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The two-mode network approach to digital skills and tasks among technology park employees

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ABSTRACT

Objective: The article predicts how the performance of tasks understood as tasks shared between a dyad can be predicted based on the perceptual difference of behaviors in terms of the digital skills of technology park employees (social actors). Here, employees serve park tenants mainly from the creative, game, IT and multimedia industries, and broadly understood audiovisuals.

Research Design & Methods: The questionnaire previously validated by other authors was used to measure employees' digital skills and two non-parametric network statistics tests based on data permutation were conducted: the quadratic assignment procedure (QAP) and the multiple regression quadratic assignment procedure (MRQAP), which are good at error autocorrelation.

Findings: The results show that there is a relationship between selected digital skills and tasks shared among employees; digital skills influence behavior patterns, thus increasing or decreasing tasks shared in the workplace; moreover, dyad embedded in an intra-organizational social network is more appropriate for anticipating inherently relational tasks sharing between employees in a knowledge-intensive organization.

Implications & Recommendations: The findings contribute to the literature on digital skills and shared tasks from a dyadic and organizational perspective by deepening the understanding of the relationship between a pair of employees. Organizations should apply digital skills training to influence interpersonal relationships and thus the effectiveness of task performance and business processes. It seems necessary to develop and implement policy's assumptions about increasing the digital skill level of its employees.

Contribution & Value Added: The article shows digital skills (information management, information evaluation, communication sharing, communication building, communication networking, collaboration, critical thinking, creativity, problem solving) in connection with the tasks performed in the workplace in terms of dyads and two-mode networks (actors and digital skills; actors and tasks performed). In this perspective, the perceptual differences of behaviors in digital skills are considered, which from the network perspective have not yet been explored by other researchers.

Article type:	research article
Keywords:	digital skills; dyad; two-mode network; tasks; social networks; social network analysis, QAP, MRQAP
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INTRODUCTION

Modern work in service organizations requires not only technical skills focused on the operation of information systems or information and communication technologies (ICT) (Van Deursen & Van Dijk, 2014) but also digital skills and acceptance of new technology. Our research portrays the adopted level of analysis (dyad) and two-mode networks to digital skills and tasks in a specific context: the informal organizational network. The way work is actually done tends to have more to do with informal networks, as an organization's formal structure only partially reflects how tasks are performed. This assumption inspired us to find out the differences and similarities in the networks of relationships oriented towards digital skills and employee tasks. We have adopted the two-mode network approach (cf. Ujwary-Gil, 2019), which is a fertile research perspective in social and behavioral sciences based on the relational approach to work and employees who perform tasks in the workplace or use resources (skills) creating a structure of relationships characterized by certain regularities. The network research in the organizational context concerns social ties, such as friendship (Hunter *et al*., 2020), sharing information and knowledge (Che Ibrahim *et al*., 2019; Jenke & Pretzsch, 2021; Steffen *et al*., 2017; Kanska *et al*., 2021; Darmawan *et al*., 2021) or trust (Li *et al*., 2020; Yao *et al*., 2019), and less known mapping of a science and technology policy network (*e.g.* Kalantari *et al*., 2021).

In our research, we used the concept of digital skills, which has a practical dimension (Kurczewska *et al*., 2020; van Laar *et al*., 2020) related to professional work and tasks performed. Contrary to Chaker's (2020) study, we focused on soft digital skills rather than hard digital skills. Though digital skills also mean the use of ICT for work, study and active participation in society, creating a complex socio-digital system (Ujwary-Gil & Potoczek, 2020). In the literature, the terms 'digital skills' and 'digital competences' are often used interchangeably. According to van Laar *et al*. (2020), digital skills are the ability to communicate using information and communication technologies; information management and evaluation; communication sharing, building, and networking; collaboration; critical thinking; creativity, and problem solving in digital space. They refer to skills relevant in a digitalized work interaction (van Laar *et al*., 2017).

To understand better the existing relationships between digital skills perceived in this way and the shared tasks understood as work performed within the organization between employees, we used a social network analysis approach to look at our research area through the prism of a network of relationships and interdependencies. The (two-mode) network is a relationship between two sets of nodes (*e.g.* actor and digital skill; actor and task). There is little research that highlights the individual digital skills of employees and their impact on the work they do. A few examples include the valuable studies of van Laar *et al*. (2020, 2019, 2018). However, their research does not concern the dyadic view of digital skills and relational work. Most of the studies look at measuring digital skills, but not in relation to the tasks performed in organizations. Therefore, our understanding of what digital skills actually influence workplace tasks is limited. Reducing this research gap would allow for more effective organization of business processes in the organization. According to our knowledge, non-parametric tests of social network analysis were used for the first time to investigate the relationships existing (or not) between digital skills and tasks shared of employees, in which the subject of analysis was a dyad (a pair of actors), and work was interdependent and relational (Androniceanu *et al*., 2022). It is important to emphasize that formal structures and processes organize the task environment over which networks are layered. Hence, the organization is a system of activities (tasks). Still, more detailed insights let us understand that there is a structure in time and space that organizes them and matches individuals to tasks.

Thus, the objective of our research was a social network analysis of digital skills in relation to the tasks shared in the workplace. In this perspective, we considered the perceptual difference of behavior in digital skills. We measured employees' digital skills based on the previously validated questionnaire by van Laar *et al*. (2018). In this research, we argued that the digital skills used and the tasks performed by employees could be observed through network behavior patterns using non-parametric tests of social network analysis. We studied networks that connect employees through digital skills and tasks. Actors' behaviors were seen as interrelated between employees, not separated. To test our hypotheses, we replaced the two-mode matrices of actor x digital skill (ADS_{ij}) and actor x task (AT_{ij}) with one-mode networks of actor x actor (AA_{ij}), which list digital skills and related tasks through dyadic actors.

The article is organized as follows: after the introduction section, we will present a literature review and hypothesis development; then the methodology section, which is divided into data and sample, methods, measures; respectively, the results and discussion section. The article will end with conclusions, including implications for theory and practice, limitations, and directions for further research.

LITERATURE REVIEW AND HYPOTHESES DEVELOPMENT

The pandemic lasting continuously since 2020 has forced employees to work remotely, in which multidimensional digital skills play a unique role in the performance of tasks (Florek-Paszkowska *et al.*, 2021; Gajdzik *et al.*, 2021; Skvarciany & Jurevičienë, 2021; Androniceanu, 2020). It has the most significant evidence in e-business development (Roshchyk *et al*., 2022), possibilities for remote work (Raišienė *et al*., 2021), implementation of AI tools in the consumer space (Sułkowski & Kaczorowska-Spychalska, 2021). It significantly influenced the processes of production of goods and services, their groundbreaking changes and potential political, social, and economic consequences (Rymarczyk, 2020). Enterprises dynamise the development of relational skills of IT-based enterprises, which affects their access to knowledge, supports innovation, and creates a competitive advantage (Benazzouz, 2019; Nuryakin, 2021). Digital skills and digital competences are essential in today's life and are even the basis of social exclusion or inequality (Ragnedda *et al*., 2020; Tewathia *et al*., 2020). In professional life, digital skills and digital competences are today a determinant of success in performing tasks at the individual level (Mazurchenko & Maršíková, 2019), innovation (Shakina *et al.*, 2021) and competitive advantage (Benešová & Hušek, 2019; Capestro & Kinkel, 2020) at the organizational level, and in macro terms – the level of digitization of society (Sá *et al.*, 2021) or smart cities (Komninos *et al.*, 2021).

The essence of the task (activity) in our research was the work performed within the organization. The action's dynamics was reflected in the constant interpenetration, emergence, and loss of relationships between people. The tasks were always analyzed within particular organizational and environmental contexts (Delibasic, 2022; Mitrovic, 2016). The tasks had a wide scope and relate to the necessary organizational action; they had a humanistic and intentional overtone. In each activity, a person used the skills at his/her disposal to perform a task. Digital skills empirically investigated by van Laar *et al*. (2020, 2018), such as information management and evaluation; communication sharing, building, networking; collaboration, critical thinking, creativity, problem solving, which were the subject of our considerations, are necessary for the implementation of tasks in organizations that provide knowledge-based services. They have a universal dimension, so their application is not limited to specific industries or types of activity, although they must consider the organizational context (Vieru, 2015).

Digital information management skills concern the ability to search, select, evaluate (usefulness, credibility, up-to-date), organize and store information for professional purposes (Hwang *et al.*, 2015). Work is based on information retrieval systems to gather information necessary for problem solving and decision making, and requires the ability to save and organize files properly, and the consistent naming of digital files (Russell-Rose *et al*., 2018). The need for information is a result of the information and knowledge gap; hence, in order to minimize this gap, the employee turns to other employees for help when they share tasks or look for answers online. The use of ICT leads to better recognition of the skills and competences necessary for social inclusion through reciprocity and interaction; thus digital skills, are a predictor of ties and cooperation in the scope of performed tasks (Riemer *et al*., 2009). Employees' use of digital skills can increase or decrease the potential for task integration in their workplace. We suggested that assessing digital skills differences between a pair of actors may be a good indicator of tasks shared in a workplace. Bearing the above in mind, we hypothesized:

H1: Differences between employees' digital skills in information management **(H1a)** and information evaluation **(H1b)** will be negatively associated with the tasks shared by the dyad.

Today, communication using ICT has become commonplace in the workplace. Digital communication skills are the ability to interact with each other to achieve career goals. However, employees, especially specialists who want to create a positive image of an expert or a given organization, take care of the possibility of sharing knowledge and experience based on a critical selection of places for publishing and establishing and maintaining contacts (Van Deursen *et al.*, 2014). Communication influences social interactions and relationships (Hwang *et al*., 2015). Employees perceive communication as essential for their daily routines and so undertake online content sharing activities, including posting news, articles, blogs, and even starting online discussions on topics related to professional work (Lewin & McNicol, 2015). We put forward a hypothesis:

H2: Differences between employees' digital skills in communication building **(H2a)**, communication sharing **(H2b)**, and communication networking **(H2c)** will be negatively associated with the tasks shared by the dyad.

Organizations are relational in nature, which means that employees with complementary competences constantly contact each other and share tasks, experiences, and information via online media (Makkar *et al.*, 2020). Collaborative digital skills are assigned to employees on the basis of their specialized knowledge and skills required to complete tasks and support others in their work *(*Pitafi *et al*., 2018). The complexity of tasks requires the collaboration of employees whose knowledge and skills are complementary, making it necessary to understand their own tasks and colleagues' tasks. We put forward a hypothesis:

H3: Differences between employees' digital skills in collaboration will be negatively associated with the tasks shared by the dyad.

Critical thinking skills allow one to understand the relationships between facts or concepts and recognize mistakes in reasoning and action. The digital approach in critical thinking focuses on defining problems, collecting data, opinions, and arguments from various, usually online, sources. In addition, digital critical thinking skills allow to evaluate the data in terms of their reliability and objectivity, on the basis of which employees perform their tasks more effectively (Oberländer *et al*., 2020). By thinking critically, the employee evaluates, synthesizes, and interprets relevant information related to the task situation (Tripathy, 2020). We put forward a hypothesis:

H4: Differences between employees' digital skills in critical thinking will be negatively associated with the tasks shared by the dyad.

The creative potential of employees is supported by online platforms allowing them to participate in the performance and sharing of online tasks (Pitafi *et al.*, 2018; Sun *et al.*, 2020). Employees can use information and communication technology to be original in their work and be creative in their tasks. Creative digital skills are related to the ability to use ICT in bisociative linking of distant associations (content, ideas) in order to create new configurations used to carry out tasks (Carter *et al.*, 2020). Increasingly common online platforms enabling participation and task sharing contribute significantly to the creation of new products and/or services (Falco & Kleinhans, 2019). In this sense, creativity is related not only to novelty, but also to the utility value of the proposed solutions. In the digital context, it is challenging to study the features of creative thinking ignoring social factors like support or sharing tasks, thus, we hypothesize:

H5: Differences between employees' digital skills in creative thinking will be negatively associated with the tasks shared by the dyad.

Employees with digital problem-solving skills are able to define a problem situation to which they correctly assign a problem-solving strategy. In conjunction with creative and critical thinking skills, ICT helps to find many solutions, effectively implement knowledge into tasks, and solve professional problems (van Laar *et al*., 2020). Information and communication technologies enable quick and relatively unlimited access to knowledge and information that employees are more or less able to use to solve problems (Attaran *et al*., 2019). Problem-solving skills help employees acquire and apply the knowledge they need to solve complex problems at work (Mehrabi Boshrabadi & Hosseini, 2020). Employee social capital refers to integration within an organization and collaborative networks to perform tasks. According to Eshet (2012), in addition to using software or operating digital devices, digital skills emphasize socio-emotional skills to complete tasks and solve problems. We put forward a hypothesis:

H6: Differences between employees' digital skills in problem solving will be negatively associated with the tasks shared by the dyad.

RESEARCH METHODOLOGY

Data and Sample

Social network research often consists of identified populations, thus enabling data collection from all organization members (Borgatti *et al.*, 2018; Maciel & Chaves, 2017). Many network surveys cover very small organizations (or departments) with 22 (Maciel & Chaves, 2017) or 29 (Gibbons, 2004; Meyer, 1994) employees. However, in social network studies, the number of relationships that are being observed is the most important element – not the individuals (Maciejewski *et al.*, 2022). In our case, the main Technology Park Department, responsible for the entire organization's functioning, became the border of the network, within which the Administrative Department and the Management Office were separated. Based on the convenience strategy of purposeful case selection (Palinkas *et al.*, 2015), we chose one of Poland's largest technology parks for research, offering tenants various sophisticated digital technology services and the benefits of locating their activities in the Park. Network research is characterized by the purposefulness of selecting the network boundary so that it is possible to study the existing relations. In this case, the network's boundary was the population of the established Technology Park Department. The number of employees was N = 33 (three employees did not complete the survey, which gave us 92% of the surveyed population (*cf.* Meyer, 1994). We conducted the research from August 2020 to February 2021. As we needed a very high response rate, it was important to work closely with top management and gain their strong support for the research project. Of those who participated in the study, 39% were men, and 61% were women. The mean age was 37.85 (SD 8.14), and the mean number of years of professional experience (tenure) in the Park was 5.06 (SD 3.81). We identified a total of 16 positions (e.g., business development specialist, company development specialist, financial coordinator, director, manager of the company support and development team). Within one matrix, we created N = 1056 observations (N*(N-1)); in total N = 14784 observations for all 14 matrices that we correlated and regressed. The fundamental assumption of network research is the dependence of observations against each other (*e.g.* actors are interdependent due to the performed tasks).

Methods and Measures

Similarly to Tsai and Ghoshal (1998), the managing director was invited to the interview, because he was the person responsible for business process management based on which the selected tasks (T) were identified. The interview made it possible to develop the categories of typical tasks that were used as answer options (items) in the survey. We conducted a pilot study, which allowed for the simplification of the survey according to the glossary of proprietary terms of the Technology Park Department, and after reducing the complexity and time required for filling in, the final version was ready. We transcribed the interview and coded it using descriptive codes (Miles & Huberman, 1994). The data was collected through an online survey, in which we asked employees to evaluate their behavior related to digital skills and the tasks performed. In particular, we asked respondents to rate the frequency of behaviors related to their experiences with specific digital skills practices (45 items) on a five-point Likert scale (see Appendix) and to rate behavior related to the tasks performed (21 statements) also on a five-point Likert scale.

The quadratic assignment procedure (QAP) and multiple regression QAP (MRQAP) are the nonparametric significance tests for correlating one-mode and two-mode networks (after conversion to a one-mode network) and matrix-like network attributes. Many square matrices with the same dimensions can be correlated (*e.g.* actors for which the type of relation or attributes have been defined). (MR)QAP are usually based on Pearson's r correlation (the Pearson product-moment correlation coefficient), in which a point-biserial correlation coefficient is used for binary and continuous variables, and a phi-coefficient for binary only variables. Matrices with binary and value data (*e.g.* interval, ordinal) are allowed, indicating the relationship's strength. Correlating matrices of a different nature of data does not change the interpretation of the correlation coefficients in which we control the effects due to the dependencies of the observations. MRQAP network method regresses many independent variables on dependent variables, allowing researchers to test the overall R^2. The observed matrices are then compared with the permutations of the random matrices for the p-value calculation, while the regression coefficients are computed using ordinary least squares (OLS). Next, the OLS regression is repeated with this new permuted matrix, resulting in different beta coefficients (see more Ujwary-Gil, 2022).

We divided our variables into: digital skills (independent variables), tasks performed (dependent variable), and employee attributes (control variables), which were created at the individual level and had to be transferred to the relational level. Before developing relational matrices (a dyad), we measured variables on an individual (actor-based) level. Consequently, the cells represented a kind of the ties between the employees and all variables were presented as matrices, in which the rows and columns represent actors, digital skills, and tasks (Raider & Krackhardt, 2017). The independent variables were the digital skills of employees (ADS_{ij}), which we did not consider in isolation from others but rather in relation to other employees' digital skills. Among other studies, social network research aimed at understanding how ties affect behaviors relies on behavioral similarity or differences (*e.g.* Meyer, 1994; Zagenczyk *et al.*, 2020). Similar to the studies by Zagenczyk *et al*. (2020), we measured the behavioral differences in the frequency of digital skills used by employees as the degree to which the digital skills used by the main employee were different from the frequency of digital skills use notified by each of his/her network connections. To assess differences, we began with measuring each employee's digital skills with a 45-question (items) and questionnaire created by van Laar *et al*. (2018). According to Cronbach's alpha, the level of reliability for all statements was 0.94. Employees answered all 45 items using a five-point Likert scale (1 = never, 2 = rarely, 3 = sometimes, 4 = often, 5 = (almost) always). We chose those items of the questionnaire that could best relate to the specificity of people's work in the main department responsible for the technology park's operation. We then grouped digital skills into nine areas (see Appendix and van Laar *et al*., 2018): information management (Cronbach's alpha (α) for the scale was 0.79); information evaluation (α = 0.68, after removing question 23); communication sharing (α = 0.80, after removing question 41); communication building (α = 0.82); communication networking (α = 0.88); collaboration (α = 0.87); critical thinking (α = 0.79); creativity (α = 0.83); problem solving (α = 0.88).

Then, each employee's responses by grouped digital skills were averaged to give an average score for the frequency of use of each digital skill, in which higher scores represented a higher frequency of digital skills activities. Then, analogously to the research of Meyer (1994), we evaluated the degree of difference, taking the absolute difference between the average score of a given *i* employee's digital skills and the average score of the *j* employee's digital skills. Finally, we used the results of the differences to create a matrix of difference, in which smaller (larger) numbers represented a greater (lesser) similarity between each pair of respondent's digital skills.

The dependent variable was created based on the measurement of the frequency of tasks performed by employees in the Technology Park Department, which resulted from the organizational context. Employees answered 21 statements (Cronbach's alpha = 0.84), how often they perform a given task (T1-T21) on the five-point Likert scale, where 0 = do not perform this task, 1 = once a year, 2 = once every few months, 3 = at least once a month, 4 = at least once a week, 5 = daily or almost daily. Examples of tasks are T1) Creating promotional content (website, articles, reports, dedicated graphics); T4) Monitoring the competition (analysis of the activities of similar entities in Poland and abroad); T7) Development of cooperation agreements; T12) Conducting regular interviews with clients on their condition and needs; T18) Accounting for clients (for development purposes, completing formalities, de minimis aid, and payments). The mean for the responses was 3.02 (SD 1.12), then we binarized the two-mode matrix of the actor x task (AT_{ij}) assuming the value of 1 wherever the respondents chose a response scale above 3.02, respectively 0 when the responses were below the mean (cf. Diez-Vial & Montoro-Sanchez, 2014). We received an assignment of the employee to a given task (strong relationships). Such a binarized matrix was the basis for the projection, *i.e.* the transformation of a two-mode matrix into a one-mode matrix, where at the intersection of rows and columns, we obtained the number of shared (the same) tasks by a pair of actors (dyad). The control variables were based on the homophily concept (Kossinets, 2006), which assumes that the similarity of the actors increases the likelihood of a relationship. Similar to creating a relational matrix of digital skills, the result was a symmetric pseudo-network that was binary for gender identity and position, and valued for age and tenure. In particular, the gender identities and work positions were 1 if *i* and *j* were of the same position or gender, and 0 otherwise. The age and tenure difference (in years) variables were measured as the absolute age difference between *i* and *j*.

RESULTS AND DISCUSSION

For the presentation of the results, we used the ORA (Organizational Risk Analyzer) program, version ORA-PRO 3.0.9.9.87 (Altman *et al.*, 2020) and UCINET 6 (version for Windows, 6.717) (Borgatti *et al.*, 2002), including two non-parametric tests: quadratic assignment procedure (QAP) and multiple regression quadratic assignment procedure (MRQAP). To use ORA-PRO and UCINET, we created a total of 14 matrices that included all the answers obtained in the study. To correlate and regress matrices, it is required to transform a two-mode matrix into a one-mode matrix. We transformed the two-mode matrix analogically to Jasny (2012) into the following one-mode projection of network A and its transposition AT in which rows (n) and columns (m) are replaced, creating a network $A_{ij} = A^T_{ji}$ for each pair of actors *ij*.

Our research unit is the dyadic relationship between two employees (cf. Tsai, 2001) who can be involved in several relationships in dyads. On the basis of the presented projection, the dependent variable was prepared as a matrix describing common tasks for each pair of employees. We used the QAP to obtain the estimation of the coefficients for the predictive models based on bivariate variables. Researchers (*e.g*. Krackhardt, 1988) recommend using QAP for dyadic data analysis in view of significance tests based on the permutation that is less prone to autocorrelation problems than, for instance, OLS regression models. QAP computes the Pearson correlation coefficients for two matrices by permuting multiple times (10000 in our case) the rows and columns of matrices, randomly assigning the results of the dependent variable to the result vector of each case for the independent variables. The number of possible permutations increases rapidly with the size of the network. The p-value of a statistic is the percentage of the number of times the observed correlations resulted from different matrix permutations. Table 1 shows the descriptive statistics: the means and standard deviations of the variables that make up the 14 matrices.

There was a low correlation between the independent variables, except for the digital skills in communication networking and dyadic digital skills in communication building ($r = 0.53$, $p < 0.001$), digital skills in creativity and digital skills in collaboration ($r = 0.42$, $p < 0.001$), digital skills in communication networking ($r = 0.37$, $p < 0.001$), digital skills in communication building ($r = 0.35$, $p < 0.001$). The correlation between digital skills in problem solving and the creativity ($r = 0.36$, $p <0.001$), and collaboration ($r = 0.37$, $p < 0.01$) was at a similar level. We observed that the correlations covering the control variables were practically non-existent, except for the correlation between the dyadic age difference and the dyadic tasks shared ($r = -0.20$, $p < 0.05$) and the dyadic tenure difference and the dyadic age difference ($r = 0.34$, $p < 0.01$).

Another non-parametric test is the MRQAP, which similarly to QAP, is based on permutation and takes error autocorrelation into account (Borgatti *et al.,* 2018). MRQAP considers many independent variables, in our case, these were digital skills divided according to the approach of van Laar *et al*. (2018) into nine types (see Table 2), which enabled the use of regression analysis on matrices (each variable corresponds to one matrix). As part of MRQAP, we used the Double-Dekker Semi-Partialling Method (Dekker *et al.*, 2007). We computed multiple regressions for the respective cells from the dyadic tasks shared matrix, the dyadic digital skills differences matrices, and the control variable matrices (Borgatti *et al.* 2002). As to QAP, we repeated the permutations 10000 times as suggested by Borgatti *et al*. (2018) to estimate the standard error.

Table 2 shows the MRQAP results. We first regressed the dyadic tasks shared matrix on the control variables (Model 1), then on independent variables (Model 2), and all variables combined (Model 3).

Table 1. Results of descriptive statistics and QAP correlations

Variables	M	SD	1	2	3	4	5	6	7	8	9	10	11	12	13
1. Dyadic tasks shared	1.80	1.05	1.00												
2. Digital skills in information management	1.00	0.59	0.00	1.00											
3. Digital skills in information evaluation	0.94	0.46	-0.01	0.05	1.00										
4. Digital skills in communication sharing	1.29	0.72	-0.12+	0.14*	0.01	1.00									
5. Digital skills in communication building	1.18	0.66	0.01+	-0.06	-0.01	0.05	1.00								
6. Digital skills in communication networking	0.95	0.68	-0.04	0.10	0.07	0.11+	0.53***	1.00							
7. Digital skills in collaboration	0.65	0.49	-0.18+	-0.04	0.02	-0.05	0.21*	0.08	1.00						
8. Digital skills in critical thinking	0.66	0.42	0.22*	-0.17+	-0.12+	0.09	0.17+	0.02	-0.18+	1.00					
9. Digital skills in creativity	0.74	0.49	-0.18	0.00	0.12+	0.01	0.35***	0.37***	0.42***	-0.14	1.00				
10. Digital skills in problem solving	0.69	0.44	0.05	-0.02	0.01	-0.06	0.33***	0.25*	0.37**	0.17+	0.36***	1.00			
11. Gender	–	–	-0.05	0.06*	0.04	0.02	-0.02	0.03	0.07*	-0.07*	0.02	0.04	1.00		
12. Dyadic age difference	9.68	7.08	-0.20*	0.03	-0.01	-0.08+	-0.12*	-0.10	0.02	-0.05	-0.03	-0.13*	-0.01	1.00	
13. Dyadic tenure difference	4.86	3.17	-0.08	-0.06	-0.06	-0.05	-0.11*	-0.10+	0.08	-0.02	-0.02	0.10	-0.01	0.34**	1.00
14. Position	–	–	0.02	-0.02	-0.01	-0.02	0.01	-0.04	0.04	0.04	-0.06	0.07+	0.04	-0.03	0.03

N = 1056 relationships; Gender: male = 1, female = 0; Position: same position = 1, different = 0

*p < 0.05, **p < 0.01, ***p < 0.001, +p < 0.1

Source: own study.

Table 2. MRQAP results for dependent variable: 1. Dyadic tasks shared

Variables	Model 1	Model 2	Model 3
2. Digital skills in information management	–	0.02 (0.14)	0.04 (0.14)
3. Digital skills in information evaluation	–	-0.19+ (0.13)	-0.19+ (0.13)
4. Digital skills in communication sharing	–	-0.18* (0.11)	-0.20* (0.10)
5. Digital skills in communication building	–	0.11 (0.15)	0.09 (0.15)
6. Digital skills in communication networking	–	-0.03 (0.18)	-0.04 (0.17)
7. Digital skills in collaboration	–	-0.50* (0.28)	-0.45+ (0.28)
8. Digital skills in critical thinking	–	0.50* (0.26)	0.43* (0.25)
9. Digital skills in creativity	–	-0.55* (0.23)	-0.52* (0.22)
10. Digital skills in problem solving	–	0.32+ (0.25)	0.28 (0.24)
11. Gender	-0.12 (0.11)	–	-0.08 (0.10)
12. Dyadic age difference	-0.03* (0.02)	–	-0.03* (0.01)
13. Dyadic tenure difference	-0.01 (0.03)	–	-0.01 (0.03)
14. Position	0.05 (0.23)	–	-0.04 (0.20)
R^2	0.04*	0.12***	0.15***
Dyadic observations	1056	1056	1056
Permutations	10000	10000	10000

Unstandardized Coefficients; Standard Errors in Parentheses
*p < 0.05, **p < 0.01, ***p < 0.001, $^{+}$p < 0.10
Source: own study.

The coefficients in Table 2 are unstandardized regression coefficients. Model 1 introduces control variables that show little effect on the dyadic tasks shared; the percentage of variance included is 4% (R^2 = 0.04, p < 0.05). Model 2 includes independent variables and increases the explanatory power to 12% (R^2 = 0.12, p < 0.001). In Model 3, we added all the variables and the variance was 15% (R^2 = 0.15, p < 0.01). This suggests that 15% of the variance in the performed tasks can be explained based on relational factors. As expected, some digital skills were significantly associated with the dependent variable. Hypothesis H1 predicted that digital skills in information management (H1a) and information evaluation (H1b) between employees in the network would reduce the tasks shared. The digital skills in information evaluation were negatively and marginally significantly related to the tasks shared (β = -0.19, p < 0.10) but not the digital skills in information management (β = 0.04, p > 0.05). Overall, we found that the tasks shared had no impact on employees who have different approaches to digital information management. Regarding hypothesis H2, we expected that digital skills in communication such as communication building (H2a), communication sharing (H2b), and communication networking (H2c) between employees in the network would be negatively associated with the tasks shared.

We found partial support for this hypothesis, because the digital skills in communication sharing were negatively and significantly related to the tasks shared (β = -0.20, p < 0.05). We did not find support for the hypothesis H2a and H2c, because the digital skills in communication building (β = 0.09, p > 0.05) and the digital skills in communication networking (β = -0.04, p > 0.05) were not related to the tasks shared. We found no evidence supporting the assumption that employees adopt behaviors in these digital skills similar to those associated with task-sharing relationships. In hypothesis H3, we predicted that the digital skills in collaboration in the network would have a negative impact on the tasks shared. We found support for this hypothesis, because the digital skills in collaboration were negatively and marginally significantly related to the tasks shared (β = -0.45, p < 0.10). We predicted in hypothesis H4 that differences in the critical thinking between employees in the network would be negatively associated with the tasks shared. Overall, we found no support for this hypothesis, because the digital skills in critical thinking were positively and significantly related to the increase of tasks shared (β = 0.43, p < 0.05). Moreover, for our last hypothesis, H5, we predicted that the digital skills in creativity between employees in the network would have a negative impact on tasks shared (β = -0.52, p < 0.05). At the same time, we did not find support for hypothesis H6, because the digital skills in problem solving ($\beta = 0.28$, $p > 0.05$) was not related to the tasks shared. If we consider the significance level, the research supported a total of three hypotheses (H2b, H4, and H5). Or, additionally, if we accept the marginal level of significance, then we can conditionally assume that the dyadic information evaluation digital skills negatively affects the tasks shared at a marginal significance level ($\beta = -0.19$, $p < 0.10$), and therefore H1b can be confirmed, and the digital skills in collaboration negatively affect the tasks shared, also at a marginal level of significance ($\beta = -0.45$, $p < 0.10$), which H3 may confirm.

The roots of organizing work from the dyadic perspective can be found in Barnard (1938), known as the progenitor of the dyadic theory of organizational behavior, who sees organizations as negotiated systems and cooperation as the essence of organizing. Barnard wrote about employees interacting with each other to achieve goals, what Graen and Scandura (1987) call dyadic organizing, and Weick (1979) calls organizing a process built on individual behaviors that are related between two or more people. Therefore, any behavior of one person is dependent on that of another person. Our two-mode networks, especially their projection, are characterized by symmetry (Breiger, 1974) which means that if actor A_{ij} is connected with actor A_{ji} by different/similar behavior, then A_{ji} is also associated with A_{ij}. It can be predicted that if two actors share digital skills or tasks, they are related to each other. Breiger (1974) and Feld (1981) point out that the ties and affiliations that take place in two-mode networks are related, and ties emerge from shared connections. Thus, when two employees share the same digital skills or perform the same tasks, it usually leads to the creation of social ties between the actors. As two people have different (similar) digital skills or tasks, the strength of their social ties will decrease (increase). Tie strength is a characteristic that either leads to more interaction between the two employees or an interaction that is more valued.

In addition to finding out whether social network analysis provides a new description of the digital skills activity of employees, our main expectations were related to the linkage patterns that reflect the performance of tasks through the lens of employees' digital skills. Digital skills shaped through practical action and experience indicate to what extent an individual is able to use digital skills to perform specific tasks assigned to a given work. The results for these hypotheses emphasize the significant impact of behavioral differences on the variability of the performed tasks. According to Umphress *et al*. (2003), negative signs in the correlation and regression tables have been inverted. Positive coefficient scores represent a greater similarity in digital skills, and negative scores represent a lesser similarity (differences) in employees' digital skills. As a result of a decrease in the similarity of digital skills, behavior on the employee side, and an increase in behavioral similarity in the digital skills of a co-worker, the digital skills similarity will decrease for the dyad. Our results show that selected digital skills contribute to the formation of patterns of behavior and interpersonal relations, thus increasing or decreasing the number of tasks shared in the workplace.

In their research on organizational behavior, Wagner *et al*. (1984) indicate that differences affect relationships between individuals and organizational cohesion. In other words, there is a strong argument that differences between nodes affect how networks are linked, or that differences can keep employees apart. Another line of research focuses on the reverse trend, called homophily, which indicates that similarity brings people closer together in networks. In our research, matrices described some kind of similarity or difference in behavior between employees that may have had something to do with the similarity in the way an organization performs tasks within its business processes. The opposite, the heterophily phenomenon is different employee relationships that tend to disappear as the network grows (Mehra *et al*., 1998). In our research, neither gender, tenure, nor the position held determined the dependent variable. The dyadic approach to intra-organizational relationships allowed us to understand how an individual's behavior becomes integrated with others through coordinated and interdependent tasks. In the informal approach to the organization, as mentioned in the introduction, unstructured tasks are not specified and cannot be analyzed and reduced to written standard procedures like standardized tasks (Graen & Scandura, 1987). A dyadic approach involving two employees and their interrelationships can reveal differences in the behavior of digital skills used to complete tasks, as is the case of our research.

CONCLUSIONS

In our research, we used social network analysis applied in a dyadic context to examine the relationship between digital skills and the tasks performed by technology park employees. We established the relational level on digital skills and performed tasks embedded in an intra-organizational social network that are relational in nature. Digital skills as a construct has been placed on the individual's properties that accumulate in the organization through social interactions and relations. Table 3 summarizes the evidence for the research hypotheses.

Table 3. Final results for the research hypothesis

Hypothesis		Beta (β)	p-value	Status
H1a	Digital skills in information management ---> task shared	0.04	0.40	Not confirmed
H1b	Digital skills in information evaluation ---> task shared	-0.19	0.08	Confirmed
H2a	Digital skills in communication building ---> task shared	0.09	0.29	Not confirmed
H2b	Digital skills in communication sharing ---> task shared	-0.20	0.03	Confirmed
H2c	Digital skills in communication networking ---> task shared	-0.04	0.39	Not confirmed
H3	Digital skills in collaboration ---> task shared	-0.45	0.06	Confirmed
H4	Digital skills in critical thinking ---> task shared	0.43	0.04	Not confirmed
H5	Digital skills in creativity ---> task shared	-0.52	0.01	Confirmed
H6	Digital skills in problem solving ---> task shared	0.28	0.12	Not confirmed

Source: own study.

The hypothetical relationship between dyadic digital skills, such as information management (H1a), communication building (H2a), communication networking (H2c), creative thinking (H5), and problem solving (H6) with the dependent variable, was not confirmed in our research. On the other hand, dyadic digital skills in information evaluation (H1b), communication sharing (H2b), collaboration (H3), and critical thinking (H4), may be alternative paths to understanding the tasks performed between employees in knowledge-intensive organizations. Our dyadic approach to digital skills was in line with the multiplexity concept of Zagenczyk *et al*. (2015), who considers relationships between the dyad as overlapping. This feature of the social network perspective implies that multiple ties can be considered simultaneously and that certain relationships should retain their separate features, predecessors, and consequences (see also Raider & Krackhardt, 2017).

The findings contribute to the literature on digital skills and tasks shared from a dyadic and organizational perspective by deepening the understanding of the relationship between a pair of employees (actors) in reference to the tasks performed. Our theoretical input is predicting the relationship between digital skills and the tasks performed as actor-based constructs transformed into relational constructs. It seems that the assumptions in Model 3 are better suited to predicting the dyadic tasks shared, which is inherently relational. Moreover, by adopting a social network perspective, we identified a new source of variation in digital skills by arguing that digital skills differ at the dyadic level of analysis. On the other hand, this is the first empirical study we know of that has shown a direct influence of digital skills on internal task performance practices. We introduced a new relational measure based on the dyadic approach for the various types of digital skills mentioned in the research and performed MRQAP on the basis of a previously validated questionnaire (see van Laar *et al*., 2018) on behaviors related to the digital skills of employees.

Most importantly, our study predicted how specific digital skills influenced the dyadic approach to the tasks shared, based on empirical evidence obtained through MRQAP. So far, according to our knowledge, no research has been undertaken to investigate the dyadic digital skills differences of co-workers and their relationship with the dyadic tasks shared. Most of the publications concern the study of the social network's impact on many other phenomena (Kirschbaum, 2019). Our research approach can also be seen as an incentive to those who hope to address the complexities of management studies, as is the case with the studies by Kaše *et al.* (2009), especially since in the knowledge-intensive service industry in which technology parks operate, research in management literature rarely discusses employees' individual digital skills. On the other hand, multilevel research enables an understanding of the organizational business processes occurring at different levels (multilevel) by combining actor-based and relational levels. The results suggest that digital skills are a potentially essential source of social impact analogous to research on organizational coordination (Meyer, 1994), or emotion crossover in organizational social networks (Zagenczyk *et al*. 2020). However, no previous research that we are aware of has explored the possibility that shared dyadic tasks were socially influenced through the prism of dyadic digital skills differences. Our research indicates that social impact studies can benefit from considering whether ties exist and how strong these ties are (measured by the frequency of behavior) and whether they are multiplexed. Van Laar *et al*. (2020, 2018) note that most organizations lack a description of the skills their staff needs, and organizations would benefit from defining a digital profile for performed work and job position. There is a pressing need to identify which digital skills employees need to learn in the workplace to develop effective impact assessments.

Managers should consider the digital skills development practices targeted at employees as training and improvement often translate into their relationships. As a result, interventions that involve an individual may have far-reaching effects over time on the social network in the organization and, therefore, on the tasks and work performed. Organizations should apply digital skills training to influence interpersonal relationships and thus the effective performance of tasks and business processes. It seems necessary to develop and implement any policy's assumptions about increasing the skill level of its employees. As Chaker (2020) points out, the digital divide is viewed as an inequality in the use of digital skills; hence, policy should cover lifelong learning alongside other adult learning programs.

Our research has some limitations. We tested the model in one of the technology park departments with a high level of services and specialist knowledge of employees; therefore, a statistical generalization is not possible, which does not rule out a theoretical generalization (see more a single case network study, *e.g.* Zagenczyk *et al*., 2020; Ujwary-Gil & Potoczek, 2020; Maciel & Chaves, 2017; Gibbons, 2004; Umphress *et al*., 2003; Tsai, 2001). The department employed people with diverse positions, whose duty was to coordinate the entire technology park's tasks and work. The model requires re-verification in a different technology park or organization and a different organizational context in which digital skills play an essential role. Our research model should have considered longitudinal studies and network dynamics in order to make inferences about the causality and directions of inference valid. As Umphress *et al*. (2003) point out, the cross-sectional data leaves the question of causation open.

Data analysis required the construction of a difference score-based matrix that served as independent and control variables. Edwards (1993) suggests that differential scores could pose problems on reliability or regression to the mean when using them both as independent and dependent variables, which is not the case in our research. After Raider and Krackhardt (2017), we can conclude that MRQAP is less prone to problems related to the application of differential results, as is the case with more conventional estimation techniques. Moreover, as Zagenczyk *et al*. (2015) point out (see also Gibbons, 2004), QAP uses permutation-based hypothesis tests, which exclude the possibility of calculating statistical power, degrees of freedom, and effect size. Significance levels of the correlations and beta values may differ because of a limited number of correlations in the network data. As a result, R^2 values are also usually smaller than in an OLS regression (still, our R^2 is bigger than in Zagenczyk's *et al.* 2020 studies), and the p-value seems to be more critical in QAP analysis. Hence, many researchers ignore the R^2 value when presenting network regression results (*e.g*. Diez-Vial & Montoro-Sanchez, 2014). The model's overall fit may not sufficiently explain other important predictors, such as organizational culture, working climate, and leadership style, which may influence employee's behavior.

As rightly pointed out by Tobback and Martens (2019), we can distinguish two main types of relational data: real and pseudo-network data. A real network assumes that two actors are connected because, for instance, they communicate directly with each other. A pseudo-network assumes that two actors are connected, because they share behaviors or activities, and the network is implicit. We rely on two-mode network data and use data in a relational way. We create an implicit or pseudo-social network in which two employees are connected if they perform the same tasks or use the same digital skills (cf. Ujwary-Gil, 2019). The transposition of a two-mode network into a one-mode network assumes that this conversion necessarily entails data loss. Recent work, however, suggests that these fears have been exaggerated (Borgatti et *al*., 2018; Everett & Borgatti, 2013).

Future research on digital skills in organizational and network contexts can be more broadly linked to the type of tasks performed and resources used within specific business processes in creative, game, IT and multimedia industries, and broadly understood audiovisuals. This would allow an examination of whether the type of work performed and, thus, the identified business processes can be predicted on the basis of digital skills.

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Appendix:

Appendix: Questionnaire

Digital skill / Cronbach's alpha	Item	M	SD
Information management / 0.79	Do you save useful digital files directly to the right folder	4.09	0.91
	Are you consistent in the naming of digital files	4.00	1.00
	Do you organize digital files via a hierarchical folder structure	3.85	0.83
Information evaluation / 0.68	Do you check the reliability of a website	4.06	0.83
	Do you check the information found on a different website	3.85	0.80
	Do you check if the information found is up to date	4.30	0.68
Communication sharing / 0.80	Do you post new messages on the internet	2.82	0.95
	Do you post a blog/article on the internet	2.06	1.17
	Do you share information on the internet to start a discussion	3.09	0.98
Communication building / 0.82	Do you establish online contacts to collaborate with	3.79	0.78
	Do you find experts on the internet to start a project with	3.42	1.09
Communication networking / 0.88	Do you spend time and effort in online networking with people from your field	3.61	1.03
	Do you build online relationships with people from your field	3.58	1.03
	Does the internet help you approach new professional contacts	3.67	0.82
	Do you use your online network to increase brand awareness	3.18	1.10
	Do you start a conversation with other professionals via the internet	3.21	0.86
Collaboration / 0.87	Do you share important information with your team via the internet	4.00	0.97
	Do you use the internet to share information that supports the work of others	3.88	0.86
	Do you use the internet to share resources that help the team perform tasks	3.88	0.86
	Do you use the internet to provide each other with information that progresses work	4.52	0.67
	Does the internet help you get support from co-workers	4.42	0.66
	Do you communicate via the internet with co-workers from other disciplines	4.12	0.93
	Do you share work-related knowledge with each other via the internet	3.58	1.06
	Do you use the internet to give feedback to co-workers	4.09	0.58
	Does the internet help you carry out tasks according to the planning	3.55	0.94
	Do you use the internet to discuss your role and contributions with team members	3.79	0.78
	Does the internet help you use other professionals' expertise	4.33	0.89
Critical thinking / 0.79	Do you give proof or examples of arguments you give	3.82	0.68
	Do you ask questions to understand other people's viewpoint	4.15	0.62
	Do you consider various arguments to formulate your own point of view	3.97	0.73
	Do you connect viewpoints to give a new turn to the discussion	3.70	0.95
	Do you generate new input from a discussion	3.64	0.78
	Are you open for ideas that challenge some of your held beliefs	3.73	0.80
	Do you use the internet to justify your choices	3.09	0.98
Creativity / 0.83	Do you give a creative turn to existing processes using the internet	3.30	0.88
	Do you use the internet to generate innovative ideas for your field	3.64	0.82
	Do you show originality in your work using the internet	3.61	0.70
	Do you use the internet to execute your tasks creatively	3.79	0.78
	Do you follow trends on the internet to generate original ideas	3.76	0.79
	Do you use the internet to evaluate the usability of your ideas	3.33	0.92
Problem solving / 0.88	Does the internet help you find the best way to solve the problem	3.48	0.67
	Do you solve the problem using the internet	3.76	0.61
	Do you come up with solutions to the problem via the internet	3.88	0.65
	Are you confronted with a problem that you are sure you can solve using the internet	3.64	0.78
	Does the actual outcome you achieved via the internet match what you expected	3.39	0.56

The items were asked in Polish on a five-point Likert scale: 1 = never, 2 = rarely, 3 = sometimes, 4 = often, 5 = (almost) always.
Cronbach's alpha; M (Mean); SD (Standard Devotion) were own calculations.
Source: Van Laar *et al.* (2018).

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The contribution share of authors is equal and amounted to 50% for each of them.

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Conflict of Interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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