A Conceptual Model of the Product Development Process using Tacit Knowledge of People with Disabilities

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Abstract: Knowledge management (KM) in an organization has always been an important element of creating its value and ensuring its development. Economic entities and market organizations that strive to ensure a competitive advantage must care for the best use of their knowledge, both explicit and tacit. Tacit knowledge may constitute up to 80% of all knowledge accumulated in an organization, but its nature is much less accessible to codification. The aim of the conducted research is to present a conceptual model of product development for the disabled, which assumes the functioning of the value network (VN) based on information technologies (IT). These people are the best source of knowledge necessary to formulate the framework defining the parameters of the developed product. The presented model considers the specific requirements of a given social group, which is characterized by a large dispersion and diverse needs. This is the biggest obstacle to extracting the knowledge necessary in the design and testing process. The article is an introduction to the discussion on the acquisition of tacit knowledge for personalization and adaptation of products to the needs of a given social group. The research into the conceptual model is the initial stage of research work that focuses on the analysis of literature and the creation of the concept of tacit knowledge management in the product development model based on the value network. The management of dispersed tacit knowledge is to systematize specific information in the field of product adaptation to the needs of the disabled. The concept of using tacit knowledge is always a challenge in the organization's knowledge management. The disabled often face difficulties in everyday life. Especially in the current situation in Ukraine, where military operations lead to an increase in the number of injured people for whom later adaptation in society will require appropriate knowledge and resources managed within the value network.

Keywords: Knowledge management, Product development, Value network, IT, Modelling

1. Introduction

Satisfying the demand for custom products requires enterprises to respond quickly and efficiently. This has become particularly important at a time when the markets are placing more and more demands in terms of competition and struggling with turbulence in the global economy (Kolberg *et al.* 2016). The struggle of companies has led to the growing importance of information and communication technology (ICT) used in relations between customers and enterprises. The importance of customer participation (CP) in product development processes has increased significantly, where this share is defined as the amount of involvement in the process (Fang 2008). Identification of needs and solutions that guarantee satisfaction initially became the mainstream of customer-business relations. However, over time, this has evolved to much greater customer participation in all stages of the New Product Development Process (NPDP) (Morgan *et al.* 2018). Changes in the approach to NPDP were already emphasized in the literature many years ago,(von Hippel, 2003)(Nambisan 2002) where the concepts of virtual communities, toolkits for clients or lead users were presented. The success of a new product depends on the identification and understanding of factors that are a key source of managerial knowledge. They strive by all means to reduce risk and uncertainty by engaging CP in creating innovation and matching the product to the market (Poetz and Schreier 2012). These activities were initially motivated only by economic reasons, this concerned primarily self-service technologies where employees were replaced with customers (Bendapudi and Leone 2003). Currently, NPDP takes into account CP by assigning it different roles in the subsequent stages of product development, they can be involved in the work as sources of information, co-creators or innovators (Cui and Wu 2016).

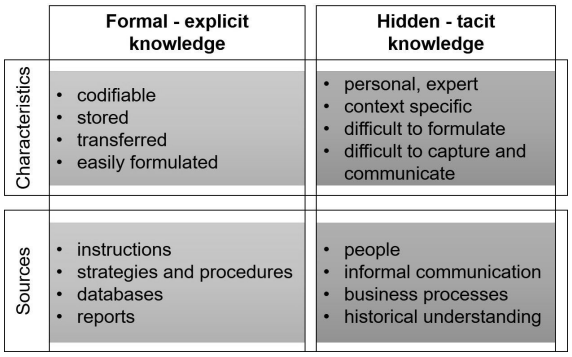
The client's involvement in the company's internal processes may have a different impact on the final effect, both positive and negative, which is emphasized in the literature (Mahr, Lievens, & Blazevic, 2013) (Menguc, Auh, & Yannopoulos, 2014). This allows for the conclusion that there are certain conditions in which CP may have a more or less favorable effect on NPDP (Naeem and Di Maria 2020).

2. Literature Overview

2.1 Tacit Knowledge Management in the Organization

The importance of tacit knowledge has been gaining popularity in recent years, especially in the sphere of organizational behavior. Research and measurements are a challenge for organizations and researchers who strive to formalize and structure it (Fernie *et al*, 2003). Literature defines two ways of classifying the types of

knowledge, where structural and organizational knowledge is distinguished (Edvinsson and Malone 2014). Structural knowledge is characterized by the possibility of recording and reproducing (e.g., reports, instructions), it is the effect of the accumulation of information collected in databases. Organizational knowledge is the result of a learning process within an organization. It is characterized by elusiveness and individuality in terms of human perception. Tacit knowledge as a concept was formulated in 1966 by Polanyi (Polanyi 2009). He described it as knowledge that is difficult to measure and conceptualize, which is difficult to articulate. Also, Nonaka and Takeuchi (1995) argued that codified or structured information is explicit and formal knowledge, and unstructured knowledge that is difficult to codify is tacit knowledge (Fig. 1). It is also defined as the knowledge that explains differences arising in management effectiveness, leadership, or team performance (Ryan and O'Connor 2009).



Source: Nonaka & Takeuchi, 1995

Figure 1: Types of Knowledge in the Organization

Tacit knowledge is characterized by its uniqueness and difficulty in formalization and transmission. It is usually assigned to specific organizational units or persons in a given position (Patalas-Maliszewska and Kłos 2017)(Piotrowska 2012). The acquisition and systematization of knowledge therefore requires the involvement of employees who are the basic source of tacit knowledge. Their experience is particularly important, through which the acquired knowledge is shaped, and it is acquired individually during (Mendryk 2011):

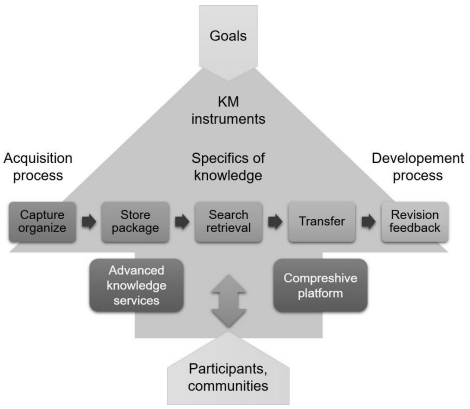
- independent activities while implementing projects and tasks,
- feedback with the client,
- tests and research,
- analysis of complaints,
- joint meetings in teams - brainstorming, multifaceted approach.

Organizations usually focus on explicit knowledge because it is much more accessible and identifiable. Achieving goals through knowledge management poses new challenges to them in the form of converting tacit knowledge into formal knowledge, which leads to the development of implementation activities and the enforcement of tacit knowledge acquisition processes. (Wang and Noe 2010). In their research, Chergui, Zidat and Marir proposed an ontological model, which in its construction is to facilitate the acquisition, storage and transformation of tacit knowledge. It is also important that they also show actions taken to share knowledge in the future, creating a kind of information base (Chergui et al. 2020). Moreover, each member has their own personality traits, which makes managing a group of people complicated, especially if conflicts arise (Mezghani et al. 2016).

2.2 Significance of ICT in Knowledge Management

The increase in importance of the field of knowledge management (Brzozowska and Szymczyk 2017) would not be possible without the development and support of ICT. Technology is a key element for increasing the efficiency and productivity of activities by providing tools and methods to acquire, understand and share knowledge. (Dieng *et al*, 1998). ICT is the basis for communication in organizations, where opportunities for joint learning and searching for knowledge dynamically translate into knowledge management processes (Abubakar *et al*, 2019). The dynamics, amount of data and complexity of knowledge becomes almost impossible to manage without the appropriate tools. Knowledge management systems (KMS) (Ruggles 1996) defined in the literature are identified as tools supporting activities such as generation, codification, and transfer of knowledge. These tools improve decision-making processes in terms of ensuring the entire knowledge process. The role of technology, which is a factor enabling the achievement of KMS objectives (Fig.

2), is significantly increasing, where the main goal of KMS is to facilitate the implementation of the knowledge process through its creation, structuring and sharing (Tyndale 2002).



Source: Maier & Hädrich, 2006

Figure 2: Characteristics of KMS

IT tools enable faster communication, help to clarify complex relationships, find tacit knowledge as well as create and organize the course of activities. This nature of IT creates a platform for the automation of certain knowledge-based activities that are intended to relieve people and enable the efficient conduct of the knowledge process. KM digital tools allow for performing all management operations: capture, storage, and distribution. The diverse types of IT tools include knowledge maps, knowledge repositories, intranet, chats, push technology, full-text indexing tools, document management, profiling, expert directories, Web 2.0 tools (Zouari and Dakhli 2018).

Tacit knowledge is inherently unstructured, its acquisition is usually supported by ICT that provide communication and data entry capabilities. Some of these technologies (e.g., e-mail, videoconferencing, teamwork systems) are used to manage tacit knowledge. On the other hand, knowledge acquisition, decision support or expert systems are used to transform tacit knowledge into explicit knowledge (Nemati *et al*, 2002). This transformation requires systems that include both unstructured and structured information processing tools. The problem was solved using decision support techniques and artificial intelligence (Mitri 2003). Kucharska, Erickson emphasize in their research that the creation and sharing of tacit knowledge is important in the context of emerging innovations. It is important to create the right working conditions for knowledge sharing where knowledge awareness and employee interaction effectively contribute to increasing innovation (Kucharska and Erickson 2023).

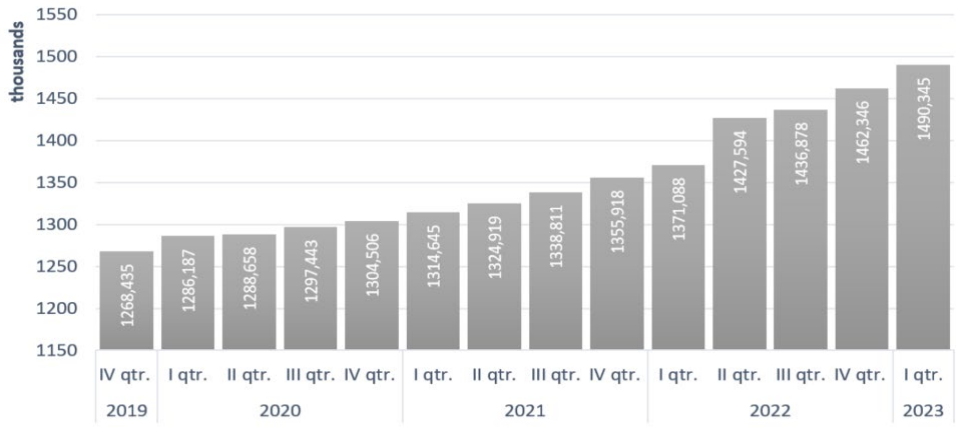
2.3 Knowledge Transfer in the Value Network

The value network (VN) is defined in the literature as a set of entities (actors), customers, suppliers, intermediaries, cooperating and integrating their own resources and knowledge to co-create value as integrated solutions. This network no longer refers only to the creation of value within the company's borders, but to a broader and more extensive link between market entities (Pinho *et al*, 2014). In this approach, knowledge constitutes the basic source of value (Bagheri *et al*, 2016). The dynamic cooperation of VN entities is based on the transfer of knowledge and ICT. This provides the possibility of quick response and flexible approach to customer needs. Knowledge is the source of value creation and competitiveness (Schoneveld and Weng 2023), while ICT provides appropriate technological solutions for knowledge transfer and ensuring the functioning of networks (Bagheri *et al.* 2014). Knowledge transfer in VN is complex and often disrupted, therefore the implementation of these processes is based on the use of the latest generation of KMS systems. They are called network knowledge management systems (VN-KMS). They consist of internal and inter-organizational computer systems that are often heterogeneous and distributed, but also interoperable (Bagheri, Kusters and Trienekens 2016). The necessary condition for effective cooperation between entities in VN is the transfer of knowledge, which refers to the process of continuous interactions between actors. This resulted in the change in the knowledge transfer objective from improving product innovation and operational efficiency to integrated solutions in enhancing the customer experience (Vargo and Lusch 2017).

3. Research results

3.1 Disability – Identification of the Target Group

First of all, it is necessary to identify the research area, which consists of dispersed units, i.e., people with disabilities living in Poland. When considering the complexity of data collection, three main tools for data collection must be distinguished: censuses, surveys, and administrative data and records. According to the results of the National Population and Housing Census 2011, the total number of the disabled at the end of March 2011 amounted to almost 4.7 million (exactly 4,697.0 thousand). Thus, the number of people with disabilities in Poland constitutes 12.2% of the country's population, compared to 14.3% in 2002 (almost 5.5 million people with disabilities in 2002). The percentage of men among the disabled is 46.1% compared to 53.9% among women. Biologically disabled people are those who experience limitations in their age-appropriate (basic) daily living activities. There are three degrees of limitation in the ability to perform basic activities: complete, severe, or moderate limitation. Compared to the results of the 2002 census, the total number of people with disabilities decreased by 759.7 thousand people, which corresponds to 13.9%, and the number of people with legal disabilities decreased by 1,316.6 thousand to 29.6%. On the other hand, the number of people with only biological disabilities increased by 559 thousand, i.e., by 55.5%. The National Population and Housing Census 2011 was conducted using a different method than before, compared to 2002, where an administrative database was used. Moreover, data on disability were collected as part of a representative census, which means that not all Poles were asked about their disability. Representative census data were generalized to the entire population (BPRdsON 2023).



Source: Own study

Figure. 3: Number of Disabled People in Poland with Locomotor Impairment

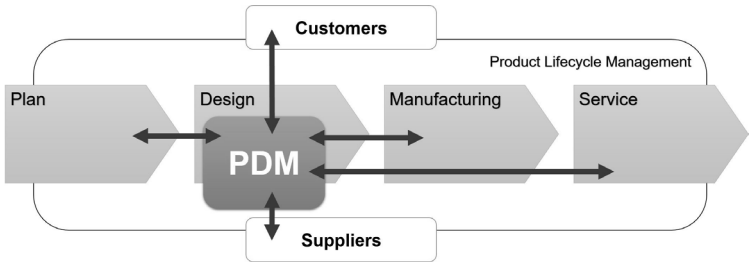
The published quarterly data (Fig. 3) from the period 2019-2023 clearly indicate an increase in the number of the disabled with locomotor impairment. They represent on average about 29% of all the disabled.

According to the results of the European Health Interview Survey (EHIS)(EHIS 2023), in 2014, in Poland, there were 7.7 million (exactly 7,689.8 thousand) people with biological disabilities, i.e., those who showed limited ability to perform activities that they do on a daily basis (in accordance with the unified EU definition used in the study, both severe and less severe restrictions were taken into account, resulting in the inability to perform the above activities for at least the last 6 months). Among them there are 2464.8 thousand with severe disability and 5,225 thousand with less severe limitations. It should be noted that depending on the adopted criterion of biological disability (more precisely, the degree of limitation), the population of the disabled in Poland may vary from 4.9 million to 7.7 million (Ministry Council of Poland 2020). According to the data of the Central Statistical Office, in 2021 the number of the disabled in Poland amounted to 5,447.5 thousand in total, in 2022 it was 4,758.5 thousand and in the first quarter of 2023 already 4,852.8 thousand.

3.2 Development of Assumptions and Concepts for the Knowledge Acquisition and Management Model

The effective implementation of the product development strategy requires effective information management in the production process. It depends on providing the right information to the right person at the right place and time. An important role in the proper synchronization of information flow is played by database management systems (DBMS) (Simon 2014) and product data management systems (PDM) (Klonowski 2004). PDM is used to integrate data recorded and generated by computer systems (Fig. 4).

Without the appropriate level of integration, these data will appear in different formats and various applications. This results in data redundancy, duplication of work and communication problems between systems. That is why PDM systems have evolved where data on the structure of products, design documentation and their manufacturing processes are collected and possibly further processed in the environment of data exchange systems in an electronic form. PDM systems are used in the basic approach to storing product data updates, but the extended approach also covers the issue of managing the ongoing design process, which means that the integration of computerized systems can be seen as a development trend.



Source: Duda and Stadnicki, 2011

Figure 4: Integration Role of PDM Systems in Product Development Management

Data management in the product development process is a significant factor influencing the competitiveness of companies. PDM enables quick exchange of data on documentation related to product design, considering the participation of the client as well as engineers responsible for production or project development. The flexibility of systems and subsystems is the key to improving manufacturing and design. By using PDM, companies can ensure that projects are available to those who need them (Huhtala *et al.* 2014).

3.3 Conceptual Model of Product Development

The NPDP process involves several key stages, including customer needs identification, product concept development, design creation, product testing and launch. At each of these stages, many functional areas of the organization are involved - including research and development, marketing and production where effective communication and cooperation are essential, which are the basis for successful product development. It is also important to recognize the needs of the client and their participation in the process. Successful product design is primarily based on understanding customer needs and then developing products that meet those needs. The importance of the customer's opinion and their impact on the structure of the final product is very important from the point of view of the final success. In addition to knowing the customer's requirements, the information collected must be translated into specifications and integrated with the product concept.

The structure of the process and its stages assume a certain algorithmization of decisions, considering the participation of the client and the condition of profitability of the product implementation. In addition, the model assumes the use of PDM and KMS systems that support the flow of information in the ICT structure.

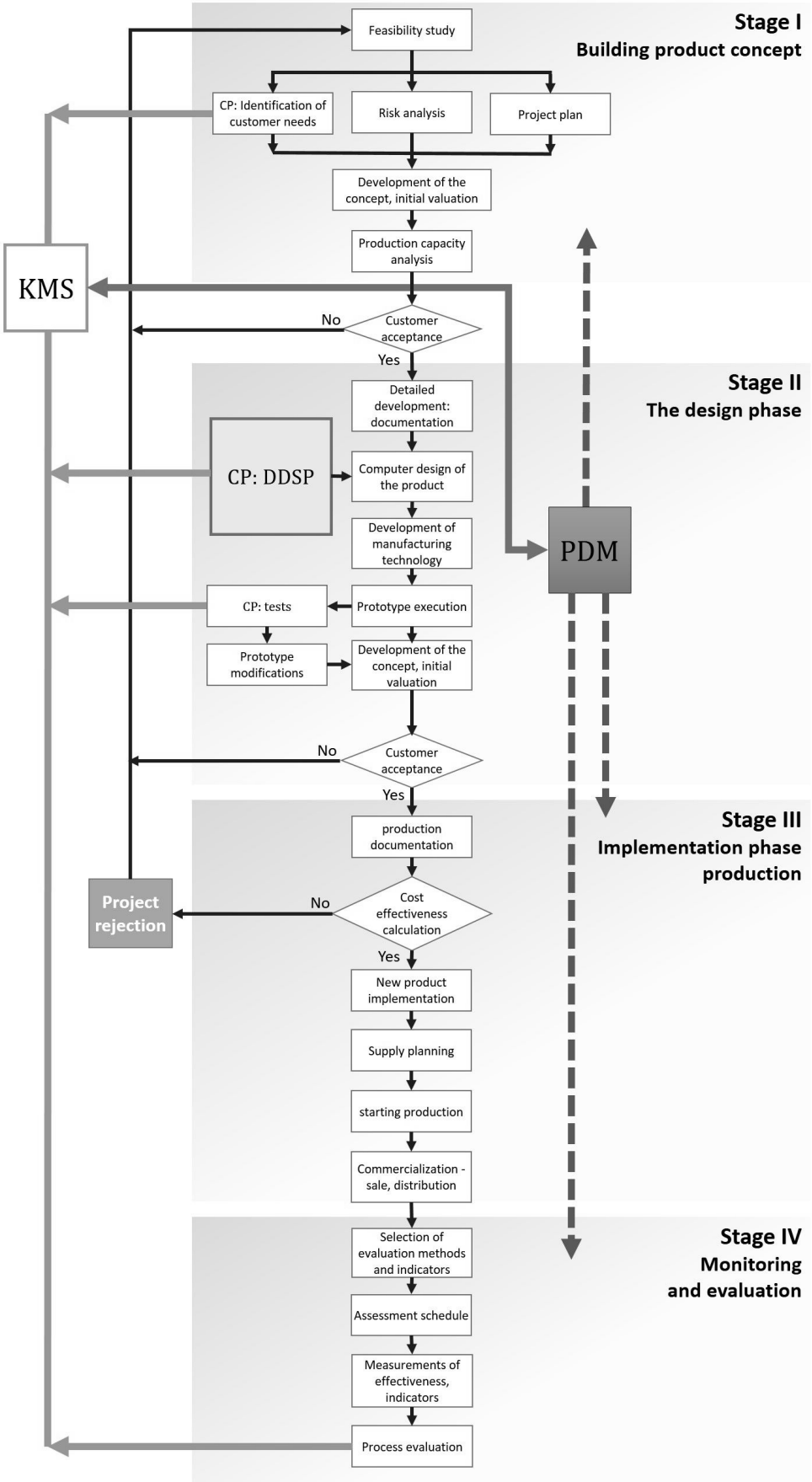
The NPDP concept developed based on the literature analysis assumes four stages of product development (Fig. 5).

- Stage I - Building the product concept.

The initial stage of development in which activities focus on acquiring as much information as possible in the field of: customer needs, risk analysis, planning and concept development, up to the analysis of production capacity. This stage is completed when the client accepts the proposed product concepts.

- Stage II - Design stage.

This is the stage in which the launch of a digital platform supporting design is assumed. Its task is to actively involve the end user in the product design process. The next steps concern the creation of design documentation and the development of production technology for the prototype. The participation of the client as a tester for the proposed design solution is included, but it is not required. The stage ends with the valuation and final acceptance of the client.



Source: Own study based on Kazimierska & Grębosz-Krawczyk, 2017; Olkowicz, 2006

Figure 5: Conceptual Product Development Model

- Stage III - Implementation stage, production.

The activities of this stage assume the launch of production after accepting the previous design assumptions. This involves the preparation of design documentation, supply planning, but above all, the calculation of the product profitability. Sale and distribution are the final stage, which also opens the last stage of NPDP.

- Stage IV - Monitoring and evaluation.

Evaluation is an essential element of any complex process where performance assessments must be made. In most cases, ratio analyzes based on production data and customer opinion surveys are performed. This allows for verifying disruptions and errors that occurred during the entire process.

Increasing the customer's participation in the product design process significantly increases the chances of its future implementation and commercialization. For this purpose, it was proposed to introduce an additional tool, which is digital design support platform (DDSP). Its task is to enable people with disabilities to actively participate in product design, also for individual needs. The functionality of the platform is intended to allow the user to select components proposed and designed earlier with the participation of customers. As a rule, they are to meet the requirements of the end user, ensuring a high level of satisfaction. The essence of the development of the DDSP concept is the possibility of using tacit knowledge hidden in the minds of people with physical disabilities and dispersed over a large area. The research verifying the relationship between the market situation and the development of a new product and the level of innovativeness of the company in the field of technology. It creates a wide range of technological and commercial barriers (Bond and Houston 2003)(Ju *et al*, 2013).

When measuring the effectiveness of projects and new product development processes, an important role is played by technical and technological aspects, examined against the background of the prevailing market situation in the industry. The research indicates that the advantages, such as technological synergy and knowledge of the current state of the market, are of decisive importance when introducing and developing a new product in enterprises (Pattikawa *et al.* 2005). The company's motivation to develop technological and knowledge resources also affects the cost and time of the implementation of the project of launching a new product to the market (Sisodiya and Johnson 2014). The aspects of communication and interaction are important when launching new product development projects (Felekoglu *et al.* 2013). Researchers focus mainly on issues related to: communication of employees during the selection of ideas for new products (Lechler and Thomas 2015), creation of specialized project teams, possession of appropriate project manager skills, quality of the process of management of the new product development project (Sheng *et al.* 2013). The latest research points to a problem resulting from a lack of trust, understanding and different perception of the requirements for new products (Liebert and Trzeciak 2016).

4. Conclusions

The objective of the conducted research was to develop the conceptual model of product development for the disabled, which assumes the functioning of the value network based on information technologies (IT). The article is an introduction to the discussion on the acquisition of tacit knowledge for personalization and adaptation of products to the needs of a given social group. People are the most important link in the acquisition of tacit knowledge. Supporting these processes using IT and generally progressing social digitization, prompt discussions on the creation of new channels for the flow of knowledge. The proposed conceptual model aims to show the structure of the new product development process, assuming the use of tacit knowledge of the disabled. The use of direct participation of future customers in the design and testing stage, creates much greater opportunities for better product development as well as increases the chances of its commercial success. DDSP also creates an opportunity to collect knowledge gained in a given NPDP and use it to build a value network. The results of the research will be used as a tool in the methodology of further research conducted as part of project activities with the economic environment in Poland. The next stage of research work will focus on the creation of a database in which the knowledge of the disabled will be collected for the purposes of creating the DDSP.

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