Are We Pulling on the Same Rope? Connotations of Digit(al)ization in a General as Well as in an Educational Context

Stefanie Zarnow
LMU Munich

Numerous activities and measures can be observed in the context of digit(al)ization in general and educational contexts. However, they are often not interrelated or sufficiently anchored institutionally and structurally with regard to overarching goals. Therefore, this study aims to carry out a theory-based clustering of connotations with the concept of digit(al)ization in general and also in an educational context to explore subjective perceptions and to find a starting point for a joint dialog, as well as for concrete implementations. A questionnaire was developed to collect the data, which was content-analyzed using Bronfenbrenner's ecological systems theory (1979, 1989) in a first step. A latent class analysis was then implemented to classify the data and validate the findings. The results show differences between the general and the educational context on a qualitative and quantitative level. For each context, three different archetypes concerning the connotations with digit(al)ization and sociodemographic factors can be identified.

Keywords: digitization, digitalization, connotations, Latent Class Analysis, Ecological Systems Theory

INTRODUCTION

Digit(al)ization is increasingly permeating far-reaching areas of life in both the social and private spheres, and also in the economic sphere (Haefner & Sternberg, 2020). It offers many opportunities for society and individuals but also brings immense challenges. In particular, education is strongly affected by the influence of digit(al)ization (Benning et al., 2020; Schmidt & Tang, 2020; Timotheou et al., 2022). Due to the serious effects of COVID-19, the deficits and the importance of digit(al)ization have become apparent, especially in the specific context of education (Amankwah-Amoah et al., 2021; Connolly & Abdalla, 2022; Faraj et al., 2021; Zancajo et al., 2022). Although the concretization of measures to implement digit(al)ization has been discussed intensively, implementation in practice is often only successful to a limited extent, and progress is slow. Measures are often not interrelated or sufficiently anchored institutionally and structurally concerning the overarching goals (Hauge, 2014; Pettersson, 2021). There are many reasons for the slow progress in incorporating digit(al)ization. An important reason, which refers to the core of the problem, are the individually strongly diverging ideas and delimitations of the concept of digit(al)ization in general, as well as in the field of education (Demlehner & Laumer, 2019; Mynbayeva et al., 2017). There are differences of opinion regarding the term—conscious or unconscious—even before the actual implementation of measures. No common starting point exists for a joint dialog or for the promotion of concrete implementations—we are not all pulling on the same rope.

Previous research has examined the conceptualization of digit(al)ization with a focus on digital public health (Iyamu et al., 2021), business model development (Ziyadin et al., 2020), public administrators (Mergel et al., 2019), or digital human resource management (Strohmeier, 2020), among others. Efforts have also been made to provide an overview of existing definitions and theories to clarify and systematize the terms (Reis et al., 2020). A theoretically sound analysis of the conceptual understanding and the interpretation of the term digit(al)ization in a general context, in contrast to the specific field of education, is not yet available. In addition, an overall societal analysis considering the influences of social demographics has yet to be conducted.

This study aims to carry out a theory-based clustering of connotations with digit(al)ization to examine it across the breadth of society, for a general and for educational context. For this study, the two English terms "digitization" and "digitalization" are merged to create the term "digit(al)ization" because they are only covered by a single term in German (*Digitalisierung*). An in-depth understanding of the concept of digit(al)ization should be gained to raise awareness regarding the use of the term and to perceive more distinct perspectives. Therefore, we operationalize the conceptual understandings and the interpretations of digit(al)ization with connotations made with this term. This should facilitate more targeted discussions, which may lead to the initiation of purposeful measures to further implement digit(al)ization. In this study, N=246 people were surveyed with an online questionnaire. The data were content-analyzed and classified qualitatively using Bronfenbrenner's (1979, 1989) ecological systems theory. In addition to classifying the connotations, the frequency of the connotations made at each model level was analyzed. I use these frequencies to compare connotations made concerning a general context with those regarding education. A Latent Class Analysis (LCA) will then be conducted to identify patterns in the connotations and the impact of sociodemographic characteristics.

To address these matters, I derive the following research questions (RQ):

RQ 1: *Which connotations with the term digit(al)ization are made at chronolevel, macrolevel, exolevel, mesolevel, and microlevel in a general and educational context?*

RQ 2: *To what extent do chronolevel, macrolevel, exolevel, mesolevel, and microlevel differ with respect to the frequency of connotations made in the general and educational context?*

RQ 3: *Which patterns can be observed when analyzing the connotations with digit(al)ization made in a general and educational context?*

THEORY

Digit(al)ization

It is difficult to find a uniform definition of the term digit(al)ization, as it is often used imprecisely and in an inflationary manner. Not only is there a lack of definitions per se but terms such as digital transformation, digitization, digitalization, or digital change, which are often used synonymously and interchangeably, also complicate the matter (Frenzel et al., 2021; Gong & Ribiere, 2021; Legner et al., 2017; Mergel et al., 2019; Parida et al., 2019). The definitions of the terms show a broad spectrum of content, which (depending on the field and application) can be unclear or even contradictory concerning the target idea (Gong & Ribiere, 2021; Mertens & Wiener, 2018). To date, there have hardly been any standardizations or attempts to commit to a uniform term.

This is even more of a problem as the importance of digit(al)ization increases and the acquisition of digital skills is inevitable in a digital world (van Laar et al., 2020). The relevance of digital skill acquisition from primary school to university education and subsequent lifelong learning is constantly increasing, especially to enable people to constantly adapt to the changes induced by digit(al)ization (OECD, 2021). When defining the term digit(al)ization in the specific field of education, the situation is similar compared to the term digit(al)ization in general. Clear, robust, and uniformly deployed definitions are difficult to find because they often based on an implicit understanding only or are adapted to the respective contexts and

needs (Mouthaan et al., 2023; Siljebo, 2020; Tsybulsky & Muchnik-Rozanov, 2021). There is also a partly synonymous and partly divergent use of terms such as digital education, media education, digital competence or media competence, as well as terms such as e-learning, e-teaching, digital media, computer-based training or web-based training (Barboutidis & Stiakakis, 2023; Ellaway, 2011; Gutiérrez & Tyner, 2012; Ilomäki et al., 2016; Lau, 2014).

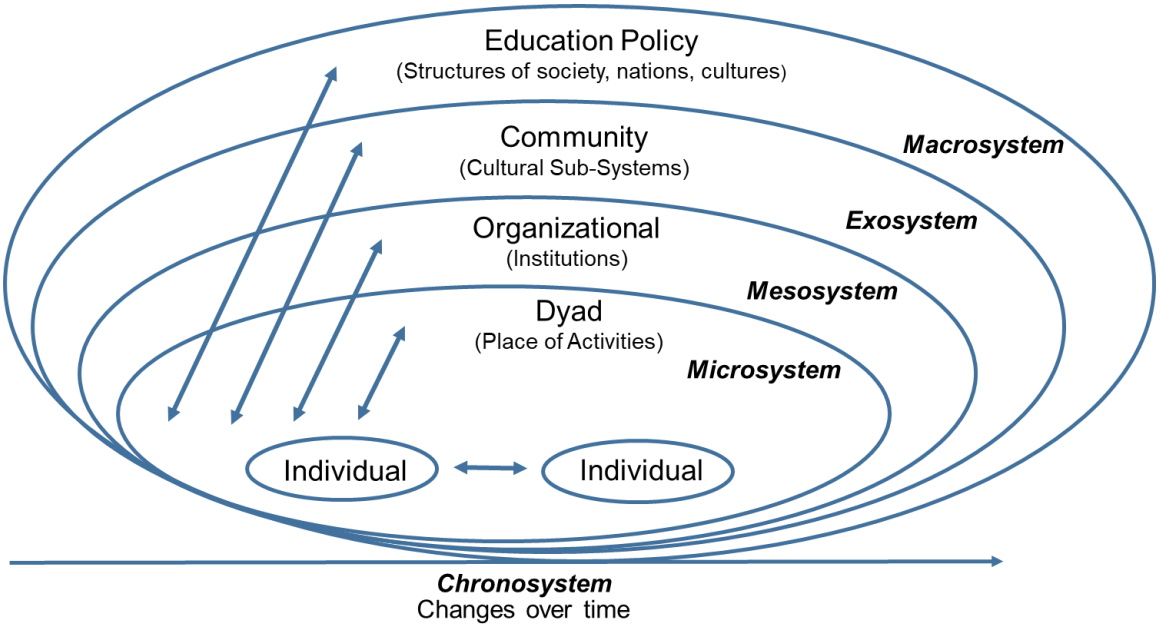
A (non)uniform understanding of terms entails far-reaching consequences. Term formation, definitions, and the effects and consequences of ambiguity are described by Pawlowski (1980a, 1980b): a definition, in the broader sense of the word, is used whenever the meaning of an expression is to be explained. Definitions and perceptions of a terminology can differ, among others, regarding language or cultural differences and need verification and potentially renewal between whiles (van Mil & Henman, 2016). The multiplicity and diversity of definitions make precise, targeted communication difficult, and errors and fallacies can be the result (Pawlowski, 1980). A fundamentally inconsistent understanding of terms, goals, and instruments concerning the implementation of measures to promote the incorporation of digit(al)ization brings problems with it per se. Every person has their own understanding of the term, which is closely related to their behavior when it comes to implementation (Thomas & Thomas, 1928). More ambiguity regarding digit(al)ization is expected to emerge when differentiating along sociodemographic factors, such as age, gender, job position, (professional) qualification, etc. Taking concrete measures within the framework of a coordinated overall concept, with a commitment to a concrete goal, is universally demanded but often becomes problematic (Leibniz Education Research Network Alliance, 2020). Consistent understanding would provide the basis for comparable, coordinated measures with a uniform pursuit of goals. However, different definitions can lead to various misunderstandings and inhibit comparability, as well as the pursuit of a commonly recognized goal (Pawlowski, 1980a). A lack of definitions thus leaves room for interpretations, which hinders for measures and projects and stands in the way of taking concrete action.

The measures taken to implement digit(al)ization in the field of education involve the setting of priorities by the actors involved. A conceptual understanding of digit(al)ization in the education sector (at least the one that is inherently present) is necessary. Therefore, it can be assumed that the explicit processing and localization of conceptual understandings of digit(al)ization is conducive to concerted action.

Ecological Systems Theory

Bronfenbrenner's (1979, 1989) ecological systems theory is the theoretical model used for the analysis. This concerns the progressive mutual adaptation between the active and developing human being, and the changing characteristics of its immediate spheres of life (Bronfenbrenner, 1979). Humans shape the environment, and vice versa. This so-called reciprocity is based on the phenomenological approach (Bronfenbrenner, 1979, 1992; Lewin, 1935). As Thomas and Thomas (1928) stated, a subject's view of a situation is possibly the most important element in interpreting their behavior. The immediate behavior is closely related to the definition of the situation, which can be presented either in terms of objective reality or a subjective assessment. From an ecological perspective, the environment is viewed topologically as a nested arrangement of concentric, interlocking structures, as can be seen in Figure 1, with the structures referred to as microsystem, mesosystem, exosystem, macrosystem, and chronosystem (Bronfenbrenner, 1979, 1989).

FIGURE 1
BRONFENBRENNER´S ECOLOGICAL SYSTEMS THEORY



Note. Ecological systems theory. Adapted from "The ecology of human development: Experiments by nature and design" by U. Bronfenbrenner, 1979 and "Foreword: Using Bronfenbrenner's ecological systems theory to frame quantitative, qualitative, and mixed research" by A. Onwuegbuzie, 2013.

The individual is directly involved in the micro- and mesosystem and can exert a direct influence or be directly influenced. The microsystem represents the direct environment of a person in which they participate and is described as the patterns of the activities, roles, and interpersonal relationships experienced by the developing person in a given area of life (Bronfenbrenner, 1979). The mesosystem comprises several microsystems and the interrelationships between the areas of life in which the developing person is actively involved (Bronfenbrenner, 1979, 1992). In the exosystem and the macrosystem, events and processes take place that influence the person in their areas of life but in which they have no active participation. Therefore, the individual is only indirectly influenced or can only indirectly influence structures in the scope of these systems in an indirect way (Bronfenbrenner, 1979; Onwuegbuzie et al., 2013). By the exosystem, Bronfenbrenner (1979) understands one or more spheres of life, in which the developing person is not involved but in which events take place that influence what happens in his/her sphere of life, and vice versa. The macrosystem refers to the formal and substantive similarity of the lower-order systems (microsystem, mesosystem, and exosystem) that exist or might exist in the subculture or culture, including their underlying worldviews and ideologies (Bronfenbrenner, 1979). The chronosystem represents the model's time dimension, valid across the four other systems and specifically focuses on the development processes over time (Bronfenbrenner, 1989, 1992).

METHOD AND DATA

I address RQ1 by conducting a qualitative content analysis (Mayring, 2022) to analyze connotations regarding the general and the education-specific understanding of the term digit(al)ization. The goal of the content analysis is to examine the material in a systematic, rule-based, and theory-driven manner (Mayring, 2022). The qualitative coding is conducted with the program *MAXQDA 2022*. To compare the connotations made in the general context with those made in the educational context (RQ2), I conduct a Wilcoxon signed-rank test. RQ3 is addressed by an LCA following, among others, Vermunt & Magidson (2002, 2005, 2016)

and Vermunt (2010) to identify different subgroups within the sample. The analysis is conducted with the software Latent GOLD 6.0 (Statistical Innovations, 2023).

Questionnaire

A questionnaire has been developed for data collection (see Appendix 1). It is predominantly based on existing scales, which were partly adopted to the current research interests (for origins of the questions and modifications, see Appendix 2). The questionnaire was piloted several times, whereby the order of the questions, individual formulations, structure, and visual presentation were optimized. In total, the questionnaire contains four main sections. The first section starts with questions about connotations made with digit(al)ization in general and in an educational context. These two questions, which can be seen as the central questions for this study, follow:

- *Question 1*: Please think of the term digit(al)ization. What five connotations come to mind when you think about digit(al)ization?
- *Question 2*: Please think of digit(al)ization in education. What five connotations come into your mind when you think of digit(al)ization in education?

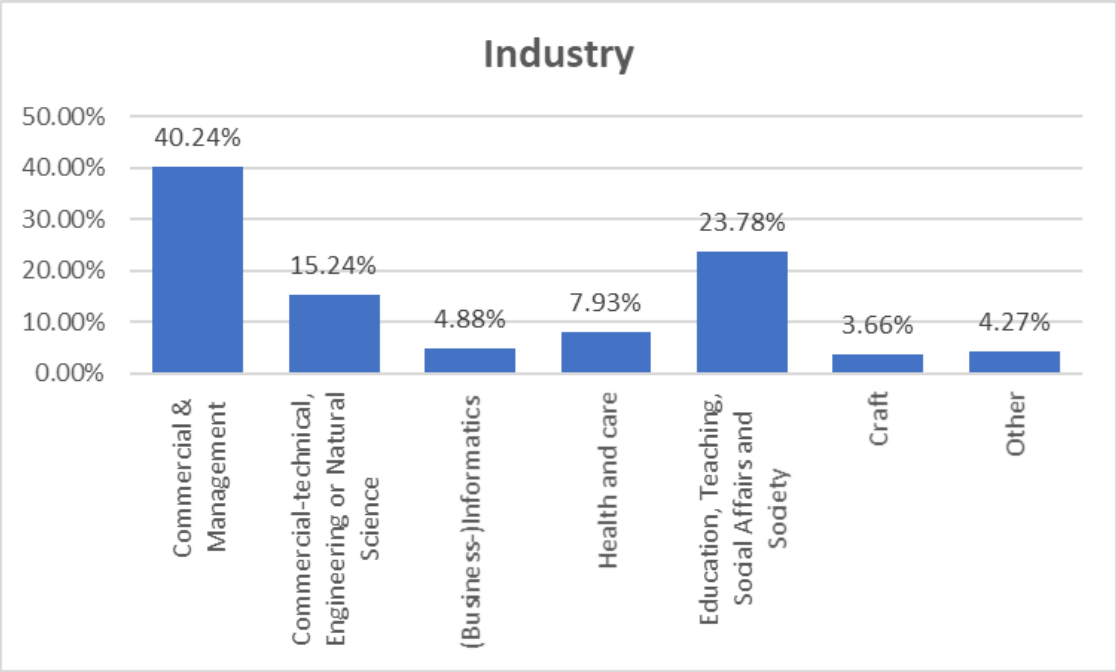
The aim is to capture the participants' thoughts as directly as possible and in line with their spontaneous initial notion. Five free fields (without a maximal number of characters) were provided for participants to enter their connotations with the term digit(al)ization. In summary, each participant stated 10 connotations, five each for the general context as well as for the educational context. The second and third sections contain questions on digit(al)ization in participants' professional lives (Section 2) as well as in their private lives (Section 3). Meanwhile, some sociodemographic data were compiled in section four, which are age, gender, the highest professional qualification (no professional education, vocational training, higher education, other), industry (commercial & management, commercial-technical, engineering or natural science, (business)informatics, health and care, education, teaching, social affairs and society, craft, other), job (pupil, student, apprentice, employee, official, self-employed, freelance, houseman/-wife, retiree), and the importance of digital media at work and in the private area / at home. The survey was technically implemented in the experience management software *Qualtics* (2023) as an online survey for web applications and mobile use. The survey period was from December 2020 to January 2021. In total, 246 participants took part with a median response time of just under nine minutes.

Sample and Data

For data collection, the participants were acquired primarily through personal contact and dissemination via social media. In total, 246 persons took part in the survey, which is the population for RQ1. Because not fully completed surveys did not allow an assignment to sociodemographic characteristics collected at the end of the questionnaire, I utilized a strict procedure of listwise deletion for RQs 2 and 3 by removing all participants from the sample who did not complete the survey (Allison, 2009, pp. 5–6), resolving in a total amount of N=164.

The final sample contains 34.76% of participants who were aged up to 25 years old, 14.02% aged between 26 and 35, 10.98% aged between 36 and 45, 24.39% aged between 46 and 55, 9.15% aged between 56 and 65, and 6.71% aged between 66 and 99. The largest share of the participants is female (63.41%), while 35.37% are male. One person each is diverse or gives no information regarding gender. Concerning the highest qualification of the respondents, 16.46% stated to have no professional qualification, 28.05% have completed vocational training and 53.05% possess a degree in higher education. The remaining 2.44% class themselves in the category other (i.e., having a military education). Regarding the industry in which a person's main activity is performed, the distribution is shown in Figure 2.

FIGURE 2
DESCRIPTIVE STATISTICS REGARDING THE INDUSTRIES OF THE RESPONDENTS



Note. N=164. Own figure.

At 38.41%, the largest share of respondents is employed. The proportion of students in the sample is 25.61%. The other occupations were distributed among civil servants with 11.59%; pensioners with 8.54%; freelancers, trainees, and self-employed persons at 3.66% each; and househusbands/housewives and pupils at 2.44% each. Retirees, students, or househusbands/housewives are deliberately included in the study because their thinking is expected to correspond to the field of specialization, such as in a previous or current (part time) job or in a former education. For example, it can be assumed that the mindset of a retired teacher still corresponds to the field of education, teaching, social affairs, and society. The selection in the category other was possible (n=4).

Additional data were collected to assess the importance of digital media on respondents, both in their professional and private lives. The results are given in Table 1.

TABLE 1
IMPORTANCE OF DIGITAL MEDIA IN PROFESSIONAL AND PRIVATE LIFE

Degree of Importance	Professional Life		Private Life	
	n	%	n	%
Extremely Important	53	32.32	30	18.29
Very Important	61	37.20	68	41.46
Important	26	15.85	44	26.83
Partially Important	17	10.37	19	11.59
Unimportant	7	4.27	3	1.83
Sum	164	100.01[1]	164	100.00

Note. N=164. Own table.
The importance of digital media in professional life is rated as very or extremely important by n=114 respondents, and in private life by n=98 participants. However, n=24 assessed the importance of digital media in the professional life as only partially important or unimportant, whereas only n=22 respondents make that point for their private life.

Analyzing the Data

For the qualitative content analysis (RQ 1), the first step was the deductive coding of the connotations, with the main categories formed according to Bronfenbrenner's (1979, 1989) ecological systems theory (Mayring, 2022, pp. 89–90). These are the chronosystem, the macrosystem, the exosystem, the mesosystem, and the microsystem. The formation of appropriate subcategories further differentiates the connotations coded in the main categories. The subcategories are formed inductively for the chronosystem, exosystem, and mesosystems and deductively for the macrosystem and the microsystem (following Helmrich et al., 2020 and Herzig, 2014; see Appendix 3). Table 2 gives a short overview of the coding system, defining the categories and some exemplary anchor examples (Mayring, 2022, pp. 89–90). Detailed coding schemes with the subcategories at the first level can be found in Appendices 4 (chronolevel), 5 (macrolevel), 6 (exolevel), 7 (mesolevel), and 8 (microlevel).

TABLE 2
CODING SCHEME FOR MAIN CATEGORIES WITH ANCHOR EXAMPLES AND CODING RULES

Category	Definition	Anchor examples
Chrono-system	Time dimension, focuses on the development processes over time (Bronfenbrenner, 1989, 1992). In the context of digit(al)ization, the coding follows the connotations with reference to the past, present, and the future.	▪ progress ▪ pace of development ▪ antediluvian
Macro-system	Formal and substantive similarity of the lower-order systems that exist or might exist in the subculture or culture, including their underlying worldviews and ideologies (Bronfenbrenner, 1979). In the context of digit(al)ization we focus on developments and phenomena throughout society.	▪ technological development ▪ megatrend ▪ anonymity and autonomy
Exosystem	One or more spheres of life, in which the developing person is not themselves involved but in which events take place that influence what happens in their sphere of life or are influenced by it (Bronfenbrenner, 1979). In the context of digit(al)ization we focus on structural guidelines and developments in the cultural sub-systems.	▪ costs ▪ media literacy ▪ little consideration in the curriculum
Meso-system	Composed of a system of several microsystems and comprises the interrelationships between the areas of life in which the developing person is actively involved (Bronfenbrenner, 1979, 1992). In the context of digit(al)ization, we focus institutions and organizations such as schools or workplaces.	▪ better digital equipment in schools ▪ process optimization ▪ less time for fellow humans
Micro-system	Direct environment of a person in which they participate and is described as patterns of activities, roles, and interpersonal relationships experienced by the developing person (Bronfenbrenner, 1979). In the context of digit(al)ization, we focus on the usage of digital media, learning processes in the classroom, and on learners and teachers in a direct manner.	▪ education on demand ▪ hardware and software ▪ immersive learning

Note. Own table.

The coding was performed independently by two educated coders. The interrater reliability of the coding is Cohens Kappa κ=0.909, which is considered as an excellent agreement (Cohen, 1960; Fleiss et al., 2003). For the general context, N=1019 connotations are coded; for the educational context, a total of

N=929 codings were assigned. According to the total possible number of connotations (five connotations per N=246 participants) of 1230 for the general and the educational context each, 211 general and 301 education-specific connotations were included as missings[2] for RQ1. The connotations were always coded in their entirety. The smallest coding unit is one word, and the largest is the entire conceptualization, which consists of 13 words in this study. Multiple coding was not performed. Each connotation was coded only once.

After the coding process, a frequency analysis was carried out to quantify the qualitative data for further analysis (Mayring, 2022). Thereby, the frequency of mentioning a category in the material is counted and compared based on the other categories. These frequencies are used for the following analyses to answer RQ2 and RQ3. For RQ2, I compare the frequencies for the general context with the frequencies of the educational context for each system separately. For example, the number of connotations in the general context coded to the chronosystem is compared to the number of connotations in the educational context coded to the chronosystem, and so forth. I use a Wilcoxon signed-rank test as the data is non-parametric, and normal distribution cannot be assumed according to the Kolmogorov-Smirnoff-Test (Massey, 1951).

To answer RQ3, I employ an LCA. This finite mixture modeling approach aims to identify qualitatively different subgroups within the participants regarding their understanding of digit(al)ization and in relation to sociodemographic factors (covariates) (Sinha et al., 2021; Weller et al., 2020). Conducting the LCA, I use a bias-adjusted three-step LCA to correct classification errors (Bakk et al., 2013; Vermunt, 2010). In the first step, the LC model is estimated with the indicator variables, the connotations made at each level of Bronfenbrenner's model (1979, 1989). A bootstrap approach with N=500 replications is applied to account for the rather small sample size (Vermunt & Magidson, 2005, 2016). Following that, the decision on the optimal number of classes is made. In the second step, the individuals are classified by re-estimating the model with the final number of classes. In the third step, the covariates are integrated into the analysis with the correction for classification errors.

RESULTS

When analyzing the frequencies of the qualitative content analysis (RQ 1), differences in the number of connotations made in the general context compared to the educational context became apparent. While in the general context, the macro level is addressed most often (n=545, 53.48%), in the educational context, the micro level is mentioned the most (n=450, 49.09%). Generally, the micro level, chronolevel, mesolevel, and exolevel (in descending order) follow the connotations at the macro level. For the educational context, the order following the microlevel is macrolevel, chronolevel, exolevel, and mesolevel. The detailed results for each level are depicted in Table 3; the frequency of the codings distributed among the subcategories in each level can be found in Appendix 3.

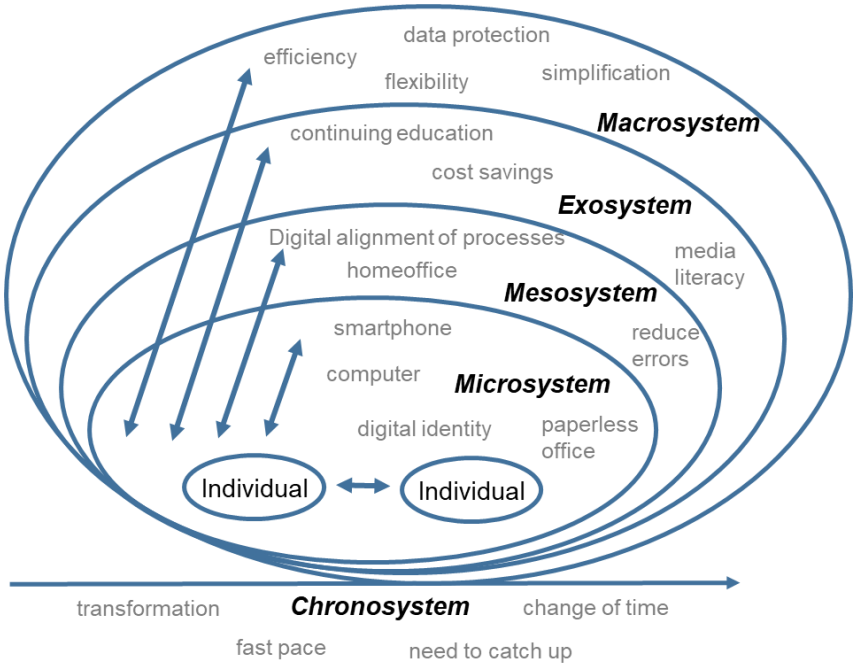
TABLE 3
RESULTS OF THE FREQUENCY ANALYSIS FOR RQ1

	General Context (N=1019)		Educational Context (N=929)	
	n	%	N	%
Chronolevel	108	10.60	122	13.13
Macrolevel	545	53.48	216	23.25
Exolevel	25	2.45	71	7.64
Mesolevel	100	9.81	70	7.53
Microlevel	241	23.65	450	49.09
Sum	1019	99.99[3]	929	99.99[4]

Note. Own table.

A selection of frequently named connotations is shown in Figure 3. Concerning the general context, at the micro level, 199 of 241 connotations (82.57%) are related to digital media, most of them to hardware components. At the mesolevel, connotations refer to the workplace (n=67, 67.00%) or digit(al)ization at schools (n=23, 23.00%). Changing competence requirements (n=8, 32.00%) or the costs (n=12, 48.00%) associated with digit(al)ization are comprised at the exolevel. The connotations at the macrolevel refer predominantly to economic aspects (n=349, 64.04%) under which technological developments are also captured. The respondents connote to the labor market and new forms of employment (n=88, 16.15%) and social changes such as individualization, flexibility, or social justice (n=72, 13.21%). The connotations made at the chronolevel refer predominantly to future progress and change (n=91, 84.26%).

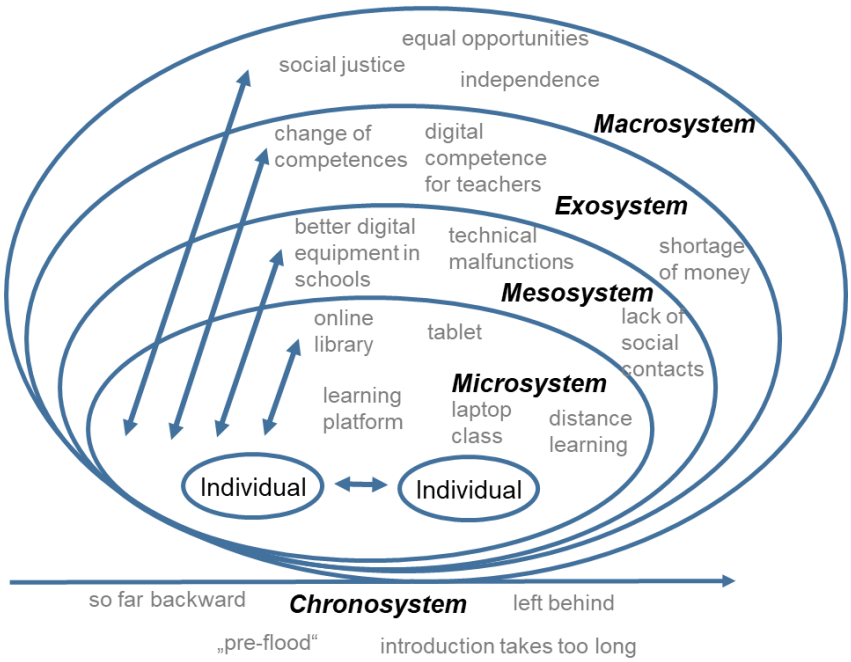
FIGURE 3
CONNOTATIONS IN THE GENERAL CONTEXT



Note. Selection of exemplary and frequently mentioned connotations of digit(al)ization in general. N=1019 codings.

The results for the educational context at the micro level reveal that digital media, such as hardware, information, communication tools, or learning tools, are being addressed predominantly (n=240, 53.33%). Furthermore, instructional processes in the classroom, such as the learning processes or the place of learning (e.g., distance learning, online teaching, or homeschooling), are mentioned (n=183, 40.67%). At the mesolevel, the school as an institution is mentioned the most often, more specifically, the improvement of technical equipment at schools and the error-free use of technology (n=37, 52.86%). With the exolevel, people connote the adaptation of education and curricula (n=23, 32.39%), further education and training of teachers (n=18, 25.35%), as well as a change of required competencies (n=16, 22.54%). At the macro level, economic aspects and technological developments (n=81, 37.50%), as well as the labor market with aspects of simplification but also of increasing complexity (n=77, 35.65%), are addressed. At the chronolevel, connotations are primarily made with a retro-perspective (n=72, 59.02%), focusing on what was missing concerning digit(al)ization in the past. Exemplarily connotations in the educational context are shown in Figure 4.

FIGURE 4
CONNOTATIONS IN THE EDUCATIONAL CONTEXT



Note. Selection of exemplary and frequently mentioned connotations of digit(al)ization in the educational context. N=929 codings.

A comparison of the number of connotations made at each level for the general and the educational context on a quantitative base (RQ2) reveals a highly significant difference in understanding of the term digit(al)ization at four of five levels. Only at chronolevel is the difference not significant ($z = -.960$[i], $p < .337$, $r = .07$). At the macrolevel ($z = -8.990$[ii], $p < .001$, $r = .70$), the exolevel ($z = -5.135$[5], $p < .001$, $r = .40$), the mesolevel $z = (-2.878$[6], $p < .001$, $r = .22$), and the microlevel ($z = -7.821$[5], $p < .001$, $r = .61$) the number of connotations made in the general context differs significantly from the number of connotations made in the educational context. The effect sizes can be interpreted as small for the chronolevel, medium for the exolevel and the mesolevel, and as large for the macro and microlevel, according to Cohen (1988).

To detect patterns in the data and integrate sociodemographic factors, an LCA is conducted to answer RQ3. The results of step one of the three-step LCA for the indicator variables following the levels of Bronfenbrenner (1979, 1989) are depicted in Table 4 for the general context and in Table 5 for the educational context.

The model fit indices with one to five classes allow us to discuss the model with the optimal number of classes. I specifically focus on the information criteria as the most common criteria for model selection (Vermunt & Magidson, 2004; Weller et al., 2020): the Bayesian information criterion (BIC), and the Akaike information criterion (AIC). These criteria give important statistical information to decide the optimal number of classes; however, the interpretation should be always in line with interpretability (Nylund-Gibson & Choi, 2018; Vermunt & Magidson, 2004; Weller et al., 2020). The model is chosen not by an absolute value for the model fit, but the model with the lowest value of the information criteria is preferred (Nylund-Gibson & Choi, 2018). The BIC suggests the 1-class model for the general context and the 2-class model for the educational context, the AIC suggests the 3-class model for both contexts. To match the complexity of the model and account for the theory with different levels, I chose the 3-class model for both the general and the educational context.

TABLE 4
LATENT CLASS ANALYSIS FIT INDICES WITH 1-5 LATENT CLASSES FOR THE GENERAL CONTEXT

Number of classes	LL	BIC(LL)	AIC(LL)	Npar	L^2	df	p-value	Max. BVR	VLMR	p-value	Class. Err.	Entropy R^2
1	-845.589	1788.0755	1729.178	19	548.8058	145	2.80E-48	6.1434			0	1
2	-804.1708	1807.2364	1686.3416	39	465.9694	125	8.70E-41	3.6085	82.8364	0	.0002	.9961
3	-777.4967	1855.8856	1672.9935	59	412.6212	105	4.70E-38	2.6298	53.3482	0	.0187	.9276
4	-759.555	1921.9994	1677.1099	79	376.7377	85	2.40E-38	2.0313	35.8835	0	.0049	.9755
5	-744.8111	1994.5089	1687.6221	99	347.2499	65	3.70E-40	1.9265	29.4878	.0025	.0084	.9711

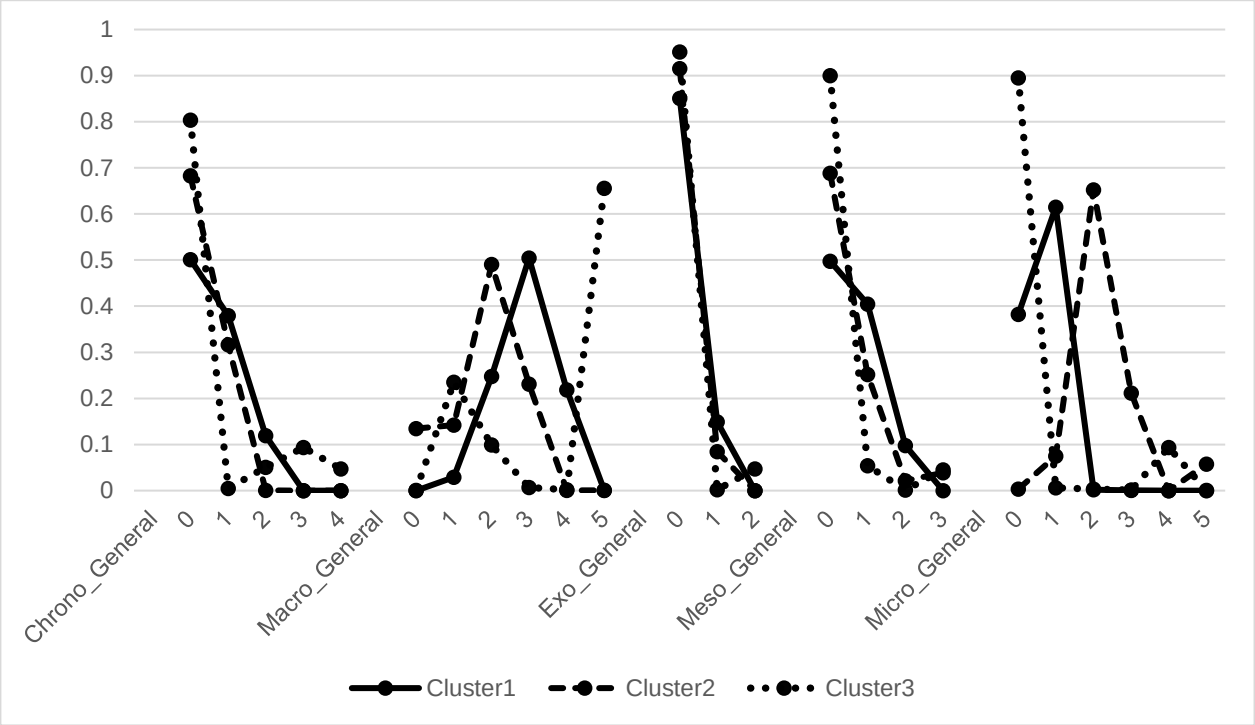
Note. LL = log likelihood; BIC = Bayesian information criterion, AIC = Akaike information criterion, Npar = number of parameters, L^2 = likelihood ratio chi-squared statistic, df = degrees of freedom, Max. BVR = maximal bivariate residuals, VLMR = Vuong-Lo-Mendell-Rubin, Class. Err. = proportion of classification errors. Own table.

TABLE 5
LATENT CLASS ANALYSIS FIT INDICES WITH 1-5 LATENT CLASSES FOR THE EDUCATIONAL CONTEXT

Number of classes	LL	BIC(LL)	AIC(LL)	Npar	L^2	df	p-value	Max. BVR	VLMR	p-value	Class. Err.	Entropy R^2
1	-945.0007	1991.9988	1930.0015	20	692.087	144	1.50E-72	5.1997			0	1
2	-874.54	1958.1744	1831.0799	41	551.1655	123	1.80E-55	1.948	140.9216	0	.0027	.9809
3	-851.2334	2018.6585	1826.4668	62	504.5523	102	1.40E-54	2.1141	46.6131	0	.0029	.9828
4	-834.9106	2093.1102	1835.8212	83	471.9068	81	1.70E-56	2.2783	32.6455	.0028	.0475	.9083
5	-815.4564	2161.2989	1838.9128	104	432.9984	60	6.60E-58	2.0008	38.9084	.0001	.0203	.9623

Note. LL = log likelihood; BIC = Bayesian information criterion, AIC = Akaike information criterion, Npar = number of parameters, L^2 = likelihood ratio chi-squared statistic, df = degrees of freedom, Max. BVR = maximal bivariate residuals, VLMR = Vuong-Lo-Mendell-Rubin, Class. Err. = proportion of classification errors. Own table.

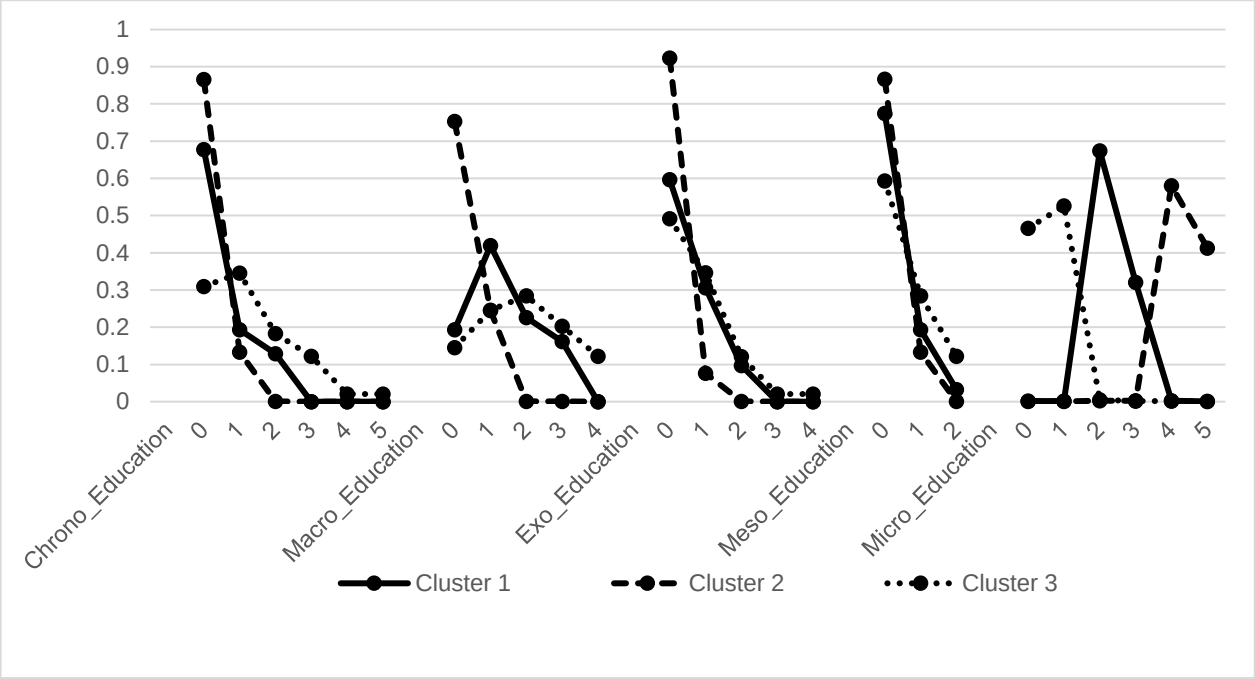
FIGURE 5
PROFILE PLOT OF THE CONNOTATIONS MADE IN THE GENERAL CONTEXT



Note. Conditional probabilities of connotations at each system for the three clusters. Own figure.

The re-estimation of the model with the final number of three classes each follows in Step 2. For Step 3, the covariates age, gender, qualification, job, industry, and the importance of digit(al)ization in work and private life are integrated into the analysis. Choosing the 3-class model, the profile plots concerning the perception of digit(al)ization following the levels of Bronfenbrenner's model (1979, 1989) are depicted in Figure 5 for the general context and in Figure 6 for the educational context.

FIGURE 6
PROFILE PLOT OF THE CONNOTATIONS MADE IN THE EDUCATIONAL CONTEXT



Note. Conditional probabilities of connotations at each system for the three clusters. Own figure.

The Wald-Test gives information on the significance of the relationship between the classes and the covariates. The results for the general context reveal a significant relationship regarding age, gender, job, and industry of the participants, for the educational context gender, importance private and industry show a significant relationship with the classes. More detail on the Wald-Tests can be found in Appendix 9 (general) and Appendix 10 (educational).

Analyzing the general context, Cluster 1 shows a focus on the macrolevel with without special conspicuities regarding age, gender, job, or the industry that a person works in. What is striking, however, is the high proportion of persons possessing a degree in higher education and the perception of digit(al)ization as being (very/extremely) important for their working and their private lives. Therefore, we designate this cluster as *highly educated people with society orientation*. Cluster 2 is named *microcosm-oriented young adults* due to their focus on the microlevel. Furthermore, this cluster is characterized by a large share of persons without professional qualifications and an age structure younger than 35 years. Cluster 3 mainly contains persons aged 25 years or younger with a completed vocational training, many of them currently being full-time students. Their connotations with digit(al)ization predominately refer to the macrolevel. Therefore, they are named *digital natives with completed vocational training and almost exclusively social perspective*. For the general context, Cluster 1 is the largest cluster with 55.51% grouped in here. Cluster 2 contains 31.53% of the participants and Cluster 3 contains 12.96%. The exact results with the integration of the covariates for the general context can be found in Appendices 11 (data table profile plot), 12 (data table profile covariates), and 13 (data table prob means).

The results for the educational context show that many perspectives are addressed for Cluster 1. This cluster can also be characterized by a higher importance for digit(al)ization at work than for the private life, resulting in a label of *highly digital people at work with manifold perspectives on digit(al)ization* for Cluster 1. Specific sociodemographic factors do not characterize people in Cluster 2 but show a strong focus on the microsystem, and therefore they are called the *microcosm-oriented across society.* People grouped into Cluster 3 work in professions related to education, teaching, social affairs, and society, as well as in health and care. They focus on the Chronosystem and predominately relate to negative and retro-perspective

aspects across time (see RQ1). They are called the *improvement seeking and society-oriented working in education, social, health, and care professions.* For the educational context, the three clusters are quite equal, with 37.69% grouped into Cluster 1, 32.35% into Cluster 2, and 29.96% into Cluster 3. The exact results with the integration of the covariates for the educational context can be found in Appendices 14 (data table profile plot), 15 (data table profile covariates) and 16 (data table prob means).

The cluster proportional shows high conformity, and therefore low classification errors, between the assigned and true cluster membership. For example, a person who belongs to cluster 1 has a probability of .9706 to be assigned to cluster 1. For further details, see Table 6.

TABLE 6
CLUSTER PROPORTIONAL FOR THE GENERAL AND THE EDUCATIONAL CONTEXT

	General context			Educational context		
Cluster	**clu#1**	**clu#2**	**clu#3**	**clu#1**	**clu#2**	**clu#3**
1	.9706	.0283	.0011	.9926	.003	.0044
2	.05	.9491	.0008	.0035	.9962	.0002
3	.0046	.002	.9935	.0055	.0002	.9942

Note. Matrix with classification errors between the assigned cluster membership (clu#1, clu#2, clu#3) and the true cluster membership (1, 2, 3). Own table.

DISCUSSION

The results give valuable insights into the respondents' understanding of the term digit(al)ization. Differences regarding the general and the educational context can be seen on a qualitative and quantitative level. Focusing on the qualitative analysis, most participants see digit(al)ization in the general context as a phenomenon across society, which they can influence only indirectly. In contrast, most of the participants focus on the level of individuals with direct influence when it comes to digit(al)ization in the educational context. What stands out both in the general and the educational context are the only sparsely addressed institutional and structural levels. Digit(al)ization is perceived as either being an overarching and large phenomenon that affects society as a whole or as a very individual phenomenon without large reach. The middle structure is missing importance, although it is indispensable to bridge between society and the individual (Pettersson, 2021). Especially in education, the structural and institutional perspective is needed to successfully develop and implement coordinated measures regarding digit(al)ization. However, according to this study, people take these perspectives only to a very limited extent. Looking deeper into the qualitative analyses, differences within the levels of Bronfenbrenner's model (1979, 1989) become visible. The most striking may be the connotations regarding the time dimension: predominately positive, future-oriented connotations with digit(al)ization in the general context compared to the more negative connotations regarding what was missed and what was unsuccessful in the past. At the level of society, it becomes apparent that the general understanding of digit(al)ization heavily focuses on (innovative) technological developments, such as artificial intelligence, cloud computing, or big data.

In comparison, technological developments do not play such an important role in interpreting digit(al)ization in the educational context, leading to the assumption that people are less aware of integrating innovative tools and technologies in this specific field. Furthermore, social changes such as individualization, autonomy, and anonymity are addressed more frequently in the general context, which implies that self-determination and new processes of personal development are not that prevalent in education. Surprisingly, the school as an institution is addressed only to a small extent in the connotations made in the educational context. In contrast, the workplace is mentioned largely in the general context. It can be concluded that the view on institutions is not that much incorporated into the understanding of

digit(al)ization in the field of education when compared to the general understanding and that schools as learning sites are—according to the initial thoughts of the respondents—accountable and involved only to a limited degree. For the educational context, it becomes apparent that at the place of activities, digital media and teaching/learning processes at the classroom are predominately connoted with the term digit(al)ization. The direct mention of the individuals, namely teachers and learners, takes place only to a very limited extent. This implies that despite the reference to the individual level, it is not the individuals per se that affect the understanding on digit(al)ization but the small-level processes to which the individuals are subject.

On a quantitative basis, the differences concerning the understanding of digit(al)ization between the general and the educational levels are confirmed. There are differences in the population's perception of digit(al)ization in the educational context compared to the general context, elucidating that these two cannot be treated as the same thing but must be considered separately. Furthermore, the understanding of digit(al)ization differs regarding the sociodemographic factors, demonstrating the different viewpoints across society. Three classes each for the general and the educational context were found. Therefore, it can be confirmed that there are certain patterns and delineations with different focuses on understanding digit(al)ization across society. When it comes to implementing measures to foster digit(al)ization, there must be a distinction between people—they cannot all be seen and treated in the same way. In particular, the differentiation between people perceiving digit(al)ization as a phenomenon across society and as a happening in their actual place of activities should be kept in mind. The latter will see their own possibilities and influence to advance the integration of digit(al)ization, and will possess a feeling of direct affection but may miss a broader view of the proceedings. In contrast, people with a societal orientation will perceive the implementation of digit(al)ization as being out of their direct reach, and will rather rely on society and political decisions than proactively showing individual initiative. It is also important to keep different sociodemographic factors in mind when it comes to analyzing the understanding of digit(al)ization. For example, when conducting a study or designing and implementing measures to generally foster digit(al)ization with/for digital natives with a degree in vocational education and training, there is a high probability that they perceive digit(al)ization as not being in their direct reach. Of course, this will affect their approaches and ideas to handle this theme (i.e., by an initial wait and see with reactive behavior when specifications come from higher levels). For the educational context, it should be kept in mind that a person working in education, social, health, and care professions has a high probability of taking a negative perspective of digit(al)ization. Therefore, a pessimistic supposition about future possibilities and developments will affect their willingness to further implement digit(al)ization and may lead to procrastination.

In summary, the different understandings of digit(al)ization make a precise and targeted communication difficult. A common starting point does not exist for a joint dialog or for the promotion of concrete implementations regarding digit(al)ization. Misunderstandings occur and a joint pursuit of goals is barely possible—we are not all pulling on the same rope. This should be kept in mind when it comes to communication and debating, as well as designing and implementing measures to foster digit(al)ization in the general and educational contexts. It is not necessarily a matter of imposing a single universal definition but of being aware of and taking into account different perceptions. Another implication is to remember that the structural and institutional perspectives are not as conscious as the individual and the society perspectives. Consequently, the effort involved in communicating measures may be correspondingly higher.

LIMITATIONS AND FURTHER RESEARCH

Despite a very conscientiously and carefully documented procedure, some underlying limitations of this study must be addressed. The connotations are often rather short and only conditionally contextual, leaving space for interpretation concerning the context that they are related to. I addressed this problem by being clear on the methodology and defining distinct and delimitable criteria for the coding process to make the procedure transparent and replicable. Bronfenbrenner's model (1979, 1989) is an established theoretical

model that can be applied in comparable contexts. However, despite detailed descriptions and delimitation of the categories, complete freedom from overlap cannot be guaranteed. For example, the internet at the macrolevel is a phenomenon and a development on the social level, but also affects all other levels. Concerning the data, no representativeness is on hand. However, as described by Döring and Bortz (2016), representativeness is not mandatory for an explorative approach. The data collection took place during the COVID-19 crisis, so it can be presumed that this situation partially shapes connotations. In addition, an off-line implementation of the questionnaire will be useful to reach older or less digital affine persons in particular. Concerning the LCA, the sample size is critical because a sample size larger than 300 is desirable (Nylund-Gibson & Choi, 2018). Nevertheless, no fixed minimum of samples is needed for the LCA because the adequate sample size is also affected, among others, by the number of indicators in the model or the separation between classes (Nylund-Gibson & Choi, 2018; Sinha et al., 2021). To verify the results, the analysis was replicated using the programs R and MPLUS, showing quite similar results. Furthermore, the naming fallacy (Weller et al., 2020) may be another point to discuss because the classes are rather complex, which makes finding appropriate names difficult and limits naming to only certain main factors.

The present explorative study gives valuable insights concerning the connotations of digit(al)ization in general and education. However, identifying solution strategies for an accelerated integration of digit(al)ization remains open. Sociodemographic factors, in particular, appear to cause differences in terms of connotations with the concept of digit(al)ization. Therefore, future research should examine further influencing factors and invest in in-depth statistical analysis concerning the correlations and effects with the understanding of the term digit(al)ization. In addition, an expansion of the LCA (i.e., with a larger, representative sample or a comparison between the understandings in different countries) would be beneficial.

ENDNOTES

1. Rounding difference
2. Out of 1230 possible connotations made by the respondents, 211 (general) and 301 (educational) connotations were not entered at all, not comprehensible or entered with / or x, while the remaining questionnaire was completed.
3. Rounding difference
4. Rounding difference
5. Based on negative ranks
6. Based on positive ranks

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APPENDIX 1

Questionnaire with Scales, Origin of the Questions, and Their Adaptation

Thank you for taking part in this survey on digit(al)ization in your work and life!

The processing time takes about 5-10 minutes.

The data collected is used exclusively for scientific purposes and will be processed anonymously.

A direct allocation to your person is not possible.

Digit(al)ization is constantly being talked about and it is impossible to imagine our life and work without it. With your participation in this survey, you are helping us to specify and concretize this term. Your point of view is very important to us – we look forward to hearing from you! There is no right or wrong, let us know what you think and let your thoughts run free!

Block 1

Question 1: Please think of the term *digit(al)ization*.
What five terms come to mind when you think of *digit(al)ization*?

Please enter the terms in the five fields below.

Term 1	
Term 2	
Term 3	
Term 4	
Term 5	

Question 2: Please think of *digit(al)ization in the educational field*.
What five terms come to mind when you think of *digit(al)ization in the educational field*?

Please enter the terms in the five fields below.

Term 1	
Term 2	
Term 3	
Term 4	
Term 5	

Block 2

Question 3: The following questions relate to your work life:

How important are digital media in your workplace?

not at all important	slightly important	important	fairly important	very important
○	○	○	○	○

Question 4: How often do you use the following digital media at your workplace?

	very often	often	sometimes	rarely never	never	N/A
Smartphone	○	○	○	○	○	○
Laptop/Notebook	○	○	○	○	○	○
Stationary PC/ Desktop computer	○	○	○	○	○	○
TV/Smart TV	○	○	○	○	○	○
Tablet	○	○	○	○	○	○
E-Reader (Kindle, Tolino, etc.)	○	○	○	○	○	○
Wearables (fitness tracker, smartwatch, VR glasses)	○	○	○	○	○	○
Social Media (Instagram, Twitter, WhatsApp, etc.)	○	○	○	○	○	○

What other media do you use at your workplace? (voluntary information)

Question 5: What do you mainly use digital media for at work?
Please mark the two most important areas!

- ☐ search, process and store
- ☐ communicate and corporate
- ☐ produce and present
- ☐ protect and operate safely
- ☐ problem solving and action
- ☐ analyze and reflect

Block 3

Question 6: The following questions relate to your private life:

How important are digital media in your workplace?

not at all important	slightly important	important	fairly important	very important
○	○	○	○	○

Question 7: How often do you use the following digital media at in your private life?

	very often	often	sometimes	rarely	never	N/A
Smartphone	○	○	○	○	○	○
Laptop/Notebook	○	○	○	○	○	○
Stationary PC/ Desktop computer	○	○	○	○	○	○
TV/Smart TV	○	○	○	○	○	○
Tablet	○	○	○	○	○	○
E-Reader (Kindle, Tolino, etc.)	○	○	○	○	○	○
Wearables (fitness tracker, smartwatch, VR glasses)	○	○	○	○	○	○
Social Media (Instagram, Twitter, WhatsApp, etc.)	○	○	○	○	○	○

What other media do you use in your private life? (voluntary information)

Block 4

Question 8: What do you mainly use digital media for in your private life?
Please mark the two most important areas!

- ☐ search, process and store
- ☐ communicate and corporate
- ☐ produce and present
- ☐ protect and operate safely
- ☐ problem solving and action
- ☐ analyze and reflect

Question 9: How do you rate your knowledge and skills in the field of digit(al)ization with regard to the following six areas?

	basic/ simple tasks	independent/ standard tasks	advanced/ challenging tasks	highly specialized/ complex tasks
search, process and store	○	○	○	○
communicate and cooperate	○	○	○	○
produce and present	○	○	○	○
protect and operate safely	○	○	○	○
problem solving and acting	○	○	○	○
analyze and reflect	○	○	○	○

In order to be able to interpret your answers better, we need some information about your background. Of course, these answers will also be treated as strictly confidential and will only be processed anonymously.

Question 10: Please select your age here!

≤ 25 years	26 – 35 years	36 – 45 years	46 – 55 years	56 – 65 years	66 – 99 years
○	○	○	○	○	○

Question 11: Please select your gender here!

male	female	divers	N/A
○	○	○	○

Question 12: What is your current job? If you have multiple jobs, please refer to your main job.

- ○ pupil
- ○ apprentice
- ○ university student
- ○ employee
- ○ official/civil servant
- ○ self-employed
- ○ housewife/husband
- ○ freelancer/independent assistant
- ○ retiree

Block 5

Question 13: What is your highest professional qualification?

- ☐ No professional qualification
- ☐ Vocational training as … (e.g. office management clerk)
- ☐ University degree as … (e.g. diploma, bachelor's degree or master's degree in the relevant subject)
- ☐ Other:

Question 14: In which professional field do you carry out your main activity?

- ○ Commercial & management
- ○ Commercial-technical, engineering or natural science
- ○ (Business-) Informatics
- ○ Health and care
- ○ Education, teaching, social affairs and society
- ○ Craft
- ○ Other professional field:

Note. Original survey conducted in German.

APPENDIX 2

TABLE 7
ORIGIN AND MODIFICATIONS OF THE QUESTIONS

Number of Question	Block	Question	Reference	Modification
1	Term digit(al)ization	Please think of the term digit(al)ization. What five terms come to mind when you think of digit(al)ization?	own question	N/A
2		Please think of digit(al)ization in the educational field. What five terms come to mind when you think of digit(al)ization in the educational field?	own question	N/A
3	Work life	How important are digital media in your workplace?	Jeanneret et al., 1999	Literally translated from English
4		How often do you use the following digital media at your workplace?	Beck et al., 2018	Scale
			German Association for the Digital Economy [BVDW], 2019	Tools
5		What do you mainly use digital media for at work?	Standing Conference of the Ministers of Education and Cultural Affairs of the Länder in the Federal Republic of Germany [Kultusministerkonferenz], 2016	N/A
6	Private life	How important are digital media in your private life?	Jeanneret et al., 1999	Literally translated from English
7		How often do you use the following digital media at in your private life?	Beck et al., 2018	Scale
			BVDW, 2019	Tools
8		What do you mainly use digital media for in your private life?	Kultusministerkonferenz, 2016	N/A

APPENDIX 3

TABLE 8
CATEGORIES AND SUBCATEGORIES:
CATEGORY SCHEME AND FREQUENCY OF CODINGS

Chronolevel	*General*	*Education*
Future	**91**	**41**
Chances and opportunities	11	8
General	12	8
Modernization	4	6
Progress and change	64	19
General	**0**	**7**
Past	**11**	**72**
Failures in the past, retrofit, adaptation necessary	10	68
Preparation and requirements	1	4
Present	**6**	**2**
Macrolevel	***General***	***Education***
Demographics	**15**	**8**
Health and medical, social and nursing care	11	8
Mobility	3	0
National and international demographic developments	1	0
Economics	**349**	**81**
Climate change and climate impact adaptation	0	3
Economy and prosperity	2	0
Globalization	9	5
Resource efficiency and scarcities	1	0
Technological development	337	73
Labor market and participation	**88**	**77**
Qualification and knowledge intensification	13	12
Self-marketing and new forms of employment	75	65
Lockdown/COVID-19	**7**	**6**
Megatrends (in general)	**3**	**0**
Politics	**8**	**3**
Social changes	**72**	**41**
Individualization, communication, anonymity and autonomy	65	24
Social justice and participation	7	17
Terminology	**3**	**0**

Exolevel	*General*	*Education*
Adaptation of education and curricula	**0**	**23**
General	0	9
Integration of digit(al)ization	0	4
Knowledge application	0	3
Preparation for future jobs	0	2
School subjects (computer science, math, etc.)	0	5
Changed competency requirements	**8**	**16**
Communication skills	0	1
Creativity	0	2
Digital writing	1	1
General	3	1
Information literacy	0	1
Knowledge about digit(al)ization/digital competence/IT skills	0	4
Media literacy	3	4
Programming	1	2
Costs	**12**	**13**
Ministry of Education and Cultural Affairs	**0**	**1**
Training and further education	**5**	**18**
Mesolevel	*General*	*Education*
Contacts (general, parents, friends, etc.)	**9**	**14**
Alienation, loneliness, impersonal	8	11
Friendship	0	2
General	1	0
Parents	0	1
School	**23**	**37**
Conferences	0	1
Failures in schools	2	2
General	21	9
Improvement of equipment	0	17
Malfunctions, technical problems	0	7
Support needed	0	1
School and company in dual training	**0**	**1**
Team(-work)	**1**	**5**
University	**0**	**4**
Workplace	**67**	**9**
Business models and processes	26	4
General	10	1
Home office, mobile working, new work	26	3
Management	5	1

Microlevel	*General*	*Education*
Digital Identity	**1**	**0**
Digital Media	**199**	**240**
Analog tools	1	2
General	13	10
Hardware	144	109
Information and communication	21	57
Learning tools and organizational resources	5	39
Presentation and visualization	10	17
Software	5	4
User-friendliness	0	2
Everyday life	**7**	**0**
Learners and individuals	**2**	**18**
Negative effects on students	0	2
Thinking process	2	0
Way of learning	0	16
Teachers	**0**	**9**
Age difference (also in comparison to students)	0	2
Effort	0	1
General	0	2
Lack of motivation	0	2
Overextension	0	2
Teaching and working processes	**32**	**183**
Learning/working process	2	17
Learning/working objectives	0	8
Place of working/learning	8	114
Teaching design and new forms of teaching/learning/working	22	44

Note. N=246 participants, based on MAXQDA analysis. Own table.

APPENDIX 4

TABLE 9
CHRONOSYSTEM CODING SCHEME FOR SUBCATEGORIES WITH DEFINITIONS OF THE CATEGORIES, ANCHOR EXAMPLES, AND CODING RULES

Definition of main category: **Time dimension, focuses on the development processes over time (Bronfenbrenner, 1989, 1992). In the context of digit(al)ization, the coding follows the connotations with reference to the past, present and the future.**			
Subcategory	**Definition**	**Anchor examples**	**Coding rules (if applicable)**
Future	Describes connotations with reference to future occurrences and events.	▪ progress ▪ modernization ▪ important for the future	Coding takes place if there is a reference to future developments. Connotations such as progress, opportunities, modernization or change are coded with reference to the future in this category.
Past	Connotations with reference to past occurrences and events.	▪ suspended ▪ backward so far ▪ lack of preparation	Connotations are coded, which contain the word sound of the past. This category is also chosen if the main content of the connotation has already taken place or should have taken place in the past (e.g., lack of preparation).
Present	Connotations with reference to current, present occurrences and events.	N/A	Only connotations with an explicit reference to the present are coded into this category. Associations without past or future reference are not automatically coded into this category.

Note. Own table.

APPENDIX 5

TABLE 10
MACROSYSTEM CODING SCHEME FOR SUBCATEGORIES WITH DEFINITIONS OF THE CATEGORIES, ANCHOR EXAMPLES, AND CODING RULES

Definition of main category: **Formal and substantive similarity of the lower-order systems that exist or might exist in the subculture or culture, including their underlying worldviews and ideologies (Bronfenbrenner, 1979). In the context of digit(al)ization we focus on developments and phenomena throughout society.**

Subcategory	Definition	Anchor examples	Coding rules (if applicable)
Demogra-phics	Describes national and international demographic changes, health, urbanization, and mobility addressed (Helmrich et al., 2020).	▪ telemedicine ▪ autonomous driving ▪ smart hospital	N/A
Economics	Includes globalization, the next industrial revolution "Industry 4.0," climate change, and the use of scarce resources (Helmrich et al., 2020).	▪ resource saving ▪ global networking ▪ robotic process automation	N/A
Labor Market and Participation	Focuses on the area of work and employment, specifically also the qualification of employees and their self-marketing (Helmrich et al., 2020).	▪ more opportunities ▪ modern work ▪ global knowledge ▪ unified knowledge	N/A
Lockdown/COVID-19	Describes changes induced by COVID-19 with regard to digit(al)ization in education at the societal level. This category lies across the other megatrends, i.e., influences on all megatrends are to be expected (Helmrich et al., 2020).	▪ COVID-19 has positively accelerated things ▪ lockdown ▪ necessary in pandemic times	Only general, overarching associations are coded here (e.g., effects on teaching), and thus the individual sphere of life, are assigned at the microlevel.

Megatrends (in general)	**Connotations that generally refer to megatrends.**	▪ **megatrends** ▪ **globalization**	**N/A**
Politics	Describes connotations of politics in general, across megatrends.	▪ bad policy ▪ politics	Specific proposals for change that affect the education and credentialing system are coded at the exolevel.
Social changes	Describes changes in society, such as the increasing importance of a work-life balance and the issue of social justice (Helmrich et al., 2020).	▪ inclusive ▪ inequality of opportunity ▪ high flexibility	N/A
Terminology	Connotations that relate directly to the conceptualization of digit(al)ization.	▪ Term covers many aspects ▪ Fashion word	N/A

Note. Own table.

APPENDIX 6

TABLE 11
EXOSYSTEM CODING SCHEME FOR SUBCATEGORIES WITH DEFINITIONS OF THE CATEGORIES, ANCHOR EXAMPLES, AND CODING RULES

Definition of main category: **One or more spheres of life, in which the developing person is not themself involved, but in which events take place that influence what happens in their sphere of life or are influenced by it Bronfenbrenner (1979). In the context of digit(al)ization we focus on structural guidelines and developments in the cultural sub-systems.**

Subcategory	Definition	Anchor examples	Coding rules (if applicable)
Adaptation of education and curricula	Includes changes or rearrangements of curricula to adapt to advancing digit(al)ization. The changes in the organization of education and training are also reflected.	▪ little consideration in the curriculum ▪ computer science ▪ learning to use computer/office programs in lower grades	Changes in skill requirements and competencies are not coded in this category, but in the category *changed competency requirements.*
Changed competency requirements	Describes changes in competency requirements for students due to digit(al)ization. It includes what needs to be done more, but also a decrease in skills, or skills that lose importance, are assigned here.	▪ decrease in communication ability ▪ research skills ▪ digital competence	Changes in the organization of education are coded in the category *adjustment of education and curricula*.

Costs	Focuses on the costs and investments needed to successfully implement digit(al)ization.	▪ Financial burden ▪ High cost ▪ Investment	N/A
Ministry of Education and Cultural Affairs	Refers to the Ministry of Education and Cultural Affairs.	▪ Ministry of Education and Cultural Affairs not modern enough	N/A
Training and further education	Includes continuing education and training of staff in relation to the implementation of digit(al)ization. The way in which training is provided is also included (e.g., online training).	▪ digital competence for teachers ▪ continuing training ▪ pedagogical staff must be more future-oriented ▪ continuing education online	N/A

Note. Own table.

APPENDIX 7

TABLE 12
MESOSYSTEM CODING SCHEME FOR SUBCATEGORIES WITH DEFINITIONS OF THE CATEGORIES, ANCHOR EXAMPLES, AND CODING RULES

Definition of main category: **Composed of a system of several microsystems and comprises the interrelationships between the areas of life in which the developing person is actively involved (Bronfenbrenner, 1979, 1992). In the context of digit(al)ization we focus institutions and organizations such as schools or workplaces.**

Subcategory	Definition	Anchor examples	Coding rules (if applicable)
Contacts	Refers to contacts in the private life (e.g., the relationship to parents or friends).	▪ parents ▪ friends ▪ less contacts	N/A
School	Connotations relating to the school.	▪ lack of support ▪ helpless educational institutions ▪ better digital equipment in schools	N/A
School and company in dual training	Connotations that relate specifically to the dual system in the field of vocational education and training and the duality of learning locations.	▪ discrepancy between company and school	Only coded if clearly related to vocational education and training.

Team(-work)	Refers to working and learning in teams.	▪ teams ▪ easier learning in teams ▪ learning in location-independent teams	N/A
University	Describes connotations related to university or higher education.	▪ university	Only coded if clearly related to higher education.
Workplace	Changes in the workplace induced by digit(al)ization.	▪ just in time ▪ management ▪ shorten processes	Connotations from the managerial domain are clustered on the mesolevel due to the impacts on jobs and workplaces.

Note. Own table.

APPENDIX 8

TABLE 13
MICROSYSTEM CODING SCHEME FOR SUBCATEGORIES WITH DEFINITIONS OF THE CATEGORIES, ANCHOR EXAMPLES, AND CODING RULES

Definition of main category: **Direct environment of a person in which they participates and is described as patterns of activities, roles, and interpersonal relationships experienced by the developing person (Bronfenbrenner, 1979). In the context of digit(al)ization we focus on the usage of digital media, learning processes in the classroom and on learners and teachers in a direct manner.**			
Subcategory	**Definition**	**Anchor examples**	**Coding rules (if applicable)**
Digital Identity	Refers to aspects related to a digital identity.	▪ digital identity	N/A
Digital Media	Digital media can be described by various characteristics and properties. Thus, a media offering, e.g., a learning program, is characterized by specific content, objectives, forms of presentation, flow and navigation structures, interactivity properties, or learning theory implications" (Herzig, 2014).	▪ tablets ▪ language learning apps ▪ more information from the internet than from books ▪ interactive smartboards	Digital media in the sense of hardware and software are addressed. Trend developments that affect society as a whole are coded at the macrolevel.
Everyday life	Describes connotations relating to general aspects in everyday life of participants.	▪ lighter bag ▪ private life	N/A

Learners and individuals	**Related to individuals and learners, such as their prior knowledge, their cognitive resources or intellectual capacities, their values and attitudes, as well as their socio-cultural backgrounds (Herzig, 2014).**	▪ **distraction, especially for younger students** ▪ **thinking process**	**N/A**
Teachers	Teachers incorporate an expertise in the fields of subject-specific science and didactics. They possess—to a greater or lesser extent—media didactic competence, have a specific understanding of their profession, and possess values and attitudes that can influence the design of teaching-learning situations (Herzig, 2014).	▪ age difference/knowledge, also in comparison with pupils ▪ excessive demands ▪ lack of motivation ▪ effort	N/A
Teaching and working processes	Teaching process are coded into this category, that can be described by various characteristics, which include, i.e., teaching objectives, content dealt with or worked on, the didactic structure, social forms used and methods applied, as well as learning theory implications (Herzig, 2014). In addition, changes in processes at the direct workplace are assigned here.	▪ virtual learning support ▪ smaller learning groups necessary ▪ online assessment ▪ multimedia teaching ▪ paperless office	Only connotations specifically related to the individual work area are coded here, otherwise the assignment is made on a more general institutional level at mesolevel.

Note. Own table.

APPENDIX 9

TABLE 14
MODEL FOR CLASSES WITH WALD-TEST FOR THE GENERAL CONTEXT

Model for Classes

Intercept	**Cluster1**	**Cluster2**	**Cluster3**	**Wald**	**p-value**
	-.3946	2.8122	-2.4176	15.0458	.00054
Covariates	**Cluster1**	**Cluster2**	**Cluster3**	**Wald**	**p-value**
Age					
< 25 years	-.3369	-.8658	1.2027	25.7162	.0041
26 – 35 years	-.1691	.8433	-.6742		
36 – 45 years	.8076	.1021	-.9097		
46 – 55 years	.8816	-.0034	-.8782		
56 – 65 years	.3497	-.0136	-.3361		
66 – 99 years	-1.5329	-.0627	1.5955		
Gender					
Male	1.6288	-1.8478	.2191	19.6579	.0032
Female	1.8788	-1.7957	-.0831		
Divers	-.5107	1.4733	-.9625		
N/A	-2.9969	2.1703	.8266		
Qualification					
No professional qualification	-.1005	.5425	-.442	11.7942	.067
Vocational training	.0207	-.8599	.8392		
University degree	.7744	-.698	-.0764		
Other	-.6946	1.0154	-.3208		
Job					
Apprentice	.9088	1.3787	-2.2874	75.3572	1.10E-09
Employee	-1.3488	-.3962	1.745		
Freelancer/ independent assistant	.0337	2.1605	-2.1942		
Housewife/husband	-.0433	-4.8701	4.9134		
Official/civil servant	-1.521	.3638	1.1571		
Pupil	2.8716	-.4072	-2.4644		
Retiree	.4589	.1892	-.6481		
Self-employed	-.351	1.8465	-1.4955		
University student	-1.0089	-.2652	1.2741		

Industry					
(Business-) Informatics	.265	-1.0375	.7725	51.6016	7.30E-07
Commercial & management	.4871	-.0998	-.3872		
Commercial-technical, engineering or natural science	.2157	-.666	.4504		
Craft	2.4753	-.4379	-2.0374		
Education, teaching, social affairs and society	.6306	.0905	-.7211		
Health and care	.64	-.7245	.0846		
Other professional field	-4.7136	2.8753	1.8383		
Importance_work					
	.016	.0074	-.0233	.0118	.99
Importance_privat					
	-.1853	.0982	.0871	1.1144	.57

Note. Own table.

APPENDIX 10

TABLE 15
MODEL FOR CLASSES WITH WALD-TEST FOR THE EDUCATIONAL CONTEXT

Model for Classes					
Intercept	**Cluster1**	**Cluster2**	**Cluster3**	**Wald**	**p-value**
	-.1027	.3504	-.2476	.2351	.89
Covariates	**Cluster1**	**Cluster2**	**Cluster3**	**Wald**	**p-value**
Age					
< 25 years	.6218	-.8835	.2618	7.3705	.69
26 – 35 years	.3712	-.3378	-.0334		
36 – 45 years	-.5121	.3454	.1667		
46 – 55 years	-.2299	.277	-.0471		
56 – 65 years	-.2103	.0348	.1755		
66 – 99 years	-.0405	.5641	-.5235		
Gender					
Male	-.6922	-.2506	.9428	20.9528	.0019
Female	-.459	-.0959	.5548		
Divers	3.6975	-2.3745	-1.323		
N/A	-2.5463	2.721	-.1747		

Qualification					
No professional qualification	-.5288	.1724	.3564	4.2359	.64
Vocational training	.2082	.0051	-.2133		
University degree	.0972	-.3037	.2065		
Other	.2234	.1262	-.3496		
Job					
Apprentice	.5954	.8548	-1.4502	13.05	.67
Employee	.1735	-.1209	-.0526		
Freelancer/ independent assistant	-.878	-.3184	1.1964		
Housewife/husband	.2448	-.2781	.0332		
Official/civil servant	.0423	.1224	-.1647		
Pupil	.0563	.043	-.0993		
Retiree	.2777	-.7491	.4714		
Self-employed	-.1463	-.4954	.6417		
University student	-.3658	.9417	-.5759		
Industry					
(Business-) Informatics	-.8569	1.3409	-.484	43.3783	1.90E-05
Commercial & management	-.0585	.5598	-.5013		
Commercial-technical, engineering or natural science	.1024	.5778	-.6802		
Craft	1.8563	-3.4277	1.5714		
Education, teaching, social affairs and society	-.3227	.2628	.0599		
Health and care	-.5291	.0854	.4437		
Other professional field	-.1916	.6011	-.4095		
Importance_work					
	-.3704	.325	.0454	5.3408	.069
Importance_private					
	.6435	-.4977	-.1458	11.7275	.0028

Note. Own table.

APPENDIX 11

TABLE 16
DATA TABLE PROFILE PLOT: GENERAL CONTEXT

	Cluster1	Cluster2	Cluster3
Chrono_General			
0	.5011	.6827	.8037
1	.3792	.3166	.0049
2	.1196	.0005	.0509
3	.0001	.0001	.0936
4	0	0	.0469
Macro_General			
0	.0002	.1348	.0007
1	.029	.1424	.2352
2	.2476	.4902	.0993
3	.5043	.2311	.0066
4	.2186	.0009	.0022
5	.0004	.0005	.656
Exo_General			
0	.8509	.9152	.9513
1	.1491	.0848	.0018
2	0	0	.0469
Meso_General			
0	.4976	.6881	.8997
1	.4047	.2515	.054
2	.0975	.0213	.001
3	.0002	.0391	.0453
Micro_General			
0	.3825	.0031	.8951
1	.6151	.0748	.0063
2	.0021	.6525	.0034
3	.0003	.2116	.0014
4	0	.0001	.0936
5	.0001	.0578	.0003

Note. Own table.

APPENDIX 12

TABLE 17
DATA TABLE PROFILE COVARIATES: GENERAL CONTEXT

	Cluster1	Cluster2	Cluster3	Overall
Cluster Size	.5484	.3216	.13	
Covariates				
Age				
< 25 years	.2891	.3571	.5733	.3479
26 – 35 years	.1189	.1955	.0933	.1402
36 – 45 years	.1402	.0823	.0483	.1096
46 – 55 years	.3032	.183	.1427	.2437
56 – 65 years	.1088	.0605	.0948	.0914
66 – 99 years	.0398	.1216	.0475	.0671
Gender				
Male	.3092	.3802	.4775	.3539
Female	.6908	.5819	.5225	.6339
Diverse	0	.019	0	.0061
N/A	0	.0189	0	.0061
Qualification				
No professional qualification	.1177	.2532	.1438	.1647
Vocational training	.2564	.2435	.4758	.2808
University degree	.6146	.4657	.333	.5301
Other	.0113	.0376	.0475	.0244
Job				
Apprentice	.0434	.0395	.0001	.0365
Employee	.4243	.2799	.4734	.3842
Freelancer/ independent assistant	.0332	.0571	0	.0365
Housewife/husband	.0331	0	.0481	.0244
Official/civil servant	.1165	.1421	.0477	.1158
Pupil	.0219	.0385	0	.0244
Retiree	.0872	.0973	.0477	.0853
Self-employed	.0282	.0655	0	.0366
University student	.2123	.2802	.383	.2563
Industry				
(Business-) Informatics	.0429	.0403	.095	.0488
Commercial & management	.4225	.358	.4278	.4024
Commercial-technical, engineering or natural science	.1572	.1095	.2392	.1525
Craft	.0543	.0207	.0006	.0365
Education, teaching, social affairs and society	.2249	.2976	.1435	.2377
Health and care	.0982	.0603	.0459	.0792
Other professional field	0	.1134	.0481	.0428

Importance_work				
Very	.3579	.2605	.3315	.3231
Fairly important	.3564	.3939	.3832	.372
Important	.1564	.1686	.1423	.1585
Slightly important	.0968	.0997	.1429	.1037
Not at all important	.0324	.0772	.0001	.0426
Importance_private				
Very important	.2164	.1604	.0965	.1828
Fairly important	.3887	.3969	.5696	.4149
Important	.2579	.2978	.2389	.2683
Slightly important	.1155	.125	.0947	.1158
Not at all important	.0215	.02	.0003	.0183

Note. Distribution of covariates for each of the classes (Vermunt & Magidson, 2016). Own table.

APPENDIX 13

TABLE 18
DATA TABLE PROBMEANS: GENERAL CONTEXT

	Cluster1	**Cluster2**	**Cluster3**
Cluster Size	.5484	.3216	.13
Covariates			
Age			
< 25 years	.4557	.3301	.2141
26 – 35 years	.4652	.4484	.0865
36 – 45 years	.7012	.2415	.0573
46 – 55 years	.6824	.2415	.0761
56 – 65 years	.6525	.2127	.1348
66 – 99 years	.3251	.5829	.092
Gender			
Male	.4791	.3455	.1753
Female	.5976	.2952	.1071
Diverse	.0001	.9993	.0005
N/A	.0001	.9992	.0007
Qualification			
No professional qualification	.392	.4945	.1135
Vocational training	.5009	.2789	.2202
University degree	.6358	.2825	.0816
Other	.2529	.4947	.2524

Job			
Apprentice	.6521	.3477	.0002
Employee	.6056	.2343	.1601
Freelancer/ independent assistant	.4975	.5024	.0001
Housewife/husband	.7435	.0004	.2561
Official/civil servant	.5517	.3948	.0535
Pupil	.4919	.5081	0
Retiree	.5605	.3668	.0727
Self-employed	.4237	.5762	.0001
University student	.4543	.3515	.1942
Industry			
(Business-) Informatics	.4818	.2656	.2526
Commercial & management	.5757	.2861	.1381
Commercial-technical, engineering or natural science	.5653	.231	.2038
Craft	.8152	.1826	.0023
Education, teaching, social affairs and society	.5189	.4027	.0784
Health and care	.6798	.2448	.0754
Other professional field	.0005	.8534	.1461
Importance_work			
Very	.6074	.2593	.1333
Fairly important	.5255	.3406	.1339
Important	.5412	.3421	.1167
Slightly important	.5119	.309	.179
Not at all important	.4172	.5826	.0002
Importance_private			
Very important	.6492	.2822	.0686
Fairly important	.5139	.3077	.1784
Important	.5272	.357	.1157
Slightly important	.5468	.347	.1063
Not at all important	.6465	.3514	.0021

Note. The ProbMeans output gives the distribution of the latent variable for a certain level of the covariates (Vermunt & Magidson, 2016). Own table.

APPENDIX 14

TABLE 19
DATA TABLE PROFILE PLOT: EDUCATIONAL CONTEXT

	Cluster 1	Cluster 2	Cluster 3
Chrono_Education			
0	.6776	.8659	.309
1	.1932	.1331	.3459
2	.129	.0006	.183
3	.0002	.0002	.1216
4	0	0	.0203
5	0	0	.0203
Macro_Education			
0	.1933	.7527	.1449
1	.4191	.2452	.246
2	.2259	.0011	.2845
3	.1615	.0008	.203
4	.0002	.0002	.1216
Exo_Education			
0	.5965	.923	.4918
1	.3063	.0764	.3462
2	.0971	.0005	.1215
3	0	0	.0203
4	0	0	.0203
Meso_Education			
0	.7745	.8666	.5934
1	.1931	.1331	.2848
2	.0324	.0003	.1217
Micro_Education			
0	.0013	.0009	.4655
1	.0017	.001	.5258
2	.6737	.0022	.005
3	.3205	.0024	.0013
4	.0021	.5806	.0015
5	.0008	.4129	.0009

Note. Own table.

APPENDIX 15

TABLE 20
DATA TABLE PROFILE COVARIATES: EDUCATIONAL CONTEXT

	Cluster1	Cluster2	Cluster3	Overall
Cluster Size	.3771	.3234	.2995	
Covariates				
Age				
< 25 years	.3553	.3581	.3264	.3476
26 – 35 years	.1286	.1513	.143	.1402
36 – 45 years	.0961	.1131	.1233	.1098
46 – 55 years	.2267	.2641	.2437	.2439
56 – 65 years	.1126	.0569	.1022	.0915
66 – 99 years	.0807	.0565	.0614	.0671
Gender				
Male	.3229	.3591	.3866	.3537
Female	.661	.6221	.6134	.6341
Diverse	.0161	0	0	.0061
N/A	0	.0189	0	.0061
Qualification				
No professional qualification	.129	.1884	.184	.1646
Vocational training	.3081	.3015	.2229	.2805
University degree	.5308	.491	.5727	.5305
Other	.0321	.019	.0205	.0244
Job				
Apprentice	.0483	.0377	.0205	.0366
Employee	.4198	.3585	.367	.3841
Freelancer/ independent assistant	.0163	.0374	.0613	.0366
Housewife/husband	.0319	.0193	.0203	.0244
Official/civil servant	.0965	.1321	.1228	.1159
Pupil	.0161	.0188	.0409	.0244
Retiree	.1126	.057	.0817	.0854
Self-employed	.0323	.0188	.0613	.0366
University student	.2262	.3205	.2242	.2561
Industry				
(Business-) Informatics	.0163	.0942	.0408	.0488
Commercial & management	.4357	.4342	.3262	.4024
Commercial-technical, engineering or natural science	.1943	.1322	.1216	.1524
Craft	.0645	.0001	.0409	.0366
Education, teaching, social affairs and society	.1934	.2261	.3065	.2378
Health and care	.0638	.0568	.1231	.0793
Other professional field	.0322	.0565	.041	.0427

Importance_work				
Very	.3558	.2821	.3265	.3232
Fairly important	.4195	.3779	.3056	.3719
Important	.0808	.1884	.2244	.1586
Slightly important	.0956	.114	.1027	.1037
Not at all important	.0484	.0377	.0409	.0427
Importance_private				
Very	.112	.2085	.2448	.183
Fairly important	.3711	.5273	.3478	.4146
Important	.3063	.2264	.2656	.2683
Slightly important	.1772	.0378	.1228	.1158
Not at all important	.0334	0	.019	.0183

Note. Distribution of covariates for each of the classes (Vermunt & Magidson, 2016). Own table.

APPENDIX 16

TABLE 21
DATA TABLE PROBMEANS: EDUCATIONAL CONTEXT

	Cluster1	**Cluster2**	**Cluster3**
Cluster Size	.3771	.3234	.2995
Covariates			
Age			
< 25 years	.3855	.3332	.2813
26 – 35 years	.3458	.3488	.3054
36 – 45 years	.3303	.3333	.3364
46 – 55 years	.3505	.3502	.2993
56 – 65 years	.4642	.2012	.3346
66 – 99 years	.4535	.2723	.2741
Gender			
Male	.3443	.3284	.3273
Female	.3931	.3172	.2897
Diverse	.9986	0	.0014
N/A	.0001	.9998	0
Qualification			
No professional qualification	.2954	.37	.3346
Vocational training	.4143	.3477	.238
University degree	.3774	.2994	.3233
Other	.4959	.2526	.2515

Job			
Apprentice	.4984	.3337	.168
Employee	.4121	.3018	.2861
Freelancer/ independent assistant	.1683	.3303	.5014
Housewife/husband	.4938	.2564	.2498
Official/civil servant	.3141	.3686	.3173
Pupil	.2482	.2494	.5024
Retiree	.4975	.2158	.2867
Self-employed	.3325	.166	.5016
University student	.3331	.4047	.2622
Industry			
(Business-) Informatics	.1256	.6241	.2502
Commercial & management	.4083	.3489	.2428
Commercial-technical, engineering or natural science	.4806	.2805	.2389
Craft	.6645	.0006	.3348
Education, teaching, social affairs and society	.3066	.3074	.3859
Health and care	.3034	.2317	.4649
Other professional field	.2842	.4281	.2876
Importance_work			
Very	.4152	.2823	.3025
Fairly important	.4253	.3286	.2461
Important	.1921	.3842	.4237
Slightly important	.3478	.3555	.2967
Not at all important	.4274	.2856	.2871
Importance_private			
Very important	.2308	.3685	.4007
Fairly important	.3375	.4113	.2512
Important	.4305	.2729	.2965
Slightly important	.5769	.1055	.3176
Not at all important	.6884	.0005	.3111

Note. The ProbMeans output gives the distribution of the latent variable for a certain level of the covariates (Vermunt & Magidson, 2016). Own table.