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Employees' Acceptance of Digital Technologies: Assessment Tools for a Comprehensive Evaluation of Digital Technologies During Implementation

Angela Schorr[1,*], Alexander Gorovoj[2]

[1]Department of Psychology, Media Psychology Lab, Faculty II, University of Siegen, Siegen 57068, Germany.
[2]Fraunhofer Institute for Industrial Engineering IAO, Stuttgart 70569, Germany.

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***Corresponding author:** Angela Schorr, Department of Psychology, Media Psychology Lab, Faculty II, University of Siegen, Siegen 57068, Germany.

Abstract

Experts in all major industries are currently deeply concerned about two profound, evolving changes: the difficult and costly implementation of digital transformation measures in their companies and the growing shortage of skilled workers. Employers and politicians are pinning high hopes on digitalization to alleviate the growing skills shortage. Successful digitalization, in turn, requires staff always qualified to the latest standards. To bring this together, reliable tools are needed to more carefully monitor and evaluate the design, workplace implementation, and on-the-job training of digital innovations. Guided by a human resource development approach, in this study, employees' digital technology acceptance (N = 323 aged 18-65) was measured using a cognitive TAM2-based acceptance scale combined with scales measuring motivation central to new learning challenges. The assessment tools validated here are suitable for evaluating new digital technologies by future users (employees, consumers) and can also be used to capture training progress in on-the-job training.

Keywords

Digital technology acceptance scale (DTAS); Cognitive TAM2; Employees; Age-diverse workgroups; Human resource development

1. Introduction: Purpose of the Study

The study has three main objectives: First, to bring Davis' technology acceptance model (Davis, 2015; Davis & Granić, 2024) back to its original content and to simplify and open it up as a primarily cognitive approach in the psychological analysis of digital transformation processes. Second, to statistically verify the dimensionality and construct validity of the Digital Technology Acceptance Scale (DTAS). Third, to further expand and validate this tool by a set of well-founded digital technology use and psychological tests for use in the implementation phase of new digital technologies and on-the-job training. The study focuses on cognitive as well as emotional and motivational variables that accompany the acceptance of digital technologies and that help generate user-friendly adaptations to new digital technologies (software and hardware) in the workplace. The entire toolset is primarily aimed at non-IT employees (participants in this study) and users in general, whereby the variables age and gender are also taken into account. The employees surveyed belong to the majority of today's workforce who are expected to be able to handle new or rapidly changing digital technologies without being IT-specialists/developers themselves. With the help of the toolset used in this study, it should be possible to adapt innovations in the course of digital transformation more precisely to the respective (age and gender diverse) user groups.

2. A Cognitive TAM2-based Analysis

From a psychological perspective, the term *acceptance* (as opposed to the broader term adoption) is well chosen, *as it always refers to an object*, in this case, the new digital technologies that are to be implemented in the workplace. While individuals or organizations demand acceptance of digital technologies from employees/users, the term draws attention to the decision-making process of those who are supposed to use them. The acceptance process includes a central cognitively controlled emotion regulation strategy that can be trained (Burghard et al., 2022; Herbert & Brandsma, 2015; Huits et al., 2012; Ong et al., 2023; Upham et al., 2015; Wojnarowska et al., 2020). It is also a learning process, which is why it is advisable to carefully measure the TAM2 variable Intention to Use (Nagdev et al., 2024).

Conceptually, this study is based on Davis' *Technology Acceptance Model* (TAM2 for short; see Davis, 2015; Davis & Granić, 2024), which is strongly influenced by the prestigious *Theory of Reasoned Action* and the *Theory of Planned Behavior* (TRA/TPB) by Ajzen and Fishbein (Ajzen & Fishbein, 1980; Ajzen, 2020). Today, Davis' TAM is still rated "the most popular theoretical framework" for research on technology adoption (Feng et al., 2021). He and his team were the first to address the issue of user reactions to digital technologies by tackling the "implementation problem". The model should provide the theoretical basis for practical tests that developers of new software and hardware can use to evaluate digital technologies before and during implementation (Davis, 2015; 2024). Originally, TAM2 has *four core components*: The two cognitive beliefs, *Perceived Usefulness* (PU) and *Perceived Ease of Use* (PEU), which, as a result, shape the *Attitude towards Usage* (ATT; *TRA/TPB variable*), followed by a *Behavioral Response* (BR), i.e., the actual use of the technology. Davis defined the two core variables, the two cognitive beliefs, as follows: *Perceived Usefulness*: The degree to which an individual believes that using a particular system would enhance his or her performance; *Perceived Ease of Use*: The degree to which an individual believes that using a particular system would be free of physical and mental effort (Davis et al., 1989; Davis, 2015).

As the TRA/TPB variable *Behavioral Intention to Use* (BI), which was added at a later stage of theory development, turned out to be highly correlated with self-reported user behavior, this easier-to-collect variable moved up as the new fourth core variable in TAM2 (Davis, 2015). Subsequently, systematic (digital) recording of user behavior—which often proves to be ambiguous in its significance and clearly flawed (selection of indicators, implementation mode, etc.)—was rarely carried out. Over the years, the extensive collection of subjective user data met with criticism from the information science community (Ammenwerth, 2019; Kelly, Kaye, & Oviedo-Trespalacios, 2023; Lai, 2017; Olbrecht, 2010; Opoku & Francis, 2019; Rahimi et al., 2018; Upham et al., 2015), but Davis succeeded in convincing the most of his critics with the argument that the user's subjective perception of the usefulness of a system is more relevant to his or her decision whether or not to use the system (Davis, 2015; Dwivedi et al., 2015). Independent of the work of the Davis team, Ajzen (2005) concluded in his overview of the state of research on attitudes and behavior that there are study results that support the claim that measured intentions predict behavior even better than attitudes alone (see also Ajzen 2014; Ajzen et al. 2018). He classified the technology acceptance model as essentially "content-specific" and mainly suitable for application to technology acceptance issues (Ajzen, 2020, p. 322). Over several decades, Davis and his collaborators, most notably Visvanath Venkatesh, expanded the basic model to examine the influence of additional "determinants" on single TAM2 core variables. The technology acceptance model formed the basis for a wealth of studies in information management research, consumer research, education research, and health research (for reviews on theory development and publication activity, see Davis & Granić, 2024; Kemp et al. 2019; Lai, 2017; Marangunić & Granić, 2015; Opoku & Francis, 2019; Rosli et al., 2022; Schorr, 2023; Tang & Hsiao, 2016)—thereby introducing many more variables relevant to acceptance in a variety of different contexts. The additional variables most frequently examined were subjective norm, voluntariness, facilitating conditions, and self-efficacy.

The two TAM2 beliefs, perceived usefulness (PU) and perceived ease of use (PEU), as well as the variable behavioral intention to use (BI), can be classified as primarily cognitive variables. The variable attitude towards usage (ATT), which Davis described early on as an "emotional response" (Davis, 1985), encompasses cognitive (decision-making) and emotional components and is still measured as a cognitive-emotional mix. Not only TAM research, but also Ajzen's TPB research has continued to advance over the decades. Reviewing psychological attitude research (Ajzen, 2001; Ajzen, 2014; Ajzen et al., 2018; La Babera & Ajzen, 2020), he notes that the debate about cognitive versus affect contributions to attitude formation is not yet over. Citing, among other things, a comparative study on attitude formation for two software products (computer game, grammar checking software), which shows that and how individuals differ in their tendency to base their attitudes on cognition or affect, he ultimately concludes that contributions of affect and cognition to overall evaluation vary with the attitude object. This is confirmed in a study published in 2020 on energy-saving behaviors in workplaces, in which the authors employed an extended model of the TPB "considering two components (affective and cognitive) of the attitude towards these behaviors" (Bosnak, Ajzen & Schmidt, 2020, p. 354).

3. The Four Core TAM2 Variables: Back to the Original Formula

In order to apply the Technology Acceptance Model (TAM2) to the increasingly complex innovations of the future, also those based on artificial intelligence, it makes sense from a research strategy perspective to first reduce it to its well-researched four core concepts. The result is a predominantly cognitive TAM2-based approach—thereby retaining the Theory of Planned Behavior idea that people make rational choices—with a central measurement instrument to be designed as a fully four-dimensional scale for recording the core variables perceived usefulness, perceived ease of use, attitude towards usage, and behavioral intention to use.

The decision not to include other well-known concepts in this reduced formula, potentially influencing technology acceptance, can be explained using the example of the concept of *subjective norm*, which for several decades has received a great deal of attention in TAM research. However, these efforts met only with moderate success – an experience that TAM researchers shared with prominent research groups in TPB research. As La Barbera and Ajzen comment on this: "It is worth noting that in many TPB studies, subjective norms tend to have a relatively weak or nonsignificant regression coefficient in the prediction of intention (…) leading to the conclusion that subjective norms are of little importance in determining behavioral intentions." (La Babera & Ajzen 2020, p. 413). In general, many of the complementary variables known today in TAM research can be better explored and utilized when they are considered as independent concepts. In this way, they can be thoroughly researched in their own right, while also giving greater consideration to the respective field of application.

As Ozili (2025) correctly describes, the introduction of new technologies always involves a *technology expectation impact gap*, which keeps users in suspense during implementation. These and other phenomena that occur when users deal with digital technologies, and the rapid advancement of digital technology as a whole, require innovative, independent theory-building efforts that give human cognition and emotions more space in theories on the use of digital technologies, based on thorough psychological analyses. It is something the present study can only initiate but not achieve. The independent measurement of various psychological variables (well-known and well-researched) should contribute to this.

4. Age-diverse Workgroups and Digital Transformation

Age-diverse workgroups are increasingly in the focus of human development research, often based on the active/successful aging paradigm (Fasbender et al., 2021; Burmeister et al., 2022; Fasbender & Gerpott, 2022; Dietz et al., 2022; Tang & Martins, 2021). But positive insights of life-span research have not yet caught on in the world of work. Although retaining older workers seems to be more important than ever, the critical view of aging prevails. The assumption that general work motivation declines across the life span is widespread in organizational practice, although a solid body of evidence exists that age is not a reliable predictor of work outcomes (Ackerman & Kanfer, 2020; Erber & Szuchman, 2014; Livingston, 2019; Paruzel et al., 2020; Previtali & Spedale, 2021; Zacher et al., 2018). The situation is complex; even positive myths of aging can be counterproductive. As one of the most common (positive) beliefs about older employees, Hanrahan et al. (2017) identified the conviction that they are "experienced", a myth with a double-edged effect: When organizations offer training, older employees are often left out. More research is urgently needed (Ackerman & Kanfer, 2020), all the more so as the number of people extending employment up to and beyond the age of 70 (e.g., in Germany, 4%-14% depending on industry; Destatis, 2023) is currently growing, not least enabled by digitalization gains.

4.1 Transformation Pressures We Already Know About

A high percentage of today's employees have not had the opportunity to grow up with digital technologies. Often, they learned how to use these tools on their own or with minimal professional guidance. To date, society largely relies on the willingness of users to embrace digital applications through a strategy mix of self-directed learning, social guidance, and trial-and-error attempts. The fast pace of innovation in software and hardware means that users need to constantly update their knowledge in order to use digital technologies effectively. At work, people often experience the stress caused by digitalization as *job insecurity* (fear of job loss due to new technologies or better qualified personnel), as *information overload* (being forced to work more and faster) and as *uncertainty* in dealing with digital technologies due to changes and updates and the resulting pressure to constantly relearn and retrain (Bencsik & Juhasz, 2023; Nastjuk et al., 2022). The more profound and faster digitalization affects the economy and society, the higher the demands on employees' digital skills. Molla et al. (2024) distinguish three user groups that are affected differently by these developments: In everyday life, *users/consumers* usually have basic digital skills, but are presently affected by ad hoc digitalization (when shopping, banking, voting, communicating with authorities, etc.). *IT professionals* who—while having the highest level of digital skills—constantly have to make great efforts to keep their expertise up to date. The third (and largest) group, the *non-information technology workforce*, which is the target group in Molla et al.'s study *as well as in this study*, currently experiences the greatest pressure to renew and expand their IT skills (Molla et al., 2024). In response to this, experts are calling for a continuous learning culture, the design and structural organization of which is currently up for discussion (e.g., Alcover, 2021; Hubschmid-Vierheilig et al., 2020; Molla et al., 2024; Neeley & Leonardi, 2022; Siderska, Moh'd Alsqour, & Alsaqoor, 2023). The study presented here, with its tools and results, is intended as a contribution to this discussion.

4.2 Research Findings on Age and Gender Relevant to This Study

Age as a variable: In research on age-diverse workgroups, there is no uniform standard for the variable age. In some studies, employees aged 40 and up are already classified as "senior" or "older" workers; other studies do not state the exact age of the participants, but compare "younger" with "older" employees, or compare very young employees with employees at the end of their careers (e.g., Bashir et al., 2021; Drazic & Schermuly, 2024; Garcia et al., 2018; Nagarajan et al., 2019). The authors of this study are of the opinion that the rising retirement age in many nations must be given greater consideration. More samples are needed that cover the entire working life in terms of age. Midlife in particular covers a long period of time if working life is to be further extended up to the age of 70. This is no longer a distant vision: In the United States and in Germany, approximately 50-60% of people between the ages of 60 and 70 (often referred to as "the young-old") are still employed. More men than women opt for it, and the majority are well-educated people. Many decide to extend their working life for economic reasons, and from age 65, transitioning into retirement often involves part-time work models (cf. Destatis, 2023; Livingston, 2019).

With regard to the participants, this study is based on current findings in lifespan research and thus on the belief that human development continues throughout the lifespan and exhibits lifelong plasticity into old age (Baltes et al., 1980; Greve & Staudinger, 2015). Researchers found several answers to the question of which attitudes and characteristics promote the acquisition of new skills over the entire lifespan. These include psychological variables such as self-efficacy, autonomy, conscious setting of developmental goals, openness, etc. (Hülür & Macdonald, 2020; v. Humboldt & Leal, 2014; Leipold, 2012; Leipold, 2015; Mühlig-Versen et al., 2012). When dividing the respondents into different age groups, for this study, the updated version of life stages in adulthood of Mehta et al. (2020) is applied (Table 1). According to them, adulthood can be further subdivided in the stages of *emerging adulthood* (18-29 years) and *established adulthood* (30-45 years)—both grouped together in this study in one subgroup (GROUP1, 18-45 years) because they have comparable experience in dealing with digital technologies—and in the *midlife stage* (GROUP2, 46-65 years), thereby focusing the analysis on two periods of life of roughly equal length. The stage of emerging adulthood is characterized by "exploration, information gathering, and career preparation", while in *established adulthood* (age 30-45), employees strive to gain more expertise, take on greater responsibilities, and move up in the hierarchy. In private life, there may be variations in the 18-45 age group, such as single life, coupled but no children, one full-time parent, "no career, just a job" (Mehta et al., p. 434). The *midlife stage* (46-65 years) as a key period of life is characterized by seniority at work, mentoring the next generation, expertise, special skills and knowledge, problem anticipation, and increasing crystallized intelligence. In private life, mid-life employees have to cope with multiple roles and challenges in the generational dynamic with ageing parents, adult children and grandchildren, financial burdens, etc. (Infurna et al. 2020; Mehta et al., 2020).

Gender as a variable: Gender is an important variable in this study. Recent studies prove that differences in education and interest in IT applications, IT professions, and professions with a high IT content become smaller for female and male employees in emergent and established adulthood (Chau & Quire, 2020; Geitz & Schnabel, 2023; Schorr, 2019; Gorovoj & Schorr, 2020). Also, both genders do not shy away from new learning processes with regard to their digital skills (e.g, Woźniak-Jęchorek, Rydzak, & Kuźmar, 2023). Nevertheless, women are still disadvantaged by the fact that they have significantly less higher career aspirations than men and less often actively engage in behavior to advance. Instead, they usually seek to feel competent in a work role prior to seeking out (Hartmann & Barber, 2020). This applies in particular to the technology sector, which Chau and Quire (2020) describe as a still male-dominated culture. The senior managers in the tech industry interviewed characterized women but also as paying “greater attention to detail” and “long-term and visual thinkers” (Chau & Quire, 2020, p. 8).

5. Study Design and Methodology

5.1 Information on Sampling, Participants, and Procedure

The data for this study were collected by questionnaire as part of a larger study including employees and retirees. Participation was voluntary and anonymous, i.e., the respondents were approached at home, completed the questionnaire there—free from workplace-related influences—and sent it back to the University of Siegen anonymously and postage paid. Of the 572 hard copies distributed, 487 were returned and usable (net return: 85.1%), including both employees (N = 323; mean age M = 39,82) and retirees (N = 164; mean age M = 73,09). The data of the N = 164 retirees are analyzed in a separate validation study. Further information on the structure of the final sample can be found in Table 1.

To ensure that the sample adequately represents the non-IT workforce in terms of education, the educational level of the participants was also determined. Until today, few researchers have studied the psychological dynamics related to the introduction of new technologies involving this biggest subgroup of the current workforce (e.g., Molino et al., 2020). *Level 1*: 58.1% had lower secondary school or middle school qualifications with subsequent apprenticeship or professional training; *Level 2*: 22.4% had bachelor’s degrees; master craftsmen and industrial foremen were also assigned to this level; *Level 3*: 19.6% had a technical college or university degree (diploma or master).

These figures suggest that *non-IT employees* are well represented. Overall, the sample is well-suited to investigate further questions regarding technology acceptance.

Table 1. Participants (age and gender; N = 323)

Employees	N	Percentage male to female
Total Group (Age 18-65)	323	47,8% to 52,2%
GROUP1 Emerging & Established Adulthood (Age 18-45)	177	49,2% to 50,8%
GROUP2 Midlife (Age 46-65)	144	45,5% to 54,5%

Note: Two employees are missing information on their ages.

5.2 Statistical Verification of the DTAS Scale, the Four Subscales, and Their Properties

All instruments used in this study are intended to be versatile and need to be further validated. Based on research on the Technology Acceptance Model (TAM; Davis, 2015; Davis & Granić, 2024) and other preliminary work (Schorr, 2023), the Digital Technology Acceptance Scale (DTAS) has to be further validated with psychological scales that are suitable for capturing the motivational situation of employees with a focus on the constant requirement to learn/relearn in the context of digitalization. The final set of tools by measuring acceptance and acceptance change is applicable to better adapt new software and hardware to users in the implementation phase of new digital applications and to make workplace learning, where indicated, age- and gender-appropriate. The information on the statistical quality of the scales is based on employees only (N = 323), thus focusing on the statistical characteristics that are important for studies on the world of work. In addition, it should be noted that all scales used in this study have proven to be applicable across ages (Moersdorf et al., 2022). Unless otherwise noted, the scales listed below have a five-point response format (1 = strongly disagree, 5 = strongly agree).

As announced, the four core dimensions of the TAM2 model (*perceived ease of use, perceived usefulness, attitude towards usage, behavioral intention to use*) are combined in a scale that in total represents the concept of digital technology acceptance (Schorr, 2020; Gorovoj & Schorr, 2020). The four-dimensional Digital Technology Acceptance Scale (DTAS) replaces the (mainly for theory building purposes)—widespread use of single TAM2 core variables as criteria/variables in complex regression and structural equation models. After checking the quality of the scale and the four subscales (factor analysis, homogeneity tests) for use as a research tool as well as a practical tool to support implementation processes for digital technologies, in a second step two scales measuring *digital media self-efficacy* and *computer affinity* are introduced to further validate the DTAS by exploring the connection between the participants' technology-related experiences with DTAS documented therein.

5.3 Confirmation of the Four-dimensional Structure of DTAS by Factor Analysis

Based on an earlier version of the scale that was applied to a sample of university students and same-age employees (N=485¸Gorovoj & Schorr, 2020; Schorr, 2020), the scale was slightly revised (one item was added to the attitude variable). A confirmatory factor analysis was performed, and the four-dimensional structure was reconfirmed based on N = 323 employees. The *Digital Technology Acceptance Scale (DTAS)* is a four-factor scale with 14 Items and 4 subscales measuring *perceived usefulness* (4 items; Cronbachs alpha: .92; average inter-item correlation: .73), *perceived ease of use* (4 items; Cronbachs alpha: .83; average inter-item correlation: .68), *attitude towards usage* (4 items; Cronbachs alpha:.85; average inter-item correlation: .59), and *behavioral intention to use* (2 items; Cronbachs alpha: .81; r = .68). The Cronbachs alpha for the overall scale (DTAS) is r = .91, average inter-item correlation r = .41. The variance explanation is 75.2% with eigenvalues of 6.44, 1.98, 1.36, and 0.76 for the four factors. Falling below the eigenvalue limit of 1 (Kaiser-Guttman criterion) was tolerated in order to maintain the four-factor structure. The items in the scale have been widely used and validated in prior research on digital technology acceptance (Venkatesh & Davis, 2000; Schorr, 2020; Teo et al., 2008; Teo et al., 2011).

Table 2. Factor Analysis of the Digital Technology Acceptance Scale (N=323)

	Factor 1 (PU)	Factor 2 (ATT)	Factor 3 (PEU)	Factor 4 (BI)
TA1	**0,87511**	0,08505	0,21452	0,12067
TA2	**0,87390**	0,19151	0,11407	0,19433
TA3	**0,79963**	0,21332	0,11389	0,31186
TA4	**0,82476**	0,16237	0,15397	0,10759
TA5	0,36040	0,24040	0,13537	**0,78105**
TA6	0,22230	0,30111	0,10638	**0,84083**
TA7	0,26660	0,15259	**0,80504**	0,08567
TA8	0,17103	0,20319	**0,82246**	0,16758
TA9	0,17346	0,21168	**0,83699**	0,01655
TA10	-0,06368	0,44907	**0,54626**	0,06667
TA11	0,07831	**0,69095**	0,35076	0,11023
TA12	0,36288	**0,77512**	0,10443	0,21573
TA13	0,24661	**0,77775**	0,25242	0,15687
TA14	0,12369	**0,74533**	0,17197	0,25324

5.4 DTAS Validation by Scales Measuring Experience with Digital Media/Technologies

The *Digital Media Self-Efficacy Scale* and the *Computer Affinity Scale* were used here to validate the Digital Technology Acceptance Scale (DTAS). According to Bandura, self-efficacy beliefs play a crucial role in determining how much effort a person puts into completing a task and how consistently people persist in their actions when faced with problems or obstacles (Bandura, 2001; 2013). Davis and Venkatesh (1996) demonstrated that computer self-efficacy beliefs—both positive and negative—primarily impact an individual's perceptions of *ease of use* when using a computer system. So far, TAM researchers have primarily used digital technology-related (i.e., domain-specific) scales. In this study, the *Digital Media Self-Efficacy Scale* was used to cover the broader technology domains of "digital media" and "internet". The scale consists of 4 items based on the ICT Familiarity Questionnaire (OECD) and has proven to be reliable in previous research (OECD, 2015; Chen & Hu, 2020; Odell et al., 2021; Schorr, 2020). The scale's internal consistency is high, as indicated by a Cronbach's alpha of $\alpha = 0.78$. The *Computer Affinity Scale* is a short, two-item scale that has been used successfully in a study to predict student interest in IT careers (Schorr, 2019). Despite its brevity—which is no disadvantage if a few rules are followed (Eisinga et al., 2013)—the scale is particularly well suited for comparative surveys of different user generations because it economically captures the use of digital media from a biographical perspective. The correlation between the two items is $r = 0.70$, $p < .001$. The Cronbach's alpha reaches a high value of $\alpha = 0.83$.

Hypothesis 1. *The two employee age groups differ statistically significantly in terms of their digital technology acceptance and the digital technology-related attitudes: Specifically, we assume that as for the values for the three digital technology-related attitudes (digital technology acceptance, digital media self-efficacy, digital media affinity), they are statistically significantly lower in GROUP2 (midlife employees) compared to GROUP1 (emergent & established employees),—presumably as a result of the missing early socialization in dealing with digital media in GROUP2. It is also assumed that the values of female participants are statistically significantly lower in den three digital technology-related scales compared to those of males.*

Table 3. Results of two-factor variance analyses, group comparisons (age, gender)

	GROUP X SEX
(1) Digital Technology Acceptance Scale	GROUP (N = 317, $M^{employees18\text{-}45} = 49.69$; $M^{employees}$ 46-65 = 44.43); $F(3, 313) = 15.97$, $p < 0.001$ SEX ($M^{male} = 49.00$, $M^{female} = 45.82$); $F(3, 313) = 5.48$, $p < 0.05$
(2) Computer Affinity Scale	GROUP (N = 320, $M^{employees18\text{-}45} = 3.49$; $M^{employees\ 46\text{-}65} = 3.44$); $F(3, 316) = 4.498$, $p < 0.05$ SEX ($M^{male} = 4.34$, p = , $M^{female} = 3.16$); $F(3, 316) = 28.740$, $p < 0.001$
(3) Digital Media Self-Efficacy Scale	GROUP (N = 319, $M^{employees18\text{-}45} = 15.73$; $M^{employees\ 46\text{-}65} = 12.12$); $F(3, 315) = 63.900$, $p < = 0.001$ SEX ($M^{male} = 15.28$, $M^{female} = 13.07$); $F(3, 316) = 22.705$, $p < 0.001$

Note: Digital technology-related Attitudes & Motives (1-3).

Results on Group Differences: As for the *three digital technology-related scales*, the results of variance analyses confirm the *Hypothesis 1* predictions: The following applies to all three scales, the Digital Technology Acceptance Scale, the Computer Affinity Scale and the Digital Media Self-Efficacy Scale: The results of the two-factor variance analysis GROUP X SEX confirm the hypothesis, that the values are statistically significantly lower for midlife employees. Likewise, as predicted, the female employees in this sample have statistically significantly lower scores on the three scales compared to the male employees!

5.5 Two sets of psychological scales for further DTAS validation purposes

5.5.1 Scales' selection and quality

Two further sets of scales relevant for learning and retraining were applied in the sample. The following applies to their quality and content scope:

(1) The Performance Goal Orientations Scales

The motivation scales used in this study are based on Carol Dweck's Social-Cognitive Goal Orientation Theory (Dweck, 1986; Elliott & Dweck, 1988), which proposes that actions taken to achieve desired states, particularly in performance situations, are characterized by underlying goals. Dweck distinguishes between two classes of goals: *learning goals* and *performance goals*. Learning goals involve seeking to increase one's own competence through learning processes in order to understand and master new challenges. When pursuing learning goals, individuals orient themselves towards individual reference norms and view feedback—both positive and negative—as informative and relevant for learning. Performance goals, on the other hand, involve either demonstrating or hiding one's own competencies, depending on whether the individual seeks to receive positive feedback or seeks to avoid negative feedback (Elliott & Dweck, 1988). When pursuing performance goals, negative feedback is perceived as threatening and is avoided, while positive feedback is appreciated (Dweck & Leggett, 1988; Kleinbeck, 2010; Geitz et al., 2016). They are oriented towards seeking external validation or recognition, rather than improving their own understanding and abilities. As Button, Mathieu, and Zajac (1996) found out, the two goal orientations represent independent

dimensions, which is why the individual pursues performance goals and learning goals at the same time.
In organizational research, the two goal orientations have been examined for their potential influence on employees' decisions to engage in professional development and to apply the knowledge and skills gained from on-the-job training activities. Studies by Mun and Hwang (2003) and Al-Aulamie (2013) have found that learning goal orientations have a positive influence on the acceptance of new digital technologies. These studies confirmed that individuals with a *learning goal orientation* view learning new digital technologies as a challenge and continue to use them even when faced with technical difficulties.

A current study from the world of work by Bakker et al. (2020, p. 351) confirms that "learning goal orientation strengthened and performance goal orientation weakened the links between proactive vitality, work management and engagement, and between work engagement and creativity". Johnson and Beehr (2014), who conducted a review of the research, concluded that the two goal orientations produce different results, with *performance goal orientation* in particular producing "mixed findings" in workplace learning. Orvis et al. (2010) who examined the use of digital technology (video game-based military training) in relation to the participants' goal orientations found that people with a high degree of performance goal orientation "believe that their ability and skill levels are stable and unlikely to change" and that "their concern with competence is more about superficial demonstration than substantive development" (Orvis, Horn, & Belanich, 2010, p. 477). Interpreting this evidence, the authors of this study conclude that regardless of whether it relates to human feedback or feedback from a digital system, learning new content requires more trial-and-error strategies from learners who mainly pursue performance goals when using new digital technologies, while learners who mainly pursue learning goals explore new digital applications in a more systematic and self-directed way.

The two goal orientation scales created by Köller and Baumert (1998) were used in this study. Each scale consists of 8 items; the response format of the scales was reduced from seven to five levels (without any loss of scale quality; 1 = strongly disagree, 5 = strongly agree) in order to maintain a consistent response mode within the survey. The factor analysis of 16 items in this study also shows a clear two-factor structure with an explained variance of 55.1% and eigenvalues of 4.86 and 3.95. The *Performance Goal Orientation Scale* achieves a Cronbach's Alpha of $\alpha = 0.84$; the *Learning Goal Orientation Scale* achieves a Cronbach's Alpha of $\alpha = 0.90$, i.e., both scales have a high internal consistency and are reliable measures of the two goal orientations.

(2) The Basic Needs Scales

Deci and Ryan (2000) describe basic psychological needs as universal and innate factors that contribute to optimal functioning, personal growth, well-being, and social development. The three central needs—the *need for autonomy*, the *need for competence*, and the *need for relatedness*—have a lasting impact on individuals (Brand & Ekkekakis, 2021; Deci & Ryan, 2011; Van den Broeck et al., 2016). These needs have been found to be universal, e.g., in a large-scale comparative study on Chinese and Belgian samples (Chen et al., 2015). The *need for autonomy* is associated with psychological well-being outcomes and is achieved when an individual perceives his or her behavior as self-determined and free from external contingencies (Hagger & Hardcastle, 2014). Mlekus et al. (2021) found that employees need to feel in control of the situation during the implementation of new technologies, and that to meet this need for autonomy is essential for effective participation (Mlekus et al., 2021; Paruzel et al., 2020). Xie et al. (2023) were able to prove in a study of employees aged 40 and over that access to digital technology training opportunities increased midlife employees' autonomy need satisfaction. The *need for competence* includes psychological aspects usually grouped under terms such as determination and ambition at work. "It fuels persistence, sustained effort and attention, and the desire to improve." (Legault, 2020; p. 3128) Such striving for challenging and satisfying experiences allows the personality to grow and increases well-being (Legault, 2020; Xie et al., 2023). Both needs, the need for competence and the need for autonomy, drive performance behavior. The *need for relatedness* refers to the desire to establish mutually caring bonds and positive alliances with others. As far as the need for relatedness is concerned, the research situation is still contradictory with regard to its significance for work engagement in (multigenerational) teams (Burmeister et al., 2021).

The items for the scales measuring the three basic psychological needs were developed by Chen et al. (2015). In analogy to the Basic Psychological Needs at Work Scale (BPNWS) by Brien et al. (2012), the scales were shortened to four items each and a five-point response format (1 = strongly disagree, 5 = strongly agree). A factor analysis was conducted to confirm the three-factor structure, which explained 62% of the variance (eigenvalues: 4.54, 1.60, 1.30). The *Need for Autonomy Scale has a good homogeneity* ($\alpha = 0.72$), the *Need for Competence Scale* has a high homogeneity ($\alpha = 0.84$), and the *Need for Relatedness Scale* also has a high homogeneity ($\alpha = 0.80$). These scales were also initially tested for group differences (age, gender). The following hypotheses guided the statistical analysis:

Hypothesis 2. *The two employee age groups differ statistically significantly in terms of their motivation to learn, i.e. operationalized here as two performance goal orientations and three basic needs. There are also statistically significant differences in these dimensions for both genders.*

To test these hypotheses, two-factor analyses of variance were carried out. For all five scales (two goal orientations, three basic needs) we assume that the values for the learning goal orientation drop from emergent & established adulthood to midlife, while the values for the performance goal orientation—which results in more trial and error learning processes—may remain constant over the course of professional life. As for the three basic needs, the need for autonomy is likely to play an important role in all stages of work life. As for the need for competence, no age or gender-based group differences are expected. The need for relatedness is probably more pronounced among female employees, consistent with what experienced managers often assert higher social competence among female employees (Chau & Quire, 2020).

Table 4. Results of Two-Factor Variance Analyses, Group Comparisons (Age, Gender)

	GROUP X SEX
(4) Learning Goal Orientation Scale	GROUP ($N = 318$, $M^{employees18\text{-}45} = 32.09$; $M^{employees46\text{-}65} = 31.40$); $F(3, 314) = 4.18$, $p < 0.05$ SEX p = n.s.
(5) Performance Goal Orientation Scale	GROUP ($N = 320$; $M = 28.90$), p = n.s. SEX p = n.s.
(6) Need for Autonomy Scale	GROUP ($N = 317$, $M = 14.40$), p = n.s. SEX p = n.s.
(7) Need for Competence Scale	GROUP ($N = 317$, $M = 16.05$), p = n.s. SEX p = n.s.
(8) Need for Relatedness Scale	GROUP ($N = 318$, $M = 17.46$), p = n.s. SEX ($M^{male} = 17.15$, $M^{female} = 17.74$); p = n.s.

Note: Performance Goal Orientations & Basic Needs (4-8).

5.5.2 Results on group differences

The results of the two-factor variance analysis GROUP X SEX for the *Learning Goal Orientation Scale* confirm the hypothesis that the midlife employees' values are statistically significantly lower. But Hypothesis 1 is only confirmed for the GROUP factor, because male and female employees do not differ in their learning goal orientation. As predicted, the values on the *Performance Goal Orientation Scale* show no statistically significant differences for the GROUP factor and no statistically significant differences for the SEX factor, i.e., the employees' performance goal orientation does not differ between the two age groups or in terms of gender!

As expected, there are no statistically significant differences in the age and gender factors for both scales, the *Need for Autonomy Scale* and the *Need for Competence Scale*. The same applies to the *Need for Relatedness Scale:* Here, too, there are no statistically significant differences in the age and gender factors, i.e., the hypothesis that the need for connectedness is more pronounced among female employees has not been confirmed. For the statistics of all results, see Table 3 and Table 4.

6. Media/Technology Use and Psychological Scales: Their Impact on the Acceptance of Digital Technologies (Regression Analyses)

Whether and to what extent psychological factors such as performance goal orientations and basic needs are related to the acceptance of digital technologies can be determined statistically using multiple regression analyses. At the same time, conducting these analyses represents a useful final step in validating the entire set of tools for future use in the implementation of new digital technologies in the workplace and for accompanying on-the-job training. Based on the results of this study so far, the following two hypotheses were tested:

6.1 Hypotheses on the prediction of digital technology acceptance

Hypothesis 3. *With the help of the above mentioned seven variables and the variables age and educational level, digital technology acceptance can be predicted by regression analyses with good to high goodness-*

of-fit models, which means that these variables/dimensions are an important prerequisite for digital technology acceptance in a non-IT workforce and influence the acquisition of digital skills.

Hypothesis 4. *Different patterns of variables are expected to predict the acceptance of digital technologies for male and female participants.*

Given the documented gender disparities in technology adoption (e.g., Geitz & Schnabel, 2023), we further examined this hypothesis by hierarchical multiple regression analyses (stepwise): With the *Digital Technology Acceptance Scale* as the criterion in the regression analyses, the following scales were used as predictors: The *Computer Affinity Scale*, the *Digital Media Self-Efficacy Scale*, the two *Learning Goal and Performance Goal Orientation Scales*, the three *Basic Psychological Needs Scales*, and the variables *Age* and *Educational Level*.

6.2 Regression Results for the Total Group of Employees (N=323)

The R^2 for the overall model (employees: $\boldsymbol{R = 0.56, R^2 = 0.31}$) is indicative of a high goodness-of-fit according to Cohen (1988). It is noteworthy that the employees' *digital media self-efficacy* is central to the high variance explanation of the model ($\beta = 0.26$), as well as two predictors also shaped by past learning experiences, namely *computer affinity* ($\beta = 0.29$) and *educational level* ($\beta = 0.10$). In terms of learning motivation and needs, the variables *performance goal orientation* ($\beta = 0.12$) and *need for autonomy* ($\beta = 0.11$) dominate in the final analysis for the total group of employees (age 18-65). The beta for the *age* variable loads negatively ($\beta = -0.11$), based on an inverse relationship between age and digital technology acceptance – a result that comes as no surprise and is also reflected, for example, in a study by Fasbender et al. (2023). The six predictors yield a high explained variance of 30%. The above hypothesis for the total group is confirmed as far as the variables digital media self-efficacy, computer affinity, performance goal orientation, need for autonomy, educational level, and age are concerned.

Table 5. Summary of Multiple Linear Regression Analysis for Digital Technology Acceptance (Criterion): Employees (Age 18-65)

Predictors	r	B	SE B	β	t	p
Digital media self-efficacy	0.44	0.70	0.15	**0.26**	4.71	0.000
Computer affinity	0.41	1.69	0.29	**0.29**	5.84	0.000
Performance goal orientation	0.12	0.20	0.10	**0.10**	2.13	0.034
Need for autonomy	0.14	0.50	0.194	**0.12**	2.59	0.010
Educational level	0.15	1.54	0.70	**0.10**	2.20	0.027
Age	-0.26	-0.09	0.04	**-0.11**	-2.08	0.038

Model Summary: $\boldsymbol{R = 0.56}$; $\boldsymbol{R^2 = 0.31}$; ***adj.*** $\boldsymbol{R^2 = 0.30}$; $F(6, 314) = 23.77$, $p < .001$; No. of observations: 321

6.3 Regression Results for the Subgroups of Male and Female Employees

As expected, the patterns of variables predicting digital technology acceptance differ between male and female employees. The R^2 for these two overall models (Table 6, male employees; $\boldsymbol{R^2 = 0.33}$; Table 7, female employees; $\boldsymbol{R^2 = 0.25}$) is indicative of a high goodness-of-fit according to Cohen (1988). In addition to the digital media variables self-efficacy ($\beta = 0.41$) and computer affinity ($\beta = 0.24$), the *performance goal orientation* ($\beta = 0.14$) is a major predictor for male employees' digital technology acceptance. Among the female employees, in addition to the variables digital media self-efficacy ($\beta = 0.22$) and computer affinity ($\beta = 0.32$), the variable *learning goal orientation* ($\beta = 0.15$) predicts their digital technology acceptance, *thereby giving evidence of a fundamental difference in the patterns of the achievement-related goal motivation in men and women as far as the adoption of digital technologies are concerned*. In the final regression equations, in addition to the variable *Age*, the variable *Educational Level* no longer plays a role in predicting digital technology acceptance in either subgroup (Table 6; Table 7).

Table 6. Summary of Multiple Linear Regression Analysis for Digital Technology Acceptance (Criterion): Male Employees (Age 18-65)

Predictors	r	B	SE B	β	t	p
Digital media self-efficacy	0.52	1.20	0.38	**0.41**	5.54	0.000
Computer affinity	0.40	1.25	0.22	**0.24**	3.28	0.001
Performance goal orientation	0.20	0.29	0.13	**0.14**	2.14	0.034
Model Summary: ***R = 0.58; R^2 = 0.33; adj. R^2= 0.32****; F(3, 150) = 24.77, p <.001, No. of observations: 154*						

Table 7. Summary of Multiple Linear Regression Analysis for Digital Technology Acceptance (Criterion): Female Employees (Age 18-65)

Predictors	r	B	SE B	β	t	p
Digital media self-efficacy	0.35	0.56	0.19	**0.22**	2.99	0.003
Computer affinity	0.39	2.33	0.50	**0.32**	4.71	0.000
Learning goal orientation	0.28	0.32	0.16	**0.15**	2.07	0.042
Model Summary: ***R = 0.50; R^2 = 0.25; adj. R^2= 0.23****; F(3, 164) = 17.96, p <.001, No. of observations: 168*						

The differences between women and men in performance goal orientation point to different goals relevant for their digital technology acceptance, and also to different perceptions of their own experience and competence in relation to digital technologies among both genders, —a complex interaction that Förtsch and Gärtig Daugs (2020) have already deciphered in a study of computer science graduates. Anyway, adhering to different performance goal orientations can be very useful in the workplace and can help avoid mistakes, especially in times of digital transformation, if gender-mixed teams work together. For human resource development, tailoring training to autonomy needs (β = 0.12) and gender-specific goal orientations (learning vs. performance) may enhance acceptance.

7. Discussion and Conclusions

With the set of tools of psychological and information science/usability scales presented here, it is possible to systematically identify shortcomings of newly introduced digital technologies (software, hardware) before or during implementation by the prospective users/employees. At the same time, these tools can also be used to evaluate progress in on-the-job training. In order to expand digital skills in employees of all ages, it is important to further decode the psychological dynamics of variables motivating and facilitating continuous learning during phases of digital transformation in the workplace.

With reference to the sample of employees examined here, it is concerning to find out that—when considering the group of midlife employees in this sample—digital technology acceptance and digital self-efficacy values are statistically significantly lower compared to the group of emergent & established employees. Midlife employees in the non-IT workforce are generally qualified, competent specialists who companies are dependent on and cannot do without. For them, the offer of regular on-the-job training is the order of the day. Poorly implemented digitalization measures can lead to qualified specialists leaving earlier, reducing performance, or leaving the company for alternative career opportunities. As the findings of this study show, the key to keeping them in work for longer is the systematic expansion of training opportunities, integrated in everyday work as flexibly as possible (Alcover, 2021; Hubschmid-Vierheilig et al., 2020; Johnson & Beehr, 2014; Molino et al., 2020; Xie et al., 2023).

As the regression analyses show (Tables 6 & 7), male and female employees are guided by different performance motives that influence their technology acceptance and thus the acquisition of new digital skills. For female employees, the acceptance of digital technologies goes hand in hand with a learning goal orientation, which is important for sustainable learning of new content as digitalization progresses. For male employees, a performance goal orientation, which is more geared towards quick learning success and trial-and-error strategies, is a decisive feature of their technology acceptance. However, in terms of the strength of their learning goal and performance goal orientations in life in general, the genders do not differ (Table 3). Therefore, these results must not lead to less support for one or the other group. Men and women, especially in midlife, form an important human resource reserve and complement each other. Different patterns of performance motives important for the acceptance of new digital technologies can be taken into account when implementing new digital applications and, in particular, when providing training on their use.

7.1 The Need for Autonomy and the Dangers of Ad Hoc Digitalization

For the overall group of the non-IT workforce surveyed here, according to the results in the regression analysis (Table 4) the *need for autonomy* plays a decisive role in relation to digital technology acceptance. In many fields of work, digital transformation is currently taking place as an ad hoc process, termed "cold digitalization" in Germany. "Digital change is often radical, and it involves shifting shared values, norms, attitudes, and behaviors", is how Neeley & Leonardi (2022, p. 52) describe this process that is currently being followed not only in the tech industry, but in a multitude of companies worldwide. It is characterized by an ad hoc digitalization strategy "to start things off with a bold stroke", followed by a "long march" that can be accelerated by measures such as "hiring a digital transformation czar who reports to the CEO, and announcing that a legacy system is being phased out" (Neeley & Leonardi, 2022, p. 52). The idea is to drive employees forward to a point where the value of such a "clear roadmap" (ideally) leads to the development of a "digital mindset" enabling them to realize how the newly introduced digital technologies open up new possibilities (Neeley & Leonardi, 2022; Molla et al., 2024). In practice, we assume that such an ideal result may fail to materialize if no further measures are taken.

In view of the important link between *the need for autonomy and technology acceptance* among the non-IT workforce found in this sample, such strategies raise questions that urgently require further research: What are the dangers of such radical implementation strategies? How costly could they be? With regard to the basic needs, i.e., also the need for competence and the need for relatedness, the age groups in this study do not differ. The violation of employees' need for autonomy through cold digitalization measures can trigger psychological reactance in them, i.e., an aversive motivational state when confronted with the unforeseen restriction of personal freedom. Research has shown that those affected can react with increasing arousal and attempts to restore the threatened freedom. Aroused for a longer period, these employees are probably difficult to win back. The consequences can be non-compliance, loss of performance, increased error rates, etc. (Rosenberg et al., 2023; Miller et al., 2020).

7.2 Human Cognition and Emotion Research vs. Big Companies' Attempt to Create "Cognitive Mindsets" by Ad hoc Digitalization Strategies

Even though the results of the study are based on a non-representative sample, they are sufficiently meaningful to be applied to improve the design of new software, hardware, and employee training programs during phases of ongoing digitalization. In the future, theory building in human resource development research has to expand on and take greater account of findings from psychological cognition and emotion research. *Digital technologies, especially the rapidly increasing use of artificial intelligence (AI), can lead to changes/adjustments in human cognitive structures, but certainly not to a "cognitive mindset" as the result of a simple reprogramming measure, as tech industry developers, manufacturers, and even authors of scientific articles on digital technology such as Neeley and Leonardi (2022) ideally imagine.*

8. Limitations

The study is based on a German sample. The results provide new insights but are not representative. That the employees participated in the study anonymously and remotely from their workplace contributed to obtaining valid data. While remote participation reduced workplace bias, self-selection may limit generalizability.

Endnote. i. Two pilot studies, including university students (twice) and same-age employees, were carried out to test the quality of the scales. For the final scales, the surveyed employees form the final benchmark, i.e., as far as scale development is concerned, priority is given to the statistical characteristics that are important for studies in the world of work.

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Conflicts of interest

The authors have no relevant financial or non-financial interests to disclose.

Informed consent statement

Informed consent was obtained from all test subjects involved in the study.

Institutional Review Board statement

This study was conducted in accordance with the Declaration of Helsinki and approved by the University of Siegen Ethics Committee (Rat für Ethik in der Forschung, ER_10_2019).

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