How to Evaluate Digital Leadership: A Cross-sectional Study

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Research

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Abstract

Background: With the increasing digitalization of the working environment, the demands on managers are changing fundamentally to the point of an emerging field of research in digital leadership. Municipal administrations are particularly affected by the digital transformation processes. Therefore, a score to measure the construct of digital leadership competence in the context of virtual-based workstation was developed and tested.

Methods: Based on an online survey with n = 546 employees at virtual-based workstations in municipal administrations in 2020, the instrument is tested regarding selectivity (coefficients), dimensionality (principal component analysis), homogeneity (inter-product-moment correlations), reliability (Cronbach’s $\alpha$) and construct validity (correlation with general leadership skills).

Results: The instrument can be considered selective, one-dimensional, homogeneous, reliable and constructively valid in the sense of the formulated hypotheses. By integrating the employees’ perspective, the instrument aims to be one of the first of its kind to initiate a scientific further discourse. Among other things, the categorization of the co-determination component as either traditional or digital leadership can be discussed.

Conclusions: The developed instrument for measuring digital leadership performs well concerning the aspects of discriminatory power, one-dimensionality, homogeneity, reliability as well as construct validity. It aims to induce further research and a scientific discourse on the topic of health-oriented leadership within the world of work 4.0.

Background

This article presents an instrument for measuring the construct of digital leadership competence at the computer workstation. Digitalization is considered one of the mega-trends that is causing profound social change in the sense of a transformation of living and working environments. Both, general media and scientific publications attempt to develop a comprehensive definition of the term. The Federal Agency for Civic Education initially defines digitalization on a technical level as a “process that converts information into machine-readable data and stores it, as well [it defines it] as processes of data processing, transmission and combination” [1].

In the context of work, the concept of digitalization experiences an expansion that is increasingly oriented toward people and their social interaction at the macro, micro, and me-so levels [1]. The interpretation of the term and aspects of the concept are therefore complex and vary, depending on the subject. Traum et al. (2017), as part of the KODIMA project, developed a definition that explicitly includes the working individual affected by digitalization:

"Digitalization is the introduction or increased use of information and communication technologies (ICT) by (working) individuals, organizations, economic sectors and societies with the characteristic consequences of acceleration, increasing abstractness, flexibilization, and individualization of processes and outcomes." [2]

Piasecki (2020) draws a narrower frame of reference around municipal administrations and describes digitalization as "essentially the shift of administrative tasks to a new digital level and the integration of traditional (paper-based) processes into computer-based processing structures to optimize results and accelerate procedures" [3]. The goal of work-related digitalization is the transition to the working world 4.0, in which routine activities are replaced by knowledge-based decision-making with complex, dynamically changing activities. Thus, office work can be organized and designed more individually. The expansion of existing technologies encourages mobile working at flexible workplaces with flexible working hours [4]. "Arbeit 4.0" (English: Work 4.0), has established itself as a signal term referring to the fundamental structural change in gainful employment resulting from advancing digitalization [5]. Digital and mobile communication enable companies to collaborate and coordinate over greater spatial distance as well as
with temporal flexibility. It also facilitates access to specialized knowledge, expertise, and resources [6]. A variety of new work models result from the changing work opportunities. Boundaries in different areas, such as between locations, companies, customers, and workforces are becoming increasingly blurred [6]. Routine activities become more and more automated, so much that tasks for employees can be designed to be more cross-functional and cross-divisional. Their work becomes increasingly information-based. The targeted further qualification of the workforce is of crucial importance [6]. Therefore, demands on managers are more often subject to digital transformation processes, too.

The changes in work described above are reflected in society's understanding of leadership. The concept of employee leadership and the demands placed on managers keep changing as digitalization progresses.

In general, leadership is required whenever several people work on problem solutions in a division of labor with need for coordination [7, 8]. "The increasing complexity of organizations and work requires leaders to manage people as effectively and efficiently as possible" [8]. Socially, the notion of leadership is evolving since the beginning of the 20th century from unidirectional control to a holistic, reciprocal influence in which leaders solicit and use employee feedback for advancement. In the process, two major leadership styles have emerged which have been proven effective in the face of the demands of the modern workplace [9, 10].

Transactional leadership is characterized by defined objectives. Work performance gets traded for rewards in various forms. The manager acts as an intermediary for employer and employee. The focus is on achieving the defined goals [9]. The manager's competence is to identify work-related aspects, which satisfy employee's needs, and to fulfill them. Accordingly, they respond to existing interests [10]. In the context of transformational leadership, the manager acts as a positive role model and multiplier. Employees are inspired by their ideas and visions. Their personal development is encouraged by enhancing a positive working attitude [9]. In this way, managers effect employee motivation to pursue ambitious goals more personally than in the context of a transactionally driven employment relationship [10]. Nevertheless, various aspects of both leadership styles can be combined and are already described in literature to reach successful digital leadership and leadership culture.

Meier et al. (2017) identify four key aspects for digital leadership culture based of interactive leadership (transactional and transformational) [11].

(1) Collaborative - working closely with colleagues and co-workers in terms of transparent or shared decision-making;
(2) Integer and social - social skills to work with (interchanging) project groups while giving individuals the necessary free space for their work;
(3) Inspiring and open - being open to criticism, acting as a role model, and providing impetus for change;
(4) Fostering resilience - confidence in one's own abilities combined with a culture of constructive criticism.

Some aspects of positive leadership culture are found in the components of digital leadership. In literature, the term digital leadership is not defined consistently, as different emphases are placed on it. Promsri (2019) compiles 64 characteristics of digital leadership in a review paper and aggregates them into six characteristics of a digital leader [12]:

(1) Digital knowledge and literacy - knowledge of the possibilities of digitalization-related changes;
(2) Vision - clear objective regarding desired digital transformation processes;
(3) Customer focus - taking into account the expectations and wishes of customers with regard to digital processes;
(4) Agility - good adaptability toward the rapidly changing work processes;

(5) Risk-taking (creation of an experimental atmosphere) - establishing a culture of constructive criticism that enables trial and error as well as innovation;

(6) Collaboration - strengthening the cooperation among employees in terms of location, time, culture, etc.

Overall, there is an observable trend from rigid, hierarchical management toward dynamic decision-making processes with flat hierarchies, joint decision-making and changing responsibilities. Social skills become increasingly relevant alongside expert knowledge [6, 11, 12]. This trend is expressed in the empowerment approach [13]. Individual, employee-related empowerment aims to influence the perception of the employee role positively. Accordingly, the perception of one's own significance, competence, self-determination, and influence during work should be strengthened [13]. Central connections to successful digital work can be found in the experienced self-determination and the experienced influence on the working process. This goes hand in hand with greater freedom of choice for employees regarding working hours, work location and the sequence of working processes. Flattened hierarchies in project groups also enable and require self-organization with changing leadership role focused on personal skills [4, 6].

The results of current reviews [14, 15] indicate that positive leadership styles and behaviors are associated with better health, less health complaints and less stress experience. Negative leadership behaviors as a risk factor are analyzed significantly less. Nevertheless, the reviews point out that negative leadership behavior is associated with low psychological well-being, lower job satisfaction and higher sick leave. [15] The “health-oriented leadership” (HoL) approach of Franke and Felfe goes beyond these studies and provides a broader model of health-specific leadership behavior. Within this approach, more aspects of a leader’s communication and the health-promoting design of working conditions are integrated. In addition, values and awareness of managers towards the health of their employees as well as the awareness and behavior of the employees themselves are addressed. [16]

From the transformation processes described above, a need for evaluating digital leadership styles can be derived. A particular need arises in Germany around municipal administrations. This is due to the fact that they are, for example, obligated to keep digital records and offer electronic citizen services according to the framework of the Act to Promote Electronic Administration in North Rhine-Westphalia. While it is also called E-Government Act and the municipal administrations have accepted the challenge, there is a need to operationalize digital leadership.

Existing approaches for constructing an index of digital leadership competence refer to small and medium-sized enterprises [17], are based on a survey of the executives themselves [18], or do not have a sufficient number of cases for validation [19]. Other existing approaches are used for personnel selection and classification of managers [20, 21].

The score proposed in the following, on the other hand, is based on the subjective perspective of managed employees at VDU workstations in municipal administrations and was developed as part of the project “Health and Digital Change” (GudW), in which it is also being tested. The score is called “DigiFuehr” due to the German word “Führung”, which means leadership. The following hypotheses are to be tested:

1. The items of the DigiFuehr score have a high discriminatory power, i.e. all items have at least medium correlations with the remaining overall construct \((r > .3)\).

2. The DigiFuehr score measures a one-dimensional construct, i.e., in a principal component analysis only one factor can be extracted that has an eigenvalue greater than one \((\text{EV} > 1)\).

3. The items of the DigiFuehr score are homogeneous, i.e. they show at least medium correlations among each other \((r > .3)\).

4. The items of the DigiFuehr score are highly reliable, i.e. they show a high internal consistency \((\alpha > .8)\).
5. The DigiFuehr score can be construct-validated via an analogous summative score to classic leadership (called “ClassicFuehr”), i.e., the two scores have at least a medium correlation with each other \( (r > .3) \).

**Methods**

Following a literature review and joint consultations with eight experts from the HR and OHM fields in the steering committee of the GudW project, seven core areas of digital leadership competence were identified. These core areas are operationalized by the closed questions listed in table one. This results in the following four-stage response options with point values in parentheses: not applicable (1), rather not applicable (2), rather applicable (3), fully applicable (4). These seven items are summed up, resulting in a point score in the sense of a Likert scale \([22]\), which is referred to as “DigiFuehr”. Finally, the values are projected onto the value range between 0 and 100 for the sake of clarity. The addressees of the survey are digitally managed employees.

| Description     | Formulation                                                                 |
|-----------------|----------------------------------------------------------------------------|
| DigiFuehr 1     | “I am involved in decisions that affect my work and my digital work environment.” |
| DigiFuehr 2     | “My digital literacy is encouraged by my manager.”                         |
| DigiFuehr 3     | “When there is a need for questions about digitalization, I receive support from my manager.” |
| DigiFuehr 4     | “I get regular feedback on the quality of my digital work.”                |
| DigiFuehr 5     | “I get all the information I need to do my digital job.”                    |
| DigiFuehr 6     | “I am supported by my manager to better understand and use digital applications.”|
| DigiFuehr 7     | “In my department, digital working methods are encouraged.”                 |

The score was tested in an online survey in the municipal administrations of three model regions in North Rhine-Westphalia participating in the GudW project. The model regions were selected in such a way that the entire federal state was sufficiently represented structurally, for example in terms of the relationship between urban and rural regions and sociocultural dimensions. Inclusion criterion was a (pre-pandemic) presence activity at the VDU workplace. In this way, 1319 employees were invited to participate in an online survey in October 2020, of whom 710 had taken part in the survey up to and including December 2020 (response rate: 53.83 %), after a reminder was sent out again in November. Ex post, employees with own management responsibilities were excluded, resulting in a net case number of \( n = 546 \) employees, whose sociodemographic are listed in Table 2. Since item nonresponse was found to be between 24 and 34 percent, depending on the item, the missing values were filled using multiple imputation (MICE) \([23]\).
Table 2
Sociodemographic of the respondents in the project (n = 546)

| Gender: female   | 63.68 % |
|-----------------|---------|
| Age in years    | 43.57 (±12.95) |
| Education:      | 64.71 % |
| At least university entrance qualification |
| Model region I  | 30.95 % |
| Model region II | 31.32 % |
| Model region III| 37.73 % |

Alternatively, in order to test the influence of the items on symmetry and thus the legitimacy of summation, a score is constructed based on the contribution of the individual items to the overall correlation (product-moment correlation). In addition, a normal distribution is tested using the Shapiro-Wilk test [24].

The first hypothesis is tested using coefficients of discriminatory power, for which a part-whole correction was applied [25]. The classification of the strength of the association is based on Cohen [26]. For the second hypothesis test, a principal component analysis (PCA) is calculated using eigenvalue decomposition of the standardized correlation matrix [27]. The homogeneity of the score (hypothesis three) is assessed using the intercorrelation matrix itself, and the internal consistency of the score (hypothesis four) is assessed using Cronbach's $\alpha$ [28]. A test of criterion validity formulated in hypothesis five is conducted via a correlation analysis with a score of classical leadership competence constructed with the items listed in table three (analogous to the DigiFuehr). Imperfect reliability of the two constructs is accounted for with a double reduction correction [29].

Table 3
Items of the summative score ClassicFuehr

| Description | Formulation                                      |
|-------------|--------------------------------------------------|
| ClassicFuehr 1 | "My professional development is encouraged." |
| ClassicFuehr 2 | "I am supported in balancing my work and personal life." |
| ClassicFuehr 3 | "I receive recognition and appreciation for my work." |
| ClassicFuehr 4 | "I feel treated fairly, decisions are transparent and understandable." |
| ClassicFuehr 5 | "I feel like I'm allowed to make mistakes." |
| ClassicFuehr 6 | "Phases where I have more stress or less stress are balanced." |
| ClassicFuehr 7 | "I know exactly what is expected from me." |

Results

An alternative correlation-based score leads to the weighting of the items between 11 and 16 percent mentioned in Table 4, so that symmetry can be assumed approximately and a summation also seems justified for the sake of simplicity.
Table 4
Weighting of the correlative score formation

| Description    | Weighting |
|----------------|-----------|
| DigiFuehr 1    | 11 %      |
| DigiFuehr 2    | 16 %      |
| DigiFuehr 3    | 16 %      |
| DigiFuehr 4    | 14 %      |
| DigiFuehr 5    | 13 %      |
| DigiFuehr 6    | 16 %      |
| DigiFuehr 7    | 14 %      |

Table 5 shows the means and standard deviations of the initial variables and of the score transformed to the range of values between 0 and 100. A plot of the probability density is provided in figure one, which shows approximately a normal distribution in terms of the plotted bell curve, which can be confirmed computationally using Shapiro-Wilk (p < .001).

| Description    | Arithmetic mean (±standard deviation) |
|----------------|---------------------------------------|
| DigiFuehr 1    | 2.36 (±0.86)                          |
| DigiFuehr 2    | 2.32 (±0.87)                          |
| DigiFuehr 3    | 2.52 (±0.92)                          |
| DigiFuehr 4    | 2.14 (±0.88)                          |
| DigiFuehr 5    | 2.59 (±0.80)                          |
| DigiFuehr 6    | 2.30 (±0.94)                          |
| DigiFuehr 7    | 2.69 (±0.88)                          |
| DigiFuehr     | 47.33 (±22.26)                        |

Table 6 points to an acceptable discriminatory power of the items, because all correlations are above .4. While codetermination (DigiFuehr_SQ001) is the least related to the remaining overall construct (r = .47). This can also be seen from the inter-correlation matrix. Cronbach's α = .88 indicates high internal consistency and thus, as a surrogate parameter, high reliability of the score.
Table 6
Inter-correlation matrix (DigiFuehr describes the part-whole correlations) and Cronbach’s α excl. DigiFuehr (n = 546).

|       | DigiFuehr 1 | DigiFuehr 2 | DigiFuehr 3 | DigiFuehr 4 | DigiFuehr 5 | DigiFuehr 6 | DigiFuehr 7 | DigiFuehr 8 |
|-------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|
| α = 0.88 | 1           | 0.52        | 0.34        | 0.36        | 0.39        | 0.34        | 0.31        | 0.47        |
| DigiFuehr 1 | 0.52        | 1           | 0.66        | 0.57        | 0.47        | 0.70        | 0.52        | 0.76        |
| DigiFuehr 2 | 0.34        | 0.66        | 1           | 0.55        | 0.52        | 0.77        | 0.57        | 0.75        |
| DigiFuehr 3 | 0.36        | 0.57        | 0.55        | 1           | 0.51        | 0.60        | 0.49        | 0.67        |
| DigiFuehr 4 | 0.39        | 0.47        | 0.52        | 0.51        | 1           | 0.51        | 0.43        | 0.61        |
| DigiFuehr 5 | 0.34        | 0.70        | 0.77        | 0.60        | 0.51        | 1           | 0.57        | 0.77        |
| DigiFuehr 6 | 0.31        | 0.52        | 0.57        | 0.49        | 0.43        | 0.57        | 1           | 0.62        |
| DigiFuehr 7 | 0.47        | 0.76        | 0.75        | 0.67        | 0.61        | 0.77        | 0.62        | 1           |

By means of principal component analysis, one factor could be extracted that explained 58.18 percent of the total variance of the items and obtained an eigenvalue of 4.06, respectively, explaining as much as 4.06 manifest variables. The eigenvalues of the other extracted factors are below one, which is displayed graphically in Fig. 2 in as a scree plot.

At α = .81 of the analogous score to classical leadership competence, a medium-strong correlation with DigiFuehr of $r = .42$ can be calculated with double reduction correction.

Thus, the previously established hypotheses one to five can be confirmed.

**Discussion**

The DigiFuehr score was validated as an employee-oriented instrument for measuring digital leadership competence in municipal administrations in the sense that its items are selective, homogeneous and reliable. The score shows a moderate correlation with classic leadership competencies, indicating that additional competencies are required with regard to Work 4.0.

What should also be emphasized is that in the present study, as experts of themselves, employees without management responsibility (in municipal administration) were deliberately surveyed, whose needs may well collide with the interests of managers as well as of the top management. However, the paradigm shift in leadership described above also explicitly includes a resource-oriented empowerment approach. Thus, it is suggested that following further surveys examine the extent to which the assessments of managers and those managed (about digital leadership competence) converge. The extent to which such an approach may have already been internalized would be valuable to analyze.

Further research should address whether co-determination, as a resource factor regarding psychological stress, should rather be categorized as a classic leadership aspect. However, this depends on the theoretical foundation of the construct of digital leadership: As mentioned before, many theories of digital leadership focus on a flattening of hierarchies and varying leadership (changing according to the respective context), which underlines the item's relevance for digital leadership.

Although the score was validated in the setting of the municipal administration, the transfer to digital leadership competencies in other VDU workplaces seems possible and useful. Even more so because it is not exhaustive, for example with regard to the topic of leadership at a distance and in the home office, the score initially has the character
of a suggestion that is intended to initiate a scientific discourse, whereby there is a fundamental openness to modifications and improvements.

**Conclusions**

In recent years, there has been a particular increase in scientific interest in the relationship between leadership and health. Meanwhile, the digitalization of work processes advances, affecting the management regarding VDU workplaces in municipal administrations. Therefore, a standardized instrument for measuring digital leadership was developed and tested. It performs well concerning the aspects of discriminatory power, one-dimensionality, homogeneity, reliability as well as construct validity. It aims to induce further research and a scientific discourse on the topic of health-oriented leadership within the world of work 4.0.

**Abbreviations**

EV eigenvalue

GudW Health and Digital change (German: Gesundheit und digitaler Wandel)

HoL health-oriented leadership

PCA principal component analysis

VDU visual display unit

**Declarations**

**Ethics approval and consent to participate**

The study was positively approved by the Ethics Committee of the University of Witten/Herdecke under reference number 158/2020, i.e. it was checked for compliance with the Declaration of Helsinki on Medical Research Involving Human Subjects as well as with the applicable data protection regulations.

**Consent for publication**

Not applicable.

**Availability of data and materials**

The dataset supporting the conclusions of this article is included within the article. Data available on reasonable request.

**Competing interests**

The authors declare that they have no competing interests.

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**Authors' contributions**

KC was responsible for the conception as well as the methodology and wrote the original article. DRdA conducted the survey and dealt with data curation as well as text review. JK took care of the software, the formal analysis and the visualization. HCB’s responsibilities included validation, supervision, and project administration. All authors read and approved the final manuscript.

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**Authors' information**

Not applicable.

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Figures
Figure 1
Plot of the probability density

Figure 2
Scree plot eigenvalues