system.

The significance of such processes also carries over to the area of social policy. In the national context of Kazakhstan, assistive technologies, in the process of their implementation, turn out to be closely related to issues of medical rehabilitation, but also to broader issues of participation and inclusion. This also affects access to education, employment, public space for people with disabilities and helps to remove structural forms of exclusion, which is consistent with the current state-level priorities of equal opportunities and social cohesion.

Simultaneously, there is a focus on infrastructural conditions for the long-term implementation of technologies. The spread and effectiveness of innovative solutions are in many ways due to the presence of testing environments, certification routes, applied research platforms. In a practical sense, this is about laboratories, pilot facilities, as well as other collaborative mechanisms and channels that connect public structures and private developers. In the case of assistive technologies, the question of infrastructure is key. The presence of a solid infrastructure and iterative training processes in it determines whether a device can be flexibly adapted to the variability of real users' needs and environmental conditions.

An additional aspect is added if Kazakhstan's position in the international innovation ecosystem is considered. The case of the ExoRoller is evidence of an opportunity for entry into global collaboration structures. The exchange of technological know-how, the development of joint projects and cooperation with external partners can integrate it into global knowledge flows.

From the point of view of the economic environment, inclusive technologies themselves form new segments of activity. Demand for assistive products and systems underpins the emergence of specialized markets, from production and supply to maintenance and service. In this way, over time, conditions are created for the development of small and medium-sized

businesses and the expansion of employment opportunities in high-tech and socially oriented sectors.

In the long run, the discussed issues and the implementation of the proposed approaches in the study can contribute to the transformation of Kazakhstan's innovation system in a social sense, technological maturity and international competitiveness. This is particularly important in the face of global challenges related to the digitalization of the economy, demographic changes, and the need to ensure sustainable development.

5.7. Comparison with international practices

ExoRoller hybrid device, developed as part of the study and created by LLP “MBionics”, with international practices in the field of assistive technologies allows us to identify key developments in this industry, as well as determine the degree to which the solution under consideration complies with global trends in inclusive innovation.

Current international practices in the field of assistive technology are characterized by a high degree of technological maturity, the active implementation of robotics, artificial intelligence, and sensor systems, as well as a focus on personalized solutions. In particular, devices such as exoskeletons and intelligent wheelchairs are actively developing in the United States, Japan, South Korea, and the European Union. Examples include exoskeleton systems developed by universities and companies such as Ekso. Bionics, Vanderbilt University and Cyberdyne, which are widely used in both medical rehabilitation and in the daily mobility of users.

Hybrid designs that are multipurpose or modular systems rather than highly-specialized devices is one of the trends in international development in this area. Mobility systems that combine the functionality of wheelchairs and exoskeletons are becoming one of the main trends in assistive technology direction. The main advantage of such a system is the ability to switch

from sitting mode of locomotion and upright position, which significantly expands the functionality of such a device. In this sense, the ExoRoller is aligned with similar design rationale, consistent with wider international engineering trends in hybrid mobility solutions.

For example, the UPnRIDE system developed by UPnRIDE Robotics and the standing wheelchairs produced by LEVO AG allow users to move in both seated and upright positions. Mobility is only provided by means of wheels and electric drive systems and not by actively moving legs.

The Rex Bionics developed HAL robot support system offers support for standing and walking and is now commonly used in rehabilitation, but it is not designed to serve as a typical wheelchair for daily seated mobility. These systems are equipped with stabilizing mechanisms, sensors for monitoring body position and movement, as well as intelligent control algorithms that continuously monitor the device and make real-time adjustments to its operation.

In terms of worldwide practices, the trend is for end-users to be involved directly in development and testing activities. A successful example of this is the CYBATHLON at ETH Zurich, where people with physical disabilities and teams of engineers test out assistive devices, getting them closer to market. The approach bridges the gap between laboratory conditions and real-life requirements by having solutions adjusted and optimized in close cooperation with end users. One more important aspect of worldwide development is its interdisciplinary character: R&D and engineering efforts are commonly distributed among robotics, biomechanics, clinical medicine, and computer science. In this context, hybrid systems are gradually becoming more complicated, merging such combinations of robotic actuation and physiological mechanisms of interaction with the body as functional electrical stimulation. The trend reflects a shift towards adaptive and responsive systems that are capable of operating in a changing environment.

There are also regional differences in terms of market maturity and institutional support structures. Mature markets often incorporate assistive technology into their healthcare systems,

whether through reimbursement, public grants, or other compensation models that enable users to obtain the equipment they require. Systems of this kind are often combined with public-private partnerships that speed up the commercialization and dissemination of assistive devices.

In contrast, growing markets such as Kazakhstan lack many of these facilitating systems. Devices are often not affordable to the majority of users and there is less public awareness of available technology. Furthermore, these countries lack public healthcare or social systems that are adapted to work with high tech mobility devices. Given this, broad implementations of new mobility technologies are limited. For this reason, middle ground technologies like the ExoRoller that act as hybrid systems may provide a gap solution.

Another difference is visible in technology. Sensors, machine learning, and real-time data processing are being implemented into many prototypes and commercially available systems abroad. Motion tracking, computer vision, and predictive control mechanisms are used to adjust device behavior dynamically, improving safety and reducing physical strain on users. These features indicate a move toward intelligent assistive systems rather than purely mechanical mobility aids. The cost of exoskeletons and advanced assistive devices remains high on the international market, limiting their widespread adoption. Research shows that component production costs in countries with developed manufacturing bases can vary significantly, impacting the final price of the devices. In this regard, the hybrid characteristic might also result in being perceived as lower cost solution as it optimizes design and decreases the number of components.

In many countries around the world, assistive technology is moving away from a single assistive device mentality and becoming integrated into larger systems. Some examples of this can be found in the design of "smart cities" and autonomous infrastructure, universal design codes and digital inclusion initiatives that take into account accessibility from an environmental perspective.

Mobility solutions in these environments become just one piece of an accessibility-minded ecosystem. Built into larger systems, their value and longevity are increased.

From this perspective we can view that the ExoRoller meets current international trends. It is a hybrid system that focuses on the individual adaptation and their needs, which aligns with integration, customization and user-oriented design. At the same time, there is potential for further improvement based on international experience, particularly in terms of increasing automation, reducing cost, and expanding functionality.

ExoRoller generally aligns with current global trends, particularly in terms of combining various functions and focusing on the user's actual needs. Moreover, additional evolution of this kind of solutions was connected with their smarter design, availability of extended device functions and closer integration with healthcare and social support systems.

Drawing analogies with foreign experience, such a concept appears to be quite reasonable. Hybrid mobility systems implementation increasingly starts getting connected to development of inclusive environment however its successful advancement relies on balanced progress of technology, institutions, and infrastructure not merely on engineering solutions.

Studying experience from abroad allows to conclude that assistive technology development depends on numerous external factors. It can range from overall level of technological development, to public policy setup, available financing methods and supporting institution maturity. These combined factors influence how quickly development occurs and to what extent relevant solutions become available in reality.

At the same time, national models for implementation may vary significantly. In some countries it relies heavily on private entrepreneurship and market forces while in others it is closely tied to state and its connection to healthcare system and social support provision. Apart from institutional setup, overall direction of society towards inclusive environment and public

acknowledgment of disability related issues can also impact how widely those technologies are spread.

In order to formalize previous statements main parameters of AT development in a selection of countries are described in Table 8. Parameters include technological, governance, market and implementation aspects. This data serves as a foundation for interpretation of practices abroad and selection of potential referential solutions that could aid in implementation of hybrid solutions like ExoRoller by LLP “MBionics”.

Table 8: Comparison of assistive technology development by country

Country	Level of technological development	State support	Market maturity	Key Features	Examples of practices
USA	Very tall	Strong (grants, insurance, Medicare/Medicaid programs)	High	A developed startup ecosystem, active R&D investments, and the implementation of AI and robotics	Ekso Bionics, ReWalk Robotics
Germany	High	Strong (social insurance, rehabilitation programs)	High	Integrating technology into the healthcare system, focusing on quality and safety	Ottobock, exoskeletons for medicine and industry
Japan	Very tall	Very strong (government programs for population aging)	High	Focus on robotics, automation, and elderly care	Cyberdyne (HAL exoskeleton)

Table 8: Comparison of assistive technology development by country (continued)

South Korea	High	Strong (government investment in innovation)	Medium-high	Active development of robotics and smart devices	Hyundai Medical Exoskeleton
China	Tall (fast-growing)	Very strong (state innovation strategy)	Medium-high	Large-scale production, reduced technology costs	Local exoskeleton startups, rehabilitation robotics
United Kingdom	High	Strong (NHS, research grants)	High	Focus on clinical trials and research	Bionic limbs, university-driven innovations
France	High	Strong	Average	Development of medical technologies and rehabilitation	Wondercraft exoskeleton
Israel	Very tall	Strong (innovation grants, venture capital)	High	Startup ecosystem, military and medical technologies	ReWalk Robotics
Kazakhstan	Average (emerging)	Moderate	Low-medium	Limited infrastructure, early stage development of inclusive technologies	Local initiatives, pilot projects, LLP “MBionics” ExoRoller

The experience of countries around the world indicates that the development of assistive technology markets is depends on the country's level of economic development, the quality of the institutional environment, and the intensity of government involvement in innovative activities. In developed economies, assistive technologies are integrated into health care and social protection systems infrastructure and benefit from widespread distribution and usage within a stable institutional environment.

Development of assistive technology is often accompanied by targeted policy instruments. Policy instruments typically include targeted financing of research and innovation activities, partial reimbursement systems for the end users, regulatory standardization and institutional design promoting private sector involvement. In many cases, innovation does not occur in isolation but emerges through continuous interaction between universities, industry actors, and public institutions.

Equally significant is developed innovation infrastructure. Laboratories, centers for applied engineering, accelerators and venture financing help bring prototypes and designs into working products. This helps compress the time between the development of an idea and its real-world implementation and improves the efficiency of innovation as a whole.

Innovation ecosystems in countries with developing innovation systems experience systemic limitations that restrict similar dynamics. In Kazakhstan today, the problem is not the lack of ideas, but a lack of coherent conditions for their complete realization. Establishing interconnected environment where research activity is aligned with production capacity and users' access is facilitated continues to pose a formidable challenge.

Given these conditions, the adaptation of international experience becomes especially pertinent. hereas rapid implementation is dependent on local institutions aligning for joint action, readiness of local infrastructure, and the establishment of sustainable public–private partnership frameworks. Overall, cross-national experience shows that AT develops most strongly in contexts where technological capacity is complemented by institutional stability and mutually reinforcing policy tools, rather than by technological advancement alone.

5.8. Practical recommendations

The value added of the study consists of the developed set of recommendations for creating conditions for the development of an innovative environment, as well as improving the

accessibility of AT and their integration into the socioeconomic environment of Kazakhstan. One of the key problems for Kazakhstan is the lack of a formed, comprehensive institutional base for AT. At this stage, regulatory mechanisms need improvement primarily by developing standards of safety, control and certification of quality. On the other hand, there are international practices that are worth taking into account, especially when planning to integrate local developments into the regional market.

Policy tools are often the key driver of development in this area. Forms of support ranging from research funding to user subsidies and tax breaks tend to determine whether projects stay in the realm of prototypes or make it to practical application. Measures of this kind, as a rule, stabilize the market at an early stage of its development, mitigating risks for both sellers and consumers of technology.

Financial affordability is another critical aspect. The price of AT solutions depends on many factors, from the scale of production and materials used to the complexity of the developed designs. When it comes to more complex systems (especially hybrid ones), affordability is usually associated with not a reduction in functions but smart engineering decisions and manufacturing methods.

On the technical side, advancement currently continues to be tied to digital components. Sensors, self-learning mechanisms and edge computing are making devices more adaptive and safer. Particularly in rehab, these features can be used to actively monitor the patient's condition, increasing both efficiency and personalization of the device.

Developing AT also starts to include users and specialists more and more often at the initial stages. This approach is gradually transforming the decision-making process in the industry. Testing phases, pilot deployments, and iterative feedback loops therefore become not auxiliary, but structural elements of innovation development. However, technology alone is not enough. The availability of appropriate infrastructure is crucial. Accessible environment,

availability of public spaces, creation of special centers, service support – all this influences the degree of availability of AT devices.

Moreover, there is also a problem of low awareness – many potential users and specialists themselves are not aware of what opportunities already exist. Exchanging experience, participating in joint projects and cooperation with international organizations allows to adapt and implement new solutions more quickly using global best practices.

Finally, public-private partnerships remain one of the key tools. Pooling resources and knowledge: the government supports and regulates, while businesses develop and use new technologies. Given limited resources, this is becoming one of the most effective ways to develop the industry. (Table 9).

Table 9: Practical recommendations for the development of inclusive innovations

Direction	Recommendations	Expected effect	Level of implementation
Institutional development	Improvement of the regulatory framework, standardization, certification	Simplifying technology adoption, increasing trust	State
State support	Grants, subsidies, tax incentives	Stimulating production and demand	State
Economic measures	Reducing costs, developing local production	Improving device availability	Business

Table 9: Practical recommendations for the development of inclusive innovations (continued)

Technological development	Implementation of AI, sensors, and digital solutions	Increased functionality and adaptability	Business
User-oriented approach	Involving users in development	Improving compliance with needs	Joint
Infrastructure	Development of barrier-free environments and service centers	Expanding the possibilities of use	State
Education	Training of interdisciplinary specialists	Improving human resource potential	Education
Informing	Conducting campaigns and user training	Growing awareness and demand	State
International cooperation	Partnerships, exchange of experience, participation in projects	Acceleration of innovative development	All participants
Public-private partnership	Implementation of joint projects between the state and business	Effective implementation of innovations	Government/business

The recommendations for practical use, developed based on the results obtained, are aimed at promoting inclusive innovations development in Kazakhstan and creating conditions for more efficient implementation of hybrid assistive technologies. The implementation requires coordinated action of government agencies, scientific and educational sector, business and civil society institutions.

One of the key conditions is the systematic development of all components of the innovation environment. This includes improving the regulatory framework, while simultaneously strengthening technological infrastructure, expanding research potential and training qualified specialists. Only with such an integrated approach is it possible to form a sustainable assistive technology market focused on the real needs of users.

Special attention needs to be paid to building a balanced model of interaction between developers, medical organizations and end users. This format allows you to take into account the practical experience of using devices and adjust their functional characteristics already at the implementation stage.

In general, the proposed recommendations can be considered as a basis for further strategic planning in the field of inclusive innovation. Their implementation contributes to expanding the availability of modern technologies and to improving the quality of life of people with disabilities, as well as strengthening the social sustainability of society as a whole.

Conclusion

The conducted research is devoted to the analysis of inclusive and socially sustainable innovations in the field of assistive technologies using the example of the ExoRoller hybrid device, developed by LLP “MBionics” It allowed us to comprehensively examine the theoretical, methodological and practical aspects of the development of this area, as well as assess its significance for the innovation environment and social policy. Based on the literature review, theoretical analysis, and empirical data collected through surveys, interviews, and observations, the research questions formulated in this study can be answered with confidence. The findings show that hybrid mobility devices are a promising form of inclusive innovation and can significantly improve the quality of life of people with disabilities.

The first research question focused on the main advantages and limitations of hybrid mobility devices. The results demonstrate that these devices offer several important benefits compared with traditional mobility aids. Integration of a wheelchair with rehabilitation trainer and verticalization device enable independent mobility, stand upright and perform rehabilitation exercises using one single device. This leads to better mobility, more correct posture and muscle activation as well as greater independence from others. Respondents also highlighted psychological factors such as users feeling more confident, experiencing better self-esteem and emotional well-being.

At the same time, there are several limitations hindering broader implementation of the devices. The most commonly reported ones were associated with device development and production costs leading to a high purchase price, technical complexity as well as training and maintenance needs. Participants also emphasized that infrastructure remains an issue. Difficulties in using the device on uneven surfaces, curbs, and in inaccessible public spaces show that the effectiveness of such technologies depends on their design as well as on the surrounding environment.

The second research question examined current trends in assistive technology and social policy. Results from this study confirmed that assistive devices are being developed in conjunction with engineers, medical professionals, and social scientists. Assistive devices become more practical through application of sensors, adaptive control mechanisms, and user-centered design concepts.

On the other hand, technical development needs to be accompanied by institutional factors. Implementation of enabling technologies depends on subsidy programs, reimbursement systems and public-private partnerships. or this reason, social policy can play an important role in providing advanced mobility devices for broader populations of users.

The third research question examined how hybrid mobility devices influence social inclusion and quality of life of its users. The data offers conclusive arguments that ExoRoller has a positive impact on daily life. The study received support from a questionnaire whose respondents gave high ratings to those criteria connected to the increase in mobility, social participation, confidence, emotional comfort and readiness to recommend the device. The respondents from the questionnaire evaluated the ExoRoller as having positive impact on mobility, independence, social participation, confidence and emotional comfort. The interviews with MBionics employees provided expert perspectives on the device's design and development, as well as its functioning, testing, and barriers to implementation.

The data collected in the study were consistent with the main theoretical assumptions presented in the first section. First, the results have shown that mobility technologies need to be considered solutions for better physical mobility and as an instrument to help people to achieve autonomy and social inclusion. Second, the results support the assumptions of reciprocity in that by addressing the barriers of participation in social life, such mobility solutions help people with disabilities become more active in society.

The empirical findings provided support for the proposed hypotheses, although the results should be interpreted in the context of the exploratory nature and small sample size of the case study. The questionnaire data supported the consistency of the proposed link between mobility, independence, usability and its impact on the psychological well-being and social participation of users. The findings also supported the influence of cost and infrastructural limitations on the barriers to broader adoption of ExoRoller.

In conclusion, the research confirms that hybrid mobility devices such as ExoRoller represent an important technological and social innovation. Their value is related to improving physical mobility, to enhancing independence, dignity, and social participation. Combining engineering with rehabilitation and inclusive design, these technologies contribute to the larger goals of sustainable development and equal opportunity.

Bibliography

1. Acemoglu, D., & Restrepo, P. (2020). *Automation and new tasks. Journal of Economic Perspectives*, 34(1), 3-30.
2. Albrecht, G., Seelman, K., & Bury, M. (2001). *Handbook of Disability Studies*.
3. Barnes, C., & Mercer, G. (2005). *Disability Policy and Practice: Applying the Social Model. Disability Press*.
4. Borg, J., Larsson, S., & Östergren, P.O. (2011). *The right to assistive technology: For whom, for what, and by whom?. Disability & Society*, 26(2), 151-167
5. Brynjolfsson, E., & McAfee, A. (2014). *The Second Machine Age: Work, Progress, and Prosperity in a Time of Brilliant Technologies*. W. W. Norton & Company.
6. Dees, J. G. (1998). *The Meaning of Social Entrepreneurship. Center for the Advancement of Social Entrepreneurship, Case Western Reserve University*.
7. Elkington, J. (1997). *Cannibals with Forks: The Triple Bottom Line of 21st Century Business*. Capstone Publishing.
8. Goodley, D. (2011). *Disability Studies: An Interdisciplinary Introduction*. Sage Publications.
9. Foster, C., & Heeks, R. (2013). *Conceptualising inclusive innovation: Modifying systems of innovation frameworks to understand diffusion of new technology to low-income consumers*. *European Journal of Development Research*, 25, 333-355.
10. Lundvall, B. (2012). *National Systems of Innovation: Toward a Theory of Innovation and Interactive Learning*. Anthem Press.
11. Mace, R. L. (1998). *Universal design: Housing for the life span of all people*. *Designers West*, 147-152. <https://doi.org/10.1080/10400435.1998.10131957>
12. Mulgan, G., Caulier-Grice, J., & Norman, W. (2007). *Social innovation: What it is, why it matters and how it can be accelerated*. Skoll Center for Social Entrepreneurship.

13. Nussbaum, M. (2011). *Creating Capabilities: The Human Development Approach*.
14. Oliver, M., & Barnes, C. (2010). *Disability studies, disabled people and the struggle for inclusion*. British Journal of Sociology of Education, 31(5), 547-560.
<https://doi.org/10.1080/01425692.2010.500088>
15. Porter, M. E., & Heppelmann, J. E. (2014). *How smart, connected products are transforming competition*. Harvard Business Review, 92(11), 64-88.
16. Porter, M. E., & Kramer, M. R. (2011). *Creating shared value*. Harvard Business Review, 89(1-2), 62-77.
17. Prahalad, C. K., & Hart, S. L. (2002). *The Fortune at the Bottom of the Pyramid: Eradicating Poverty Through Profits*. Strategy+Business, 26, 1-14.
18. Prahalad, C. K., & Ramaswamy, V. (2004). *Co-creation experiences: The next practice in value creation*. Journal of Interactive Marketing, 18(3), 5-14.
<https://doi.org/10.1002/dir.20015>
19. Radjou, N., Prabhu, J., & Ahuja, S. (2012). *Jugaad Innovation: Think Frugal, Be Flexible, Generate Breakthrough Growth*. Jossey-Bass.
20. Schott, J., & Steinmueller, W. E. (2018). *Three frames for innovation policy: R&D, systems of innovation and transformative change*. Research Policy, 47(9), 1554-1567.
<https://doi.org/10.1016/j.respol.2018.08.011>
21. Sen, A. (1999). *Development as Freedom*.
22. Thomas, C. (2002). *Disability theory: key ideas, issues and thinkers*. In C. Barnes, M. Oliver, & L. Barton (Eds.), *Disability studies today* (pp. 38-57). Polity Press.
23. Von Hippel, E. (2005). *Democratizing innovation*. MIT Press.
<https://doi.org/10.7551/mitpress/2333.001.0001>
24. Creswell, J. W., & Poth, C. N. (2018). *Qualitative inquiry and research design: Choosing among five approaches (4th ed.)*. SAGE Publications.

25. Yin, R. K. (2018). *Case study research and applications: Design and methods (6th ed.)*. SAGE Publications.
26. Braun, V., & Clarke, V. (2006). *Using thematic analysis in psychology. Qualitative Research in Psychology*, 3(2), 77–101. <https://doi.org/10.1191/1478088706qp063oa>
27. Kvale, S., & Brinkmann, S. (2009). *InterViews: Learning the craft of qualitative research interviewing (2nd ed.)*. SAGE Publications.
28. World Health Organization, & United Nations Children’s Fund. (2022). *Global report on assistive technology*. World Health Organization.
29. MBionics. (2025). *ExoRoller: Operating manual*.
30. MBionics. (n.d.). *MBionics*. <https://mbionics.kz/>
31. Bayley, K., Parkinson, S., Jacoby, P., Cross, D., Morris, S., Vorster, N., Schofield, C., Kava, M., Siafarikas, A., Evans, K., Gaynor, O., Chiu, L., Ryan, M. M., Cairns, A., Clark, D., & Downs, J. (2020). *Benefits of powered standing wheelchair devices for adolescents with Duchenne muscular dystrophy in the first year of use. Journal of Paediatrics and Child Health*, 56(9), 1419–1425.
32. Paleg, G., & Livingstone, R. (2015). *Systematic review and clinical recommendations for dosage of supported home-based standing programs for adults with stroke, spinal cord injury and other neurological conditions. BMC Musculoskeletal Disorders*, 16, 358.
33. Rex Bionics. (n.d.). *REX Bionics*. <https://www.rexbionics.com/>
34. UPnRIDE Robotics. (n.d.). *UPnRIDE*. <https://upnride.com/>

Applications

Questions for interviews with experts (rehabilitation specialists, specialists)

The purpose of the interview: to obtain a professional assessment of the effectiveness, safety, and prospects for the implementation of ExoRoller.

1. Questions for rehabilitation specialists

1. What mobility limitations do your patients most commonly face?
2. How do conventional assistive devices address these needs?
3. How do you evaluate the therapeutic and functional potential of ExoRoller?
4. How suitable is the device for rehabilitation practice?
5. What effects can it have on mobility, posture, and muscle activity?
6. What limitations or contraindications should be considered?
7. What improvements would you recommend?

2. Questions for professionals involved in testing and development

1. What were your main responsibilities during the development and testing of ExoRoller?
2. What technical advantages does the device offer compared with existing solutions?
3. What challenges were encountered during testing?
4. Which aspects of the design still require improvement?
5. How would you evaluate the usability of the control system?
6. What factors influence the final cost of the device?
7. What opportunities exist for entering international markets?