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Automated Competence Assessment Procedures in Entrepreneurship

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Abstract: This study endeavors to automate the assessment of competencies within the domain of entrepreneurship, specifically targeting the augmentation of entrepreneurial cognition and conduct within universities in German rural regions, like Lower Franconia. Employing methods, including literature analyses and expert interviews, we formulated and validated an entrepreneurship competence profile and accompanying self-assessment tool. The ensuing evaluative framework is poised for seamless integration into learning management systems, thereby facilitating intelligent competence monitoring within educational environments. Purpose: The aim of this thesis is to develop an automated competence assessment procedure in the field of entrepreneurship. This can be used in the university environment in the long term to promote and teach entrepreneurial thinking and behavior in order to sustainably improve the quality of learning outcomes and achieve targeted promotion of entrepreneurship. Methodology: Based on a relevant literature analysis, four guideline-based expert interviews were created and conducted. The results of the interviews were compiled and validated in a structured competence profile (entrepreneurship competence profile). Based on this competence catalog for entrepreneurs, an empirically valid self-test was created using standard psychometric questionnaire construction methods. Results: The entrepreneurship competence profile and a consequential empirically validated self-test for competence assessment were created. This test provides the basis for the long-term competence development of students and can further be embedded automatically into a learning management system (LMS) as part of intelligent competence monitoring, which allows for the recording of competencies for each student and the individual incorporation of gap closure into the curriculum. Originality/value: In previous research, there were no competence profiles or competence assessment procedures in the field of entrepreneurship that derived relevant competencies directly from actors within this environment. This work illustrates the development of a competence assessment procedure for entrepreneurs and shows which methods can be used to close prevailing research gaps in the field of intelligent competence monitoring.

Keywords: competence; measuring; assessment; development; framework; monitoring; higher education; entrepreneurship; (linked by Boolean operators)

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1. Introduction

As early as 2006, the European Commission published recommendations on key competencies for lifelong learning, referring to the knowledge, skills, and attitudes required for personal fulfillment and development, employability, social inclusion, and active citizenship.

These key competencies are necessary "in order to be able to adapt flexibly to an environment characterized by rapid change and strong networking" [1].

The knowledge required includes the ability to identify opportunities for personal, professional, and/or commercial activities, including the "bigger picture", in which people live and work, as well as a comprehensive understanding of the economic workings and opportunities or challenges facing an organization. This lifelong learning will support the individual development of personality and strength, both mental and physical.

According to the EU Commission, education geared toward entrepreneurial thinking and action is of crucial importance for Europe's competitiveness and continuous economic growth. After all, people who actively implement ideas are the driving force behind development and prosperity. This results in the need to equip young people with the necessary key skills and to improve their level of education. In particular, the Integrated Guidelines for Growth and Employment 2005–2008 [1] call for education and vocational training systems to be adapted to the new competitive requirements.

Derived from this, an academic mission has emerged to support young people in developing appropriate key competencies that equip them for entrepreneurial adult life and provide a foundation for lifelong learning and working life, and to enable adults to update their key competencies through a coherent and comprehensive offer of lifelong learning and continuing education. All these aims contribute to the development of a better future with environmental, social, and economic impacts [2].

The focus on the acquisition of competencies, which has progressed since its inception, is also becoming apparent at universities through a shift from input to output orientation. The focus is, thus, increasingly on the learning outcomes, i.e., the competencies and qualification goals, which are designed in the module manuals of the study programs [3]. This is underlined by the German Qualifications Framework for Lifelong Learning published in 2011, which describes achieving reliability through quality assurance and development and promoting the orientation of qualification processes to learning outcomes ('outcome orientation') as per the working group 'German Qualifications Framework' [4], giving more (institutional) weight to the social mission of lifelong learning.

The working group 'German Qualifications Framework' is the body through which all relevant stakeholders in general education, higher education, initial and continuing vocational education and training, social partners, business organizations, as well as other experts from academia and practice are involved in the development and implementation process of a qualifications framework [4].

If these premises are transferred to the field of entrepreneurship research at universities, the question arises as to how the competencies of students in the field of entrepreneurship for successful business development can be automatically determined, measured, and evaluated after or during their studies in order to develop the required goals and potentials in the field of educational entrepreneurship development and to strengthen the potential of young company founders from the ranks of students with strong application skills.

Based on an intensive literature review in the field of competency assessment and entrepreneurship education (EE), it becomes clear—considering the works of Grewe and Brahm [5], Retzmann and Hausmann [6], and Postigo et al. [7], in conjunction with the research gaps in these works—that it must be possible to extract relevant competencies from the field of entrepreneurship and create a competency profile from this. In addition, Postigo et al. [7] suggests the need to create an expanded competency assessment instrument regarding the prediction of entrepreneurial behavior and further entrepreneurial intentions in German rural regions, like Lower Franconia.

The studies by Bae et al. [8], Bakheet et al. [9], do Paço, A. M. F. et al. [10], Mohamad et al. [11], Nabi et al. [12], Rusko et al. [13] and Kozlinska et al. [14] described the effects of EE on the entrepreneurial activities and aspirations of students and partly substantiated these with descriptive statistical methods. Bakheet et al. [9], do Paço, A. M. F. et al. [10] developed questionnaires based on Azjen's theory of planned behavior (TBP) [15]. Mets et al. [16] developed a self-assessment questionnaire based on the 'generic' entrepreneurship competence model-*EntreComp: The Entrepreneurship Competence Framework* by Bacigalupo et al. [17], which was expanded to include the scope of entrepreneurial process competence. The results of the two tests showed a small impact on the positive intentions of founding a company by taking part in individual entrepreneurial courses.

Evaluating the *Special Issue* section of EE by Mets et al. [18] and, therefore, regarding the context of past pandemics and the current green transformation, developing the competencies of modern economies continues to play an essential role, but apart from the generic approach, one should consider a more dynamic and adaptable approach [19–21].

In view of all this, there is a consensus that university courses/modules need to focus more on entrepreneurial skills. However, these must first be determined empirically. Bakheet et al. [9] and Nabi et al. [12] also call for a meaningful and sustainable implementation of competencies in the curricula of (higher) education institutions. Furthermore, this study should pave the way for the "deeper insights into students' profiles and learning" called for by Kozlinska et al. [14] by identifying not only subject-specific competencies but also linking the group of generic competencies in an overall framework.

In order to extend the issue toward an automated competence assessment, the developed competence model and the self-assessment test developed from it can be integrated into a learning management system (LMS). The system can be supported by the automatic processing and integration of the generated data using educational data mining (EDM) and artificial intelligence (AI), providing direct and individualized feedback for students in the form of intelligent competence profiles with the help of various tools (e.g., chatbots; AI tutors [22]).

2. Methodology

Based on the research gaps identified in the literature review, the aim was to create a competence profile from the field of entrepreneurship as a first step. This goal was generated in each case with the help of a guideline-based expert interview [23].

The interviews were fully transcribed [23]. The evaluation of the transcribed information was carried out by means of qualitative content analysis according to Mayring and Fenzl [24]. In more detail, the deductive category application method was applied with regard to structuring content analysis. For this purpose, a category system was created in advance with regard to the definition of competence, according to Weinert [25].

After performing this content analysis and developing a competence framework that focused mainly on competencies in the field of engineering gained from the industry and the region of Lower Franconia, it was then consistently placed in the university context, and an initial skills profile was created from the categorized collection compiled. Figure 1 shows the overview and steps guided expert interviews and founder self-test regarding to define the competence profiles. This divides competencies into professional and interdisciplinary competencies. The professional competencies include professional knowledge and methods as well as their applications (cognitive and functional competency dimensions), which are necessary to master professional tasks [25]. Following [3], the interdisciplinary competencies were further subdivided into methodological and action competencies, with the action competencies in turn being divided into social and personal competencies (see Figure 2).

For a clear understanding of each gained competence, and as a starting point for further steps regarding the creation of a self-assessment test, a definition was established for each competence term.

Finally, the self-assessment test was constructed in the form of a questionnaire according to Bühner [26] and Bortz and Döring [27]. The empirical examination of the test design (the distribution analysis and item analysis (reliability)) as well as a specific examination of the theoretical structure of the self-test by means of confirmatory factor analysis (CFA) will be discussed in the following.

The questionnaire consists of 85 items and covers the four founding competency categories of professional competencies, methodological competencies, social competencies, and personal competencies, as theoretically justified in the developed competency profile. Each competence category is further subdivided into the associated founding competencies (GK) from the competence catalog. In some cases, some GKs contain further subdivisions into several items. This procedure serves as feedback or confirmation of the formulation of

the GK, whereby a deletion of one or more items in the Model-Fit cannot be ruled out if the variances of these items are too high [28].

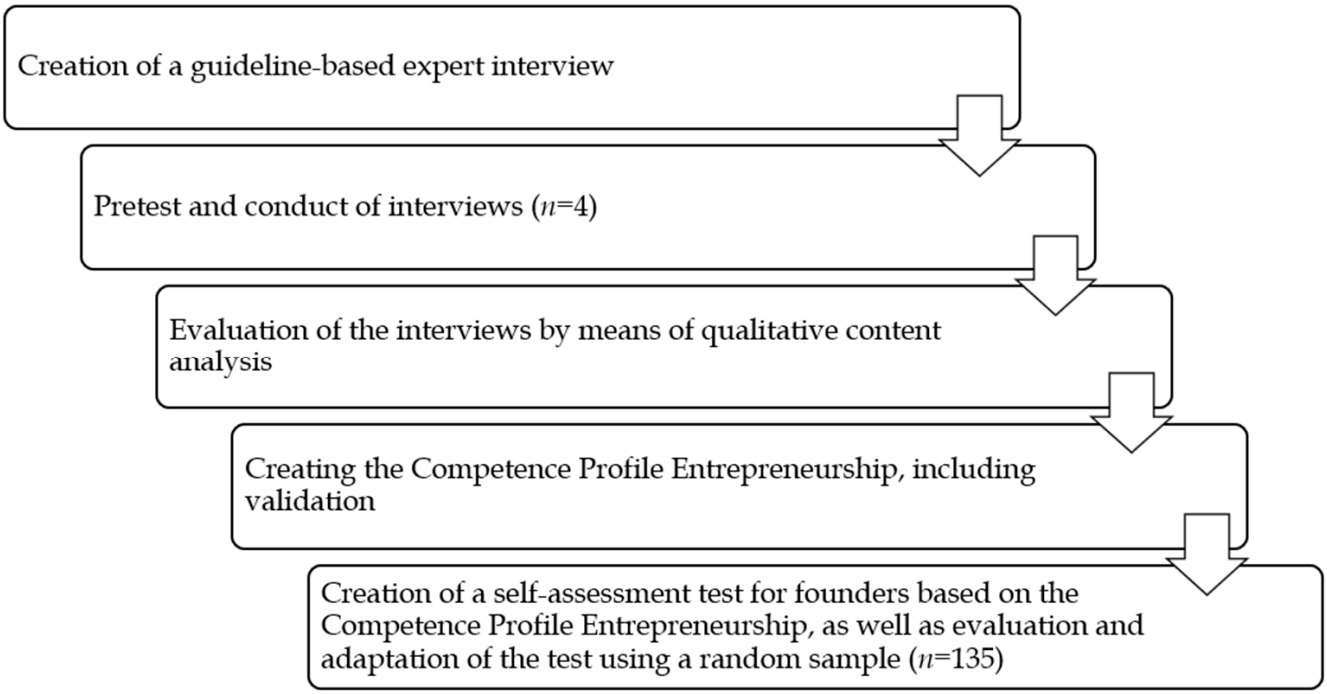

Figure 1. Overview of the methodology used.

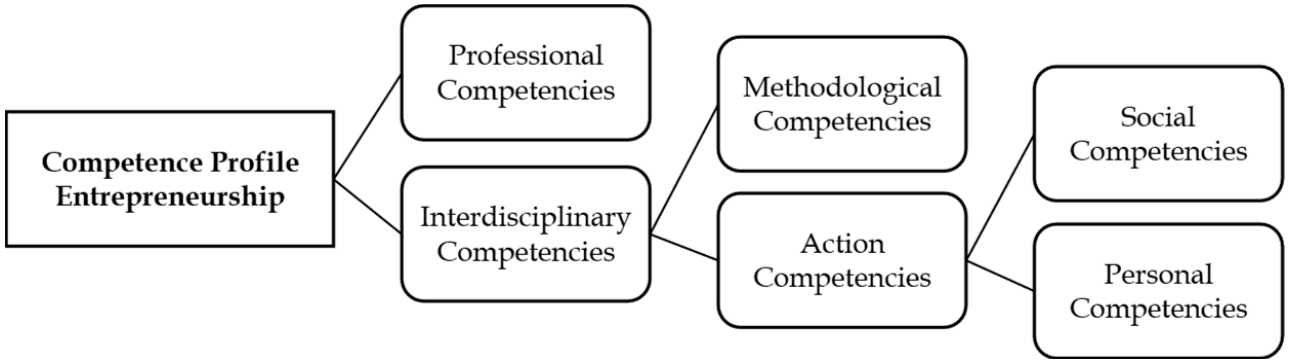

Figure 2. Classification of the entrepreneurship competence profile.

Thus, the professional competence category comprises 15 items with 10 competencies; the methodological competencies category comprises 17 items with 12 competencies; the social competencies category comprises 19 items with 11 competencies, and the personal competencies category comprises 34 items with 23 competencies. The weighting of the respective competencies corresponds to the number of mentions of the competency in the interviews and is intended to serve as a quality criterion in the subsequent test adaptation. The matrix of items or questions and the associated founding competencies (GK) are shown below (see Figure 3). The complete questionnaire in its survey form can be found in Appendix A Table A1.

Competence category			Competence	Competence Catalog	Item-No.			Question-No.			Number of items	Number of items / Category	Weighting (1-4)
Professional Competencies			Individual professional skills	GK22	GK22-1	GK22-2		22	67		2	15	4
			Business administration knowledge	GK5	GK5-1	GK5-2		5	59		2		3
			Basic legal knowledge	GK25	GK25			25			1		3
			Business management	GK49	GK49			49			1		2
			Financial accounting	GK15	GK15			15			1		2
			Sustainable management	GK33	GK33-1	GK33-2		33	75		2		2
			Website creation / operation	GK52	GK52			52			1		1
			Data protection	GK6	GK6-1	GK6-2		6	60		2		1
			Marketing	GK31	GK31-1	GK31-2		31	73		2		1
			Foreign language skills (English)	GK17	GK17			17			1		1
Interdisciplinary Competencies	Methodological Competencies		Self-organization	GK46	GK46			46			1	17	4
			Decisiveness	GK12	GK12-1	GK12-2		12	61		2		3
			Ability to prioritize	GK38	GK38-1	GK38-2		38	80		2		2
			Problem solving ability	GK39	GK39			39			1		2
			Adaptability	GK1	GK1			1			1		1
			Vision	GK53	GK53			53			1		1
			Diplomacy	GK7	GK7			7			1		1
			Consistent action	GK27	GK27-1	GK27-2		27	69		2		1
			Ability to transfer	GK48	GK48			48			1		1
			Ability to improvise	GK21	GK21-1	GK21-2		21	66		2		1
			Ability to reflect on results	GK13	GK13-1	GK13-2		13	62		2		1
			Profit-oriented thinking	GK19	GK19			19			1		1
	Action Competencies	Social Competencies	Networking ability	GK34	GK34-1	GK34-2		34	76		2	19	4
			Communication skills	GK26	GK26-1	GK26-2		26	68		2		3
			Empathy	GK11	GK11			11			1		3
			Critical faculties	GK30	GK30-1	GK30-2		30	72		2		2
			Leadership skills	GK18	GK18-1	GK18-2	GK18-3	18	65	85	3		2
			Cooperation	GK28	GK28-1	GK28-2		28	70		2		1
			Trust	GK51	GK51			51			1		1
			Attention	GK3	GK3			3			1		1
			Enthusiasm	GK4	GK4-1	GK4-2		4	58		2		1
			Story-telling	GK47	GK47-1	GK47-2		47	82		2		1
			Conveying values	GK54	GK54			54			1		1
		Personal Competencies	Open-mindset	GK36	GK36-1	GK36-2		36	78		2	34	4
			Curiosity	GK35	GK35-1	GK35-2		35	77		2		3
			Sense of responsibility	GK50	GK50			50			1		3
			Intrinsic motivation	GK24	GK24			24			1		3
			Willingness to work	GK2	GK2-1	GK2-2		2	57		2		2
			Flexibility	GK16	GK16-1	GK16-2		16	64		2		2
			Discipline	GK8	GK8			8			1		2
			Risk awareness	GK43	GK43-1	GK43-2		43	81		2		2
			Courage	GK32	GK32-1	GK32-2		32	74		2		2
			Willingness to take risks	GK42	GK42			42			1		2
			Ability for self-reflection	GK14	GK14-1	GK14-2		14	63		2		2
			Creativity	GK29	GK29-1	GK29-2		29	71		2		2
			Integrity	GK23	GK23			23			1		1
			Reliability	GK56	GK56-1	GK56-2		56	84		2		1
			Self-expression	GK45	GK45			45			1		1
			Self-confidence	GK44	GK44			44			1		1
			Willpower	GK55	GK55-1	GK55-2		55	83		2		1
			Resillience	GK41	GK41			41			1		1
			Realism	GK40	GK40			40			1		1
			Optimism	GK37	GK37-1	GK37-2		37	79		2		1
			Growth Mindset	GK20	GK20			20			1		1
			Emotional discipline	GK9	GK9			9			1		1
			Emotional intelligence	*GK10*	*GK10*			*10*			*1*		*1*

Figure 3. Overview of the basic model item matrix of start-up competencies (incl. the question assignment).

3. Implementation and Results

To enhance the scientific rigor of the validation process, various statistical analyses were employed to assess the reliability and validity of the self-assessment test of start-up competencies. The collected data underwent scrutiny to ensure the robustness of the measurement instrument.

First of all, basic demographic information of the participants, such as gender and age group, was analyzed to identify potential biases in the sample (n = 135). Understanding the demographic characteristics of the respondents is essential for generalizing the findings to broader populations and ensuring the test's applicability across diverse groups.

In order to examine the influence of gender and age on the willingness to start a business in the sample size, a chi-square test for independence was carried out in each case. The frequencies of the combinations of gender and age groups with the willingness to start a business were examined. After performing the chi-square test for independence for gender, a chi-square value of approximately 0.221 was obtained. With a significance level of 0.05 and 1 degree of freedom, this results in a critical chi-square limit of 3.841. The subsequent chi-square test for independence for the age group resulted in a chi-square value of approximately 3.093. With a significance level of 0.05 and 44 degrees of freedom, this results in a critical chi-square limit of 9.488.

As the chi-square values calculated in each case are smaller than the critical chi-square limit, there is no significant correlation between the gender or age group and the willingness to start a business in this sample group.

In addition to basic statistical values, the willingness to find a company was also queried at the beginning. Here, 4 people stated that they had already set up a business (2.96%), 42 people said they were not willing to set up a business (31.11%), 54 people were not sure about their willingness to set up a business (40.00%), 32 people could imagine setting up a business in the next five years (23.71%), and 3 people were willing to set up a business in the immediate future (2.22%).

All students at the Technical University of Applied Sciences Wuerzburg Schweinfurt were given the opportunity to participate in the online survey. Furthermore, the online survey was conducted on the web-based social network LinkedIn in order to reach actors from the field of entrepreneurship. The survey duration of the sample was 14 days. In total, the sample consisted of 135 complete questionnaires (the possibility of submitting an incomplete questionnaire was excluded from the implementation methodology).

Bühner [26] described a minimum sample size of n = 100 for a reliable estimate of reliability. It should be mentioned that small numbers of test subjects produce high sampling errors, which can distort correlations to the contrary [26]. The influence of a significantly higher desirable sample size will be taken up again in further discussion.

The data collected from the online survey and LinkedIn outreach were subjected to rigorous statistical scrutiny using specialized software tools.

This approach not only bolstered the credibility of the findings but also facilitated the identification of potential areas for refinement in the self-assessment test.

The internal consistency of the test was evaluated using Cronbach's alpha coefficient, a widely accepted measure of reliability. This analysis aimed to assess how consistently the test items measured the intended construct of start-up competencies. A high Cronbach's alpha value indicates a strong internal consistency, suggesting that the test items measure the same underlying trait [29].

Furthermore, factor analysis was conducted to explore the underlying structure of the self-assessment test. Factor analysis helps identify the latent factors or dimensions that contribute to the observed variance in responses. This step is crucial for establishing the construct validity of the test by confirming that the items indeed measure the intended competencies and not unrelated factors.

To determine the external validity of the self-assessment test, correlations with existing validated measures of entrepreneurial skills and performance were examined. This involved comparing the scores of the newly developed test with those of established assessments to ascertain whether the test effectively captured unique aspects of start-up competencies.

In conclusion, the empirical validation process involved a multifaceted approach, combining statistical analyses, factor exploration, and external comparisons. These scientific methodologies not only substantiated the reliability and validity of the self-assessment test of start-up competencies but also provided a methodologically sound foundation for subsequent research endeavors in the field of entrepreneurship.

With regard to the distribution analysis, Mardia's test was performed to test the multivariate normal distribution for each competence category. These must all be rejected due to the high sensitivity of the test and the high number of items in each category (see Table 1, values for Model-Fit (values for the basic model in brackets)). In this case, it is recommended to use a Q-Q diagram or a histogram for comparison [30–32].

In further observation of the respective histograms and Q-Q plots (see Figure 4), however, a normal distribution can be determined in each case. The generic competency groups (methodological, social, and personal competencies) have a slightly left-skewed normal distribution. The professional competencies, with their predominantly negative kurtosis values, exhibit a flatter normal distribution.

Table 1. Characteristic values for the distribution, item, and reliability analysis for the Model-Fit (values for the basic model in brackets).

Competence Category	Distribution (Mardia-Test)				Item Analysis & Reliability			
	Test Statistics Skew	Test Statistics Kurtosis	*p*-Value Skew	*p*-Value Kurtosis	Item Count	Cronbachs Alpha	Mean	SD
Professional Competencies	223.5975 −1006.948	1.4413 −6.7516	0.00162 (<0.001)	0.14949 (<0.001)	9 (15)	0.84 (0.89)	4.4 (4.6)	1.40 (1.30)
Methodological Competencies	234.1054 −1542.223	8.4876 −10.4229	<0.001 (<0.001)	<0.001 (<0.001)	7 (17)	0.83 (0.91)	5.9 (5.9)	0.94 (0.90)
Social Competencies	128.3315 −2358.884	3.8403 −13.8921	0.13268 (<0.001)	<0.001 (<0.001)	6 (19)	0.78 (0.91)	5.9 (6.1)	1.10 (0.89)
Personal Competencies	123.0877 −9794.663	1.4508 −15.7811	0.60924 (<0.001)	0.14683 (<0.001)	6 (34)	0.83 (0.95)	5.8 (6.1)	1.10 (0.88)

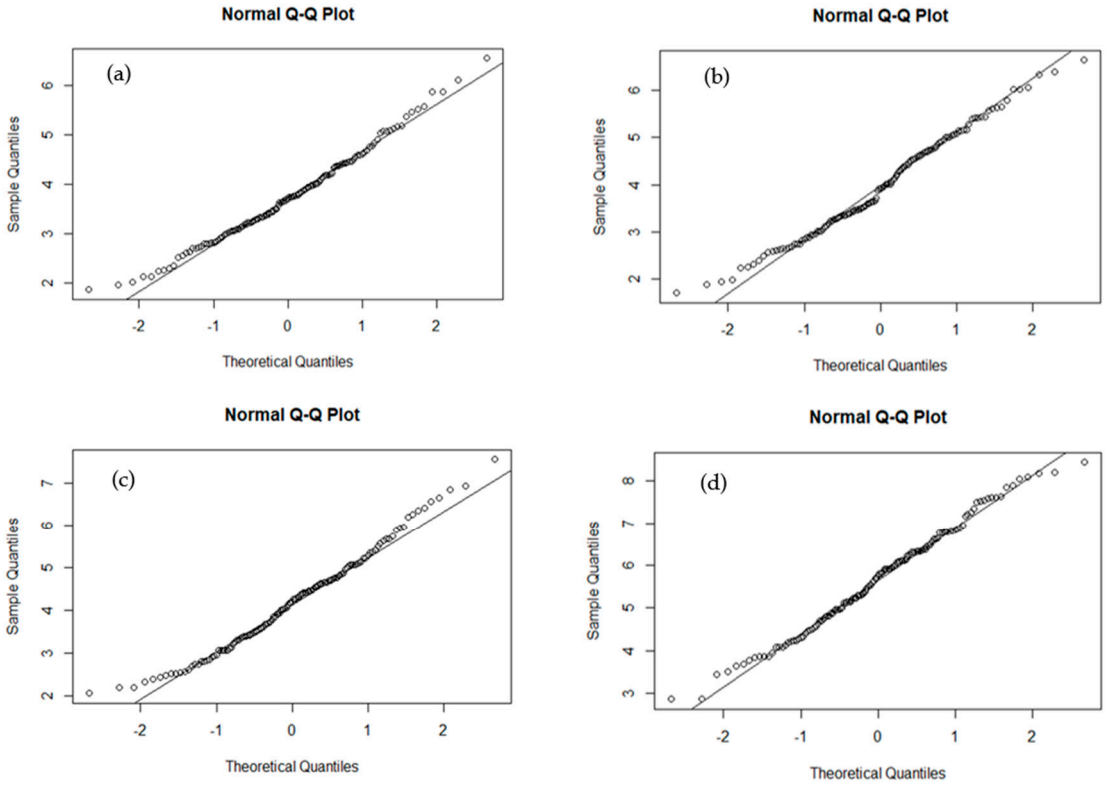

Figure 4. Overview of the normal Q-Q plots of the individual competence categories in the basic model; (**a**) professional competencies, (**b**) methodological competencies, (**c**) social competencies, and (**d**) personal competencies.

To fortify the item and reliability analysis, a detailed examination of each item's selectivity within its assigned competence category was conducted. The results indicate a favorable trend, with the majority of items demonstrating good to very good selectivity. This implies that the items effectively capture and reflect the nuances of their respective competence categories. The robustness of this reflection was further substantiated through the calculation of Cronbach's alpha coefficients, as outlined in Table 2, with values for the Model-Fit presented alongside those for the basic model in brackets.

Table 2. Resulting key values for the performed CFA of the Model-Fit (values for the basic model in brackets).

CFA—Estimation Method MLR (ML Robust)						
	Chi2 Test Statistics	**df**	***p*-Value**	**CFI**	**RMSEA**	**SRMR**
Professional	34.911	27	0.141	0.978	0.047	0.051
Competencies	(223.542)	(90)	(0.000)	(0.824)	(0.105)	(0.092)
Methodological	22.471	14	0.069	0.964	0.072	0.048
Competencies	(266.540)	(119)	(0.000)	(0.833)	(0.096)	(0.080)
Social	14.915	9	0.093	0.963	0.075	0.046
Competencies	(371.371)	(152)	(0.000)	(0.755)	(0.103)	(0.086)
Personal	16.069	9	0.065	0.963	0.079	0.045
Competencies	(1242.474)	(527)	(0.000)	(0.684)	(0.106)	(0.092)

Cronbach's alpha values exceeding 0.9 suggest a high degree of internal consistency within the test items. However, such high values may also indicate potential redundancy among items. Addressing this concern, particularly within the personal competence category, it might be prudent to consider reducing the number of items. This aligns with the recommendation of Bühner to put forth [26] to optimize the psychometric properties of the assessment tool.

Moreover, the identification of individual items exhibiting conspicuous characteristics provides an additional layer of refinement to the analysis. These standout items can be incorporated into a comprehensive Model-Fit assessment, allowing for a more nuanced understanding of their impact on the overall construct validity. This iterative process ensures that each item contributes meaningfully to the measurement of start-up competencies, enhancing the discriminant power of the test.

In conclusion, the meticulous scrutiny of item selectivity, coupled with the consideration of Cronbach's alpha values and the potential presence of redundant items, highlights the commitment to refining the self-assessment test. The incorporation of established guidelines, underscores the dedication to methodological rigor. By addressing these nuances, the assessment tool not only becomes more reliable but also better aligned with the intricacies of the entrepreneurial competence categories under investigation.

Finally, a confirmatory factor analysis (CFA) of the test model was conducted. In this case of the basic model, all four competence categories, i.e., all latent variables, show a high Chi2 test statistic with a high number of degrees of freedom (see Table 1, values for Model-Fit (values for the basic model in brackets)). This increases with the higher item number of the competence category. In the case of self-competencies, this is, in addition to the very high Cronbach's alpha value, a further indication that the number of items in this competency category is probably too high. The resulting *p*-value of the significance test is 0.000 for all four latent variables and, thus, below the limit of 0.05. Consequently, the null hypothesis must be rejected; the theoretically established model of the covariance matrix does not correspond to the empirically established model.

If we consider the available fit indices in Table 1 for the basic model, we find that for all four competence categories, the CFI (comparative fit index) should be >0.90, the RMSEA (root mean square error of approximation) should be <0.08, preferably <0.05, and the value of SRMR (standardized root mean square) should be <0.08), which have to be rejected. This may be due to the fact that, among the other things already mentioned, this value does not take into account the complexity of the model [26].

Consequently, the model created for the self-test must be rejected in the context of the CFA based on the available criteria. One possible cause for this may be that the sample size is too small. Bühner [26] describes estimation problems with a too-small sample and mentions values of N > 200 and better N > 250 as a basis for a stable CFA. Furthermore, too many items per variable in combination with a small sample can lead to inaccurate and uncertain results [33].

Since time constraints prevented the generation of a new, larger sample for a Model-Fit, an adjustment of the model, which included the recommended measure of reducing the number of items in the individual competence categories, was carried out. Decision criteria for the deletion of an individual item are the weighting of the item, the subjective relevance for the competence test, statistical parameters of skewness and kurtosis, selectivity, as well as factor loading.

In the resulting Model-Fit, the number of items for the competency category of professional competencies has, thus, decreased from 15 to 9, that of methodological competencies from 17 to 7, that of social competencies from 19 to 6, and that of personal competencies from 34 to 6 (see Figure 5).

Competence category			Competence	Competence Catalog	Item-No.	Question-No.	Number of items	Number of items / Category	Weighting (1-4)
Professional Competencies			Individual professional skills	GK22	GK22-2	67	1	9	4
			Business administration knowledge	GK5	GK5-1	5	1		3
			Basic legal knowledge	GK25	GK25	25	1		3
			Business management	GK49	GK49	49	1		2
			Financial accounting	GK15	GK15	15	1		2
			Website creation / operation	GK52	GK52	52	1		1
			Data privacy	GK6	GK6-1	6	1		1
			Marketing	GK31	GK31-1	31	1		1
			Foreign language skills (English)	GK17	GK17	17	1		1
Interdisciplinary Competencies	Methodological Competencies		Self-organization	GK46	GK46	46	1	7	4
			Decisiveness	GK12	GK12-1	12	1		3
			Sustainable management	GK33	GK33-1	33	1		2
			Problem solving skills	GK39	GK39	39	1		2
			Vision	GK53	GK53	53	1		1
			Consistent action	GK27	GK27-2	69	1		1
			Ability to improvise	GK21	GK21-2	66	1		1
	Action Competencies	Social Competencies	Ability to network	GK34	GK34-2	76	1	6	4
			Communication skills	GK26	GK26-1	26	1		3
			Empathy	GK11	GK11	11	1		3
			Leadership skills	GK18	GK18-2	65	1		2
			Cooperation skills	GK28	GK28-2	70	1		1
			Story-telling	GK47	GK47-1	47	1		1
		Personal Competencies	Flexibility	GK16	GK16-2	64	1	6	2
			Discipline	GK8	GK8	8	1		2
			Courage	GK32	GK32-1	32	1		2
			Willingness to take risks	GK42	GK42	42	1		2
			Creativity	GK29	GK29-1	29	1		2
			Self-confidence	GK44	GK44	44	1		1

Figure 5. Overview of the Model-Fit item matrix of start-up competencies (incl. the question assignment).

Regarding data from the present sample, the described test-fit criteria were performed again for the newly fitted model. Looking at the newly performed CFA in the Model-Fit (see Table 2), all criteria (CFI, RMSEA, SRMR) can be accepted for the newly set up model. This is most likely due to the extensive reduction in the number of items per competency category. Thus, this model does not represent all of the competencies developed in the original founders' competency profile.

4. Discussion and Limitations

There is evidence in the literature that people often misjudge themselves with regard to their professional competencies. For a precise determination of professional competencies, written tests are usually considered in combination with the listed competency assessment for more precise queries of these competencies [34].

This study aims to automate the assessment of entrepreneurship competencies, especially to improve entrepreneurial awareness and behavior in the university context. The perception of entrepreneurship varies widely among students. This study shows that students with international backgrounds are significantly more motivated to pursue an entrepreneurial orientation. The significantly higher number of international students in the courses offered confirms this. As far as the entrepreneurial behavior factor is concerned, we see an even distribution between national and international students. The authors see a great need in the area of student competence management to measure, compare, and increase students' entrepreneurial competencies, awareness, and behavior.

Every competence consists of the element's knowledge, skills/abilities, motives, and emotional dispositions. For a competence diagnosis, this means that a detailed competence

assessment can only be carried out by using different procedures, each of which covers different elements [35].

With reference to the predominant capitalist economic system, one would assume that an ideal 'typical' start-up profile fully expresses all competencies. Accordingly, the question arises as to which profile can be considered bad or good. If we now look at the self-test or the graphical representation of the results (see Figure 6), we will assume that a participating person with maximum values in each competence must be described as a perfect founder. Knowing well that this is a self-assessment test, this theoretical perfect profile is unlikely to be found in reality. This is also illustrated by the following competence profile (Figure 6) of a single person in entrepreneurship who has recently founded a company—one that is already successfully established (Figure 6; the competence profile here still refers to the original/basic model).

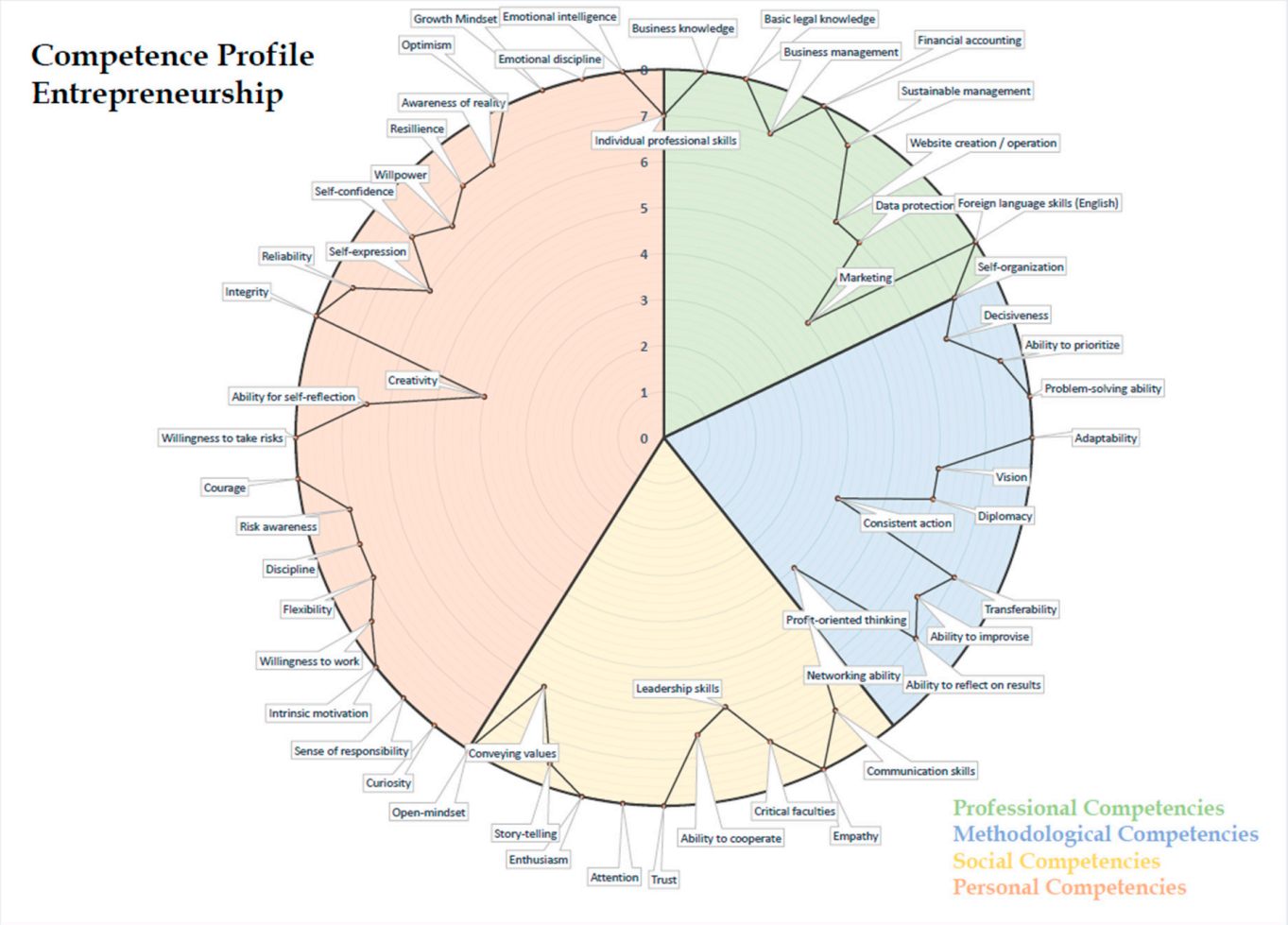

Figure 6. Graphical representation of one sample of the entrepreneurship competence profile after performing the self-test, basic model.

As already described, it is almost impossible to completely fulfill all the competencies queried here. Furthermore, it should be noted that it is not mandatory to fulfill a 'perfect start-up profile' in order to start and (successfully) establish a company.

The developed competence profile sees itself more as an instrument for self-reflection. Where does the founder stand? What areas of competence should be improved? Where are their strengths and weaknesses? These insights can be highly relevant in advance. Consequently, the question of finding a company on one's own or, if the situation allows it, finding a company with another person with whom missing or weak competencies can be

supplemented arises. The developed self-test can, therefore, be a very good starting point for targeted competence matching with regard to a business start-up. This option holds very high potential in the context of a university environment and fosters collaboration and networking among students regardless of their cohort, which, in addition to the sustainable development of a start-up network, promotes start-up activities per se. Another limitation is that the study was conducted in a German rural area and at a small university.

The heterogeneous starting positions due to different prior knowledge and cultural backgrounds increase the need for individualized learning opportunities.

The project addresses these challenges and uses individualized, AI-supported learning paths in a digital learning environment along the entire innovation process, offering tailor-made entrepreneurship education. The focus is on identifying and promoting individual learning needs. In addition to business and technical knowledge in the field of prototyping, the program also focuses on the start-up mindset, team personalities, green skills, and intercultural competencies.

In the future, students will be offered individual, AI-supported learning nuggets in various learning spaces as part of the innovation process in order to close the relevant knowledge gaps. The result is an individual learning journey for self-taught and, if required, guided acquisition of competencies in the field of entrepreneurship.

Through the holistic, integral approach of personality-building factors, business management, and technology, based on individual skills, an innovative qualification system in the field of innovation will be developed.

5. Conclusions and Further Research

Consequently, the main reasons for rejecting the original test/basic model were a small sample size and an excessive number of items per latent variable. The influence of a higher sample size on the original test is still unknown. The first item of further research on the self-assessment test would be to examine the original test with a sample size of $N > 250$, with regard to validation.

However, with the adapted Model-Fit, it was possible to create a reliable and valid (empirically based) instrument for assessing competencies in the field of entrepreneurship. This can be used at different points in time during the course of the study (at the beginning of the study; at regular intervals, such as the beginning and end of the semester; and at the end of the study), from which a competence development with regard to a start-up profile can be derived. These developments, considered individually or for an entire cohort, can play an important role in co-designing module curricula. Furthermore, the self-test can also be used for actors outside the university environment, e.g., for people who are about to start a business or people who want to acquire competencies in the long term outside a university environment, or, as already mentioned in the previous section, in the aspect of targeted competence matching, in order to close competence gaps in a targeted manner and, thus, promote the joint establishment of companies by several people. Furthermore, this can promote the targeted expansion of a founder network and entrepreneurship activities itself.

With the increased focus on the targeted and periodic use of these self-tests in the field of entrepreneurship education in a university environment, interdisciplinary competencies, such as teamwork, creativity, or problem-solving skills can be better examined with the integration of self-tests in addition to the assessment of cognitive skills in the form of module knowledge.

The inclusion of adaptive test methods, especially in conjunction with artificial intelligence and big data integrated with an LMS, could make it possible to adapt self-tests to the individual abilities and needs of the test subject. This would enable a more accurate and efficient assessment, including the potential for long-term validity of the self-test. This validity and stability could be continuously optimized by developing new items or adapting existing items to current competence standards and concepts.

As mentioned earlier, with the interplay of all these means, the opportunity can be seized to focus future research on automated and personalized development plans based on

the results of constantly optimizing self-tests, helping founders work specifically on their identified development areas and improve their entrepreneurial skills up to and beyond the start-up.

Nevertheless, the developed self-test and the associated skills monitoring represent the starting point for further research. Augmentation strategies and special educational data mining (EDM) methods can be used to support systematic data evaluation, aiming to make the documented skills assessment intelligent and automated in the long term [30].

The development of a possible process architecture, as illustrated in Figure 7, with suitable data migration, as well as the selection of suitable EDM methods or AI algorithms, with possible embedding in an LMS, can be part of consecutive research. A long-term goal of this further applied research should be the development of an intelligent competence profile, which, with the help of a self-sufficient AI-based application, such as a chatbot or an intelligent and visualized feedback tool, should make competence monitoring, including the graphically displayed competence profile, a very effective and sustainable tool for competence assessment in the field of entrepreneurship at universities.

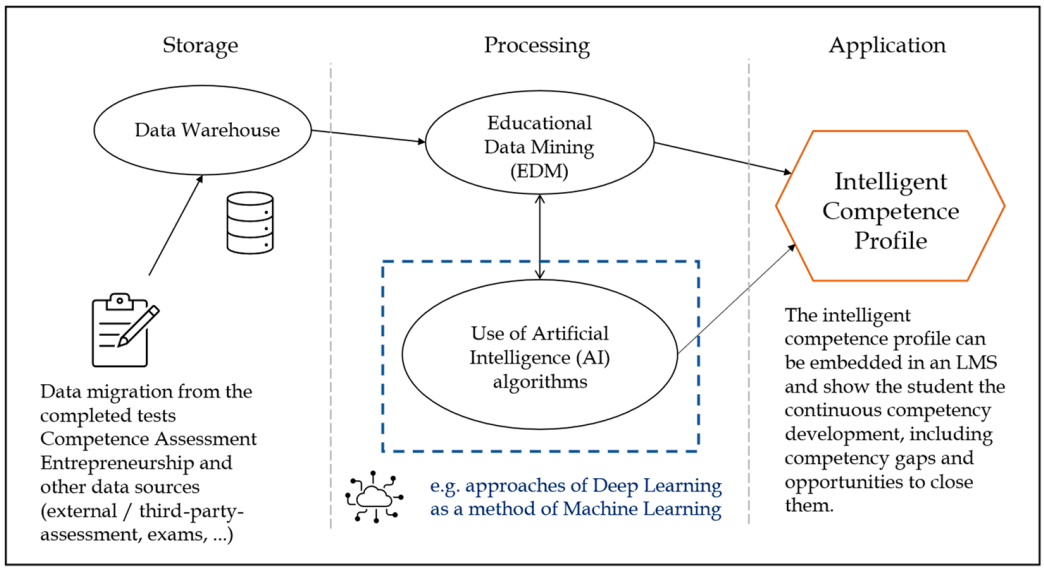

Figure 7. Possible architecture of a process for automatic intelligent data processing in the education sector.

The envisaged trajectory for students to enhance their competencies through targeted acquisition via elective and compulsory elective modules, coupled with regular competence tests, presents a promising avenue for fostering entrepreneurial skills. This proactive approach aligns with contemporary research perspectives, as evidenced by the studies of Algarni [36], Baradwaj and Pal [37], and Seufert et al. [38]. These scholars have underscored the significance of structured interventions in competency development for aspiring entrepreneurs.

By integrating continuous intelligent evaluation into this educational framework, a symbiotic relationship between competence orientation and entrepreneurship education can be forged. The insights gained from regular assessments can inform personalized learning pathways, enabling students to address specific competence gaps systematically. This dynamic process, if successfully designed and implemented, holds the potential to propel current research in the field to new heights.

This study aims to automate the assessment of entrepreneurial competencies, especially to improve entrepreneurial awareness and behavior in the university context. The limitations lie in the individual foundations of the students. Therefore, the way forward must be to first identify the individual basic skills and then derive customized teaching and learning pathways. This measure can only be implemented on a large scale with the support of software solutions. This is why anticipate automated and personalized learning support in the future through self-tests, avatars, learning recommendations, and gamified, participation-oriented learning and education concepts.

The automation of skills development represents a paradigm shift in which skills are developed in a more adaptive and personalized way. There are plans to conduct further studies and develop models in the area of individual learning assessment with adaptive learning objectives and individual learning paths supported by personal learning assistants. Artificial intelligence algorithms such as deep learning or reinforced learning will be used. The Technical University of Applied Sciences Wuerzburg Schweinfurt is very well positioned in this respect with the Institute of Digital Engineering and the AI Node Centre of Artificial Intelligence and Robotics. This approach is not only in line with current educational trends but it also has the potential to significantly improve the teaching of entrepreneurial thinking and behavior at the university level. The lasting impact of this initiative goes beyond the development of individual skills and can have an impact on the development of a wider entrepreneurial network. This further development is also a crucial basis for increasing the future viability of the region. In summary, the envisioned strategy of integrating targeted modules, competence tests, and continuous intelligent evaluation not only aligns with the latest research insights but also holds the promise of revolutionizing the landscape of entrepreneurial education. The synthesis of these elements can contribute to a more dynamic and responsive educational framework, fostering the holistic development of entrepreneurial competencies and catalyzing advancements in both research and practical applications within the entrepreneurial ecosystem.

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Appendix A

This questionnaire is a self-assessment test based on the entrepreneurship competence profile. The scale level of the response describes a bipolar ordinal Likert scale. A ranking of 1 denotes “does not apply at all” and 8 means “fully applies”.

Table A1. Self-assessment test for the competencies of founders.

No.	Question	Answers via Dropdown (1 = Does Not Apply at All; 8 = Fully Applies) Evaluation (1–8)
0.1	What age group are you in? (<18/18–25/26–34/35–45/>45)	
0.2	Which gender do you belong to? (f/m/d)	
0.3	Do you have the intention to find a company? (Yes, now/Yes, in the next five years/Maybe/No/Already established)	
1	I can adapt well and quickly to (difficult) personal and social situations and participate.	
2	I can implement upcoming tasks quickly, properly, and with great benefit.	
3	It is easy for me to direct my consciousness to certain influences from the environment in order to select and perceive specific information.	
4	I can get excited about interesting topics.	
5	I have basic business management skills as well as knowledge in the areas of law, logistics, production, human resources, and corporate management.	
6	I know the contents of the DSGVO ("Datenschutzgrundverordnung"—German Data Protection Regulation) and can apply them in the context of a company.	
7	I find it easy to lead skillful discussions about negotiable issues with colleagues, superiors, business partners, or customers.	
8	I am able to guide myself to the desired target without any distractions.	
9	It is easy for me to focus on my colleagues in my work environment and to disregard emotions.	
10	I am able to recognize a person's emotions and respond to them in an adequate way.	
11	I find it easy to put myself in the position of others.	
12	I am able to make decisions immediately, while fully perceiving the different possible choices of action and deciding in a concentrated manner.	
13	I find it easy to reflect critically on results.	
14	I find it easy to fully reflect on my own actions in terms of self-criticism and self-assessment.	
15	I have knowledge about the preparation of a P&L statement, a closing balance sheet, as well as investment and liquidity planning, and I can translate these into time period comparisons between individual months, quarters, and fiscal years in the form of reports.	
16	I am able to adapt to unforeseen situations, changes, timelines, and outcomes.	
17	In a business context, I am fluent in written and spoken English.	
18	I find it easy to lead a team.	
19	I always base my business actions on achieving the highest possible monetary profit.	
20	I see challenges and problems as opportunities to develop myself, regarding my attitude, mindset, or mentality, and to learn something new.	
21	I find it easy to improvise.	
22	I know my product/service very well.	
23	I always comply with contracts and formal and informal rules when dealing with colleagues and business partners.	
24	I possess a will of my own and a passion to complete tasks on my own initiative, as well as a high degree of self-motivation.	

Table A1. *Cont.*

No.	Question	Answers via Dropdown (1 = Does Not Apply at All; 8 = Fully Applies) Evaluation (1–8)
25	I have basic knowledge of the legal aspects of setting up a business (e.g., choice of legal form; registration of a business and compulsory chamber of commerce; tax number and registration with the tax office; industrial property rights or licenses; entry in the commercial register; shareholdings, partnerships, and recruitment of employees; drawing up contracts) and can apply this knowledge.	
26	I find it easy to communicate with other people.	
27	Once I make a decision, I stick to it.	
28	I can work well with other people.	
29	I find it easy to create something that is new or original that is also useful or usable.	
30	I am able to give constructive criticism to others.	
31	I have the ability to sell a product or service with the best possible outcome (using various advertising and sales strategies).	
32	I am prepared to do what I think is right in the face of expected disadvantages.	
33	I am prepared to manage sustainably, as well as make planned decisions about the production, procurement, and use of scarce goods for the purpose of satisfying needs, taking into account future resource supplies and environmental conditions.	
34	I am able to develop and maintain a cross-company and social network (national and international).	
35	I have an interest in various new subjects, as well as curiosity and eagerness for knowledge about unknown phenomena.	
36	I am open-minded about new professional topics, ways of working, as well as new colleagues.	
37	I look at everything and everyone from the best side and always have positive expectations.	
38	I am able to prioritize tasks and actions according to their urgency and importance.	
39	I can solve existing problems systematically.	
40	I am able to perceive the current situation or reality in its (economic) environment without disturbance and to make clear decisions based on it.	
41	I emerge stronger from crises.	
42	I am willing to take risks.	
43	If I find myself in an (economically) dangerous situation, I act willingly and am aware of my risks.	
44	I am confident in my abilities and values as a person and present myself with self-assurance.	
45	I present my personality and characteristics to others in the most advantageous and intentional way possible.	
46	I can plan work tasks independently and effectively and keep track of all open tasks.	
47	I am able to communicate non-emotional content (information, knowledge, etc.) in the form of stories to listeners, readers, or viewers.	
48	I am able to reliably apply existing knowledge to different tasks and transfer it to new situations.	

Table A1. *Cont.*

No.	Question	Answers via Dropdown (1 = Does Not Apply at All; 8 = Fully Applies) Evaluation (1–8)
49	I have knowledge of business management and can apply it successfully. This, among other aspects, is divided into strategic (e.g., planning products; defining orientation; formulating visions; sounding out the market) and operational (e.g., personnel management; allocation of tasks; process optimization; location decisions; controlling) corporate management.	
50	I am able to take and bear responsibility for a project, for my co-workers, or a work process.	
51	I act trustworthy and can easily develop trust with other people.	
52	I have the ability to create and edit a website independently and to fix errors or malfunctions on my own. This also includes the legal context (imprint, DSGVO, online store).	
53	I am able to look ahead, recognize future developments and requirements, and correctly assess them at an early stage.	
54	I am able to communicate values (moral, social, religious, political, aesthetic, and material values) to others.	
55	I am characterized by my ability to overcome feelings of unwillingness, distractions, or other obstacles on the way toward achieving my goals.	
56	I keep agreements made with other persons or business partners.	
57	I consider myself to have a high willingness to work.	
58	When something impresses and interests me, it fills me with joy.	
59	I have the ability to evaluate business issues in the areas of macro and microeconomics as well as in the complementary topics of marketing, sales, and ratio evaluation.	
60	I can process and manage data in a company within the scope of the DSGVO ("Datenschutzgrundverordnung"—German Data Protection Regulation).	
61	I find it easy to make decisions, even if they are under complex circumstances; they are well elaborated.	
62	I am able to critically question results and process them against the background of professional correctness.	
63	I am able to self-critically reflect on my own actions.	
64	If topics change unexpectedly, it is easy for me to adapt to them.	
65	I am able to manage, encourage, and motivate employees with regard to their strengths and weaknesses.	
66	Under uncertain conditions (e.g., incomplete information), I can act fast, goal-oriented, and conceptually in complex situations.	
67	I am able to solve technical questions within my field of expertise in an impeccable and targeted manner.	
68	I find it easy to interpret messages such as facial expressions, gestures, and body postures correctly and react accordingly.	
69	My actions are always consistent and free of contradictions with inner cohesion.	
70	Towards others, I can create a mutually complementary and supportive community that is open to new things and ready to act.	
71	I am able to think originally, imaginatively, and creatively, as well as invent or create something that is new and useful, and that can be experienced sensually.	
72	I am able to accept and endure criticism of my own actions.	

Table A1. *Cont.*

No.	Question	Answers via Dropdown (1 = Does Not Apply at All; 8 = Fully Applies) Evaluation (1–8)
73	I have knowledge of sales management (including assessing the market environment to draw conclusions about customer needs, segmenting the market to identify target groups, and analyzing buying behavior) and can apply it successfully.	
74	I am ready to put myself in a dangerous situation with uncertainties.	
75	The aspect of sustainability at all levels plays a major role in my company.	
76	I find it easy to network with (new) business partners.	
77	I have the desire or the wish to gain new experiences and knowledge.	
78	I am open to new things.	
79	I possess a cheerful, confident, life-affirming, and active attitude.	
80	I make sure that high-priority tasks get done first.	
81	I can handle risky situations well.	
82	I generate interest among business partners or customers by communicating information to them as part of a storytelling process using speech, text, images, or videos.	
83	I am able to achieve my goals through perseverance (persistence), tenacity, determination, drive, robustness, and determination.	
84	I reliably perform my tasks.	
85	In order to achieve a goal, I attach importance not only to the result but also to the interpersonal process within the team.	

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