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CASMIN Versus ISCED: Validating Standard Education Variables for German Microdata

Silke L. Schneider · Lennart Palm · Melanie V. Partsch

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Abstract In German surveys, educational attainment is typically assessed through two questionnaire items: the highest general school-leaving qualification and the highest vocational qualification or higher education degree. These items are often combined into one variable for analysis, but there is no standard method for doing so. This hinders comparisons across publications and the aggregation of research data. This article presents the results of a large-scale validation of candidates for a German standard education variable based on the official International Standard Classification of Education (ISCED) and the sociological Comparative Analysis of Social Mobility in Industrial Nations education scheme (CASMIN), both commonly used in Germany. Many survey datasets offer a derived ISCED variable that reflects the main ISCED levels; fewer offer CASMIN. The validation uses ALLBUS 2018 data and a data-driven selection of 157 validation variables. Candidate standard education variables that retain a higher relative partial explanatory power across validation variables in linear multiple regression models compared to the most detailed education variable are considered more valid. The results show that CASMIN-based candidates generally outperform ISCED-based candidates of the same num-

Online Appendix: <https://kzfss.uni-koeln.de/sites/kzfss/pdf/Schneider-et-al.pdf>

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ber of categories. An ISCED-based variable performs better only when measured in a highly detailed fashion that accounts for the stratification of the German educational system. The commonly used aggregation into three broad education levels loses about half the explanatory power of the detailed variable. Research data centers are called upon to provide a CASMIN variable to data users, and researchers to use CASMIN rather than ISCED whenever possible.

Keywords Measurement · Coding · Sociodemographics · Survey data · Standardization · Data quality

CASMIN gegen ISCED: Validierung standardisierter Bildungsvariablen für deutsche Mikrodaten

Zusammenfassung In deutschen Umfragen wird der Bildungsstand in der Regel durch zwei Items erfasst: den höchsten allgemeinbildenden Schulabschluss und den höchsten beruflichen Abschluss oder Hochschulabschluss. Zur Analyse werden diese oft zu einer Variablen zusammengefasst. Dafür gibt es keine Standardmethode, was Vergleiche zwischen Publikationen und die Aggregation von Daten erschwert. In diesem Beitrag werden die Ergebnisse einer groß angelegten Validierung von Kandidaten für eine deutsche Standard-Bildungsvariable vorgestellt, die auf der amtlichen Internationalen Standardklassifikation für das Bildungswesen (ISCED) und dem soziologischen CASMIN-Bildungsschema, welches im Projekt „Comparative Analysis of Social Mobility in Industrial Nations“ entwickelt wurde, basieren, welche in Deutschland häufig verwendet werden. Viele Umfragedatensätze bieten eine abgeleitete ISCED-Variable an, welche die ISCED-Hauptniveaus widerspiegelt, wenige CASMIN. Die Validierung verwendet ALLBUS 2018-Daten und eine datengetriebene Auswahl von 157 Validierungsvariablen. Kandidaten für Standard-Bildungsvariablen, die in linearen multiplen Regressionsmodellen eine höhere relative partielle Erklärungskraft gegenüber den Validierungsvariablen aufweisen, gelten als valider. Die Ergebnisse zeigen, dass CASMIN-basierte Kandidaten bei der Vorhersage im Allgemeinen besser abschneiden als ISCED-basierte Kandidaten mit der gleichen Anzahl Kategorien. Eine ISCED-basierte Variable schneidet nur dann besser ab, wenn sie in einer sehr detaillierten Weise gemessen wird, die die Schichtung des deutschen Bildungssystems berücksichtigt. Die üblicherweise verwendete Aggregation in drei breite Bildungsniveaus verliert etwa die Hälfte der Erklärungskraft der detaillierten Variable. Forschungsdatenzentren sind aufgerufen, eine CASMIN-Variable zur Verfügung zu stellen, und Forschende, wenn möglich, CASMIN statt ISCED zu nutzen.

Schlüsselwörter Messung · Kodierung · Soziodemographie · Umfragedaten · Standardisierung · Datenqualität

1 Introduction

Educational attainment, together with sex and age, is the most important and most often used background variable collected in surveys of individuals (Smith 1995; Braun and Müller 1997). In social stratification research, it is even a core variable (e.g., Blossfeld et al. 2019; Shavit and Müller 1998). The main empirical indicator of educational attainment is a person's highest educational qualification (e.g., Organisation for Economic Co-operation and Development [OECD] and Eurostat 2014), which is also used to proxy a range of related theoretical concepts, ranging from cognitive ability and investments in human capital to cultural capital and social status (for theoretical explanations for the effects of education, see Online Appendix 1).

Despite this, there is little standardization regarding how to *ask* for educational attainment in survey questionnaires or how to *code* it in survey datasets, hindering cross-study comparability. While harmonizing sex and age variables is relatively straightforward, harmonizing educational attainment is more complicated given the complexity of the underlying social reality. In principle, there are two paths to standardized variables: input and output harmonization (Wolf et al. 2016; Tomescu-Dubrow et al. 2024). Input harmonization or standardization of *measurement instruments* leads to unified stimuli across surveys and, potentially, to a high degree of measurement comparability across surveys. It is thus the gold standard. If this is not possible, to obtain comparable education variables, the variables from different surveys need to be *output harmonized*. This is facilitated by standardized target variables (Schneider et al. 2023). While this approach is well-known in the context of comparative research, it is rarely used to render variables comparable *within* countries.

The German survey landscape is an excellent example of the issue of lacking standardization of education variables. Since the early 1990s, there have been recommendations for measurement instruments for sociodemographics (for the most recent version, see Hoffmeyer-Zlotnik et al. 2024). However, while virtually all German surveys ask separately about school-leaving and postschool qualifications, the precise design of these items differs across surveys. Consequently, the resulting education variables are not directly comparable. An official German standard education variable does not exist, and practices for derived education variables also differ across surveys.

Comparable or standardized background variables would benefit research in many ways. First, standardized background variables would facilitate secondary data analysis because researchers would find identically specified variables in different survey datasets. Second, research output would become more comparable and thus more amenable for meta-analysis, strengthening the cumulative character of empirical research. Finally, standardized background variables facilitate the combination of datasets from different surveys (also called survey data recycling; Tomescu-Dubrow and Slomeczynski 2016), which is often done, for example, to increase case numbers for small and often marginalized population groups, extend timelines, or drill deeper to compare regions within a country. Standardized background variables would also facilitate data linkage by statistical matching. Therefore, there is a strong case for

(German and other) surveys to include harmonized standardized background variables in their datasets.

Given the lack of a standard education variable in Germany, what would a German standard education variable ideally look like? As the International Standard Classification of Education (ISCED; UNESCO Institute for Statistics 2012) and the Comparative Analysis of Social Mobility in Industrial Nations (CASMIN) education scheme (Brauns et al. 2003) are already well-known and commonly used both internationally and in Germany, these are natural starting points. Previous research has shown that CASMIN and ISCED do not work equally well across countries, i.e., they may exhibit different degrees of association with the same outcome variable in different countries (Braun and Müller 1997; Schneider 2010; Schneider and Urban 2025; Kerckhoff et al. 2002). More specifically, depending on the complexity of an education system, a simpler education measure may be more parsimonious and reliable, but it may also underestimate the relationship between education and other variables: Heterogeneity within education categories is likely (Kerckhoff and Dylan 1999). Such research, however, has often only compared very few of the many possible ways of implementing CASMIN and ISCED in survey data, and none has focused on Germany. Also, most past research relied on analyses of only very few potential outcome variables, mostly occupational status, which calls into question the generalizability of the results.

This article thus aims to develop and test specifications for a standard education variable for German surveys using many possible implementations and outcome variables, inspired by the idea of a multiverse analysis (Steege et al. 2016). In the next part of the article, we describe how education is measured in the German General Social Survey (ALLBUS), which is used in the analyses. We also introduce the international coding schemes ISCED and CASMIN and how these are implemented in German survey datasets. Then, we propose specifications for candidate standard education variables, which are subjected to a comprehensive empirical validation analysis in the remainder of the article. In the third part, we describe the data and methods, including the analysis strategy. Part four presents the results, and part five summarizes and discusses them.

2 Methodological Background

2.1 The Measurement of Educational Attainment in German Surveys

Following the general structure of the German educational system (see Online Appendix 2 for details) and the recommendation of the “demographic standards” that define standard questions for sociodemographic characteristics in German surveys (Hoffmeyer-Zlotnik et al. 2016, 2024), most German surveys ask for educational attainment using two or three questions: The first question asks for the highest school-leaving certificate and the second question for the highest vocational or postschool qualification (covering vocational education and training as well as higher education). A third item is sometimes recommended to distinguish different levels of

→ Liste 56 vorlegen! Als nächstes kommen jetzt Fragen zu Ihrer Ausbildung und Ihrem Beruf. Beginnen wir mit Ihrer Ausbildung: Welchen allgemeinbildenden Schulabschluss haben Sie? → Nur eine Nennung möglich! → Nur höchsten Schulabschluss angeben lassen! A Noch Schüler B Schule beendet ohne Abschluss C Volks- / Hauptschulabschluss bzw. Polytechnische Oberschule mit Abschluss 8. oder 9. Klasse D Mittlere Reife, Realschulabschluss bzw. Polytechnische Oberschule mit Abschluss 10. Klasse E Fachhochschulreife (Abschluss einer Fachoberschule etc.) F Abitur bzw. Erweiterte Oberschule mit Abschluss 12. Klasse (Hochschulreife) G Anderen Schulabschluss, und zwar:	→ Present list 56! The next questions are about your education and occupation. Let's start with your education: Which general school-leaving certificate do you have? → Only one answer is possible! → Only indicate the highest school-leaving certificate! A Still in school B Finished school without a certificate C Lower track school-leaving certificate, or completed 8 or 9 grades of lower secondary school in the former GDR D Intermediate track school leaving certificate, or completed 10 grades of lower secondary school in the former GDR E University of Applied Sciences entrance qualification F University entrance qualification, or completed 12th grade in upper secondary school in the former GDR G Another school-leaving certificate, namely:
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Fig. 1 Question F056 on highest school-leaving qualification in ALLBUS 2018 with translation/description in English

higher education following the Bologna reforms to keep the list of options for the second question manageable.

Figures 1, 2, and 3 show these items as they were asked in the (then interviewer-administered) German General Social Survey 2018 (GESIS-Leibniz-Institut für Sozialwissenschaften 2019), from which we use the data for the validation analyses (Sects. 3 and 4).

2.2 Existing Standard Education Variables

When data are analyzed, the information collected using these questionnaire items is usually integrated into one variable, and categories are condensed at different aggregation levels. So far, there is no standard education coding scheme for German data. However, there are two international coding schemes that are widely used in research and official statistics, respectively: the CASMIN education scheme and ISCED. This section describes both, assesses how well they link with the German educational system, and examines whether they are available in popular German survey datasets.

2.2.1 ISCED

The ISCED scheme (Schneider 2013; UNESCO Institute for Statistics 2012) is the official international framework for education-related administrative and survey data and is used, for example, by Eurostat, the OECD, and the German national education report “*Bildung in Deutschland*” (Autorengruppe Bildungsberichterstattung 2022). It classifies national educational programs and qualifications based on the “complexity

→ Liste 57 vorlegen! Welchen beruflichen Ausbildungsabschluss haben Sie? Was von dieser Liste trifft auf Sie zu? Nennen Sie mir bitte die entsprechenden Kennbuchstaben. → Mehrfachnennungen möglich außer wenn M genannt! A Beruflich-betriebliche Anlernzeit mit Abschlusszeugnis, aber keine Lehre B Teilfacharbeiterabschluss C Abgeschlossene gewerbliche oder landwirtschaftliche Lehre D Abgeschlossene kaufmännische Lehre E Berufliches Praktikum, Volontariat F Berufsfachschulabschluss G Fachschulabschluss H Meister-, Techniker- oder gleichwertiger Fachschulabschluss J Fachhochschulabschluss (auch Abschluss einer Ingenieurschule) K Hochschulabschluss L Anderen beruflichen Ausbildungsabschluss, und zwar: _____ M Keinen beruflichen Ausbildungsabschluss	→ Present list 57! Which vocational qualification do you have? Which options on this list apply to you? Please tell me the corresponding code letters. → Multiple answers possible except if M is mentioned! A Vocational training on-the-job with final certificate, but no apprenticeship B Semi-skilled worker qualification C Completed trade or agricultural apprenticeship D Completed commercial apprenticeship E Vocational internship, traineeship F Vocational school qualification G Technical college qualification H Master craftsperson, technician, or equivalent technical college qualification J Degree from a University of Applied Sciences (including engineering school) K University degree L Other vocational qualification, namely: _____ M No vocational qualification
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Fig. 2 Question F057 on postschool qualifications in ALLBUS 2018 with translation/description in English

→ Liste 57A/B vorlegen! Um welche Art von Hochschulabschluss handelt es sich dabei? Bitte nennen Sie mir nur den höchsten Abschluss, den Sie erlangt haben. → Nur eine Nennung möglich! A Bachelor B Master C Diplom D Magister E Staatsexamen oder Lehramtsprüfung F Promotion G Sonstiger Abschluss	→ Present list 57A/B! What type of university degree is this? Please tell me only the highest degree you have obtained. → Only one nomination possible! A Bachelor B Master C Diploma (Pre-Bologna degree after 2 years of study at vocational academy, 4 years at University of Applied Sciences, or 5 years at university) D Pre-Bologna degree „Magister“ after 5 years of study E State examination after 5 years of study in law, medical fields, and teacher training F Doctoral degree G Other qualification
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Fig. 3 Question F057A/B on higher-education qualifications in ALLBUS 2018 with translation/description in English

of content” into nine levels of education on the first digit. Furthermore, at relevant levels, ISCED distinguishes between generally and vocationally oriented education on the second digit, where the latter is defined to be “designed for learners to acquire the knowledge, skills and competencies specific to a particular occupation, trade, or class of occupations or trades” (UNESCO Institute for Statistics 2012, p. 14). Finally, at relevant levels, it defines sublevels on the third digit, defined by whether

Table 1 ISCED 2011-A coding scheme and category descriptions and corresponding ISCED 1997 levels and subcategories

ISCED 2011				ISCED 1997		
Digit				Level	Desti- nation	Orientation/ duration
1	2	3	Label			
0	0	0	Less than primary education, nfs	0	–	–
0	1	0	<i>Never attended an education programme</i>	0	–	–
0	2	0	<i>Some early childhood education</i>	0	–	–
0	3	0	<i>Some primary education (without level completion)</i>	0	–	–
1	0	0	Primary education	1	–	–
2	0	0	Lower secondary education, nfs	2	–	–
2	4	0	<i>General, nfs</i>	2	–	General, pre-voca- tional
2	4	2	Partial level completion, no direct access to upper secondary education	2	C	General, pre-voca- tional
2	4	3	Level completion but still no direct access to upper secondary education	2	C	General, pre-voca- tional
2	4	4	Level completion and direct access to upper secondary education	2	A, B	General, pre-voca- tional
2	5	0	<i>Vocational, nfs</i>	2	–	Vocational
2	5	2	Partial level completion, no direct access to upper secondary education	2	C	Vocational
2	5	3	Level completion but still no direct access to upper secondary education	2	C	Vocational
2	5	4	Level completion and direct access to upper secondary education	2	A, B	Vocational
3	0	0	Upper secondary education, nfs	3	–	–
3	4	0	<i>General, nfs</i>	3	–	General, pre-voca- tional
3	4	2	Partial level completion, no direct access to tertiary education	3	C	General, pre-voca- tional
3	4	3	Level completion but still no direct access to tertiary education	3	C	General, pre-voca- tional
3	4	4	Level completion and direct access to tertiary education	3	A, B	General, pre-voca- tional
3	5	0	<i>Vocational, nfs</i>	3	–	Vocational
3	5	2	Partial level completion, no direct access to tertiary education	3	C	Vocational
3	5	3	Level completion but still no direct access to tertiary education	3	C	Vocational
3	5	4	Level completion and direct access to tertiary education	3	A, B	Vocational

Table 1 (Continued)

ISCED 2011				ISCED 1997		
Digit				Level	Desti- nation	Orientation/ duration
1	2	3	Label			
4	0	0	Post-secondary non-tertiary education, nfs	4	–	–
4	4	0	<i>General, nfs</i>	4	–	General
4	4	3	Level completion but still no direct access to tertiary education	4	C	General
4	4	4	Level completion and direct access to tertiary education	4	A, B	General
4	5	0	<i>Vocational, nfs</i>	4	–	Vocational
4	5	3	Level completion but still no direct access to tertiary education	4	C	Vocational
4	5	4	Level completion and direct access to tertiary education	4	A, B	Vocational
5	0	0	Short-cycle tertiary education, nfs	5	B	–
5	4	0	<i>General</i>	5	B	General
5	5	0	<i>Vocational</i>	5	B	Vocational
6	0	0	Bachelor-level education and equivalent, nfs	5	A	Medium
6	4	0	<i>Academic</i>	5	A	Medium
6	5	0	<i>Professional</i>	5	A	Medium
6	6	0	<i>Orientation unspecified</i>	5	A	Medium
7	0	0	Master-level education and equivalent, nfs	5	A	Long
7	4	0	<i>Academic</i>	5	A	Long
7	5	0	<i>Professional</i>	5	A	Long
7	6	0	<i>Orientation unspecified</i>	5	A	Long
8	0	0	Doctoral-level education	6	–	–
8	4	0	<i>Academic</i>	6	–	–
8	5	0	<i>Professional</i>	6	–	–
8	6	0	<i>Orientation unspecified</i>	6	–	–

nfs not further specified

a qualification partially or fully completes a level of education, and if yes, whether it gives access to programs at a specific higher ISCED level.

The 1997 version, still used in some datasets, distinguishes only seven levels because short-cycle tertiary, bachelor's-degree, and master's-degree levels formed one level in ISCED 1997. It also used letters A, B, and C for access to (types of) higher education levels broadly corresponding to the third digit in ISCED 2011. Table 1 shows all ISCED 2011 three-digit codes and the respective category descriptions for educational attainment (ISCED-A) on the left (for a complete description, see UNESCO Institute for Statistics 2012) and the corresponding ISCED 1997 categories on the right (for a complete description, see UNESCO Institute for Statistics 2006).

Table 7 in the Online Appendix (Appendix 3) shows how German qualifications are officially mapped to ISCED 2011. It reveals that ISCED does not reflect well

Table 2 CASMIN coding scheme and category descriptions (Brauns et al. 2003, p. 223)

Level		Track	CASMIN	Description
Primary	–	–	1a	Inadequately completed general education
Secondary	Low	General	1b	General elementary education (compulsory schooling)—“social minimum of education”
		Vocational	1c	Basic vocational training above and beyond compulsory schooling
	Mediate	Vocational	2a	Intermediate vocational qualification or secondary programmes in which general intermediate schooling is combined with vocational training
		General	2b	Intermediate general education; academic or general tracks at the secondary intermediate level
	High	General	2c_gen	General maturity: full maturity certificates (e.g., the <i>Abitur</i> , A-levels)
		Vocational	2c_voc	Vocational maturity: full maturity certificates, including vocationally specific schooling or training
Tertiary	Low	–	3a	Lower tertiary education: lower-level tertiary degrees, generally of shorter duration and with a vocational orientation
	High	–	3b	Higher tertiary education: completion of a traditional, academically oriented university education

certain features of the German educational system (also see Schneider 2008). First, it does not differentiate between tracks of lower secondary education (*Hauptschule* and *Realschule*) because all types of lower secondary schooling in Germany are generally oriented and give access to the upper secondary level. Second, at the first digit, it mixes higher education and advanced vocational education and training (VET; e.g., master crafts), which are both classified as tertiary education in ISCED (ISCED 5 in ISCED 1997 and ISCED 6 in ISCED 2011), even though both have different prerequisites and, potentially, outcomes. As a result of these issues, ISCED 97 main levels have also been shown not to be very valid for Germany (Schneider 2010).

2.2.2 CASMIN

The CASMIN education scheme (Brauns et al. 2003; König et al. 1988) was developed by sociologists interested in comparative measurement of education for social stratification and mobility research, where it is still widely used. It defines three broad education levels (1 = minimum, 2 = intermediate/secondary, and 3 = tertiary) and sublevels within each broad level. Table 2 shows the CASMIN scheme.

CASMIN differs from ISCED in several ways: First, the distinction between the lower (*Hauptschule*) and intermediate (*Realschule*) tracks of lower secondary education is fundamental to the implementation of CASMIN in Germany, as it constitutes the difference between the social minimum and the intermediate/secondary level. Second, having completed vocational education leads to a different sublevel but does not elevate the main education level obtained. Third, advanced vocational education is classified with initial VET rather than tertiary education so that tertiary education in CASMIN corresponds to higher education in Germany, whereas

tertiary education in ISCED does not. Fourth, within higher education, CASMIN distinguishes types of higher-education institutions (applied vs. traditional/academic), while ISCED distinguishes levels of education (notably bachelor's, master's, and doctoral levels). Table 5 (see Sect. 2.3.2 below) shows how German education categories are mapped to CASMIN.

To sum up, CASMIN captures important distinctions in the German education system that ISCED does not capture. However, it also omits distinctions that ISCED makes. The analyses in this study will show which ones are more important.

2.2.3 Application of ISCED and CASMIN in German Surveys

Which German survey datasets offer which international standard education variables? Several German survey datasets offer ISCED-based education variables to their users: ISCED 2011 is, for example, offered by the German General Social Survey (ALLBUS; e.g., Baumann et al. 2019), the German Family Demography Panel (FReDA; Bujard et al. 2022, 2023), the German Health Update (GEDA; e.g., Allen et al. 2022), the German Social Cohesion Panel (SCP; Groh-Samberg et al. 2023), the Microcensus (e.g., Destatis 2019), and the Socio-Economic Panel (SOEP; e.g., DIW Berlin/SOEP 2022). They all include an education variable representing the first ISCED 2011 digit (main levels). Additionally, GEDA offers an ISCED 2011 variable with two digits.

The ISCED 1997 main levels are, for example, offered alongside ISCED 2011 by ALLBUS, SOEP, and SCP. The Panel Study Labour Market and Social Security (PASS; Berg et al. 2023) and the National Educational Panel Study (NEPS; FDZ-LfBi 2023) offer ISCED 1997 main levels *and* program destination, which makes them more informative than data using ISCED 2011 main levels alone. They use ISCED 1997 rather than 2011 because these panels started before 2012. The German Ageing Survey (DEAS; Behagel and Stuth 2022) offers a three-tiered ISCED variable with tiers “low”, “medium”, and “high.”

Derived education variables based on CASMIN are offered by fewer surveys. Out of the survey datasets we examined, only SOEP, NEPS, and PASS offer CASMIN variables with nine categories as defined by Brauns et al. (2003, see also Table 2). Eight categories are offered by SCP, where lower and higher tertiary education are combined. Further survey datasets screened for standard education variables were the GESIS Panel (Minderop et al. 2023), the German Longitudinal Election Study (GLES 2023), and the German Internet Panel (GIP; Blom et al. 2024). To conclude, there is no standard education variable that is consistently offered across German survey datasets. If anything, there is a tendency toward ISCED 2011 main levels.

2.3 Candidate Standard Education Variables

While ISCED and CASMIN are—at least theoretically—standard variables, they can be (and are) implemented with differing levels of detail. This section presents the candidates for a standard education variable for German surveys tested in this study. The first set of candidates is based on ISCED, and the second set is based on CASMIN.

2.3.1 Candidate Standard Variables Based on ISCED

A very popular education variable corresponds to broad ISCED levels, which summarize “low” education up to and including lower secondary education, “medium” education with upper secondary (including vocational) and post-secondary non-tertiary education, and “high” education with tertiary education (including, in the case of Germany, advanced VET). This is the minimum version of ISCED (I_Min),¹ which is often used in cross-tabulations and reports as well as in regression models.

Given that it is already commonly offered in German survey datasets, the most important candidate standard education variable based on ISCED represents the first digit of ISCED 2011, with ISCED 0 and 1 aggregated since they usually cannot be distinguished in German data. Since this is a simplified version compared to the full three-digit ISCED yet is more detailed than the minimum version, it is regarded as the first intermediate candidate (I_Int1). Two alternative intermediate candidates with a similar number of categories were developed. The second intermediate candidate (I_Int2) distinguishes advanced VET classified at the bachelor’s level from higher-education qualifications since these are likely to have different antecedents and outcomes. Most notably, they do not require a higher-education entrance qualification for entry but instead require completed initial VET. The third intermediate candidate (I_Int3) additionally splits the usually large ISCED 3 by whether a qualification generally gives access to higher education and aggregates ISCED 4, 5, and VET at ISCED 6 as well as ISCED 7 and 8. It corresponds to the European Survey Version of ISCED (ES-ISCED, available in the European Social Survey since round 5; Schneider 2010, 2020).

Table 3 shows the candidates for a minimum and intermediate version of a standard education variable based on ISCED and how these can be derived from the most detailed variable. For how this is derived from the ALLBUS education categories and how the maximum versions are constructed, see Table 4.

When educational attainment is used as an independent variable, the predictive power and thus validity of education levels as defined by ISCED (especially broad ISCED levels) may be rather low compared to the source education variables from which the ISCED levels were derived (Schneider 2010). This is due to the fact that a few main levels contain large proportions of cases, and large categories are likely heterogeneous, which depresses associations with the dependent variables of interest (Kerckhoff and Dylan 1999). Therefore, we also specify several more detailed candidates for a standard education variable (i.e., “maximum versions” presented in Table 4):

The first maximum candidate (I_Max1) provides, next to the main ISCED level (i.e., I_Int1), information on whether the educational qualification is vocationally oriented or not, which is an important feature of education in Germany, especially

¹ We give all candidates short names to unambiguously identify them. The ISCED-based candidates start with “I_”, and the CASMIN-based candidates with “C_”. This is followed by information on whether the variable is a highly aggregated minimum version (“Min”), a highly detailed maximum version (“Max”), or an intermediate version (“Int”). If several versions at a similar level of detail have been developed, a number is added.

Table 3 Candidates for a minimum version of a standard variable for education based on ISCED and their derivation from detailed codes (Maximum version I_Max2) shown in Table 4

I_Max2 (Table 4)	I_Min: broad ISCED	Label	I_Int1: ISCED11 1-digit (aggregated)	Code	Label	I_Int1: ISCED11 1-digit aggregated	Code	I_Int2: ISCED11 with level 6 split into professional/academic	Code	Label	I_Int3: European Survey version of ISCED (ES- ISCED)	Code	Label
100	1	Low	1	1	Less than lower secondary education	1	1	Less than lower secondary education	1	1	I Less than lower secondary education	1	I Less than lower secondary education
212, 213			2	2	Lower secondary education	2	2	Lower secondary education	2	2	II Lower secondary education	2	II Lower secondary education
321, 322	2	Medium	3	3	Upper secondary education	3	3	Upper secondary education	3	3	IIIb Upper secondary qualifications without access to ISCED 6 academic	3	IIIb Upper secondary qualifications without access to ISCED 6 academic
312, 313									4	4	IIIa Upper secondary qualifications with access to ISCED 6 academic	4	IIIa Upper secondary qualifications with access to ISCED 6 academic
422, 423			4	4	Post-secondary non-tertiary education	4	4	Post-secondary non-tertiary education	5	5	IV Post-secondary/advanced vocational education below ISCED 6 academic	5	IV Post-secondary/advanced vocational education below ISCED 6 academic
520	3	High	5	5	Short-cycle tertiary education (empty)	5	5	Short-cycle tertiary education (empty)					
			6	6	Bachelor's level	6	6	Bachelor's—professional	6	6			
610, 620								Bachelor's—academic	7	7	V1 Medium duration higher education (ISCED 6 academic)		
710, 720			7	7	Master's level	8	8	Master's or equivalent level	7	7	V2 Long higher education (ISCED 7–8 academic)		
800			8	8	Doctoral level	9	9	Doctoral degree—academic					

when analyzing labor market outcomes or when using education as a proxy for cognitive skills. This two-digit version of ISCED 2011 is, therefore, the most promising variant of the official ISCED scheme for the German application from a conceptual point of view. This candidate corresponds to the ISCED variable contained in the GEDA dataset.

The second maximum candidate (I_Max2) is an unofficial extension of maximum candidate I_Max1, which introduces additional distinctions relevant to the stratification of secondary schooling (ISCED levels 2 and 3) and higher education systems (ISCED levels 6 and 7). Stratification of educational systems or parts thereof refers to selecting individuals into different educational pathways, only one of which leads to the maximum number of years of education (Allmendinger 1989). I_Max2 corresponds to the detailed international education variable (variable “edulvlb”) developed for the European Social Survey (ESS) in round 5.² For Germany, it distinguishes the lower- vs. intermediate-track school-leaving qualifications (*Hauptschulabschluss* vs. *Realschulabschluss*) on the one hand and the university of applied sciences vs. (traditional) university entrance qualification (*Fachhochschulreife* vs. *Allgemeine Hochschulreife*) on the other hand. These qualifications are associated with different educational transitions in the educational career as well as different opportunities for subsequent education but are not distinguished by ISCED. A distinction is also made at the bachelor’s level and the master’s level (ISCED 6 and ISCED 7) between qualifications from universities of applied sciences and qualifications from traditional universities. Furthermore, candidate I_Max2 distinguishes vocational qualifications in terms of whether they offer access to advanced vocational education and training (in the German case, to master craftsperson, technician, and comparable qualifications) or not.

Maximum version I_Max3 finally builds on I_Max2 and additionally differentiates, within vocational qualifications in ISCED 3 and 6, by the school-leaving certificate previously obtained, given this has a large impact on cognitive skills (Maehler et al. 2014). This means that CASMIN (see below) can also be derived from this candidate standard variable, which is not possible with the other maximum versions based on ISCED.

Note that there is no maximum version representing the full three-digit ISCED. The third ISCED digit has only a marginal effect in Germany, as only a few current educational programs do not offer access to a higher level of education and, in addition, contain only small numbers of respondents. Since these few programs are not distinguished in the ALLBUS questionnaire, the full three-digit version of ISCED cannot be derived for and validated with ALLBUS data. It is thus also not shown in Table 4, but the full derivation is shown in Table 7 in Online Appendix 1.

² Since ISCED 2011 was not finalized when “edulvlb” was developed for the ESS in 2009, the exact codes used in the ESS on the second and third digits do not conform to the final official ISCED codes on these digits. They can still be derived, though. The variable name “edulvlb” stems from the initial name “edulvl,” a mnemonic abbreviation of “education level,” which was modified twice so that “edulvla” was the second and “edulvlb” the third specification.

Table 4 Maximum versions of candidate standard education variables based on ISCED and their derivation from ALLBUS 2018 response categories

German education categories in ALLBUS 2018		I_Max1		I_Max2 ('edulvlb')		I_Max3	
School qualification (Q056)	Postschool qualification (Q057 and 057A/B)	Code	Label	Code	Label	Code	Label
B finished school without qualification	M No vocational qualification OR E Vocational internship, traineeship	10	Less than lower secondary education	100	Less than lower secondary education		
C Lower-track school-leaving qualification or completion of eight or nine grades of lower secondary school in the former GDR		24	Lower secondary education—general	212	Lower secondary education—general, no access to general upper secondary		
D Intermediate-track school-leaving qualification or completion of ten grades of lower secondary school in the former GDR				213	Lower secondary education—general, access to general upper secondary		
E University of applied sciences entrance qualification		34	Upper secondary education—general	312	Upper secondary education—general, no access to traditional university		
F University entrance qualification (<i>Abitur</i>)				313	Upper secondary education—general, access to traditional university		

Table 4 (Continued)

German education categories in ALLBUS 2018		L_Max1		L_Max2 ('edulvb')		L_Max3	
School qualification (Q056)	Postschool qualification (Q057 and 057A/B)	Code	Label	Code	Label	Code	Label
B Finished school without qualification OR C Lower-track school-leaving qualification or completion of eight or nine grades of lower secondary school in the former GDR OR D Intermediate-track school-leaving qualification or completion of ten grades of lower secondary school in the former GDR	A Vocational training on the job with final certificate, but no apprenticeship OR B Semiskilled worker qualification	35	Upper secondary education—vocational	321	Upper secondary access to tertiary		
B Finished school without qualification OR C Lower-track school-leaving qualification or completion of eight or nine grades of lower secondary school in the former GDR	C Completed industrial or agricultural apprenticeship OR D Completed commercial apprenticeship OR F Vocational school qualification			322	Upper secondary education—vocational, no access to higher education	322a	Upper secondary education—vocational, no access to higher education, after 212 ... after 213
D Intermediate-track school-leaving qualification or completion of ten grades of lower secondary school in the former GDR							
E University of applied sciences entrance qualification	All previously mentioned vocational qualifications (A, B, C, D, F)	45	Post-secondary, non-tertiary—vocational	422	Post-secondary non-tertiary to lower-tier higher education		
F University entrance qualification (<i>Abitur</i>)	All previously mentioned vocational qualifications (A, B, C, D, F)			423	Post-secondary non-tertiary to upper-tier higher education		

Table 4 (Continued)

German education categories in ALLBUS 2018		I_Max1		I_Max2 ('edulvlb')		I_Max3	
School qualification (Q056)	Postschool qualification (Q057 and 057A/B)	Code	Label	Code	Label	Code	Label
B Finished school without qualification OR C Lower-track school-leaving qualification or completion of eight or nine grades of lower secondary school in the former GDR D Intermediate-track school-leaving qualification or completion of ten grades of lower secondary school in the former GDR E University of applied sciences entrance qualification F University entrance qualification (<i>Abitur</i>) Any	G Technical college qualification OR H Master craftsman, technician, or equivalent technical college qualification	65	Bachelor's—professional	520	Short-cycle tertiary—professional	520a	Short-cycle tertiary—professional, after 212
						520b	... 213
						520c	... after 312
		64	Bachelor's—academic	610	Bachelor's—academic from lower-tier tertiary	520d	... after 313
	J Degree from a university of applied sciences (also from an engineering school) AND (A Bachelor's OR C Diploma)						
	K University degree—A Bachelor's			620	Bachelor's—academic from upper-tier tertiary		
	J Degree from a university of applied sciences (or from an engineering school)—AND B Master's	74	Master's—academic	710	Master's—academic from lower-tier tertiary		
	K University degree AND (B Master's OR C Diploma OR D Pre-Bologna degree “Magister” OR E State examination)			720	Master's—academic from upper-tier tertiary		
	F Doctoral degree	84	Doctorate—academic	800	Doctorate—academic		

GDR German Democratic Republic

Table 5 Candidates for standard education variables based on CASMIN and their derivation from ALLBUS 2018 response categories

German education categories in ALLBUS 2018		C_Max		C_Int1 : type of higher education		C_Int2: level of higher education		C_Min: broad CAS-MIN	
School qualification (Q056)	Postschool qualification (Q057 and 057A/B)	Code	Value label	Code	Value label	Code	Value label	Code	Value label
B finished school without qualification	M No vocational qualification OR E Vocational internship, traineeship	1a	Inadequately completed general elementary education					1	General elementary education or less
C Lower-track school-leaving qualification or completion of eight or nine grades of lower secondary school in the former GDR		1b	General elementary education						
A Still in school OR B finished school without qualification OR C Lower-track school-leaving qualification or completion of eight or nine grades of lower secondary school in the former GDR	A Vocational training on the job with a final certificate, but no apprenticeship OR B Semiskilled worker qualification OR C Completed industrial or agricultural apprenticeship OR D Completed commercial apprenticeship OR F Vocational school qualification OR G Technical college qualification OR H Master craftsperson, technician, or equivalent technical college qualification	1c	Basic vocational training above and beyond compulsory schooling					2	Intermediate/secondary education
D Intermediate-track school-leaving qualification or completion of ten grades of lower secondary school in the former GDR	2a		Intermediate vocational qualification or secondary programs in which general intermediate schooling is combined with vocational training						
E University of applied sciences entrance qualification OR F University entrance qualification (<i>Abitur</i>)	M No vocational qualification OR E Vocational internship, traineeship	2b	Intermediate general education: academic or general tracks at the secondary intermediate level						
	All previously mentioned vocational qualifications (A, B, C, D, F, G, H)	2c_gen	General maturity: full maturity certificates (e.g., <i>Abitur</i> , A-levels)						
		2c_voc	Vocational maturity: full maturity certificates, including vocationally specific schooling or training						

Table 5 (Continued)

German education categories in ALLBUS 2018				C_Max		C_Int1: type of higher education		C_Int2: level of higher education		C_Min: broad CAS-MIN	
School qualification (Q056)	Postschool qualification (Q057 and 057A/B)	Code	Value label	Code	Value label	Code	Value label	Code	Value label	Code	Value label
Any	J Degree from a university of applied sciences (or from an engineering school) AND (A Bachelor's OR C Diploma)	3a—low*	Lower tertiary education—bachelor's	3a	Lower tertiary education: lower-level tertiary degrees, generally of shorter duration and with a vocational orientation	3—low**	Tertiary education—bachelor's	3	Tertiary education		
	J Degree from a university of applied sciences (or from an engineering school)—AND B Master's	3a—high	Lower tertiary education—master's			3—high	Tertiary education—master's				
	K University degree—A Bachelor's	3b—low	Higher tertiary education—bachelor's	3b	Higher tertiary education: completion of a traditional, academically oriented university education	3—low	Tertiary education—bachelor's				
	K University degree AND (B Master's OR C Diploma OR D Pre-Bologna degree “Magister” OR E State examination OR F Doctoral degree)	3b—high	Higher tertiary education—master's			3—high	Tertiary education—master's				

**a—lower tertiary” and “b—higher tertiary” are the CASMIN distinctions foreseen at level 3. For France, the CASMIN 2003 version (Brauns et al. 2003) split 3a into “3a general” and “3a vocational” and 3b into “3b low” and “3b high.” The former distinction does not match any relevant distinction within universities of applied sciences in Germany, while the latter distinction can be used to distinguish bachelor's from master's degrees both within 3a and 3b, which is the approach taken here. This means that the detailed categories are then “lower lower tertiary” (sic), “higher lower tertiary,” “lower higher tertiary,” and “higher higher tertiary”

**Note that this code applies to all bachelor's degrees irrespective of the higher-education sector and, therefore, appears twice in C_Int2. The same applies to code “3—high” for all master's degrees irrespective of the higher-education sector. This cross-cutting nesting structure is difficult to present in a two-dimensional table

GDR German Democratic Republic

2.3.2 Candidate Standard Variables Based on CASMIN

Previous research has shown that CASMIN in some countries performs better than ISCED when predicting outcome variables (Braun and Müller 1997; Kerckhoff et al. 2002; Schneider 2010). Table 5 shows the allocation of German school and postschool qualifications, as measured in ALLBUS 2018, to the CASMIN education categories. The candidates for a detailed CASMIN-based standard education variable differ only regarding the distinctions within the higher education sector. In the last published CASMIN version (Brauns et al. 2003), the higher-education sector (university of applied sciences vs. university) is distinguished rather than the level of degrees in the sense of bachelor's and master's levels. As CASMIN has not been updated since the Bologna reforms, our candidate maximum version (C_Max) differentiates between the bachelor's and master's levels in addition to the sectoral distinction. The first intermediate version (C_Int1) corresponds to the version by Brauns et al. (2003). Intermediate version C_Int2 replaces the sectoral differentiation with the one by bachelor's and master's and higher levels. Finally, a minimal version (C_Min) reduces CASMIN to the distinction between 1) general basic education and less, 2) intermediate/secondary education, and 3) higher education.

3 Methods

3.1 Data and Measures

We used cross-sectional data from the German General Social Survey (ALLBUS; GESIS-Leibniz-Institut für Sozialwissenschaften 2019), collected between April and September 2018. The probability-based sample consisted of $N=3477$ persons and aimed to represent the German adult population living in private households. The ALLBUS 2018 includes both detailed measures of educational attainment and numerous items assessing attitudes and behavior in a wide range of topics, such as the economy, media use, politics, social inequality, national pride, right-wing extremism, and religion. Since respondents living in eastern Germany are oversampled in ALLBUS, the person-based east–west weight (*wghtpew*) was used to proportionally adjust the distribution of respondents to the population.

We created the most detailed benchmark variable of educational attainment by assigning the specific combination of highest school-leaving certificate (variable “educ”; Fig. 1) and highest postschool qualification (extracting the highest one from indicator variables “de05” to “de18” given the multiple response character of the question in ALLBUS; Figs. 2 and 3) to each respondent. This resulted in a variable with 77 categories, the most informative variable to which the aggregated less informative but more parsimonious candidate standard education variables were compared. We excluded respondents who reported to be still in school and those with unknown or missing information on both items. If information on postschool qualification was available but not on the school-leaving certificate, we assumed them to have an intermediate school-leaving certificate to be able to code their level of vocational education and training. Then we created the candidate standard

education variables described in detail in Sect. 2.3 (Tables 3, 4 and 5). We used age (continuous) and sex (dichotomous) as control variables to be parsimonious and close to the usual research practice.

In contrast to previous research (Braun and Müller 1997; Kerckhoff et al. 2002; Kerckhoff and Dylan 1999; Schneider 2010), we did not use only one or a few dependent variables for the validation, but a broad pool of 157 outcomes from various research topics selected in a data-driven approach to obtain robust and broadly applicable results. We identified these outcome variables in the following way: First, we included all continuous variables as well as all ordinal variables that were recorded on a Likert scale of at least five levels and can, therefore, be treated as continuous variables in the analyses. Second, variables that applied only to small subgroups were excluded, and variables that were equivalent across subgroups were combined (e.g., social status according to current or, if not currently employed, former occupation). Third, to ensure that the validation variables could be meaningfully predicted by educational attainment, we selected validation variables in a data-driven way so that the benchmark education variable had to explain at least 1% of the validation variable's variance beyond the control variables for inclusion in the pool. As a result, in addition to a few objective (but self-reported) sociostructural characteristics (e.g., income, social status), the pool of validation variables consisted mostly of self-reported attitudes and behaviors within the whole range of topics covered in ALLBUS 2018. We present the validation variables including their descriptive statistics (i.e., n , minimum, maximum, M , SD , skewness, excess) and their paR^2 by the benchmark education variable in the electronic supplementary material (ESM) 1 on the project website on the Open Science Framework (<https://osf.io/paxtb/>).

3.2 Statistical Analyses

Following previous research, we measured the validity of a standard education variable by its *explanatory power relative to the benchmark* (i.e., the most detailed) *education variable*. More precisely, it was indicated by the relative partial adjusted R^2 (paR^2) resulting from a multiple linear regression model predicting each of the 157 validation variables by the respective education variable. To yield the relative paR^2 s, we estimated many baseline and full multiple regression models. In the baseline models, we predicted each validation variable only by the control variables. In the corresponding full models, we added one of the education variables (dummy coded) to the baseline model.

We evaluated the validity of the candidate standard education variables in three steps: First, we compared the overall validity of the candidate standard education variables based on the mean of the relative paR^2 s across all 157 validation variables. Second, we compared the variability in the validity of the candidate standard variables across outcomes based on a visual inspection of the full distribution of the relative paR^2 s using kernel density plots (Wickham et al. 2016). The kernel density estimation is an alternative to the histogram for continuous data. Third, we compared the validity of all education variables for the 20 most important validation variables in our dataset (i.e., the 20 variables for which the benchmark education variable showed the highest paR^2) using line plots. This step was added to exam-

ine whether a candidate standard education variable performed equally well across these most relevant education outcomes. The paR^2 s of the 20 validation variables most strongly associated with the benchmark education variable ranged from 0.14 (di07: per capita income) to 0.55 (isei08c: international socioeconomic index (ISEI); Ganzeboom et al. 1992). While the top ten most empirically relevant validation variables mostly represented sociostructural characteristics, the top 11–20 mainly represented political and attitudinal variables. We used the statistical software R (R Core Team 2020) and estimated the regression models using the *svyglm* function from the *survey* package (Lumley 2020) to account for the person-based east–west weight (*wghtpew*). We obtained KL divergence–based (partial) adjusted R^2 s from the package *rsq* (Zhang 2022) using the functions *rsq* and *rsq.partial*, respectively. We provide the R analysis scripts (including *renv* lock-file for reproducibility; Ushey 2020) and the corresponding HTML output files as ESM 2 and ESM 3 on the Open Science Framework.

4 Results

4.1 Step 1: Means of Relative paR^2 s

Table 6 summarizes how much explanatory power the different standard variables retain—or, to put it the other way around, *lose*—relative to the benchmark education variable based on their mean relative paR^2 s across all 157 validation variables. The ISCED-based maximum versions retained an explanatory power between 67% (the official I_Max1 with main levels and vocational/general distinction) and 77% (the unofficial I_Max3, which enriches official ISCED by elements of CASMIN beyond the vocational/general distinction). This means that even the most detailed ISCED-based standard variable, on average, entailed a loss of almost a quarter of the maximally possible explanatory power, and the most detailed official one almost a third. Among the ISCED-based intermediate versions, the often-used official one-digit ISCED variable indicating ISCED main levels (I_Int1) leads to a staggering loss of explanatory power of 48% and showed a 15–percentage point higher loss of explanatory power than the unofficial ES-ISCED variable (I_Int3) borrowed from the ESS with seven categories, just like I_Int1. This result shows that the same number of categories can go along with a substantial difference in validity. Moreover, the loss of explanatory power was essentially the same for I_Int3 as for I_Max1, even though the former has two fewer categories. The popular ISCED-based “low–medium–high” aggregation (I_Min) showed the highest loss of explanatory power among all 11 candidate standard education variables, at almost 60%.

Among the CASMIN-based candidates, the two intermediate versions comprising nine categories (C_Int1 and C_Int2) and the maximum version comprising 11 categories (C_Max) showed essentially the same losses in explanatory power (approximately 25%). The CASMIN-based aggregation into just three categories showed a loss of explanatory power of 50%, ten percentage points less than the respective ISCED-based measure. Comparing the performance of both ISCED and CASMIN-based candidate standard education variables, the CASMIN-based variables were

Table 6 Relative explanatory power of candidate standard education variables compared to benchmark education variable averaged across all 157 validation variables

Candidate standard education variables		Number of categories	Mean relative paR^2 s (%)	Mean loss of paR^2 s (%)
ISCED	I_Max3 (I_Max2 + CASMIN)	19	77.44	22.56
	I_Max2 (=edulvlb in ESS)	15	71.55	28.45
	I_Max1 (2-digit ISCED: level, gen/voc)	9	67.48	32.52
	I_Int1 (1-digit ISCED: main levels)	7	52.40	47.60
	I_Int2 (I_Int1 + 6 prof)	8	56.68	43.32
	I_Int3 (ES-ISCED in ESS)	7	66.78	33.22
	I_Min (low, medium, high)	3	40.91	59.09
CASMIN	C_Max	11	75.16	24.84
	C_Int1 (higher education sector)	9	73.91	26.09
	C_Int2 (higher education level)	9	73.68	26.32
	C_Min (basic, intermediate, higher)	3	50.03	49.97

superior to the ISCED-based variables, especially regarding the trade-off between parsimony and explanatory power.

4.2 Step 2: Full Distributions of Relative paR^2 s

Figure 4 shows the kernel density plots of the relative paR^2 s of the ISCED-based (top) and the CASMIN-based (bottom) standard variables. The kernel density plots indicate a high validity of an education variable if they have the following shape: The maximum of the distribution is on the right. Furthermore, the distribution declines steeply to the left of the maximum and does not rise (much) again further to the left. This shape visualizes that most of the relative paR^2 s of the corresponding education variable across the 157 validation variables are high and their variability is low.

Overall, the kernel density plots corroborated the mean values reported in Table 6. In addition, the kernel density plots showed that the lower the mean relative paR^2 , the higher the variability of the relative paR^2 s across the 157 validation variables. Thus, when a candidate variable showed an overall high validity, this tended to apply also to the individual validation variables. Nevertheless, even the most valid candidate standard education variable performed poorly for a small number of outcome variables.

4.3 Step 3: Relative paR^2 s of a Subset of Empirically Most Relevant Validation Variables

Turning to step three of the analyses, the line plots in Figs. 5 and 6, respectively, show the relative paR^2 s of all standard education variables for the 20 empirically most relevant validation variables. The upper line plots of Figs. 5 and 6 show the results for the ISCED-based standard variables; the lower line plots show the results for the CASMIN-based standard education variables. The line plots are to be interpreted as follows: The stronger and further up the y-axis the validation variables cluster, the

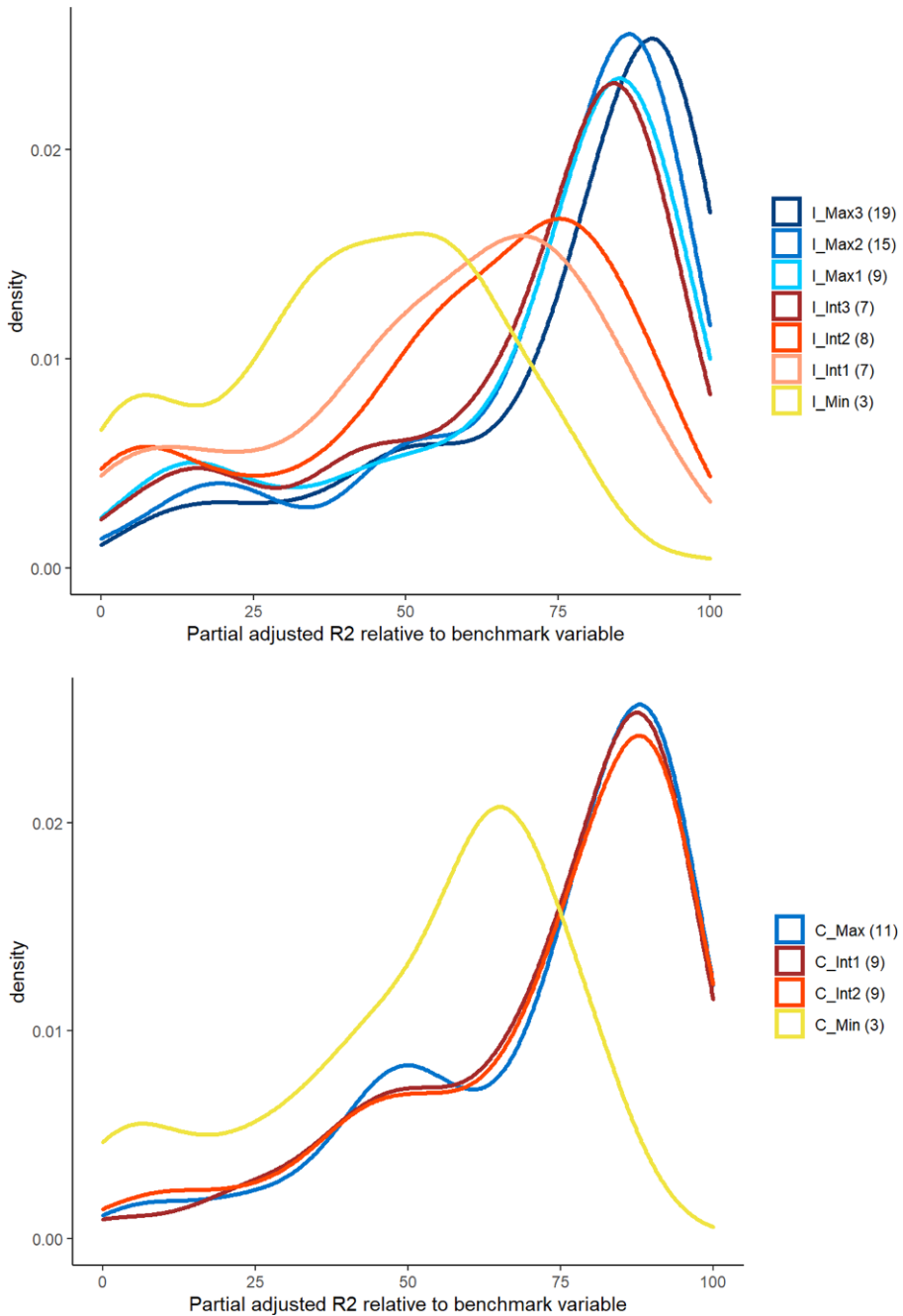


Fig. 4 Distribution of the relative partial adjusted R^2 s for the 157 validation variables of each of the 11 candidate standard education variables (top: ISCED-based; bottom: CASMIN-based variables)

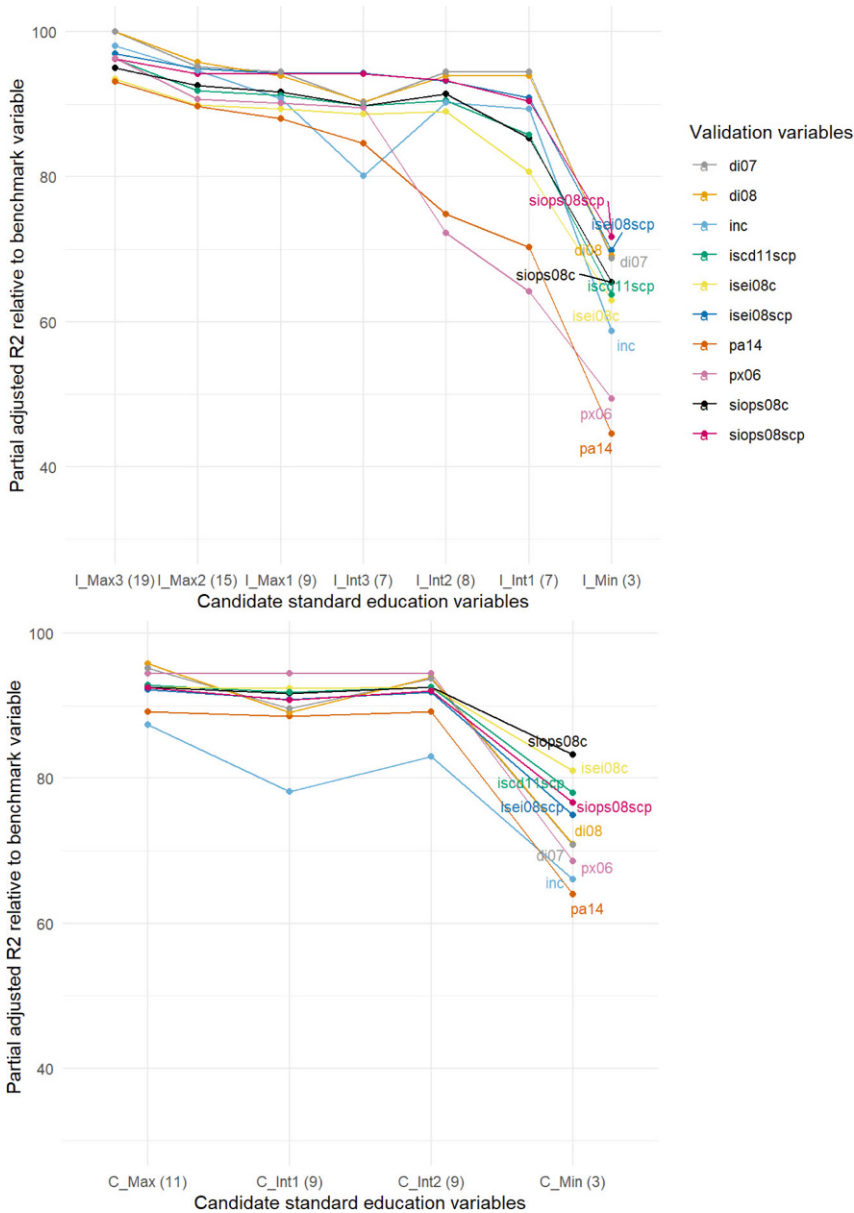


Fig. 5 Loss in explanatory power in the ten most empirically relevant validation variables. Validation variables in descending order of the benchmark education variable's paR^2 : *isei08c*: International socioeconomic index (ISEI) combined (c); *siops08c*: SIOPS combined (c); current and former occupation, *isei08scp*: ISEI current spouse or partner (scp), *iscd11scp*: ISCED current spouse or partner (scp), *siops08scp*: SIOPS current spouse or partner (scp), *inc*: R.: Monthly net income—open+closed, *pa14*: Stiffer sentences for offenders, *di08*: Equivalent income Organisation for Economic Co-operation and Development—modified scale, *px06*: Dangerously many immigrants in Germany, *di07*: Per capita income, net monthly

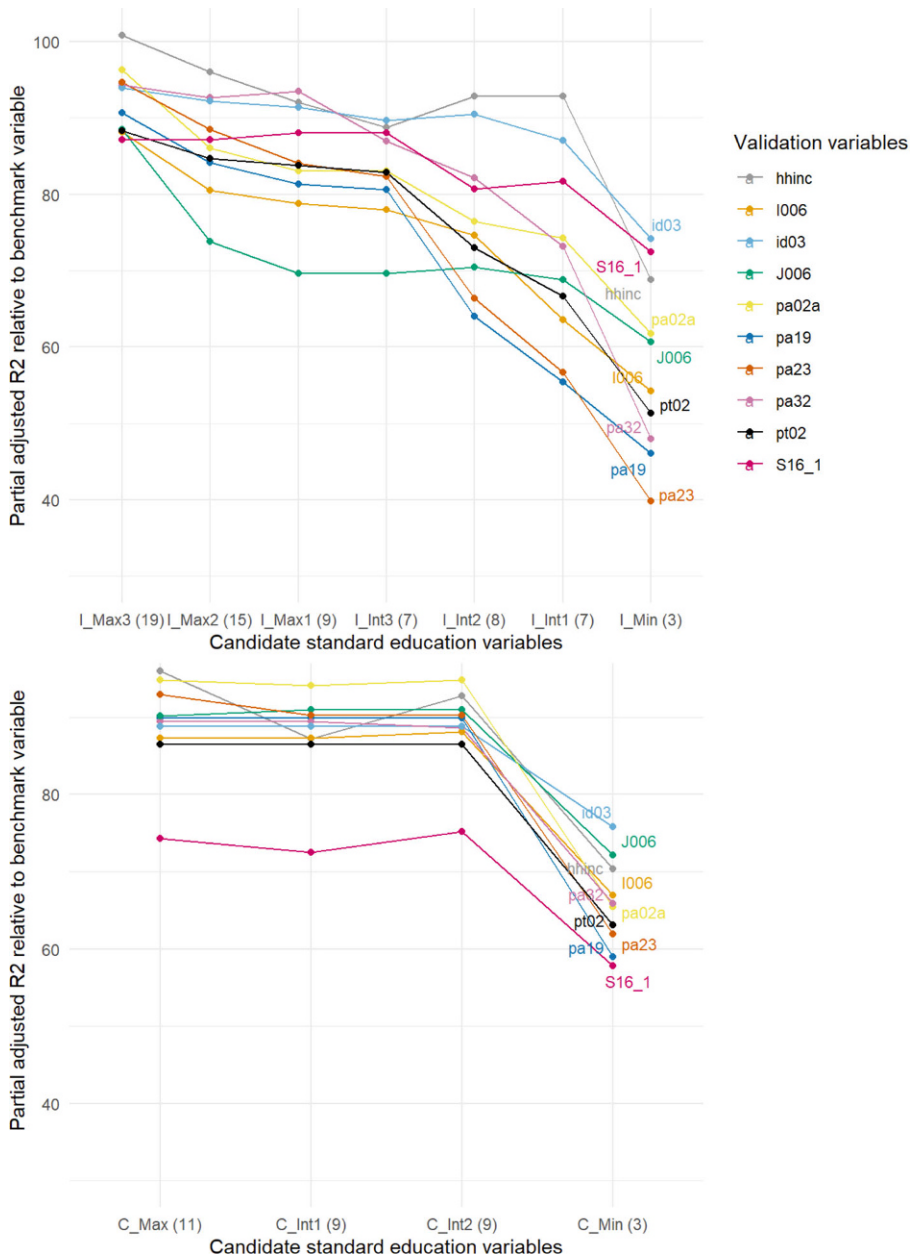


Fig. 6 Loss in explanatory power in the 11th to 20th most empirically relevant validation variables. Validation variables in descending order of the benchmark education variable's paR^2 : *pa19*: Stopping the immigration of refugees, *pa02a*: Political interest (ordinal), *hhinc*: Monthly net household income—open+closed Q., *pa32*: Political compromise is a betrayal of principles, *J006*: Man earns money, woman does housework, *I006*: Have no influence on the government, *id03*: Top-bottom-scale: self-classification, *pa23*: Left-right party assessment: CSU, *pt02*: Trust: Federal Constitutional Court, *S16_1*: Making ends meet with household income

better and more consistently they are predicted by the education variable indicated on the x -axis. By contrast, the greater the dispersion of the validation variables across the y -axis, the more inconsistently the respective education variable predicts outcomes and the less generally valid it is as a result. Here, our results indicated whether the validity of the candidate standard education variable varied according to the analysis topic.

In line with Table 6 and Fig. 4, among the ISCED-based standard variables, the maximum versions showed the highest validity. In the ten most empirically relevant validation variables, all maximum versions lost no more than up to approximately 10% of the explanatory power relative to the benchmark variable. In contrast, in the top 11–20 validation variables, all maximum versions lost up to 30%, resulting from a rather low performance of I_Max2 (the detailed ESS-variable *edulvlb*) and I_Max1 (official two-digit ISCED) when predicting gender role and anti-immigrant attitudes and political self-efficacy. I_Max3, with the highest number of categories and incorporating CASMIN criteria, showed the highest validity for almost all the top 20 validation variables. The ISCED-based intermediate versions I_Int1 (one-digit ISCED) and I_Int2 (one-digit ISCED with advanced vocational and bachelor's level distinguished) showed a larger dispersion along the y -axis of both the top 20 validation variables, with the loss of information compared to the benchmark variable ranging between approximately 5% and 45%. Thus, the validity of these depended more strongly on the specific validation variable (i.e., “research topic”) than was the case for the maximum versions. For example, while both I_Int1 and I_Int2 worked well for income variables (*di07* and *di08*), I_Int2 and especially I_Int1 performed poorly in the explanation of some social and political attitudes (e.g., anti-immigrant attitudes, *px06* and *pa19*, or stronger punishments for criminals, *pa14*). While the kernel density plots have already suggested such a pattern across the full range of validation variables, the line plots show that it also applies to the subset of the empirically most relevant validation variables. Compared to I_Int1 and I_Int2, I_Int3, which distinguishes between *Abitur* and VET at the upper secondary level in Germany, showed higher validity and higher clustering across the top 20 validation variables (i.e., the loss in explanatory power ranged between approximately 5% and 20%), comparable to I_Max1. I_Min showed the poorest performance, with an information loss ranging from approximately 30% to 60% compared to the benchmark variable.

The maximum version and both intermediate versions of the CASMIN-based standard education variables showed a loss in explanatory power of only approximately 5% to 15% relative to the benchmark variable in 18 of the top 20 validation variables. For some outcomes, the intermediate version focusing on levels within higher education (C_Int2) worked better than the one focusing on education sectors (C_Int1), and this may be changing given changes over time in the distribution of higher education attainment levels across sectors. Only the minimum version lost between approximately 15% and 40% of explanatory power across all top 20 validation variables and depended more strongly on the research topic: While C_Min showed a comparatively high validity for objective (though self-reported) social indices such as ISEI, its validity was smaller, among others, for some social and political attitudes

(e.g., *pa19*: stopping the immigration of refugees, or *pa23*: left–right party rating of the Christian Social Union in Bavaria).

Comparing ISCED- and CASMIN-based standard variables shows that, except for the ISCED-based *I_Max3* (which adds CASMIN-specific distinctions to detailed ISCED), CASMIN-based candidates clustered more strongly and further up on the y-axis across the top 20 validation variables compared to ISCED-based candidates. This applied especially to the top 11–20 validation variables (i.e., Fig. 6) that mainly represent subjective outcomes of education, such as attitudes and perceptions. Two variables that are better predicted by the ISCED-based than the CASMIN-based maximum and intermediate candidate standard education variables (except *I_Int3*) are personal income (*inc*) and whether the respondent copes well on their current income (*S16_1*), while per capita (*di07*) and equivalized incomes (*di08*) are well predicted by all candidates except both minimum versions. Regarding the minimum versions, the dispersion pattern for *I_Min* and *C_Min* is roughly the same, while the relative paR^2 s tended to be higher for *C_Min* than for *I_Min*.

5 Summary, Conclusions, and Recommendations

This study empirically evaluated the validity of 11 candidate standard education variables for output harmonization across German surveys relative to the most detailed variable that could be constructed using ALLBUS 2018 data. Results show that, on average, across a wide range of potential dependent variables, the CASMIN education scheme outperforms ISCED when coded at a comparable level of detail (e.g., *C_Int1* and *C_Int2* vs *I_Max1* with nine categories each) by six percentage points. CASMIN, therefore, better represents features of the German education system and individual characteristics that go along with pathways through this system, which are relevant to a broad range of outcomes.

The most highly performing candidate standard education variable (*I_Max3*) is one that combines the extended version of ISCED and CASMIN so that both, CASMIN as well as the official ISCED, can be derived. This variable retains 77% of the explanatory power of the most detailed education variable. The most detailed version of CASMIN (*C_Max*), the second-best candidate standard education variable, retains 75%. It distinguishes between the bachelor's and master's levels within 3a and 3b (not yet foreseen by Brauns et al. 2003). Since 2% additional validity does not offer enough added value compared to detailed CASMIN, a highly complex combined variable such as *I_Max3* with 19 categories should not become the German standard education variable, but rather the more straightforward new CASMIN variable *C_Max* with 11 categories.

Considering the overall good performance of the CASMIN-based variables, it is surprising that currently only a few surveys in Germany offer a derived CASMIN variable. Our findings call for surveys and research data centers to reconsider this omission and for researchers to employ detailed or intermediate CASMIN for all analyses except those of income. A hierarchical coding system was developed to facilitate and standardize such efforts across surveys and is presented in the Online Appendix 3.

For surveys or data users, it may be necessary to use ISCED to achieve comparability with data from official statistics, which exclusively use ISCED (albeit in various different versions, see Schneider and Urban 2025). The ISCED main levels—here, *I_Int1*, which is the ISCED variable offered by most surveys—have, however, been shown in this article to be of very limited validity, losing almost half of the explanatory power of the benchmark variable. This variable “harmonizes away” information that is empirically relevant and is only recommended for analyzing incomes. In comparison, *I_Max1*, which enriches main levels by the vocational or general orientation of education, “only” loses a third of the original explanatory power of education. This result leads us to recommend implementing *at least* the two-digit version of ISCED (*I_Max1*). Only GEDA currently does so.

Therefore, surveys should offer both CASMIN and ISCED as separate standard education variables that data users can employ based on the requirements for their specific research question. It is noteworthy that no candidate standard education variable works best across all validation variables. Researchers may thus consult ESM 2 and 3 (output as HTML files) to check to what degree the chosen education variable is valid for the outcome they wish to analyze.

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Author Contribution Silke L. Schneider as the lead author conceptualized the research underlying this article. She was responsible for the abstract, introduction, and theoretical and methodological background and conceptualized the candidate standard education variables. She also authored the summary and conclusions. Melanie Partsch developed the methodology, implemented the code/applied statistical and computational techniques to analyze the data, visualized the results, and was the main author of the method and results section. Lennart Palm performed an overview of educational variables offered by different studies. All authors together developed the research design, outlined the article, and reviewed and discussed all content before submission.

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