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WISSENSCHAFTLICHE BEITRÄGE

Effects of AI-based technologies on employees' work engagement: Implications for the human-centered design of digital work

Vera B. Rick[1] · Marie Stebner[1] · Larissa Dräger[2] · Annika Franken[3] · Alexander Mertens[1] · Verena Nitsch[1]

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Abstract

An important goal of the Regional Competence Center AKzentE4.0 is to support companies in the Rhineland region in designing their digital transformation in a human-friendly way based on scientific findings. In order to derive evidence-based guidelines for the humane design of AI-supported work, further insights are needed into how the use of AI affects characteristics of humane work design and how this differs from the general use of digital technologies. To this end, a secondary analysis of a questionnaire study conducted in the context of AKzentE4.0 was carried out. The analyzed dataset included responses from $N = 825$ digital information workers. Two central research questions were analyzed: 1. Does the perception of work engagement differ between users and non-users of AI systems? 2. Which characteristics of human-centered work design predict work engagement when working with AI and are there differences compared to those who do not work with AI?

Practical Relevance: The results show that a human-centered and humane design of AI-supported work should focus on providing meaningful tasks for employees, support from supervisors and preserving employees' autonomy. Particularly, the aspect of meaningful work can be threatened by technology. For AI systems to be effective in the workplace in terms of maintaining health and promoting learning, care should be taken to ensure that they can support work in a targeted way and do not replace, but rather promote meaningful work tasks. Employees, with the support of their managers, should also be able to control the use of AI systems to maintain greater autonomy and agency.

Keywords Humane work design · Digital and AI-supported work · Work engagement · Psychological stress

✉ Vera B. Rick, M.A.
v.rick@iaw.rwth-aachen.de

[1] Institut für Arbeitswissenschaft, Rheinisch-Westfälische Technische Hochschule, Eilfschornsteinstraße 18, 52062 Aachen, Germany

[2] Consulting, Business und Management GmbH, Niederbexbacher Straße 67, 66450 Bexbach, Germany

[3] Universitätsklinikum Aachen AöR, Pauwelsstraße 30, 52074 Aachen, Germany

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Auswirkungen KI-gestützter Technologien auf das Arbeitsengagement: Implikationen für die menschzentrierte Gestaltung digitaler Arbeit

Zusammenfassung
Ein wichtiges Ziel des regionalen Kompetenzzentrums AKzentE4.0 ist die Unterstützung von Unternehmen im Rheinischen Revier bei der menschengerechten Gestaltung ihrer digitalen Transformation auf Basis arbeitswissenschaftlicher Erkenntnisse. Um evidenzbasierte Leitlinien für die menschengerechte Gestaltung von KI-gestützter Arbeit ableiten zu können, sind weitere Erkenntnisse darüber notwendig, wie sich der Einsatz von KI auf die Merkmale menschengerechter Arbeitsgestaltung auswirkt und wie sich dies von der Nutzung digitaler Technologien im Allgemeinen unterscheiden. Zu diesem Zweck wurde eine Sekundäranalyse einer im Kontext von AKzentE4.0 durchgeführten Fragebogenstudie vorgenommen. Der analysierte Datensatz umfasste Rückmeldungen von $N = 825$ digitalen Informationsarbeitenden. Dabei wurden zwei zentrale Forschungsfragen untersucht: 1. Unterscheidet sich die Wahrnehmung des Arbeitsengagements zwischen Nutzenden von KI-Systemen und Nicht-Nutzenden? 2. Welche Merkmale der menschengerechten Arbeitsgestaltung sagen das Arbeitsengagement bei der Arbeit mit KI voraus und gibt es Unterschiede im Vergleich zu denjenigen, die nicht mit KI arbeiten?
Praktische Relevanz: Die Ergebnisse machen deutlich, dass eine menschzentrierte und menschengerechte Gestaltung KI-gestützter Arbeit insbesondere auf die Bereitstellung sinnvoller Aufgaben für die Beschäftigten, die Unterstützung durch Vorgesetzte und die Wahrung der Autonomie der Beschäftigten ausgerichtet sein sollte. Insbesondere der Aspekt der sinnvollen Arbeit kann durch die Technik gefährdet werden. Damit KI-Systeme am Arbeitsplatz gesundheitserhaltend und lernförderlich wirken können, sollte bereits bei ihrer Entwicklung darauf geachtet werden, dass sie die Arbeit gezielt unterstützen und nicht ersetzen sowie sinnvolle Arbeitsaufgaben fördern. Zudem sollten die Beschäftigten mit Unterstützung ihrer Vorgesetzten auch die Möglichkeit haben, über den Einsatz und die Nutzung von KI-Systemen selbst zu bestimmen, um eine größere Autonomie und Handlungsfähigkeit zu erhalten.

Schlüsselwörter Menschzentrierte Gestaltung · Digitale und KI-gestützte Arbeit · Work Engagement · Psychische Belastung

1 Introduction

The increasing use of digital technologies is changing the way we work (Meyer et al. 2022; Parker and Grote 2022). While some tasks are partially or fully automated with digital technologies, others are transformed altogether into new tasks that may also require different skill sets (Rothe et al. 2019; Tegtmeier et al. 2022). Typically, digitalization in companies is still technology-centered, i.e. driven by technological innovation rather than the needs and requirements of human workers (Hirsch-Kreinsen 2023). Information work, particularly in knowledge-intensive sectors, extensively employs digital technologies, showcasing a higher degree of digitalization than other occupational groups (Arntz et al. 2016). The intensified use of digital technologies in these sectors imposes new demands, which, while potentially positive, often come with adverse effects leading to psychological stress among employees (Meyer et al. 2021).

Artificial intelligence (AI)-based technologies represent a special category among digital technologies, as their versatility allows them to go beyond streamlining processes and enables them to take on different roles in the work process in relation to employees (Meyer et al. 2022). From the employee's perspective, an AI system can function as an individually used work tool, for example, when self-learning search engines are used to retrieve information from the Internet. It may also take on the role of a team member as it subsumes, or augments tasks previously carried out by the human counterpart. Furthermore, AI is increasingly used to partially or even fully automate human-related management decisions, thus expanding the capabilities of Algorithmic Management (Bucher et al. 2021). AI can therefore be seen as a counterpart in a work system, encompassing its design, implementation and use (Anthony et al. 2023; Siemon et al. 2018), while changing the role of employees (Galsgaard et al. 2022) and fostering new human-AI team situations (Berretta et al. 2023; Kluge et al. 2021).

In this way, the increasing prevalence of AI introduces both significant opportunities and challenges for humane work design as AI can have a positive impact on employee engagement at work (Jia and Hou, 2024). Managing engagement in organization is critical to the success of employees and organization as a whole, as engaged employees have a higher wellbeing, better retention, lower absenteeism and higher productivity (Harter et al. 2024). AI systems can, for example, streamline routine tasks, free up time and resources for more complex tasks, or offer decision-making support through data analysis (Konys and Nowak-Brzezińska 2023). However, they also often lead to unintended

negative outcomes. For instance, Mayer et al. (2020) observed that the introduction of an AI-based system led to a perceived loss of competence and reputation among its users. Furthermore, these changes in work dynamics pose risks such as job insecurity (Koo et al. 2021; Sureth 2020) and increasing workload (Sureth 2020), thereby presenting challenges to psychological health.

Investigating the impact of AI on human work and workers is one of the key objectives of the Regional Competence Center AKzentE4.0 (German: Arbeitswissenschaftliches Kompetenzzentrum für Erwerbsarbeit in der Industrie 4.0) as it aims to promote human-centered digitalization efforts in the Aachen region. As part of the Competence Centre, local research institutions, which specialize in work science and technology research, have teamed up to collaborate closely with 20 companies and regional organizations to explore and implement new technologies, as well as investigate their impact on human work and workers in order to derive insight for humane work design. Thus promoting socially sustainable workplace practices and attractive working conditions in the region.

This paper will present research from AKzentE4.0 with a focus on the effects of AI-based technologies on employees who primarily conduct digital work. The aim is to derive insights and recommendations for future human-centered digital work design.

1.1 Promoting organizational success through work engagement

Measuring and managing engagement in an organization is critical to the success of employees and the organization as a whole. Engagement was found to correlate with employee wellbeing, as well as absenteeism, safety incidents and productivity (Harter et al. 2024). The latest Gallup report estimates that low employee engagement could cost the global economy USD 8.9 trillion or 9% of global GDP. At the same time, global employee engagement stagnated in 2023 and overall employee wellbeing declined (Gallup 2024).

Work engagement can be described as a positive work-related state of fulfillment that is characterized by vigor, dedication, and absorption (Schaufeli and Bakker 2004). Vigor involves a high level of energy and resilience, while dedication involves a strong sense of meaning, pride and challenge at work. Absorption describes the state in which employees are fully focused on their work-related activities and are absorbed in them with pleasure. Following Bakker and Leiter (2010) work engagement can be described as the positive opposite of burnout. In contrast to those who suffer from burnout, engaged employees feel energized and effectively connected to their work and see their work as challenging rather than stressful and demanding.

The role of demands and resources in promoting employee engagement has been examined in numerous studies as described by Mazzetti et al. (2023). Literature to date emphasizes the role of particular types of demands, known as "challenging" demands, as a precursor to engagement (Kim and Beehr 2018), which is in line with the theoretical distinction between challenge and hindrance demands (Crawford et al. 2010). The former make it difficult or impossible for employees to achieve their goals and are therefore negatively associated with commitment, whereas the latter have potential to promote work accomplishment, personal growth and future gains. They stimulate positive emotions and active, problem-oriented coping strategies that increase the willingness to invest energy in mastering work-related tasks and thus increase commitment. Consequently, reducing work demands is not always the most effective strategy to increase employee engagement and may even lead to a decrease in employee commitment, as a suitable number of demands leads to the perception of a stimulating job (Einarsen et al. 2018).

1.2 Promoting work engagement through AI-based technologies

Assessing the impact of AI-based technologies on employees is challenging. However, it is clear that AI-based technologies have a broad impact on human work, as they significantly influence work processes and tasks. As already described, AI-based technologies can be regarded as a counterpart to humans in a work system (Anthony et al. 2023; Siemon et al. 2018), while changing the role of employees (Galsgaard et al. 2022) and fostering new human-AI team situations (Berretta et al. 2023; Kluge et al. 2021). Preliminary results from a six-month randomized control trial of the Microsoft Copilot application show that integrating AI into the work environment can fundamentally change the way work is done, as some tasks are no longer required or take significantly less time, so that other tasks can take up more resources (Microsoft 2024). However, the effects for the workers are ambiguous. On the one hand, AI-based technologies can be viewed as valuable resources, simplifying both physical and cognitive tasks by facilitating improved planning and flexible work arrangements (Kraus et al. 2021; Schwarzmüller et al. 2018). On the other hand, such technologies can also mean that more work must be done in the same period of time as well as a need to be flexible in response to changing work processes (Atanasoff and Venable 2017; Hartwig et al. 2020; Ragu-Nathan et al. 2008; Turel and Gaudioso 2018). As such, technologies, in particular AI systems, can be regarded as work resources or work demands (Carlson Carlson et al. 2017) and can therefore have a positive or negative impact on work engagement-related outcomes for employees, such as job-related

attitudes, individual health, and performance (Schaufeli and Salanova 2009).

Previous research demonstrates both positive and negative effects of AI-based technologies. For example, Fregin et al. (2020) underlines that introducing an AI chatbot to assist human resource department employees was perceived positively, serving as a valuable addition to the team, as employees noted a reduction in the need to engage in tedious or repetitive tasks following the implementation of the chatbot. However, Cascio and Montealegre (2016) demonstrated that AI-supported technologies can lead to work becoming monotonous and to having periods of non-utilization, e.g. when employees are entrusted with a monitoring task, during which there is a constant need for knowledge about the system status and cognitive readiness to intervene and make decisions. According to Strich et al. (2021), the effects of the AI-based technologies depends on the user and the type of support provided by the system. The authors conducted a qualitative study on the introduction of an AI-based loan system. This system enabled lower-level service employees to organize loans for customers, thereby enhancing their role, however, the opposite was found for the previously more highly qualified loan consultant. Their professional autonomy was significantly reduced as they had no influence over the allocation of a loan—the AI system made the decision, which could not be overwritten. The system thus restricted the consultants' use of expertise and skills and threatened their role identity. Work design options that would have allowed credit advisors to maintain their expertise, e.g., by taking on new tasks such as cross-selling or training and mentoring subordinates in their role, were not considered.

An overall critical picture also emerged from the research conducted by Parent-Rocheleau and Parker (2022) on how algorithmic management affects workers. For example, when algorithms directly take over scheduling (or indirectly influence scheduling by "nudging" worker behavior), the company's purpose is often to match demand (e.g., a high volume of customers) with supply (e.g., the availability of staff to serve customers). When algorithms take over management functions such as performance monitoring, goal setting, performance management, scheduling, compensation and even termination of employment, this leads, on average, to an intensification of work and a reduction in job autonomy.

As outlined by Parker and Grote (2022), AI's potential effects are diverse. While it can aid decision-making, it may also engender a sense of being "out-of-the-loop", leading to reduced control over one's own work. Delegating dangerous or monotonous tasks to AI carries the risk of task standardization, with a high proportion of monitoring tasks and technology-enabled "micro-tasks" that may become less meaningful. Furthermore, while information and communication technologies support collaboration, they may at the same time undermine connectedness and empathy. In addition, despite the potential reduction in physical demands, cognitive demands may increase especially if there are significant variations in mental stress, from underload to rapid overload. The impact of AI on employees therefore seems to depend on how the collaboration between humans and AI is organized and which tasks the AI takes on.

1.3 Research questions—differences in work engagement between AI users and non-users

Work design plays a central role in promoting engaging working conditions. Therefore, human-centered design of AI-assisted work is crucial to promote positive effects of AI-based systems. However, whilst there has been a plethora of research on human-centered design of digital work, there is little research to investigate the extent to which the findings may also apply to AI-assisted work. Work design can be defined as "the study, creation, and modification of the composition, content, structure, and environment within which jobs and roles are enacted" (Morgeson and Humphrey 2008, p. 47). Research on work design has a long history (see e.g. Parker et al. 2017 for a review of publications on this topic spanning 100 years). This wealth of research has given rise to the definition of numerous work design criteria (Parker et al. 2017). Perhaps the most widely applied collection of humane work design criteria has been compiled by Morgeson and Humphrey (2006) in form of the Work Design Questionnaire (WDQ), which encompasses a total of 21 work characteristics, including task characteristics, knowledge characteristics, social characteristics and characteristics related to the work context. This article aims to support human-centered design of AI-assisted work by exploring differences between digital and AI-assisted work in regards to human-oriented characteristics of work design and how they relate to work engagement. For this purpose, a secondary analysis was conducted based on a cross-sectional online survey, using selected items from the Copenhagen Psychosocial Questionnaire (COPSOQ), supplemented by items from the WDQ.

RQ1: Does the perception of work engagement differ between users of AI systems and non-users?

RQ2: Which characteristics of human-oriented characteristics of work design predict work engagement when working with AI and are there differences for those not working with AI?

2 Method

2.1 Procedure

The original study was conducted in January 2023, with the aim to analyze the characteristics and effects of work interruptions during digital work (Rick, under review). Data was collected via an online survey. Participants were contacted through a survey panel provider who accessed a random sample of panel members who met the inclusion criteria for the survey (at least 18 years old and no older than 67 years, office job, a laptop/computer is the predominant work device). Participation was voluntary and anonymity and confidentiality were guaranteed. Respondents received financial compensation for their participation. As the study met a list of standard criteria (e.g., anonymized participation, adult participants, no intrusive measures, no deception), further ethical approval was waived. All participants consented to the use of their data for research purposes.

2.2 Measures

To assess the psychosocial demands encountered in the workplace, the study utilized the German adaptation of the COPSOQ. This questionnaire, designed to evaluate mental stress at the workplace, was administered to participants, who provided responses using a 5-Point-Likert Scale, ranging from "Never" (1) to "Always" (5).

In addition to the COPSOQ, the study applied the WDQ to specifically evaluate participants' autonomy in their roles. Responses to the WDQ were also collected using a 5-Point-Likert scale with response options ranging from "Do not agree at all" (1) to "Fully agree" (5). In addition, participants were asked to indicate whether they use AI-assisted technologies at work. No further definition of AI was provided, or further questions were asked as to what type of AI system was used. The specific scales are detailed in Table 1.

2.3 Preprocessing of data

To ensure a sufficient data quality, a review of the received responses was performed. First, participants that did not finish the online questionnaire were excluded from the evaluation. Second, an attention check item had been integrated into the questionnaire, which users had to pass (Shamon and Berning 2019). Third, using the relative speed index (Leiner 2019) with a cut-off at 2.0, participants with impossible finishing times were excluded. Finally, the given answers were checked for plausibility, e.g., participants were asked to answer how long they had been working in their professional field as well as their position. If these open response questions were answered with an impossible timeframe, the participants were also excluded from the evaluation. As a result, 367 participants were eliminated, and 825 participants remained.

2.4 Data analysis

In a first step, an unpaired two-sided t-test was conducted to determine whether there are significant differences between AI users and non-users in regard to their self-reported work engagement. Furthermore, to analyze which human-oriented work design characteristics predict work engagement, stepwise multiple regression analyses were performed. To investigate whether there are differences between AI users and non-users, the regression was calculated for each group. The stepwise regression approach was chosen due to the exploratory nature of this analysis as well as the fact that there are no theory-based approaches for the inclusion of the variables. Stepwise regression is a method of model selection that involves both forward selection and backward elimination procedures. In forward selection, the model starts with no predictors and adds predictors one by one based on their statistical significance, typically measured by the p-value of the F-test, until no additional significant predictors can be added. In backward elimination, the model starts with all possible predictors and removes the least significant predictors one by one based on their p-values, until only significant predictors remain. Stepwise regression combines these two approaches by iteratively adding and removing predictors. The process begins with the variable that has the highest correlation with the dependent variable and includes it in the model if its F-test p-value is below a specified threshold (commonly ≤ 0.05). Subsequent variables are added or removed based on their F-test p-values, with common criteria being ≤ 0.05 for inclusion and > 0.05 for exclusion. This iterative process continues until no more variables can be added or removed based on the predefined criteria.

2.5 Sample

The overall sample size of the study included $N = 825$ participants. In total, 307 females (37%), 517 males (63%) and one participant identifying as other (0.1%) were included in the analysis. All participants indicated that they hold an office job, using predominantly a computer or laptop. $N = 730$ (88.5%) participants indicated that they worked full time, whilst $N = 95$ (11.5%) indicated they worked part time. The average number of working hours per week was $M = 38.86$ ($SD = 5.6$) hours and the average age of participants was $M = 44.99$ ($SD = 11.49$) years. Furthermore, participants were queried about their respective positions within their company. The breakdown of responses is as follows: 6.3% hold upper management positions, 15.0% hold middle man-

Table 1 Scales from Copenhagen Psychosocial Questionnaire (COPSOQ) and Work Design Questionnaire (WDQ) used for the analysis
Tab. 1 Für die Analyse wurden Skalen des Copenhagen Psychosocial Questionnaire (COPSOQ) und des Work Design Questionnaire (WDQ) verwendet

Scale	Items
Variation of work (COPSOQ)	Is your work varied?
Social support by supervisors (COPSOQ)	How often do you get help and support from your immediate superior, if needed?
	How often is your immediate superior willing to listen to your problems at work, if needed?
Social support by colleagues (COPSOQ)	How often do you get help and support from your colleagues, if needed?
	How often are your colleagues willing to listen to your problems at work, if needed?
	Is there a good atmosphere between you and your colleagues?
	Is there good co-operation between the colleagues at work?
Autonomy at work (WDQ)	The job allows me to make my own decisions about how to schedule my work.
	The job allows me to decide on the order in which things are done on the job.
	The job allows me to plan how I do my work.
	The job gives me a chance to use my personal initiative or judgment in carrying out the work.
	The job allows me to make a lot of decisions on my own.
	The job provides me with significant autonomy in making decisions.
	The job allows me to make decisions about what methods I use to complete my work.
	The job gives me considerable opportunity for independence and freedom in how I do the work.
	The job allows me to decide on my own how to go about doing my work
Quantitative demands (work intensification) (COPSOQ)	Do you have to work very fast?
	Do you work at high pace all day?
	How often do you find that you don't have enough time to complete all your tasks?
	Are you falling behind with your work?
	Do you have to work overtime?
Meaning of work (COPSOQ)	Is your work meaningful?
	Do you feel that the work you do is important?
Work engagement (COPSOQ)	At my work, I am full of energy.
	I am enthusiastic about my job.
	I am immersed in my work

agement positions, 15.3% are in lower management positions, and the majority, 63.4%, are non-managerial employees. The participants have been working in their profession for $M = 15.48$ ($SD = 10.89$) years and have held their current position since $M = 8.84$ ($SD = 7.78$) years. Of the participants, $N = 468$ (56.7%) are classified as information workers with routine requirements, where the focus is on the secure, fast, and reproducible application of their own knowledge. $N = 147$ participants (17.8%) have task-flexible requirements, which describes frequent learning requirements, while creativity requirements are only occasionally or never necessary. Finally, $N = 210$ people (25.5%) are predominantly confronted with creative problem-solving requirements, which focus on knowledge generation. Most of the sample is represented by workers who state that they do not work with AI-based technologies ($N = 589$). In contrast, $N = 236$ workers stated that they work with AI-based technologies.

3 Results

3.1 Descriptive analysis

The overall sample shows that the meaning of work is rated highest ($M = 4.07$; $SD = 0.87$), followed by autonomy at work ($M = 3.78$; $SD = 0.79$) (from 1—"strongly disagree" to 5—"strongly agree"). The lowest ratings were given to social support from supervisors ($M = 3.35$; $SD = 0.92$) and colleagues ($M = 3.50$; $SD = 0.73$) at work. Work engagement was rated with $M = 3.45$ ($SD = 0.91$).

Table 2 Descriptive statistics and Cronbach's alpha values of the analyzed variables
Tab. 2 Deskriptive Statistik und Cronbachs Alpha Werte der analysierten Variablen

Work-related Variables	Cronbach's α	AI-Users		Non-Users	
		M	*SD*	*M*	*SD*
Variation of work	–	3.69	0.94	3.71	0.92
Social support by supervisors	–	3.27	0.92	3.35	0.92
Social support by colleagues	0.832	3.44	0.74	3.50	0.73
Autonomy at work	0.934	3.69	0.82	3.73	0.79
Quantitative demands	0.824	2.55	0.86	2.58	0.84
Meaning of work	–	4.03	0.90	4.07	0.87
Work engagement	0.913	3.67	0.84	3.32	0.90

A breakdown of the analysis into AI users and non-users shows overall small differences. The largest differences were found in the assessment of work engagement, as well as social support from superiors and colleagues (see Table 2).

3.2 RQ1: Does the perception of work engagement differ between users of AI systems and non-users?

An independent two-sided Welch-Test was conducted to determine whether there are significant differences between AI users and non-users with regard to their self-reported work engagement. Both groups were not normally distributed, as assessed by the Shapiro-Wilk test ($p < 0.001$), however, the Welch-Test is robust against violation of the normal distribution (Wilcox 2012). Equality of variance cannot be assumed (Levene-test: $F = 4.24$, $p < 0.05$) which is why the Welch-Test (in contrast to an unpaired t-test) was calculated. Within the sample, $N = 589$ participants indicated that they do not work with AI-based technologies, whilst $N = 236$ participants stated that they did. The results show significant differences between the analyzed groups: $T(462.4) = -5.23$, $p < 0.001$, 95%-CI = [–0.48, –0.21]. The effect size is Cohen's $d = 0.89$ (95%-CI = [–0.54, –0.24]). AI-users report significantly higher work engagement than non-AI users ($M = 3.67$ vs. $M = 3.32$).

3.3 RQ2: Which characteristics of human-oriented work design predict work engagement when working with AI and are there differences for those not working with AI?

First, correlation analyses between the predictors and work engagement were performed. For non-users of AI-based technologies at work, the highest correlation according to Pearson's correlation coefficient is $r = 0.492$ for meaning of work and work engagement. The same applies for users of AI-based technologies at work, the highest correlation according to Pearson's correlation coefficient is $r = 0.520$ for meaning of work and work engagement. In contrast to non-users, quantitative demands do not correlate with work engagement among AI users. A full overview is given in Table 3.

3.3.1 Predictors of work engagement for non-users

A multiple regression model was calculated to analyze which human-oriented work design characteristics significantly predicts work engagement. A stepwise regression approach was chosen due to the exploratory nature of this analysis. With regard to the multiple stepwise regression model for non-users of AI-based technologies, the multiple regression model shows no auto-correlation as the value of the Durbin-Watson statistic is 1.806. First, the analysis included *meaning of work* as predictor into the regression model. The regression coefficient for *meaning of work* was found to be $B = 0.487$, $\beta = 0.489$ ($p < 0.001$). After controlling for *meaning of work*, v*ariation of work* was included into the model as a predictor ($B = 0.261$, $\beta = 0.271$, $p < 0.001$). After controlling for *meaning of work* and *variation of work, autonomy at work* also significantly predicts *work engagement* ($B = 0.179$, $\beta = 0.160$, $p < 0.001$). Furthermore, *quantitative demands* ($B = -0.133$, $\beta = -0.127$, $p < 0.001$) as well as *social support by supervisors* ($B = 0.113$, $\beta = 0.115$, $p = 0.003$) predict *work engagement* significantly. Table 4 gives a detailed overview of the results. S*ocial support by colleagues* was excluded from the model, which indicates that this variable does not significantly predict work engagement. The final model accounted for 33.8% of the variance of *work engagement,* $F(4, 549) = 56.95$, $p < 0.001$.

Table 3 Pearson correlation coefficients (r) for work engagement
Tab. 3 Pearson-Korrelationskoeffizienten (r) für Arbeitsengagement

Work-related Variables	AI-User		Non-AI-User	
	r	*p*	*r*	*p*
Variation of work	0.323	<0.01	0.452	<0.01
Social support by supervisors	0.447	<0.01	0.338	<0.01
Social support by colleagues	0.380	<0.01	0.295	<0.01
Autonomy at work	0.418	<0.01	0.319	<0.01
Quantitative demands	–0.100	>0.05	–0.157	<0.01
Meaning of work	0.520	<0.01	0.492	<0.01

Table 4 Model summary for non-users of AI with work engagement as criterion variable
Tab. 4 Modellzusammenfassung für Nicht-Nutzende von KI mit Arbeitsengagement als Kriteriumsvariable

Model	*R*	R^2	Corrected R^2	Change in R^2	Change in F	Df 1	df2	Sig. change in F
1	0.489a	0.239	0.238	0.239	172.366	1	548	<0.001
2	0.543b	0.295	0.293	0.056	43.448	1	547	<0.001
3	0.564c	0.318	0.314	0.023	18.319	1	546	<0.001
4	0.577d	0.333	0.328	0.015	12.312	1	545	<0.001
5	0.586e	0.344	0.338	0.010	8.609	1	544	0.003

Note:
a. Predictor: (constant), Meaning of Work
b. Predictor: (constant), Meaning of Work, Variation of work
c. Predictor: (constant), Meaning of Work, Variation of work, Autonomy at work
d. Predictor: (constant), Meaning of Work, Variation of work, Autonomy at work, Quantitative demands
e. Predictor: (constant), Meaning of Work, Variation of work, Autonomy at work, Quantitative demands, Social Support by supervisors

Table 5 Model summary for AI-users with work engagement as criterion variable
Tab. 5 Modellzusammenfassung für KI-Nutzende mit Arbeitsengagement als Kriteriumsvariable

Model	*R*	R^2	Corrected R^2	Change in R^2	Change in F	df1	df2	Sig. change in F
1[a]	0.495[a]	0.245	0.242	0.245	72.16	1	222	<0.001
2[b]	0.573[b]	0.328	0.322	0.083	27.35	1	221	<0.001
3[c]	0.586[c]	0.344	0.335	0.015	5.15	1	220	0.024

Note:
a. Predictor: (constant), Meaning of Work
b. Predictor: (constant), Meaning of Work, Social Support by Supervisor
c. Predictor: (constant), Meaning of Work, Social Support by Supervisor, Autonomy at work

This indicates that the model is statistically significant in predicting work engagement.

3.3.2 Predictors of work engagement for AI-users

With regard to the multiple stepwise regression model for users of AI-based technologies, the multiple regression model has no auto-correlation as the value of the Durbin-Watson statistic is 1.983. Again, the analysis first included *meaning of work* as predictor in the regression model, indicating that *meaning of work* significantly predicts *work engagement* ($B = 0.525$, $\beta = 0.495$, $p < 0.001$). Second, *social support by supervisors* was included into the model as a predictor. After controlling for *meaning of work, social support by supervisors* also significantly predicts *work engagement* ($B = 0.289$, $\beta = 0.309$, $p < 0.001$). In contrary to non-users, in this model the third step included *autonomy at work* as a predictor into the model. After controlling for *meaning of work* and *social support by supervisors, autonomy at work* also significantly predicts work engagement ($B = 0.180$, $\beta = 0.152$, $p < 0.001$). All other variables were excluded from the model, which indicates that these variables do not significantly predict *work engagement*. The final model including *meaning of work, social support by supervisors* and *autonomy at work* accounted for 33.5% of the variance of work engagement, $F(3, 223) = 38.421$, $p < 0.001$. A full overview is given in Table 5.

4 Discussion

Digitalization is continuously changing the way we work (Meyer et al. 2022; Parker and Grote 2022) and typically it is still technology-centered, i.e. driven by technological innovation rather than the needs and requirements of human workers. The increasing prevalence of AI thus introduces both significant opportunities and challenges for humane work design. As AI systems are introduced rapidly and widely into our work, considering the impact of AI-based technologies on employees is crucial. Investigating this impact is one of the key objectives of the Regional Competence Center AKzentE4.0. In this context, the presented research in this paper focuses on the effects of AI-based technologies on employees who primarily conduct digital work. The aim was to derive insights and recommendations for future human-oriented digital work design. For this purpose, two research questions were investigated. Firstly, the question of whether work engagement as an indicator of motivated, satisfied, and healthy employees differs between workers who work with AI and those who do not was investigated (RQ1). Secondly, it was researched which human-oriented work design characteristics predicted work engagement (RQ2). Two models were calculated to identify differences between workers who work with AI and those who do not.

With regard to RQ1, the results show that employees who perform office work and work with AI perceive a sig-

nificantly higher level of work engagement than employees who do not. In order to understand the results, it is essential to undertake a detailed examination of the investigated sample. The study was conducted with employees in office-based jobs who are performing information-related work tasks. In these occupational groups, the digital transformation results in a more intensive use of digital technologies, particularly AI-supported systems, which are perceived as highly beneficial. A study performed by Slack (2024) including over 10,000 participants, may provide an explanation for this. It revealed that office workers spend approximately half (41%) of their working time on tasks that are of low value, repetitive, or do not contribute meaningfully to their primary work tasks. Furthermore, the more time employees dedicate to this work, the more optimistic they become about the potential for AI and automation to take over those tasks. Amongst those who have utilized AI and automation tools in their work, approximately 80% indicated that this technology is already enhancing their productivity. Consequently, the deployment of AI in an office setting is having a favorable impact for the employees, which in turn can influence work engagement. Hence, according to Demerouti (2022), the decisive factor is whether the technology is designed as an additional demand or as a resource for employees. On the one hand, technologies can be seen as a demand, for example, when they require to do more work in the same amount of time, as well as to react flexibly to changing work processes. On the other hand, technologies can be seen as a resource and have a positive impact on one's own work, for example by providing support for physical and cognitive tasks. If office workers recognize the benefits of technology and are able to use them, AI-based technologies may be perceived as a resource that can promote work engagement rather than a stressor that decreases job satisfaction and commitment.

This leads to the 2nd research question, as it becomes clear that certain characteristics for human-oriented work design are of particular importance in the context of digital and AI-supported work. In the context of digital work, the meaning of work, variation of work, autonomy at work and, to a lower degree, also quantitative demands and social support by supervisors are particularly decisive in explaining work engagement. In the specific context of AI-supported work, an even narrower focus can be identified. The meaning of work, support from supervisors and autonomy at work contribute significantly to explaining work engagement. Meaning of work can be broadly defined as work that is personally significant and worthwhile (Pratt and Ashforth 2003) and is according to previous research positively correlated with work engagement. Furthermore, meaningful work can act as a mediating variable in the sense that employees may organize their work in a way that makes it more meaningful and engaging, thereby improving their performance. Here, the connection between autonomy at work and support from superiors becomes particularly important. Only those who have the support and autonomy to change their work accordingly are able to do so. While the meaningfulness of work is relevant for both digital and AI-supported work, specifically the role of the supervisor proves to be decisive in the context of AI-supported work. One reason may be the change in the role of supervision and the tasks of supervisors in the context of AI-supported work. According to Eriksson et al. (2020), the main obstacle when implementing AI is a lack of support from supervisors when implementing AI in work contexts. The positive benefits of AI can only unfold if supervisors have an understanding and commitment to promoting comprehensive change (Mikalef and Gupta 2021). In addition, AI is fundamentally changing the nature of leadership (Eriksson et al. 2020). As AI is increasingly used to partially or even fully automate human-related management decisions, expanding the possibilities of algorithmic management (Bucher et al. 2021), supervisors need to focus more on human aspects such as personality traits and behaviors and less on the cognitive processing of facts and information (K. Chang 2020).

In summary, the aim of the article was to derive evidence-based guidelines for the human-oriented design of AI-supported work, to find out how work design criteria are affected by the use of AI and how this might differ from the general use of digital technologies. The results show that, in the context of AI-supported work, the criteria of meaningfulness, autonomy and supervisors support are especially relevant for promoting work engagement. Even with more automated and AI-supported technical systems, human work remains crucial. Individual work tasks will be automated, but not entirely (Parker and Grote 2022). It is important to consider work design issues in order to manage the potential impact of new technologies and associated changes and to steer technological development towards the desired future of work. Overall, the presence of AI does not necessarily guarantee engaged employees or that the introduction of AI will inevitably result in increased employee engagement. However, provided that AI is integrated into the work context as a resource and employees are afforded the opportunity to perceive meaning in their work, have the support of their supervisors and can exercise a sufficient degree of autonomy at work, AI has the potential to positively influence work engagement.

4.1 Limitations

This study provides an insight into the relevant characteristics of humane work design for AI-supported work and compares them with digital work in general. However, there are some limitations that need to be considered. First, the

analysis is a secondary analysis, which has some limitations. In particular, the selection of variables was limited and thus it was not possible to systematically investigate all work design criteria included in the WDQ or other human-oriented work design models. The multiple regression models themselves also have limitations. Stepwise regression can lead to overfitting of the data, biased estimates and inflated type I errors (Harrell 2015). It should also be noted that a stepwise regression approach makes no theoretical assumptions about the inclusion or exclusion of predictors. It is usually more appropriate to use theory and previous research findings to decide which variables to include in the model, but this was not reasonably possible in this study as there is not a strong enough theoretical or empirical basis for variable selection. Therefore, stepwise regression was used, following an exploratory approach. The sample also has restrictions. Only employees who carry out digital office work in Germany were surveyed. The transferability of the results onto other occupational or cultural groups is therefore limited. With regard to the use of AI, it should be noted that employees were asked to self-assess whether they work with AI-supported technologies or not. This could have led to mistakes. No definition of AI was provided, it was only asked whether AI is used in everyday working life. Accordingly, those who were not aware of the use of AI did not indicate this. Furthermore, the data comes from a survey conducted at the beginning of 2023, i.e., before ChatGPT has become widely known. The understanding, knowledge and use of AI are therefore likely to have changed since the survey, which is why the results only provide a snapshot that needs to be interpreted in the context of its time. Furthermore, different perceptions of the work engagement and different influences of the investigated human-centered work design characteristics cannot necessarily be attributed to the use of AI. As such, the use of AI can go hand in hand with other workplaces and other work tasks, which in turn determine the results. The decisive factor is therefore not necessarily the use of AI, but the type of work tasks that were conducted.

5 Conclusion and outlook

Technology can have both positive and negative effects on workers. In order to achieve a positive impact, AI systems need to be understood as a resource for workers rather than as a stressor. As a resource, AI can, for example, improve safety and health, satisfaction and performance. To achieve this, technology development must be human-centered, i.e., technology must be developed as a resource for the people who work with it. In addition, the implementation of new technology must be human-centered and responsive to the needs of employees. In this sense, organizations must transform technology into a resource by designing the whole work system (tasks, knowledge, organizational structure, decision-making processes) accordingly, taking into account the experiences and requirements of users and providing adequate resources for the new technology-driven demands (Demerouti 2022). AI can contribute to stimulating and "healthy" workplaces if it continues to give workers meaningful tasks, if workers have control over the use of AI and are supported by their supervisors, so that they can shape their own work.

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