MATHEMATICS AND SCIENCE COMPETENCIES IN VOCATIONAL EDUCATION AND TRAINING (VET)

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MαnKobE
Mathematics and Science Competencies in Vocational Education and Training

With international large-scale assessments such as the Programme for International Student Assessment (PISA) the idea of a mathematical and scientific literacy has gained momentum as the overarching aim of mathematics or science instruction respectively. The Organisation for Economic Co-operation and Development (OECD) for example emphasizes the importance of mathematical and scientific literacy for social and vocational participation. The national educational standards for middle school mathematics and science instruction delineate the idea of a mathematical or scientific literacy for the German education system. They specify the competencies students are expected to have developed in these domains by the end of middle school (i.e., Grade 10). These competencies are believed to be particularly important for success in vocational training in science, technology, engineering, and mathematics (STEM) fields. There is, however, a lack of empirical evidence demonstrating that the mathematics and science competencies developed in middle school indeed play a significant role for successful vocational training in these fields.

Research on the transition from school to vocational training has largely focused on determinants of success that are not related to a specific subject. Sociological studies have examined the role of apprentices' social background and grades; psychological studies have shown the predictive validity of apprentices' final grades in school. Yet very few studies have investigated the importance of domain-specific competencies developed at school for success in vocational training. It was shown, however, that there is a large variation in apprentices' mathematics competencies at the beginning of their training. It is unclear whether and to what extent these differences decline over the course of vocational training, or if the gap rather increases. That is, detailed information is missing about the development of mathematics and in particular science competencies as students transition from school to the first phase of vocational training, as well as about the importance of those competencies for the development of vocational competencies and the successful completion of vocation training.

Objectives

In light of the need for research in this area, the project Mathematics and Science Competencies in Vocational Education and Training (ManKobE) aims to illuminate the role of mathematics and science competencies for successful vocational training. The project assesses mathematics and science competencies of apprentices in a variety of vocational training programs at the beginning of their training and the extent to which those competencies grow as training continues, and how that growth relates to growth in vocational competencies and thus also to a successful apprenticeship.
To analyze the interplay between mathematics and science competencies developed in school and vocational competencies developed during vocational training the project built on the model shown in Figure 1. This model distinguishes between school competencies in mathematics and science, vocation-related competencies in mathematics and science, and vocational competencies. School competencies in mathematics and science are developed prior to vocational training in school. Some of these competencies are directly applicable to the respective vocation in that they are needed to solve selected vocation-related problems. That is, they are vocation-related competencies in mathematics and science. Accordingly, they are amongst the competencies that apprentices are expected to develop during vocational training. Vocational competencies, however, also include competencies required to master vocation-specific tasks that cannot solely be mastered using competencies developed at school.

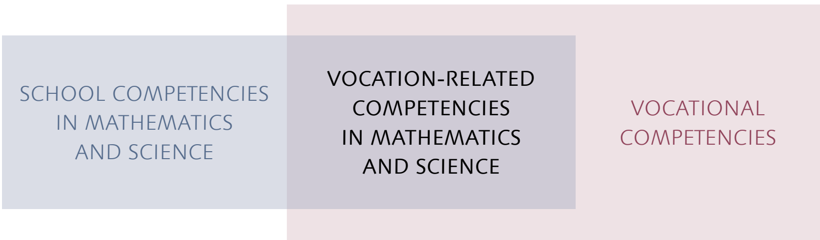

Figure 1. Structure of school and vocational competencies.

Based on this model, the ManKobE project aimed to answer the following questions:

1. What levels of school competencies in mathematics and science do apprentices exhibit at the beginning of vocational training?
2. To what extent have apprentices chosen fields that correspond to their levels of school competencies in mathematics and science?
3. To what extent do school and vocation-related competencies in mathematics and science grow over the course of vocational training?
4. How are school and vocation-related competencies in mathematics and science related?
5. What role do school competencies in mathematics and science play in the development of vocation-related competencies in these fields?
6. To what extent do school competencies in mathematics and science determine success in vocational training, above and beyond other factors?
7. To what extent do non-cognitive characteristics (e.g., personality traits and interests) contribute to success in vocational training?

Method

The empirical investigation of these questions requires a longitudinal design that can yield information on the development of individuals' school, vocation-related, and vocational competencies over the course of the first phase of training for occupations in which different mathematics and science are important. In ManKobE data were collected at four points in time. The first data collection took place at the beginning of vocational training (fall 2012), the second after approximately half of training had been completed (spring 2014), shortly before the first part of the final examination (formerly referred to as the intermediate examination). The third data collection took place during the third year of training, shortly before the second part of the final examination (spring 2015). The fourth and final collection of data after training has just been completed (fall 2016), which allows us to examine transitions into subsequent career phases (job market, university studies, etc.).

The sample included apprentices training for the following STEM occupations: clerk, industrial mechanic, electronic technician, automotive mechatronic engineer, and biology and chemistry lab assistant. These occupations were selected because they require different competencies in mathematics and the three natural sciences – biology, chemistry, and physics. To generate a sufficiently large sample of biology and chemistry lab assistants, at the beginning of the 2014 training year we added a second cohort that included medical technical assistants as well (see Figure 2).

Data on the cohort of chemistry lab assistants were gathered at three points, and data on the biology lab assistants and medical technical assistants at two points in time. Table 1 shows the composition of the sample by occupation. For each occupation the table provides the total number of apprentices training for this particular occupation, as well as the distribution across gender and International Standard Classification of Education (ISCED) level. In total, the sample comprised of *N* = 3 063 apprentices from the states of Baden-Württemberg, Bavaria, Hesse, Lower Saxony, and North Rhine-Westphalia (Table 1).

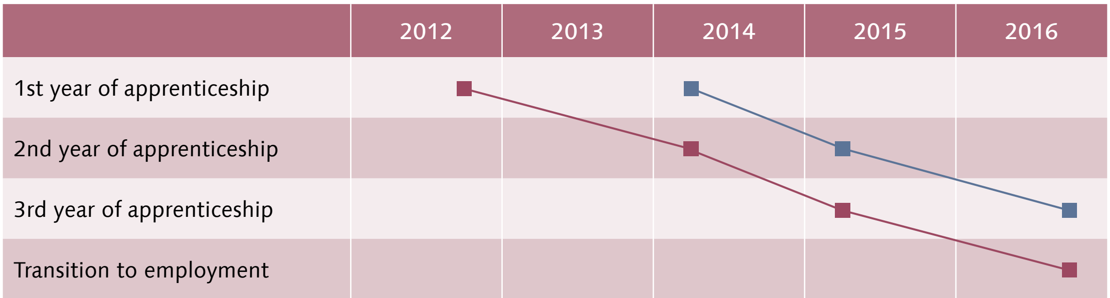

Figure 2. Design of the ManKobE project. The main cohort, consisting of apprentices training for careers as clerks or technicians, is shown in red. The supplementary cohort of biology and chemistry lab assistants is shown in blue.

Table 1. Composition of the Sample

	Gender		ISCED 2011 Level			
	♂	♀	Level 2, 9 years	Level 2, 10 years	Level 3	Total
Industrial mechanics	361	19	47	267	56	380
Automotive mechatronic engineers	511	20	201	239	55	531
Electronic technicians	391	6	130	213	34	397
Clerks	241	413	4	297	346	654
Chemistry lab assistants	255	271	2	181	339	526
Biology lab assistants	42	89	0	34	95	131
Biotechnical assistants	110	154	0	109	124	264
Medical technical assistants	20	160	2	35	140	180
Total	1 931	1 132	386	1 375	1 189	3 063

Note. ISCED: International Standard Classification of Education; ISCED Level 2, 9 years: lower secondary education (Hauptschulabschluss); ISCED Level 2, 10 years: lower secondary education (Mittlerer Schulabschluss); ISCED Level 3: upper secondary education (Abitur) ♂: male, ♀: female.

The apprentices completed an extensive questionnaire on their personal characteristics and took tests to assess their basic cognitive and language skills. We also administered tests to evaluate their school and vocation-related competencies in mathematics and science, as well as their vocational competencies. To measure school competencies in mathematics and science, we used the tests developed to benchmark the German national educational standards in mathematics and science for the end of middle school. Vocation-related competencies were assessed using tests that consisted of modified examination questions for the respective occupation from the chambers of skilled crafts and/or the chambers of industry and commerce. Problems were selected that test-takers should be able to solve based on the competencies they had acquired in middle school. To assess vocational competencies, we adapted tests from external partners active in the field of vocational education; we also created new tests. The project developed and validated an instrument to measure the vocational competencies of biology lab assistants. This instrument allowed us to assess their knowledge of responsible conduct, data management, and laboratory techniques.

Based on task analyses, we developed a test to assess the vocational competencies of chemistry lab assistants. Tasks requiring chemical synthesis, analysis, and general laboratory techniques were designed to correspond to prototypical task descriptions for laboratory assistants.

A notable feature of the ManKobE study is that all of the tests of school and vocation-related competencies were administered to all of the apprentices, no matter what their fields were. We were therefore able, for the first time, to compare domain-specific performance gains in different training programs, and thus also to estimate the impact of the first level of vocational training on various competency domains.

Gantner, S., Großschedl, J., Chakraverty, D., & Harms, U. (2016). Assessing what prospective laboratory assistants in biochemistry and cell biology know: Development and validation of the test instrument PROKLAS. *Empirical Research in Vocational Education and Training (ERVET)*, *8*(3).

Frank, C., Bernholt, S., & Parchmann, I. (2016). Modellierung des Zusammenhangs allgemeiner und beruflicher Kompetenz für die Domäne Chemie [Modeling the relation between general and vocational education in the domain of chemistry]. *Zeitschrift für die Didaktik der Naturwissenschaften*, *22*(1), 43–60.

Results

The data collected for the ManKobE project allow for a comprehensive treatment of the questions listed above. Below we present analyses of (a) apprentices' school competencies in mathematics and science as they begin vocational training, (b) growth in those competencies during the first phase of vocational training, and (c) the determinants of successful vocational training.

School competencies at the beginning of vocational training

To determine what levels of school competencies in mathematics and science apprentices in the ManKobE project had already developed by the time they began their apprenticeships, we compared their competencies with the results of the national assessment conducted in 2012 by the Institute for Educational Quality Improvement (Institut zur Qualitätsentwicklung im Bildungswesen, IQB), which assessed the school competencies of ninth graders in Germany's federal states.

Since the occupations included in the ManKobE study are closely connected to mathematics and science, we expected that apprentices who had completed *Hauptschule*, the least academically demanding school type in the German educational system, or an intermediate-level secondary school would exhibit higher levels of competency than the comparison group of (unselected) ninth graders. We expected to find a smaller gap between the group of apprentices who had graduated with a university-entrance qualification and the comparison group (ninth graders in the national assessment who were attending a *Gymnasium*, or academic track school), despite the age difference between these two groups, since students who do well in a Gymnasium typically choose to go on to university rather than to begin an apprenticeship.

The sample consisted of a total of $N = 2\,521$ apprentices enrolled in dual training programs who, at the time of the first data collection, had completed the tests that were administered to benchmark the German national educational standards, and they had provided information on their highest level of education and the type of school at which they had completed it. The apprentices, representing six occupations, were divided into three groups: chemistry and biology lab assistants (referred to below as LAB: laboratory occupations); industrial mechanics, automotive mechantronic engineers, and electronic technicians (referred to below as CTO: commercial and technical occupations, or technicians); and IC: industrial clerks. To assess the level of competency of the ManKobE sample, we used data from the IQB national assessment in Grade 9 to construct reference values for the entire sample as well as for subsamples

Retelsdorf, J., Nagy, G., & Köller, O. (in press). Lernausganslagen Auszubildender in Berufen mit hohen mathematisch-naturwissenschaftlichen Anforderungen [Initial achievement of trainees in vocations with high requirements in mathematics and science]. *Unterrichtswissenschaft*.

by type of school. Since the ManKobE sample for each vocational field differs by state, the reference values relate to specific groups of states. For CTO and IC, reference values were drawn from Baden-Württemberg, Bavaria, and Hesse. For LAB, values from Lower Saxony and North Rhine–Westphalia were included as well. To calculate the reference values, figures for the individual states were weighted by the size of the target population that was part of the national assessment. Differences across states are negligible, however, as shown in Figure 3.

Figure 3 shows the apprentices' levels of school mathematics and science competencies by vocational area, highest level of education, and type of school at which that education was completed. The pattern was similar across the four domains. In every domain, the ManKobE sample was approximately 50 points, or roughly half a standard deviation, above the respective IQB sample. The level of competency of the LAB sample was consistently highest; the advantage of the LAB sample relative to the reference sample was considerably greater in the natural sciences than in mathematics. School mathematics and science competencies of the IC group also consistently exceeded those of the IQB sample, while the competency levels of the CTO group were roughly equivalent to those of the IQB sample. Broken down by educational level, the members of the CTO and IC groups who had earned a university-entrance qualification (ISCED Level 3) were at approximately the same level as the Gymnasium students in the IQB comparison sample. An exception were the members of the CTO group who had graduated from a traditional Gymnasium, who outperformed the comparison group in physics. In these vocational fields, apprentices who had earned a general-education (Hauptschule; ISCED Level 2, 9 years of schooling) or intermediate-level secondary credential (ISCED Level 2, 10 years of schooling) showed a considerably higher level of competency than the members of the IQB comparison group. Regardless of their highest level of completed education, members of the LAB group reached considerably higher competency levels than the IQB comparison group.

Breaking these groups down further by the type of school at which they had completed their education, we find that when apprentices had earned a university-entrance qualification, it made a difference whether they had done so at a traditional Gymnasium or at some other type of school. Graduates of a Gymnasium consistently demonstrated a higher level of competency than graduates of other types of schools. The corresponding situation was similar for apprentices who had earned an intermediate-level secondary school credential, although the gap

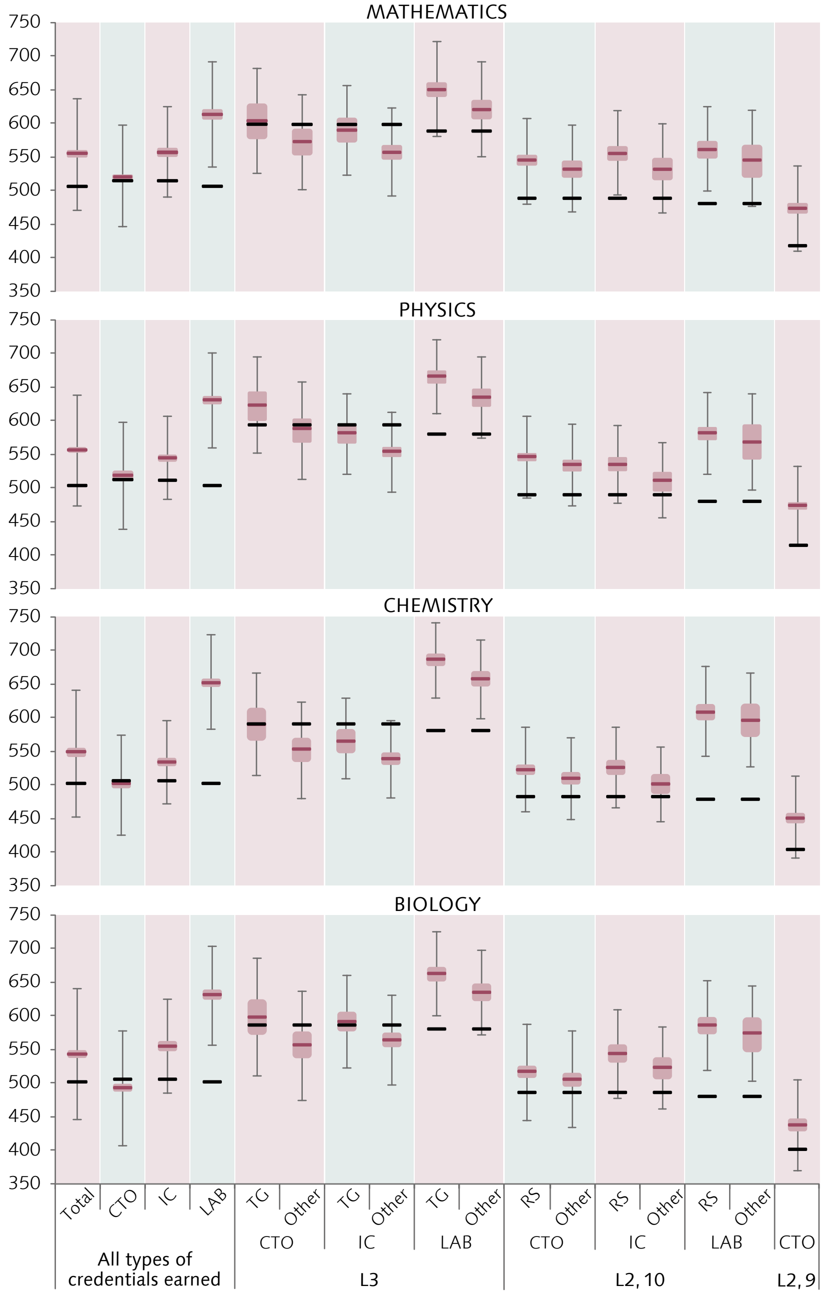

Figure 3. School competencies of the ManKobE sample by type of credential earned, type of school, and field of training, as compared with the results of the 2012 IQB state-level comparison (data only for the states from which the respective ManKobE sample was drawn). The figure shows the means, 95 % confidence intervals, and standard deviations for ManKobE. The horizontal lines show reference values from the IQB state-level comparison. CTO = commercial and technical occupations; IC = industrial clerks; LAB = laboratory occupations; L3 = ISCED Level 3; L2, 10 = ISCED Level 2, 10 years of schooling; L2, 9 = ISCED Level 2, 9 years of schooling; TG = traditional Gymnasium; RS = Realschule.

between students who had earned that credential at different types of schools was smaller than in the case of the students who had earned a university-entrance qualification at different types of schools. Those who had earned an intermediate-level secondary school credential at a traditional *Realschule* had a somewhat higher level of competency than those who had attained the same credential at a different type of school. The difference was particularly striking in the case of the IC group. In considering these results, however, it is important to note that breaking down the sample by school type created some groups that were quite small.

We next determined the extent to which strengths and weaknesses in school competencies correlated with the choice of a given field (commercial and technical occupations, industrial clerks, laboratory occupations). To do this, we estimated the prototypical patterns of school competency in mathematics, physics, chemistry, and biology associated with entry into the various training fields. We expected patterns of individual strengths and weaknesses to be predictive of involvement in certain fields. In particular, we expected that individuals who were strong in physics would be more likely to choose an apprenticeship in a technical field, those who were strong in mathematics would be more likely to choose an apprenticeship as a clerk, and those who were strong in biology and chemistry would be more likely to pursue a laboratory-based occupation. We also examined the possibility that the average level of competency across the various fields is predictive of an apprenticeship in a given field. In addition, we compared the predictive power of the average level of competency level and competency profile (i.e., the pattern of an individual's competency in mathematics, physics, chemistry, and biology).

Multinomial (profile) regression analyses confirmed our expectations; competency profiles proved to be predictive of apprenticeships in certain occupational groups. Overall, competency profiles proved to be more predictive than average competency levels, independent of the credential earned (ISCED Level 2, 10 years of schooling or ISCED Level 3). High levels of competency were particularly predictive of LAB apprenticeships, although in this group, too, the effect of competency profiles was somewhat stronger than the effect of the average competency level.

As Figure 4 shows, strength in physics coupled with weakness in chemistry was predictive of the choice of a career as a technician. Strength in mathematics and biology, along with a lower level of competency in chemistry and physics, was predictive of a career as an industrial clerk. Finally, strength in chemistry and a consistent level of competency in the other fields predicted the choice of a laboratory-based occupation. Although they were estimated separately, the coefficients on the competency patterns of apprentices who had earned an intermediate-level secondary school credential were nearly identical to the coefficients for those with a university-entrance qualification (see Figure 4).

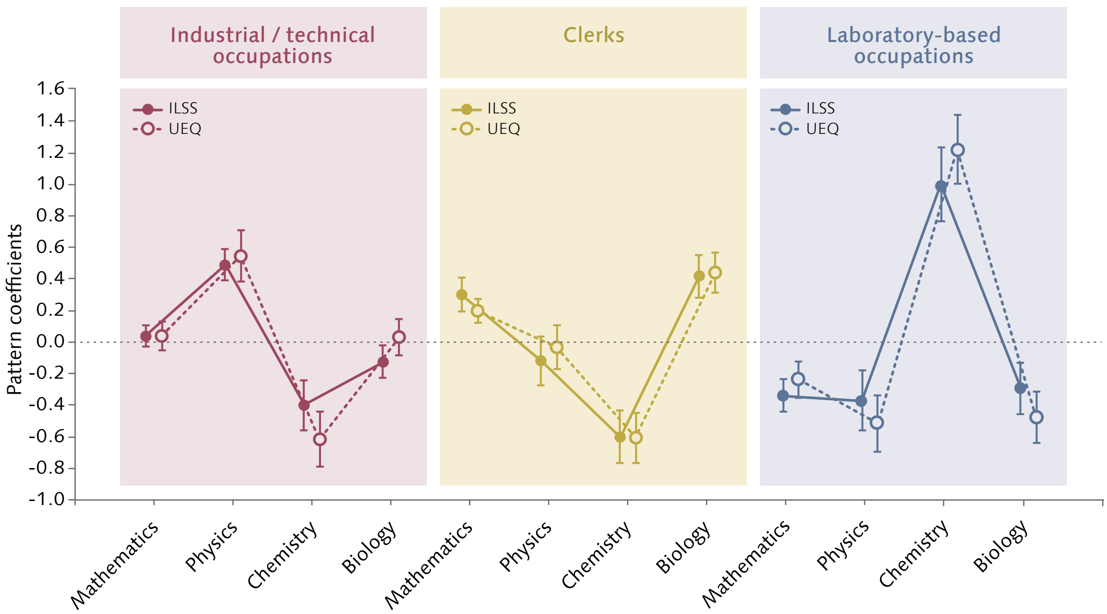

Figure 4. Pattern coefficients (with 95 % confidence intervals) from multinomial regression models for predicting the area of training. Information on students with an ISCED Level 2, 10 years of schooling (ILSS) or ISCED Level 3 (UEQ).

Overall, we found that apprentices in the fields included in the study showed positive selection in the sense that their competency levels were relatively high. This selection effect was particularly evident in the case of apprentices with a Hauptschule or an intermediate-level secondary-school credential. With the exception of the LAB group, apprentices with a university-entrance qualification tended to be in the average range. The profile analyses also suggest that students select apprenticeships that are in keeping with their strengths and weaknesses.

Development of school and vocation-related competencies during vocational training

One of ManKobE's core questions relates to the development of school competencies in mathematics and science during vocational training. The study provides an opportunity to examine not only simple growth, but also to study the effects of vocational fields on learning gains. To determine whether competency gains in the course of training are related to differences in learning opportunities across different occupations, we looked at whether clerks (N = 481) and apprentices in industrial/technical occupations (N = 853) exhibit differential gains in vocation-related mathematics and science competencies between the start of their apprenticeships and midway through them. We also estimated changes in school competencies in mathematics and physics. If differential learning opportunities do indeed have an impact, we would expect to see a smaller increase in school than vocation-related competencies. With respect to the latter, we would also expect the learning gains of clerks to be primarily in mathematics and those of technicians mainly in physics.

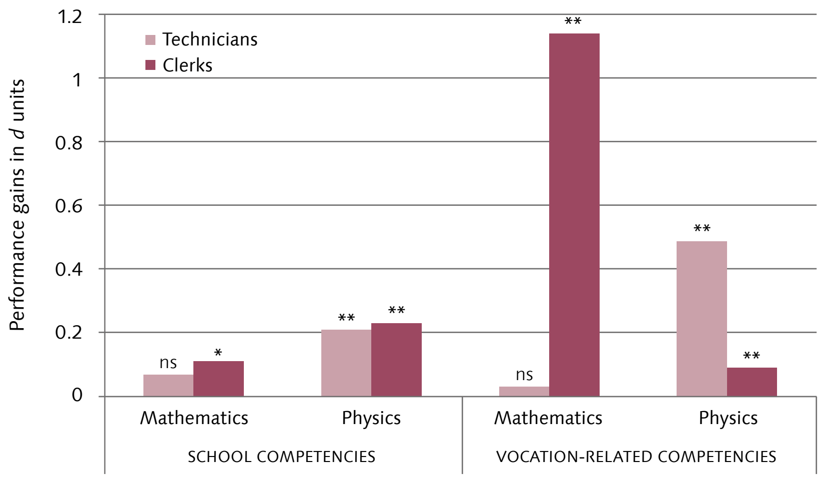

Figure 5. Gains in school and vocation-related competencies in mathematics and physics by area of training. $*p < .05$. $**p < .01$. ns = not statistically significant.

Figure 5 shows the gains in school and vocation-related competencies for apprentice clerks and technicians. Gains in school competencies are, for the most part, statistically significant, but modest in size. Particularly small are gains in school mathematics competency. Clerks achieved sizeable gains in vocation-related mathematics, but not in vocation-related physics competency. The reverse was true for technicians.

We did not expect to see increases in school competencies over the course of training, but our model (Figure 1) suggested that school competencies would be important for the development of vocation-related competencies. As a result, we assumed that school competency in physics would predict an increase in vocation-related competency in physics of technicians (e.g., expertise in mechanics or electricity).

To test this prediction, we analyzed the influence of school competency in physics on vocation-related competency in physics of technicians at data collection point T2, controlling for vocation-related competency in physics at data collection point T1 and for basic cognitive skills and in particular for language skills. Data on $N = 1\,459$ apprentices in industrial/technical occupations who participated in the survey at one or more of the two data collection points provided the basis for that analysis. The results show that school competency in physics has a statistically significant effect on vocation-related competency in physics of technicians at data collection point T2 (Figure 6). We find no statistically significant effect of basic cognitive skills or language skills. This suggests that school competencies are particularly relevant for the development of specific vocation-related competencies, and that the influence of basic cognitive and language skills is largely mediated by school competencies.

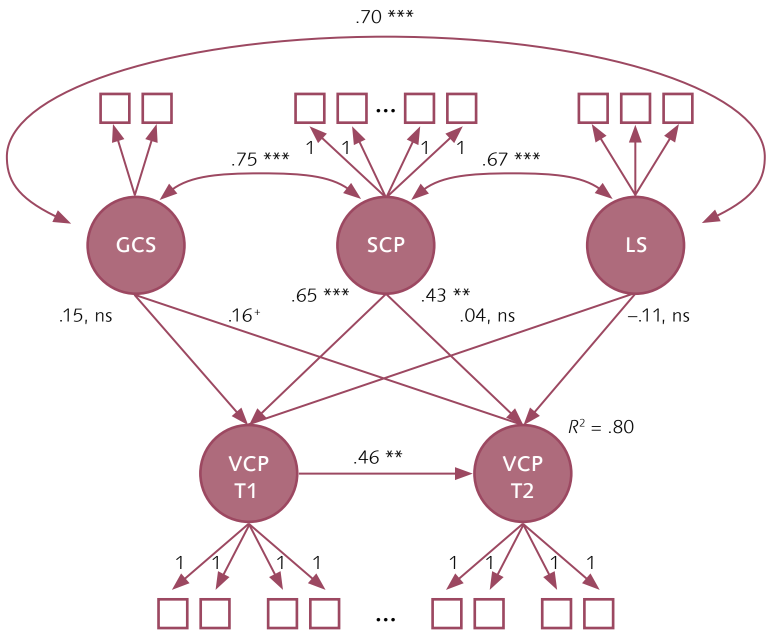

Figure 6. Regression of vocation-related competency in physics (VCP) at data collection point 2 among the group of technicians on vocation-related competency in physics (VCP) at data collection point 1, taking into account school competency in physics (SCP) and general cognitive skills (GCS) and language skills (LS). $^{+}p<.10$. $^{**}p<.01$. $^{***}p<.001$. ns = not statistically significant.

Frank, C., Härtig, H., & Neumann, K. (in press). Schulisch erworbene Kompetenzen als Voraussetzung für berufliches Wissen gewerblich-technischer Auszubildender [Competencies acquired in general education as a precondition for occupation-related knowledge of industrial-technical trainees]. *Unterrichtswissenschaft*.

To sum up, our examination of gains in school and vocation-related competencies suggests that apprentices do indeed acquire the targeted competencies during their apprenticeships. Moreover, the results indicate that the chambers of industry and commerce's tests, on which the items we used to measure vocation-related competency in physics were based, reflect success in vocational training, which supports the validity of these tests. The findings also support the idea that school competencies play an important role in the development of vocation-related competencies.

School competencies and other determinants of successful vocational training

The choice of a certain type of vocational training is one of the most important challenges young adults face – with far-reaching consequences for their professional lives. It essentially determines the field in which they will spend their careers. Yet there is considerable risk of dropout during the first phase of training. Roughly 20 to 25 percent of all apprenticeships are discontinued, approximately two-thirds of those during the first year of training. Studies have also shown that during this period, it is usually the apprentices themselves, rather than their employers, who choose to terminate their contracts.

In an effort to identify the causes of certain aspects of successful training, the ManKobE study examined the characteristics of individuals that lead to success during the first phase of an apprenticeship. Since no performance measures are available to use as criteria for assessing success during that early period, we instead looked at apprentices' satisfaction with their training, at whether or not they considered quitting their vocational education, and at whether they actually remained in the program. These criteria are widely acknowledged to be key aspects of successful training. Seeking to identify the characteristics of individuals that lead to success, we looked at personality traits, cognitive variables, and school credentials, as well as vocational interests and sociodemographic background.

In our initial analysis, we used data from the first data collection point to look at predictions of two outcomes – satisfaction with training and interest in dropping out – based on cognitive variables (basic cognitive skills and academic competencies), personality factors (extraversion, agreeableness, conscientiousness, neuroticism, openness to experience) and vocational interests (realistic, investigative, artistic, social, enterprising, and conventional). The analysis was carried out separately for clerks (N = 588) and technicians (N = 1 231). This approach is based on the congruence hypothesis, which posits that satisfaction requires a good match between the individual's interests and the surrounding environment. For these two fields with their differing job profiles – conventional in the case of clerks, realistic in the case of technicians – we therefore expected to find that an individual's vocational interests would be associated in different ways with satisfaction and with a desire to drop out.

Figure 7 shows the regression weights for important predictors, for technicians and clerks separately. We found that personality factors and vocational interests are strong predictors of satisfaction with training and lack of dropout intentions. The pattern of regression weights of personality factors was similar for both dependent variables and both fields of training (with the exception of openness to experience as a predictor of satisfaction). In keeping with the congruence hypothesis, vocational interests that best matched the job's responsibilities were significant predictors of both dependent variables. For technicians, realistic interests lead to a high level of satisfaction and a high probability that the apprentice will not consider dropping out of training prematurely, while an interest in conventional matters is a protective factor for clerks.

Volodina, A., Nagy, G., & Köller, O. (2015). Success in the first phase of the vocational career: The role of cognitive and scholastic abilities, personality factors, and vocational interests. *Journal of Vocational Behavior, 91*, 11–22.

We then analyzed whether cognitive variables (basic cognitive skills, language skills, school competencies), credentials (grades, school-leaving

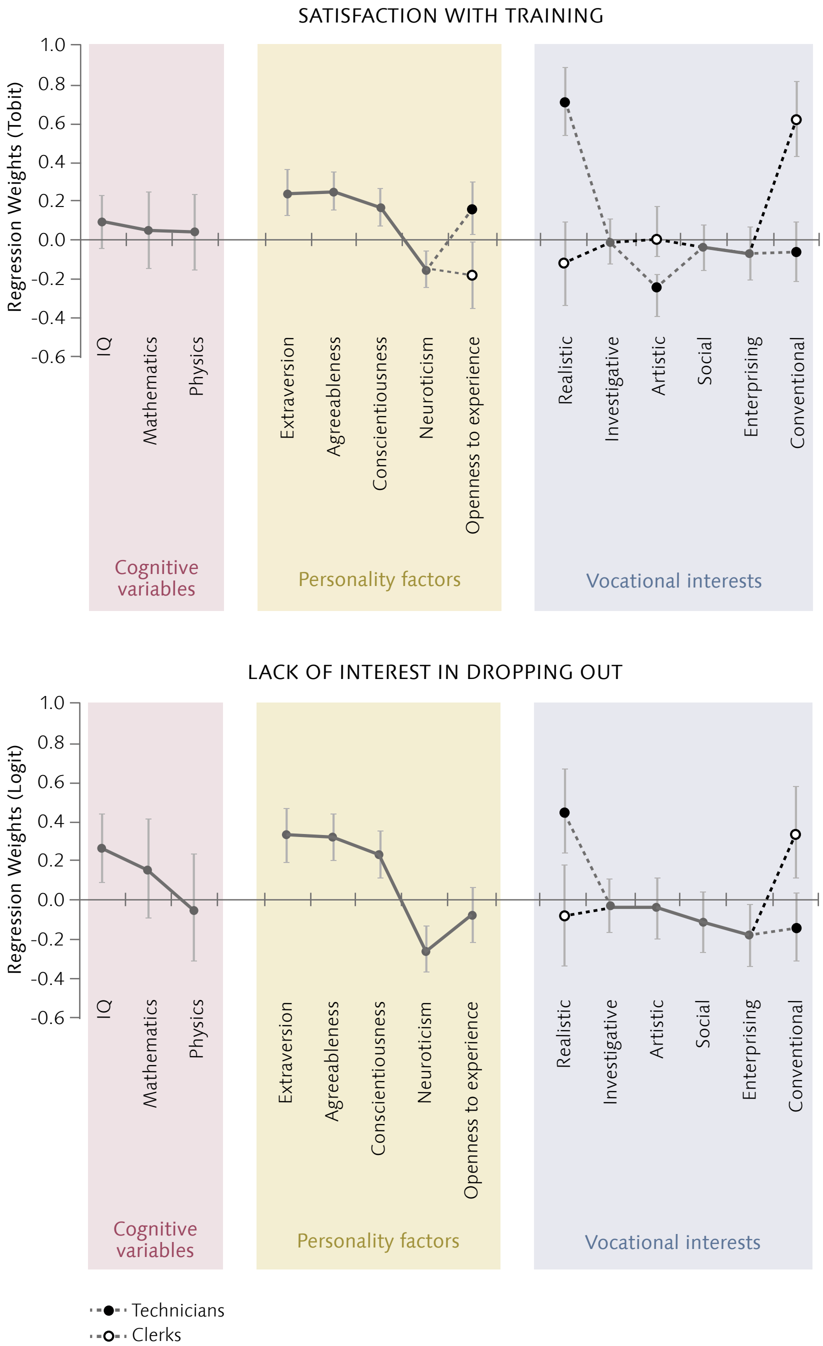

Figure 7. Regression weights for predicting satisfaction with training and lack of interest in dropping out. Shown in gray are regression weights, which do not differ from one field of training to another. Technicians = Industrial / technical occupations, Clerks = Industrial clerks.

certificates), family background (migration status, parents' education) and vocational characteristics (wages during apprenticeship, desired vocation) predict whether an apprentice will drop out prematurely. The analysis was based on a sample of N = 1 887 apprentices, with valid information about whether or not contracts were terminated and no missing values for determinants. Of this group of apprentices, 7.5 percent dropped out within the first two years. Table 2 shows the results of a Cox regression predicting the termination of apprenticeship contracts. The coefficients shown are hazard ratios (HRs). Predictors with an HR that is not significantly different from 1 are not associated with termination; predictors with HR < 1 are linked to a reduced risk of termination; those with HR > 1 are associated with an elevated risk. The left-hand column shows the HRs resulting from a prediction based on the individual determinants, and the right-hand column shows the HRs based on an estimate of the effects of all determinants. School competencies and level of completed schooling in particular, but also apprentices' wages and migration background, were associated in the expected direction with the risk of termination of the apprenticeship. An analysis of all predictors showed that school

Table 2. Hazard Ratios for Predicting Termination of Training

Determinants	Hazard Ratios	
	Separate	Together
Cognitive variables		
School competencies in math and physics	0.51**	0.79*
Language skills	0.63**	0.95
General cognitive skills	0.61**	0.93
Completed schooling		
Intermediate-level secondary school credential[a]	0.27**	0.56*
University-entrance qualification[a]	0.16**	0.42
Average grade	1.36**	1.20
Family background		
Migrant background	2.55**	1.68*
Parents' highest level of completed schooling: L2, 10[a]	0.54*	0.86
Parents' highest level of completed schooling: L3[a]	0.44**	0.74
General conditions		
Wages during apprenticeship	0.54**	0.66*
Apprenticeship in desired occupation[b]	0.75	0.75

Note. L2, 10 = ISCED Level 2, 10 years of schooling; L3 = ISCED Level 3. [a]Hauptschule completion as reference; [b]dichotomous indicator: 1 = apprenticeship in desired occupation, 0 = apprenticeship not in desired occupation. *$p < .05$. **$p < .01$.

competencies in the fields of mathematics and physics were a protective factor. We also found significant effects of level of completed schooling (lower probability of dropout for apprentices who had earned an intermediate-level credential compared with Hauptschule graduates), migration background (greater likelihood of dropout for apprentices from a migrant background) and wages (lower likelihood of dropout when wages were higher).

Taken together, the results show that personality characteristics and vocational interests are consistent predictors of the success of the first phase of an apprenticeship. Particularly relevant was the degree to which an apprentice's vocational interests matched well to the field of activity. School competencies and highest level of completed schooling did not appear to be particularly significant. Later on, however, these performance-related factors seem to play an important role in whether the apprentice remains in the program. Other factors, such as wages, are important as well. It should be noted, though, that wages are confounded with other aspects of the company in which the apprentice is training (e.g., company size), so any interpretation of the role of wages should be viewed with caution.

Discussion

Our findings show that school competencies in mathematics and science play a central role in successful vocational training. Young adults in challenging apprenticeships begin their training with a high level of school competencies, and they appear to select training programs that match their strengths. Success during the first phase of an apprenticeship (satisfaction, lack of desire to drop out) appears to depend primarily on noncognitive and affective characteristics such as personality traits and interests. However, school competencies appear to play an important role in the acquisition of further competencies and in determining whether an apprentice will remain in the program over the long term. Our analyses also show that during their training, apprentices acquire competencies mainly in areas that are specifically related to that training, while the development of school competencies tends to stagnate. By assessing school competencies using the tests that were administered to evaluate Germany's national educational standards, we were for the first time able to gain important information about the predictive validity of those standards, demonstrating that the relevant school competencies in mathematics and science play an important role in the development of further competencies and thus in the success of the first phase of vocational training.

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