

# The Role of Erasmus+ Project Leaders' Digital Competences in Sustaining European Transnational Cooperation during COVID-19 Pandemic

Pawel POSZYTEK, PhD

Foundation for the Development of the Education System  
Warsaw, 02-305, Poland

Jadwiga FILA, MA

Foundation for the Development of the Education System  
Warsaw, 02-305, Poland

## ABSTRACT<sup>1</sup>

The aim of the article is to answer the question whether digital competences can support Erasmus+ project leaders in sustaining their transnational cooperation, and if yes: to what extent? The COVID-19 pandemic poses a great threat to the implementation and sustainability of transnational cooperation projects, especially the ones based on international mobility of its participants. This is especially the case of Erasmus+ which is the flagship European program enhancing cooperation between leaders of educational, academic, vocational, industrial and business sectors. Consequently, there is an urgent need to determine what factors can contribute to sustaining this type of cooperation. For this purpose, this research concentrates on Erasmus+ project leaders from Poland who implement their transnational cooperation projects, and investigates how their digital competences and other contextual factors connected with these competences may influence their performance in the realization of projects during COVID-19 pandemic. The discussion on digital competences as remedial tools for international cooperation during COVID-19 pandemic is placed here in the broader context of competences 4.0, industry 4.0, and relational and network approach to management of modern organizations.

**Keywords:** digital competences, competences 4.0, Erasmus+, COVID-19, temporary organization, relational paradigm, network paradigm

## 1. INTRODUCTION AND THE CONTEXT OF THE STUDY

Erasmus+ Programme is European Commission's main tool for (i) stimulating the development of entrepreneurial, creative and innovative skills across all

educational and vocational sectors; (ii) improving the infrastructure for the transfer of knowledge of higher education institutions and improving their engagement in such initiatives as start-up and spin-off; (iii) encouraging to build partnerships and undertake cooperation with business; (iv) involving higher education sector in establishing integrated local and regional development plans [1]. The 30-year history of the Programme has proven its effectiveness in this respect and contributed greatly to the broader EU socio-economical and educational policies. However, Erasmus+ projects' activities are based on international mobility of pupils, teachers, students, academics, professionals and youth workers as well as on the implementation of innovative, inter-institutional cooperation projects and strategic partnerships whose aim is capacity building in reference to organizational aspects and the improvement of educational offer. In this respect, Erasmus+ projects must be treated as entities of highly relational and networking character.

The COVID-19 pandemic has evidently limited the functioning of the Programme activities in a very substantial way. The nature and the extent of the harming effect of COVID-19 pandemic as well as the potential of various sorts of remedies are proved from two sources. The COVID-19 pandemic has brought significant changes to the mode of work. As a result, 94.8% of people working in managerial positions in Poland were working from homes for more than the half of the working week in comparison to 5.3% before the pandemic [2]. This means a radical change potentially affecting work efficiency. In the case of Erasmus+ Programme, the sudden necessity to transfer cooperation into virtual reality has posed a great challenge to project leaders and become a real threat of breaking up European, transnational cooperation. This situation has required from Erasmus+ project leaders both a smooth transition to the use of electronic forms of communication which require a certain level of digital competences and content-related and methodological redefinition of projects, so that their goals and objectives could remain unchanged.

<sup>1</sup> The Authors would like to express their gratitude to prof. Małgorzata Dobrowolska and to prof. Mirosław Pawlak for their comprehensive and detailed peer-editing of this article.

At the time of the first coronavirus outbreak, the European Commission surveyed both Erasmus+ participants and project leaders on the impact of COVID-19 pandemic in reference to projects' sustainability. The first survey, focused on learning mobility activities, was carried out in April 2020, and collected data on the views of almost 40% mobility participants [3]. Its findings show that approximately 25% of the participants were not (or only very mildly) affected by the pandemic and stayed abroad during the first lockdown. The remaining 75% reported that they continued their activities with different arrangements (42% of respondents), had to suspend their activity (22%) or had their activity cancelled (36%).

The respondents were asked how they assessed the quality of virtual activities offered to them as replacement for those to be carried out abroad. A high proportion assessed the digital learning tools and platforms as very good (71%), the quality of activities as high (63%) and relevant to their planned mobility (71%). They confirmed that they were very satisfied with the overall support they received (over 80%) and in most cases (72%) these activities were recognized by the sending institutions. It also seems that the participants who have carried out virtual mobility periods are more confident about the validity of the future "blended mobility" scenario. The results show that starting the mobility as virtual learning had the highest preference and only 9% were in favor of cancelling the mobility periods [4].

The second survey examined the impact of COVID-19 on the European Universities subprogram of the Erasmus+, and was carried out in May 2020. In its main conclusions the European Commission stresses the importance of much deeper cooperation between higher education institutions in education, research and innovation, and the need to pool together and share online courses, data, digital and research infrastructure. Although the COVID-19 pandemic is a significant hindrance in international cooperation, this survey suggests that being part of a European University network may help in coping with challenges imposed by this pandemic e.g., by sharing good practices and solutions, pooling together IT tools and creating a joint environment. This line of thinking has been confirmed by more 60% of respondents. Additionally, almost 80% declared that they share good practices within their partnership and 96% say that "they would have been better prepared to face the pandemic if their European University had already been fully operational" [5].

According to the respondents – the Erasmus+ project leaders from the higher education sector, the most useful features to manage the pandemic crisis are: (i) fully-functional digital EU inter-university campuses; (ii) fully working infrastructure and methodology for joint blended courses; (iii) wide range of short learning courses leading to achieve micro-credentials for equipping workforce with "just-in-time" skills in cooperation with companies,

regions and cities; (iv) a challenge-based approach in which students work with academics, researchers, companies, cities and regions to address societal challenges [6].

## 2. THEORETICAL APPROACH AND DEFINITIONS

It is worth setting out in detail what factors can facilitate the sustainability of Erasmus+ projects in an unstable external environment. The study presented in this paper focuses on digital competences as a tool that can compensate for any breakups in the communication and realization of Erasmus+ projects.

Nevertheless, the issue of digital competences must be discussed in the broader context of (i) competences 4.0, (ii) industry 4.0 and (iii) relational and network approaches to modern organizational management. The last two aspects constitute fundamentals of the current approach to business activities of any sort. They also cover international cooperation projects which actually fulfill the criteria of being temporary business organizations [7, 8]. The network approach to modern management which one can extrapolate onto Erasmus+ project management stresses that it was turbulent, unstable, diversified, dynamic, global and unpredictable environment that led to the shift from hierarchical management towards horizontal relations between geographically dispersed partners forming different organizational units. These partners are usually connected via information and communication technologies, and they create organizational partnerships whose aim is to realize and reach specific goals. Each configuration of partners is an original combination of key competences that they contribute with. These competences make the organization or partnership stronger, more flexible and efficient than each individual partner. This type of organization fosters the processes of adaptability to new conditions of the environment where they exist [9, 10].

Other researchers also point out that communicative aspect and complementarity of partners are characteristic features of the network paradigm in modern organization management [11]. Both the external context of unpredicted COVID-19 pandemic and the network character of Erasmus+ projects, which are being conducted by organizations consisting of international partner units, draw a perfect analogy of the above-mentioned organizational approach in management.

The relational approach to management postulates knowledge sharing within units of an organization and building relations inside and outside of it to enhance competitive potential and effectiveness [12]. This point of view is also crucial in analyzing the effectiveness and sustainability of Erasmus+ projects in relation to the leaders' competences since the ability to communicate

effectively on various levels and maintaining relations constitute integral parts of these competences.

The notion of industry 4.0 was coined to define modern production and services procedures responding to emerging challenges and trends that require the introduction of more and more digitalized and fully automated processes in modern economy [13, 14, 15, 16, 17, 18, 19, 20]. The term “industry 4.0” embraces the following phenomena:

- Internet of things meaning advanced connectivity of systems, services and physical objects enabling object-to-object communication and data sharing;
- Cloud computing that provides a vast space for data storage;
- Autonomous robots which interact with each other and collaborate with humans;
- Big data obtained daily from devices connected to the internet;
- Simulation in the form of modeling real or virtual processes by using real-time data to represent the real world in a simulation model;
- Internet of services meaning services available on demand;
- Augmented reality meaning reality enhanced by virtual elements;
- Cyber-physical system and human-digital interfaces meaning systems that integrate humans with machines.

However, with respect to the study presented in this paper the most important is the concept of competences 4.0 that stems from the industry 4.0. These competences have marked the shift from strictly professional skills towards soft skills that are fundamental for the current labor market. The models of competences 4.0 differ, depending on authors. The contexts and the detailed discussion on these differences was analyzed by the author [21]. Here, the most common model of competences 4.0 is used:

- digital competences – include the use of technology on different levels of advancement, ability to solve problems with the use digital tools, knowledge of privacy and cybersecurity issues;
- managerial competences – i.e., team coordination, cooperation, entrepreneurship, leadership;
- social and emotional competences – connected with communication and interaction with others, coping with one's own emotions and ability to cooperate in a group;
- cognitive competences – related to the ways of thinking, processing and verifying information,

including creativity and critical thinking, openness [22, 23, 24, 25, 26].

In this research, social and emotional competences as well as cognitive ones are treated as some of the contextual factors, which will be further elaborated on in the analysis section. As regards the very digital competences in reference to the management of Erasmus+ projects, they are defined here by the following factors:

- Own preparation for online work;
- Using e-banking services;
- Filing tax return online;
- Filing an official application via an electronic system;
- Making use of an electronic document workflow;
- Organizing one's own online work;
- Starting a video conference with several people at the same time;
- Protecting one's own PC from network viruses;
- Sharing the screen with others during a video conference;
- Being up to date with modern ICT solutions that can be used at work;
- The use of web resources;
- The use of text editors (e.g. Microsoft Word);
- The use of spreadsheets (e.g. Microsoft Excel);
- The use of instant messengers;
- The use of e-mail;
- The use of online collaboration tools;
- The use of video conferencing tools;
- The use of project management tools.

It must be also stressed that the indicators of these digital competences are determined by the specificity of Erasmus+ projects and the role of their leaders. These indicators were reflected in the research questionnaire described below.

In order to assess whether digital competences can support Erasmus+ project leaders in sustaining their transnational cooperation, the following questions were formulated:

- (1) What is the level of Erasmus+ project leaders' digital competences?
- (2) To what extent do project leaders' digital competences facilitate the sustainability of Erasmus+ projects?
- (3) To what extent do other contextual factors connected with project leaders' digital competences facilitate sustainability of Erasmus+ projects?

### 3. STUDY DESIGN AND ANALYSIS

Having formulated the research questions and having defined the model of competences 4.0 with digital competences in it, the design of the study was proposed (Table 1).

Table 1. Analysis Design

No.	Research activity	Step
RA1	Establishing Erasmus+ project leaders' competence profile	Competences' models; factor analysis which helped to fine-tune and calibrate research competence model and questionnaire results (990 respondents – Erasmus+ project leaders).
RA2	Defining research group that is statistically meaningful, significant and valid	Dividing the research group into quartiles: 25% of highest performers and 25% of lowest performers
RA3	Finding possible relations between the level of Erasmus+ project leaders' digital competences and the sustainability of their projects	Data analysis
RA4	Finding possible relations between the level of Erasmus+ project leaders' digital competences and their other competences 4.0 in the context of the project sustainability	Data analysis
RA5	Finding possible relations between the level of Erasmus+ project leaders' digital competences and contextual factors in the context of the project sustainability	Data analysis
RA6	Formulating conclusions	Interpretation of the data

The questionnaire was sent out during the period of COVID-19 pandemic and was responded by 990 Erasmus+ project leaders in Poland (response rate: 27%). It included 70 questions which relate to the assessment of respondents' competences 4.0, their motivation, engagement, experience, sex, age, institutional affiliation and to some of their projects' characteristic features such as budget, number of project partners, etc. These questions fell into the following categories:

- Questions on the Likert's scale (from 1 to 5) – mainly concerning the assessment of competences.

- Contextual questions concerning the implementation of projects and metric ones relating to age, gender, etc.
- Indicator questions – a set of questions defining one characteristic feature, which were used to create the scale of its intensity.

It must be stressed the respondents rated their level of proficiency in subsequent competences basing on their own perception. Data was analyzed with the use of specific statistic techniques, such as factor analysis, correlation analysis, logarithmic regression, analysis of scales reliability and others.

### 4. RESULTS AND DISCUSSION

After data collection, factor analysis was carried out to create the measurable variables indicating level of every distinguished competence. The data shows the respondents assessed their digital competences relatively high with average score of 4.33 on the five-point Likert scale (Table 2).

Table 2. Distribution of Erasmus+ Project Leaders' Digital Competences in Percentiles

No. of respondents	990
Average score	4.33
Median	4.38
Minimal score	2.06
Maximum score	5.00
Percentiles	<b>25</b>
	50
	<b>75</b>
	4.38
	<b>4.75</b>

For further analysis, two groups of Erasmus+ project leaders were distinguished: those with highest (upper quartile;  $N = 255$ ) and lowest (lowest quartile;  $N = 220$ ) digital competences. The two groups were compared how they performed during COVID-19 pandemic in relation to their projects' sustainability. Overall, 21% of highest digital performers suspended, or prolonged their Erasmus+ projects, whereas it was 29% in the group of lowest digital performers. This observation, which answers the main issue of RA3 (see Table 1), is reflected in the Table 3.

Table 3. Status of the projects (projects' sustainability) run by project leaders with lowest versus highest digital competences.

Digital competences	Project status	N	%
Lowest digital performers: below 1 <sup>st</sup> quartile	Project finished or ongoing	156	70.9
	Project suspended or prolonged	64	29.1
Highest digital performers: above 3 <sup>rd</sup> quartile	Project finished or ongoing	201	78.8
	Project suspended or prolonged	54	21.2

Having established the above, relations between the level of Erasmus+ project leaders' digital competences and the levels of their other competences 4.0 in the context of Erasmus+ projects' sustainability need to be presented and analyzed according to RA4 (Table 4).

Table 4. Lowest and Highest Digital Performers Among Erasmus+ Project Leaders and Their Other Competences 4.0

Digital competence	Managerial cooperation with people	Managerial team coordination	Cognitive pro-activeness, innovation, openness to challenges	Social relations and emotions	Social adaptability and managing stress during the pandemic	Social maintaining contacts, cooperation	Social communication
Lowest digital performers: below 1 <sup>st</sup> quartile	3.56	3.57	3.68	3.72	1.71	3.70	3.39
Highest digital performers: above 3 <sup>rd</sup> quartile	3.96	4.13	4.17	4.11	1.86	4.12	3.79

The following conclusions can be drawn from the above results:

- In both groups, low digital competences correlate with low managerial, cognitive and social competences and high digital competences correlate with high managerial, cognitive and social competences.
- The above correlation does not come as a surprise because, as stated above, Erasmus+ projects can be compared to typical temporary international organizations of relational and networking character. This means that during COVID-19 pandemic, which poses challenges in relation to effective cooperation and communication, such elements as (i) managerial

competence understood as cooperation with people and team coordination; (ii) cognitive competence defined as openness to changes; (iii) social competence understood as relations, adaptability with ability to manage stress, maintaining contacts and ability to communicate can be compensated for, or facilitated by a broadly understood digital competence. Digital competences provide remedial tools in the case of breakup in personal contacts.

- Digital competence along with other so-called competences 4.0 correlated with it, according to data from RA3 and RA4 (see Table 1), provide a specific protective shield for Erasmus+ project leaders against negative effects of COVID-19 pandemic for international cooperation.

Competences as such don't function in a vacuum, and the assessment of how Erasmus+ project leaders' digital competences facilitate the sustainability of their projects should also be carried out in relation to other contextual factors such as age of a project leader, sex, work experience, type of institution, number of partners in a project, project budget as well as ex-ante assessment of a project during selection procedure for financial grant awarding. The analysis (RA5 – see Table 1) shows that the above-mentioned moderators have almost identical distributions in both researched groups. However, slight differences were observed. The young leaders and men declared slightly higher digital competences but with no significant relationship with projects' sustainability.

In order to obtain insights into other possible contextual factors that may have an influence on Erasmus+ projects' sustainability during COVID-19 pandemic (RA5), the respondents' answers to questionnaire questions have been used once again. In Table 5, the distribution of answers in both analyzed categories of project leaders have been grouped into contextual factors of the projects' sustainability.

Table 5. Distribution of Answers to the Questions On Contextual Factors of the Project Sustainability in Both Categories of Erasmus+ Project Leaders

Contextual factors of the project sustainability	Quartile	Answers	N	%
<b>Question 1: In your opinion, to what extent the project activities conducted during the Covid-19 pandemic were implemented successfully?</b>				
The effectiveness of conducted projects during COVID-19 pandemic	Lowest quartile	Maximum in 25%	88	40.0
	digital performers: below 1 <sup>st</sup> quartile	Maximum in 50%	53	24.1
	75%	Maximum in 75%	28	12.7
	100%	Between 75% and 100%	51	23.2

	Maximum in 25%	93	36.5	Highest digital performers: above 3 <sup>rd</sup> quartile	Yes, I have a clearly defined path	132	51.8	
	Maximum in 50%	45	17.6		Yes, but the path is rather general	104	40.8	
	Maximum in 75%	43	16.9		No, I do not currently have such a plan	19	7.5	
	Between 75% and 100%	74	29.0					
	Question 2: Please, undertake a self-evaluation and generally rate your work as a project coordinator.							
The quality of management	Lowest digital performers: below 1 <sup>st</sup> quartile	3 Sufficient	23	10.5	Question 5: To what extent, in your own estimation, are you emotionally and personally involved in the project?			
		4 Good	144	65.5				
		5 Very good	30	13.6	Lowest digital performers: below 1 <sup>st</sup> quartile	1	0.5	
		Difficult to say	23	10.5		2	1.4	
	Highest digital performers: above 3 <sup>rd</sup> quartile	1 Very poor	1	0.4		3	10.5	
		3 Sufficient	5	2.0		4	31.8	
		4 Good	111	43.5		5	55.9	
		5 Very good	114	44.7				
		Difficult to say	24	9.4				
	Question 3: With regard to yourself, do you have a sense of continuous learning, or do you tend to rely on previously acquired knowledge and skills?							
The quality of management		Yes, I'm still developing	105	47.7	Emotional engagement	Highest digital performers: above 3 <sup>rd</sup> quartile		
		I'm still developing, but more slowly than I used to	114	51.8		Lowest digital performers: below 1 <sup>st</sup> quartile	2	0.8
	Development of human capital	I have no need for development – I rely on previously acquired knowledge and skills	1	0.5			3	2.4
					4	18.4		
		Yes, I'm still developing	223	87.5	5	200		
		I'm still developing, but more slowly than I used to	32	12.5		78.4		
	Question 4: Do you have a planned path for your own development, career?							
Adaptability		Yes, I have a clearly defined path	51	23.2	The following conclusions can be drawn from these results:			
		Yes, but the path is rather general	122	55.5				
	Development of human capital	No, I do not currently have such a plan	47	21.4				
<ul style="list-style-type: none"> <li>• 45.9% of highest digital performers and 35.9% of lowest digital performers stated that their project activities were realized successfully in 75% or more during COVID-19 pandemic. This means that Erasmus+ project leaders with higher digital competences turned out to be more effective in the implementation, management and sustainability of their projects. Consequently, the observed relationship here is: the higher digital competences, the higher effectiveness in project sustainability .</li> <li>• Highest digital performers evaluate themselves better as project leaders. In the group of highest digital performers 44.7% project leaders assessed themselves as very good whereas in the lowest digital performers group it is only 13.6%. This means that the quality of project management is affected to great extent by the level of digital competences.</li> <li>• 87.5% of highest digital performers and only 47.7% lowest digital performers state that they are still developing. Again, this means that there is a relationship between the level of digital competences and quality of project management as well as the development of human capital. This also proves that highest digital performers adapt themselves better in relation to external conditions in which their projects function. This brings the discussion back to the issue</li> </ul>								

- of networking and relational character of modern organizations and the role of flexibility and adaptability that influence projects' sustainability described above.
- The relationship between the level of digital competences and the development of human capital can also be observed in Table 5 where 51.8% highest digital performers and only 23.2% lowest digital performers state that they have a planned development path.
  - Emotional engagement also turned out to be a significant contextual factor contributing to Erasmus+ projects' sustainability in the times of COVID-19 pandemic since 78.4% of highest digital performers and only 55.9% of lowest digital performers declared highest level of their engagement.

## 5. FINAL REMARKS

In the light of the above discussion, all three research questions mentioned in the third paragraph were answered. It must be noted that although the differences between the highest and lowest digital performers can be observed, the whole researched group of 990 Erasmus+ project leaders scores relatively high as far as digital competences are concerned. The average score for the whole group was 4.26. The question arises if even higher digital competences of Erasmus+ project leaders could support and facilitate the sustainability of their projects. The only statistical tool that could be used in this respect is logistic regression with the help of which the prediction of chances of projects' suspension could be assessed. However, at a preliminary stage of such a research, the assessment of the significance of the association of digital competences as an independent variable with a dependent variable of project suspension (yes/no) turned out to be too low to get valid results. However, this also proves that Erasmus+ project leaders' digital competences, en bloc, are high enough to form a protective shield against COVID-19 pandemic in European transnational cooperation. Potentially higher digital competences among Erasmus+ project leaders would not have a significant impact on the lower proportion of suspended projects.

Secondly, analysis prove that there is a significant difference in the ratio of suspended Erasmus+ projects in the highest and lowest digital performers groups of Erasmus+ project leaders.

Thirdly, such contextual factors as other competences 4.0, effectiveness, management of projects, project leaders' adaptability and engagement also play role in projects' sustainability. However, it must also be noted here that some of these factors are also correlated with each other. Adaptability is an integral part of social competence whereas engagement, which can be manifested by pro-activeness, has its reflection in

cognitive competence. The other reason why it would not be plausible to abstract the discussion on digital competences from other competences 4.0 is the issue of communication. Effective communication is not only one of the elements defining social competences, but it is also needed for effective cooperation and group coordination which are defining elements of managerial competence.

Finally, it should be stressed again that the use of digital tools for maintaining contacts and cooperation, which turns out to be one of the key factors in sustaining international cooperation projects in the times of COVID-19 pandemic, proves the assumptions of the modern relational and networking paradigm in management. In this respect, this research provides data in relation to the area which has not yet been researched. Since Erasmus+ projects fulfill the criteria of being organizations, although temporary ones, this research may contribute to the wider discussions on sustainability issues of modern organizations in line with relational and networking view on management.

## 6. REFERENCES

- [1] European Commission (2011). Communication from The Commission to the European Parliament, The Council, The European Economic and Social Committee and The Committee of the Regions. *Supporting Growth and Jobs – an Agenda for the Modernisation of Europe's Higher Education Systems*. Retrieved from: <https://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2011:0567:FIN:EN:PDF>. Accessed June 21, 2021
- [2] Czerniak, A., Durka, E., & Piznal, J. (2020). *Kompetencje jutra. Jak budować kompetencje przyszłości w świecie po pandemii*. Retrieved from [http://zasoby.politykainsight.pl/pi2/pdf/PI\\_NCBR\\_Kompetencje\\_jutra.pdf](http://zasoby.politykainsight.pl/pi2/pdf/PI_NCBR_Kompetencje_jutra.pdf). Accessed June 21, 2021
- [3, 4] European Commission (2011). Communication from The Commission to the European Parliament, The Council, The European Economic and Social Committee and The Committee of the Regions. *Supporting Growth and Jobs – an Agenda for the Modernisation of Europe's Higher Education Systems*. Retrieved from: <https://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2011:0567:FIN:EN:PDF>. Accessed June 21, 2021
- [5, 6] European Commission (2020b). Survey on the Impact of COVID-19 on European Universities. *Main Conclusions*. Retrieved from [https://ec.europa.eu/programmes/erasmus-plus/sites/default/files/coronavirus-eui-impact-results-may2020\\_en.pdf](https://ec.europa.eu/programmes/erasmus-plus/sites/default/files/coronavirus-eui-impact-results-may2020_en.pdf). Accessed January 17, 2021
- [7] Kast, F. E. & Rosenzweig, J. E. (1970). *Organization and Management: A Systems Approach*. New York: McGraw Hill.
- [8] Packendorff, J. (1995). Inquiring into the Temporary Organization: New Directions for Project

- Management Research. *Scandinavian Journal of Management*, 11(4), 319–333. doi: [10.1016/0956-5221\(95\)00018-Q](https://doi.org/10.1016/0956-5221(95)00018-Q)
- [9] Stead, J. G. & Stead, W. E. (2008). Sustainable Strategic Management: An Evolutionary Perspective. *International Journal of Sustainable Strategic Management*, 1(1), 62–81. doi: [10.1504/IJSSM.2008.018127](https://doi.org/10.1504/IJSSM.2008.018127)
- [10] Woźniak-Sobczak, B. (2015). Symbioza paradygmatów zarządzania przedsiębiorstwem w otoczeniu sieciowym, *Studia Ekonomiczne. Zeszyty Naukowe Uniwersytetu Ekonomicznego w Katowicach*, 222, 53–69.
- [11] Czakon, W. (2012). *Sieci w zarządzaniu strategicznym*. Warszawa: Wolters Kluwer.
- [12] Wieland, A. & Wallenburg, C. M. (2013). The Influence of Relational Competencies on Supply Chain Resilience: A Relational View. *International Journal of Physical Distribution & Logistics Management*, 43(4), 300–320. doi: [10.1108/IJPDLM-08-2012-0243](https://doi.org/10.1108/IJPDLM-08-2012-0243)
- [13, 24] Dobrowolska, M. & Knop, L. (2020). Fit to Work in the Business Models of the Industry 4.0 Age. *Sustainability*, 12(12), 4854. doi: [10.3390/su12124854](https://doi.org/10.3390/su12124854)
- [14] Górką, K., Thier, A., & Łuszczak, M. (2020). Consequences of the Fourth Industrial Revolution in Social and Economic Development in the 21<sup>st</sup> Century. In P. Buła & B. Nogalski (Eds.), *The Future of Management Industry 4.0 and Digitalization* (pp. 60–71). Kraków: Jagiellonian University Press.
- [15] Janik, A. & Ryszko, A. (2018). Mapping the Field of Industry 4.0 Based on Bibliometric Analysis. In *Proceedings of the 32<sup>nd</sup> International Business Information Management Association Conference—Vision 2020: Sustainable Economic Development and Application of Innovation Management from Regional Expansion to Global Growth* (pp. 6316–6330). Retrieved from [https://www.researchgate.net/publication/333211114\\_Mapping\\_the\\_field\\_of\\_Industry\\_4.0\\_based\\_on\\_bibliometric\\_analysis](https://www.researchgate.net/publication/333211114_Mapping_the_field_of_Industry_4.0_based_on_bibliometric_analysis). Accessed on April 7, 2020
- [16] Jeschke, S., Brecher, C., Song, H., & Rawat, D. B. (Eds.). (2017). *Industrial Internet of Things, Springer Series in Wireless Technology*. Cham: Springer International Publishing.
- [17] Rojko, A. (2017). Industry 4.0 Concept: Background and Overview. *International Journal of Interactive Mobile Technologies*, 11(5), 79–80. doi: [10.3991/ijim.v11i5.7072](https://doi.org/10.3991/ijim.v11i5.7072)
- [18] Sanders, A., Elangswaran, C., and Wulfsberg, J. (2016). Industry 4.0 Implies Lean Manufacturing: Research Activities in Industry 4.0 Function as Enablers for Lean Manufacturing. *Journal of Industrial Engineering and Management*, 9(3), 811–833. doi: [10.3926/jiem.1940](https://doi.org/10.3926/jiem.1940)
- [19] Schwab, K. (2015). The Fourth Industrial Revolution. What It Means and How to Respond. *Foreign Affairs*, December 12. Retrieved from <https://www.foreignaffairs.com/articles/2015-12-12/fourth-industrial-revolution>. Accessed April 7, 2020
- [20] Tay, S. I., Lee, T. C., Hamid, N. Z. A., & Ahmad, A. N. A. (2018). An Overview of Industry 4.0: Definition, Components, and Government Initiatives. *Journal of Advanced Research in Dynamical and Control Systems*, 10(14 – Special Issue), 1379–1382.
- [21] Poszytek, P. (2021). The Landscape of Scientific Discussions on the Competencies 4.0 Concept in the Context of the 4<sup>th</sup> Industrial Revolution — A Bibliometric Review. *Sustainability*, 13, 6709. doi: [10.3390/su13126709](https://doi.org/10.3390/su13126709)
- [22] Barata, J. Da Cunha, P. R., & Stal, J. (2018). Mobile Supply Chain Management in the Industry 4.0 Era. *Journal of Enterprise Information Management*, 31(1), 173–192. doi: [10.1108/JEIM-09-2016-0156](https://doi.org/10.1108/JEIM-09-2016-0156)
- [23] Bawany, S. (2017). The Future of Leadership in the Fourth Industrial Revolution. Retrieved from [https://www.hr.com/en/magazines/leadership\\_excellence\\_essentials/december\\_2017\\_leadership/the-future-of-leadership-in-the-fourth-industrial-\\_jar4bzay.html](https://www.hr.com/en/magazines/leadership_excellence_essentials/december_2017_leadership/the-future-of-leadership-in-the-fourth-industrial-_jar4bzay.html). Accessed June 21, 2021
- [25] Karabiegović, I. (2018). The role of industrial and service robots in the 4th industrial revolution — Industry 4.0. *Acta Technica Corvinensis – Bulletin of Engineering*, 11, 11–16. Retrieved from <http://acta.fih.upt.ro/pdf/2018-2/ACTA-2018-2-01.pdf>. Accessed June 21, 2021
- [26] Ellis, A., Van Der Merwe, A. F. (2019). Human Expertise in Additive Manufacturing Digitalization. In *The future of manufacturing layer by layer, Establishing the 3D process chain, Proceedings of the 20th Annual International RAPSADA Conference* (pp. 163–170). Bloemfontein, South Africa, 6–8 November 2019.