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How do the digital competences of students in vocational schools differ from those of students in cooperative higher education institutions in Germany?

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Abstract

Digital skills are thought to be a key competence of the twenty-first century. With the rapid growth of internet and communication tool (ICT) usage among both students and teachers, cooperative (co-op) education programmes, like other educational institutions, face the challenge of integrating and supporting digital skill development. However, little is known about how these skills are developed prior to entering cooperative education programmes. Against this background, a sample of 893 freshers, ranging from vocational students to co-op students, were tested according to their digital skills. The analysis shows that co-op students have a higher level of competence than vocational students. In addition, we found that in our sample social background has no impact on digital competences. The results are discussed and classified in the context of the current state of research.

Keywords: Digital competences, Vocational school students, Co-op students, D21-Digital-Index, Digital skills, Digital divide

Challenges and differences—an introduction

The labour market is undergoing major changes worldwide. In addition to the challenges currently faced by employers and companies in Europe—high unemployment, technical progress, globalization and an ageing population—digitization and digital techniques are thoroughly changing the world of labour due to their ubiquitousness. Because of this, the skills and qualifications provided by the European educational system may fail to align with current and future developments. They may fail to prepare pupils and students in cooperative programme in ways that encourage them to think and act responsibly and sustainably in a digital, knowledge-based network society.

In this situation, a more precise understanding of the growing challenges and circumstances surrounding digitalization in both vocational education and training (VET) institutions and cooperative higher education institutions is sorely needed. Looking first at the demographic data, one finds clear differences between cooperative higher education study programmes and vocational training programmes. VET schools primarily serve pupils whose average age (*M*) is 19.9 (Federal Institute for Vocational Education and Training 2019, p. 181), which is younger than that of students in cooperative higher education institutions. As an example of the latter, in their survey involving 5863 respondents, Wild and Alvarez (2020) noted an average age of 23.08 years ($SD=2.97$) for students at Baden–Wuerttemberg Cooperative State University (DHBW). These two educational pathways—VET schools and cooperative higher education programmes—also address different target groups. Vocational education is accessible to students with and without a university entrance qualification. Those who do obtain the university entrance qualification, are able to directly enter higher education institutions (Frommberger 2019). In comparison to vocational training programmes, cooperative higher education programmes offer academic training plus practical elements delivered by partner companies, but this on-the-job training is not allowed to hinder the academic training (Wissenschaftsrat 2013).

Furthermore, Thies (2015) and Kupfer (2013) explain that cooperative higher education study programmes attract very qualified and high-achieving students because of the recruitment policies of their partner companies. Additionally, the workload associated with this study model, which combines academic and vocational training, is even heavier than that of traditional university programmes. Last but not least, cooperative education study programmes claim to further educational advancement more effectively than do traditional university study programmes (Wolter 2016).

For VET instiutions, Seeber and Seifried (2019) identify four general challenges to vocational and educational training. First, as Baas and Baethge (2017) point out, training has been decoupled from employment and the number of apprenticeships has dropped during the past 20 years, as many companies that are willing to train cannot find eligible candidates for their apprenticeship positions. Second, low-educated and migration-based students generally lack strong integration power (Bildungsberichterstattung 2016; Seeber et al. 2019). Third, a 25% rescission of contracts in 2016 must be considered (Federal Institute for Vocational Education and Training 2018; Federal Ministry of Education and Research 2018). Fourth, the general structural change of the economy towards service-orientated organisations, as well as the effects of new technologies (digitisation) on future work processes have changed the skills required of employees.

In cooperative higher education, the situation is different. In 2016 there were 100,739 enrolled students, as compared to 64,358 in 2013 (Hofmann and König 2017), which shows a trend of increased interest in this type of education. Scholars highlight two principal reasons for this development (Graf et al. 2014). First, during the past decade German industry has proven to be robust in the face of financial and economic crises. One indicator, for example, is a continuously low youth unemployment rate of under 10% since 2007 (Federal Employment Agency 2019). The German cooperative higher education programme can be seen as a major contributor to this success. Secondly, there is a similarity between initial vocational training and cooperative higher education. As an example, learning takes place in two locations: at the higher education institution or school, and at site of the corporate partner.

However, both types of education and learning play a big role in the development both of future employers and of skills for nascent twenty-first century professions, especially with regard to digital technologies. In public discussions, there are often fears that the use of digital technology will destroy jobs because it is thought to increasingly replace the need for human workpower (Balsmeier and Woerter 2019; Brynjolfsson and McAfee 2017; Kurz and Rieger 2013). Arntz et al. (2018) predict that changes to classical working environments are a major future challenge for economic and labour market policies, especially in Germany as a leading place for technology. Such a situation offers an opportunity to train people for the future challenges in their current positions or provide targeted training to meet the needs of newly created jobs, especially for high-risk groups or later generations. This is a very important topic for education professionals, because the development and use of digital competences must be integrated into school and university curricula. Many countries have already taken action to make digital competences part of the national school curriculum (Claro et al. 2012; Wang et al. 2018). Current empirical results point to the positive effects of information and communication technology (ICT) on student achievement in reading, mathematics, and science (Skryabin et al. 2015; Hu et al. 2018).

Studies of digital skills among vocational and cooperative education students

Within the context of digitalization, a major challenge for vocational and cooperative education programmes is the rapidity and relative unpredictability of technological and social change. Digitization-related competences, as they will be needed by future students, refer to skill requirements that currently remain completely unknown or are hard to predict (Bürkardt et al. 2019). In this context, questions similar to those discussed decades ago in connection with the idea of "key qualifications" arise (Mertens 1974). Essentially, the current discourse focuses on identifying competences that make it possible to master future requirements. Research and teaching development must focus on discovering identifiable knowledge assets and specific competencies that could, with a certain degree of probability, empower students to adaptively respond to demands that are changing at an ever-increasing speed (Gebhardt et al. 2015). To date, only a few empirical studies on digital competences in cooperative education and higher education institutions have been done, such that we still know very little about the digital competences of students in vocational and cooperative education. However, we did find a few studies of relevance to this research paper.

In their survey of companies ($n = 22$) and vocational students ($n = 37$) within the industrial sector, Traub and Leppert (2019) showed that the use of standard office tools such as Excel, Word and PowerPoint is very important in the vocational school curriculum. A nearly identical and clear picture also emerged with respect to the significance of competence acquisition in the areas of data protection and data security. Vocational trainees also place importance on the use of digital communication and "programs for concurrent and joint work" and on Enterprise-Resource-Planning systems as a subject of classroom learning.

Based on mixed methods research at a university of applied science, Frischherz et al. (2018) showed that students, lecturers and representatives of the economy self-reported as needing the following digital competences: the ability to use working techniques, to seek and assess information, to prepare content in a media-friendly way, and to visualize data and structures. With respect to social media, which lecturers rated as far less important than other groups, the results varied widely. Frischherz's study further demonstrates that students have the following digital skills, in order of ranking: (1) the ability to use work techniques, (2) the ability to prepare content for media use, and (3) the ability participate in social media. Ranked fifth is the ability to visualize data and structures, and ranked eight is the ability to find and evaluate information (Frischherz et al. 2018, p. 84).

One study, by Bruns and Bruns (2019, p. 140), explicitly looked at digital competences for persons applying to a cooperative education program or vocational and training program by using the IT User Knowledge module of the GEVA test system for applicant selection. The study showed that applicants interested in pursuing occupations with a strong IT focus, such as that of qualified IT specialist, solved on average 80% of the test tasks and had a strong IT interest. In contrast, those interested in commercial and technical professions (IT-related professions) solved on average only 60% of the tasks. These percentages are higher than those for average secondary school graduates. Applicants' mathematics grades did not correlate with this score. With 75.3% of the possible points, men achieved significantly better results than women, who achieved only 57% ($p < .001$). For the professions with a strong IT focus, 70.3% of applicants were in the best category (competent) of the calibration sample, 26.1% in the middle category (independent), and only 3.5% in the lowest category (elementary). By contrast, the distribution of IT-related occupations differentiated the categories with 26.4% for elementary, 52% for independent, and 21.6% for competent. A high correlation with the applicant's professional motivation can be observed.

Digital competence frameworks

Before we can begin to study the many skills and abilities that people and especially students should acquire when they use technology in and out of the classroom, we need a concept and definition of digital competences. The ETS Report of the International ICT Literacy Panel (International ICT Literacy Panel 2002) and the IEA International Computer and Information Literacy Study (ICILS) from Fraillon et al. (2013) offer one such definition. This paper is based on the very detailed approach set forth in the DIGCOMP framework, which defines digital competences as the "confident, critical and creative use of ICT to achieve goals related to work, employability, learning, leisure, inclusion and/or participation in society" (Ferrari 2013, p. 2).

The DIGCOMP framework integrates the following five competences in the context of digitization: (1) information and data literacy (2) communication and collaboration, (3) digital content-creation, (4) safety, and (5) problem solving (Table 1). The five dimensions of competence encompass the following definitions (Ferrari 2013): *information and data literacy* is the ability to identify, locate, retrieve, store, organise and analyse digital information. Individuals with this competence have the ability to judge the relevance and purpose of information and data. *Communication and collaboration* is the ability to share resources through online tools and to use digital tools to link with and collaborate with other people in a digital environment. This competency involves interacting with and participating in communities and networks and requires cross-cultural awareness. *Digital content-creation* is the creation and editing of new content (from word processing to images and video). Content-creation focuses on creative expression, media output

Table 1 An overview of the DIGCOMP competences and their general description, according to Ferrari (2013)

Dimensions of competence	General description
Information and data literacy	Identify, locate, retrieve, store, organise and analyse digital information, judging its relevance and purpose
Communication and collaboration	Communicate in digital environments, share resources through online tools, link with others and collaborate through digital tools, interact with and participate in communities and networks, cross-cultural awareness
Digital content-creation	Create and edit new content (from word processing to images and video); integrate and re-elaborate previous knowledge and content; produce creative expressions, media outputs and programming; deal with and apply intellectual property rights and licences
Safety	Personal protection, data protection, digital identity protection, security measures, safe and sustainable use
Problem solving	Identify digital needs and resources, make informed decisions on most appropriate digital tools according to the purpose or need, solve conceptual problems through digital means, creatively use technologies, solve technical problems, update own and other's competence

and programming. Dealing with and applying intellectual property rights—for example, working with licenses—is an important aspect of this competence. *Safety* is of great importance due to its connection with personal, data, and digital identity protection issues, security measures, and the need for safe and sustainable digital technology usage. Finally, *problem solving* is the ability to identify digital needs and resources. Informed decisions on the most appropriate digital tools should be made, in accordance with purpose or need. Conceptual and technical problems can be solved through digital means. As a result, creative use of technologies and keeping one's own and other's competences up to date are important skills in this dimension.

The digital divide in research

Researchers argue about the usage trends, changes and dangers associated with digitalisation (Balsmeier and Woerter 2019; Huang et al. 2017; Nambisan 2017). For example, digitalisation is as important for education and learning as for the administration of education. In other words, Hamilton and Friesen (2013, p. 16) state that "We need to ask not only what technologies can do, but where they fail in relation to our expectations of education". Based on the term "digital divide", Ritzhaupt et al. (2013) summarised the digital divide on three levels: (1) equitable access to hardware, software, the Internet, and technology support within schools; (2) how frequently students and teachers use technology in the classroom, and for what purposes they are using technology; and (3) whether student users know how to use information and communication technology (ICT) for their personal empowerment.

Researchers write about socio-economic status and other factors, such as gender and ethnicity, with regard to access to the Internet and technology (Rowsell et al. 2017). Empirical results reveal a gender gap for primary and secondary school pupils and a relationship between socioeconomic status (SES) and ICT literacy. For example, Scherer and Siddiq (2019) show in a meta-analysis that girls perform better than boys on performance-based ICT literacy assessments ($g = .12$). Siddaq and Scherer (2019) show in another meta-analysis a correlation between SES and ICT literacy with $r = 0.21$.

However, little is known about student ICT literacy capacity and its relationship to other forms of engagement, as well as the resultant learning outcomes (Luu and Freeman 2011). Research also points to a digital divide in higher education (Murray and Pérez 2014). It is, therefore, important for researchers in higher education to understand the inter-relationships between ICT use, learning and development, and learning conditions (Canchu and Louisa 2009). For example, Tadesse et al. (2018) show that ICT use has an effect on general education, personal and social development, and higher-order thinking in higher education.

Research question

We had the opportunity to collect data regarding students' digital knowledge enrolled in both programmes at the beginning of their course. To the best of our knowledge, to date there has been no study comparing the digital competence of co-op students and vocational training students. This study aims to fill that research gap. As Weich et al. (2017) and Weiß (2016) note, there is a dearth of research studies in Germany for the field of cooperative education in particular.

Given the many differences between students of cooperative higher education and those in vocational training programmes and the differences between the programmes themselves, we expected to find differences in the digital competences of these two student groups. Accordingly, we deduce the following study hypothesis (H_1):

H_1 Students in cooperative higher education possess higher digital competences than students in vocational training.

Drawing on the research of the digital divide, we also want to test the study-hypotheses H_2 and H_3, because research results above and theory expect correlations here:

H_2 Female students have more advanced digital competences than male students.

H_3 Students with an upper social background have more advanced digital competences.

From the research sample we also collected and analysed data on the demographic variables of age and educational biography. This was felt necessary, because more highly qualified persons have, for example, better chances on the labour market (Hausner et al. 2015).

Method

Design and participants

To test the hypotheses, data was collected from a cross-sectionally designed survey involving 893 participants and a paper and pen questionnaire, in lectures that took place from November 2018 to March 2019. A privacy policy was adhered to, and participation was voluntary. No incentives were given. The dataset used for this study is available from the corresponding author of this paper upon reasonable request.

In the sample group, 61% of the participants were female students, 38% were male, and 1% could be classified as neither male nor female (diverse). The average age (*M*) of the participants was 19.87 ($SD = 2.21$); 98% were in their first academic year, and 46% were students of cooperative higher education at the Baden–Wuerttemberg Cooperative State University (bachelor degree programme in Industry Trading or Industrial Management). Details of this education programme are shown in Wild and Neef (2019). 54% of the sample participants were enrolled in five Baden–Wuerttemberg vocational training schools from the business sector (Industrial Management Assistant, Retail Sales and Retail Business).

Detailed analysis of these two groups show that the students in cooperative higher education institutions were nearly 1 year older ($M = 20.44$; $SD = 1.85$) than students in VET ($M = 19.38$; $SD = 2.33$) in our sample ($F(1, 891) = 55.61$, $p < .001$). A gender effect for these two groups did not exist (χ^2 $(2) = 1.50$, $p = .47$). However, more cooperative higher education students were pursuing a vocational apprenticeship degree (journeyman certificate) than were students in VET (30% versus 11%, respectively); χ^2 $(1) = 50.42$, $p < .001$. Parents of the VET students rarely (33%) had an academic degree from higher education institution; by comparison, 48% of those of the cooperative higher education students did (χ^2 $(1) = 18.59$, $p < .001$). We also found a difference with respect to school-leaving certificates (χ^2 $(4) = 461.91$, $p < .001$): 85% of students of cooperative higher education possessing a university entrance qualification, whereas most (63%) of the VET students possessed a lower school qualification with a General Certificate of Secondary Education in a "Hauptschule" (20%) or a "Realschule" (43%).

Measurement

In order to test our hypotheses, we used a modified instrument by Müller et al. (2018) based on the DIGCOMP framework (Ferrari 2013) to measure digital competences and added the two items "connecting hardware" and "learning to handle new program versions" under the competence "dimension problem solving". All items are listed in Table 2. We used self-reports, allowing the respondents to choose a single option from each item in the questionnaire, if the item was relevant. The decision to measure the items based on self-reports was based on the arguments put forth by Lucas and Baird (2006, p. 41) that "although errors surely do occur, they often do not severely limit the validity of the measures". The analysis of the measurement quality drew on the item response theory that Birnbaum (1968) implemented in his approach. The five dimensions, with a total of 24 items, show an acceptable measurement quality and are empirically separable. Every scale was introduced with the phrase "What can you do, recognize and what is your behaviour" with regard to: Information and data literacy (EAP/PV-Reliability = .66; 5 Items; item example: "Data transmission between devices"), communication and collaboration (EAP/PV-Reliability = .64; 4 items; item example: "Recognizing fake news"), digital content-creation (EAP/PV-Reliability = .69; 5 items; item example: "Design web applications"), safety (EAP/PV-Reliability = .56; 5 items; item example: "Regular updates of antivirus software") and problem solving (EAP/PV-Reliability = .74; 5 items; item example: "Learning to use new program versions"). A full report of the quality of the testing instrument can be found in Wild and Schulze Heuling (in review). Analysing the instrument of local item independence show a value of less than 0.20 for item residual correlations, with only one exception. We estimated four models to check the multidimensionality of

Table 2 Items and dimension in translation and in their original language

Item in English	Item in German
Information and data literacy	*Informationsverarbeitung*
Internet research	Internetrecherchen
Data transmission between devices	Datenübertragung zwischen Geräten
Use of multiple sources	Nutzung mehrerer Quellen
Recognition of advertisements	Erkennen von Werbeanzeigen
Level of attention for search results, beyond the first page	Beachtung von Suchtreffern über die erste Seite hinaus
Communication and collaboration	*Kommunikation*
Online bank transfer	Online-Überweisung
Recognizing fake news	Erkennen von Fake News
Posting information on social networks	Inhalte in soziale Netzwerke einstellen
Handling hostility on social networks	Umgang mit Anfeindungen über soziale Netzwerke
Digital content-creation	*Erstellen von Inhalten*
Create articles (text programs)	Texte erstellen (Textprogramme)
Create calculations (tabulation program)	Berechnungen erstellen (Tabellenprogramme)
Create a presentation	Präsentationserstellung
Design web applications	Webanwendungen gestalten
Programming	Programmieren
Safety	*Schutz und Sicherheit*
Awareness of services/app sharing Transferring of data	Bewusstsein, dass Dienste/Apps Daten weitergeben
Posting little personal data online	Wenige persönliche Daten ins Netz stellen
Regular updates of antivirus software	Regelmäßiges Update der Antivirensoftware
Changing password regulary	Regelmäßiger Passwortwechsel
Awareness of the server origin (country)	Bewusstsein der Serverherkunft (Land)
Problem solving	*Problemlösung*
Installation of devices	Installation von Geräten
Establishment of a (home)network	Einrichtung (Heim-) Netzwerk
Helping other persons with problems on the Internet and PC	Anderen bei Internet- und PC-Problemen helfen
Connecting hardware to a device	Hardware anschließen
Learning to use new program versions	Mich in neue Programmversionen einarbeiten

Text in the introduction: "Think about your digital skills. What can you do, recognize and what is your behavior?"

the instrument, using Akaike Information Criterion (*AIC*), Bayesian Information Criterion (*BIC*) and Log-likelihood (*LL*): one competence dimension with 1 PL Model ($AIC = 25{,}953.69$; $BIC = 26{,}079.71$; $LL = -12{,}951.85$; $Deviance = 25{,}903.69$; $df = 25$), one competence dimension with 2 PL Models ($AIC = 25{,}540.80$; $BIC = 25{,}782.75$; $LL = -12{,}722.40$; $Deviance = 25{,}444.80$; $df = 48$), five competence dimensions in accordance with the structure of Table 2, with 1 PL Model ($AIC = 25{,}420.37$; $BIC = 25{,}616.95$; $LL = -12{,}671.18$; $Deviance = 25{,}342.37$; $df = 39$) and the dimensions with the five competences, in accordance with the structure of Table 2 with 2 PL Model ($AIC = 25{,}204.22$; $BIC = 25{,}496.57$; $LL = -12{,}544.11$; $Deviance = 25{,}088.22$; $df = 58$). Furthermore, we tested the multidimensional model with five competence dimensions (2PL model) based on χ^2-Difference Tests with better significant fits against the model with one competence dimension with 1 PL Model ($\chi^2 = 815.47$; $df = 33$; $p < .001$), one competence dimension with 2 PL Model ($\chi^2 = 356.58$; $df = 10$; $p < .001$) and at last the five competence dimension with 1 PL Model ($\chi^2 = 254.15$;

df = 19; $p < .001$). The five dimensions correlate according to Pearson vary between $r = .46$ and $r = .68$.

In addition to digital competences, we assessed demographic variables. Social background was measured using one variable. For this, students were asked to rate their own social background at the age of 15 on a scale from 1 (= working class) to 10 (= upper class) (subjective classification of social background). Educational biography was measured using three variables: when the student completed secondary school, whether she/he had obtained the university entrance qualification, and whether she/he had already successfully completed a vocational training programme.

Statistical analysis

After the primary data analysis, we conducted a second data analysis using multilevel modelling by estimated random intercept and random slope models via restricted maximum likelihood (Raudenbush and Bryk 2002). This analysis showed a cluster size of 37 classes, with $M = 24.14$ ($SD = 9.69$) and a range of 10 to 64 participants. Furthermore, metric data was grand-mean centred. We first tested our assumptions by calculating the intra-class correlation coefficient (ICC) and the design effect (shown in Table 3). An ICC_0 of > .05 (Heck et al. 2010) and a design effect of > 2 (Snijders and Bosker 1999) are often used as a cutoff criteria for poor models. For the dimensions "information and data literacy" and "communication and collaboration", our assumptions were confirmed. For the dimension "safety", the score fell slightly below the cutoff point. The scores for the dimensions, digital content-creation and problem solving fell below the cutoff point.

As a result, the dimensions "information and data literacy" and "communication and collaboration" were further analysed using multilevel modelling. The remaining dimensions were analysed with robust regressions (Jann 2010). In these analyses, the models for comparison were estimated through ordinary least squares (OLS), a quantile (including median) regression model with 500 bootstraps (LAV), a Huber-M-Estimator with a 95% efficiency of a normal distribution (M95), and a MM-Estimator of 50% breakdown point with an 85% efficiency of a normal distribution (MM85).

Given that there were missing values for M = 1% (range between 0.2% and 7.2%) in the data, we decided to estimate metric values using an EM-algorithm (Enders 2010).

Table 3 Intra-class correlations (ICC) und design effect for dependent variables of digital competence

	ICC_0	Design effect
Information and data literacy	0.09	3.02
Communication and collaboration	0.07	2.65
Digital content-creation	0.01	1.15
Safety	0.04	1.97
Problem solving	0.02	1.38

ICC_0 Intra-class correlations empty model (without independent variables), design effect according to formula "1 + (average size of Level 2 clusters − 1) * ICC_0"

The analysis was conducted using SPSS software (Version 25) and STATA (Version 14).

Results

Primary analysis

In accordance with our research question, we first analysed the digital competence between the two cooperative student concepts (Fig. 1). For the dimension "information and data literacy" and "communication and collaboration", boxplot values for the group of cooperative higher education students was higher than those for the other group. By contrast, both groups showed a similar distribution pattern for the dimension "digital content-creation". The dimensions "safety and problem solving" showed slightly higher values for cooperative higher education students than for vocational training students.

In a second step, we analysed gender effects. This analysis was problematic, because the diverse group numbered only 10 participants. However, comparing male and female participants, Fig. 2 shows differing boxplots for the dimensions "problem solving", "information and data literacy", and "safety", with the male participants scoring higher values. The "diverse" gender also had higher values for the dimension "problem solving".

In a third step, we compared participants' social background in the context of their digital competences. Following Pearson, the correlation rate (*r*) shows effects between $r = -.01$ and $r = .06$. The dimensions "safety" ($r = .04$) and "communication and collaboration" ($r = .06$) showed the highest correlations. The analysis presented above is the starting point for the following multivariate analysis used to test our hypotheses.

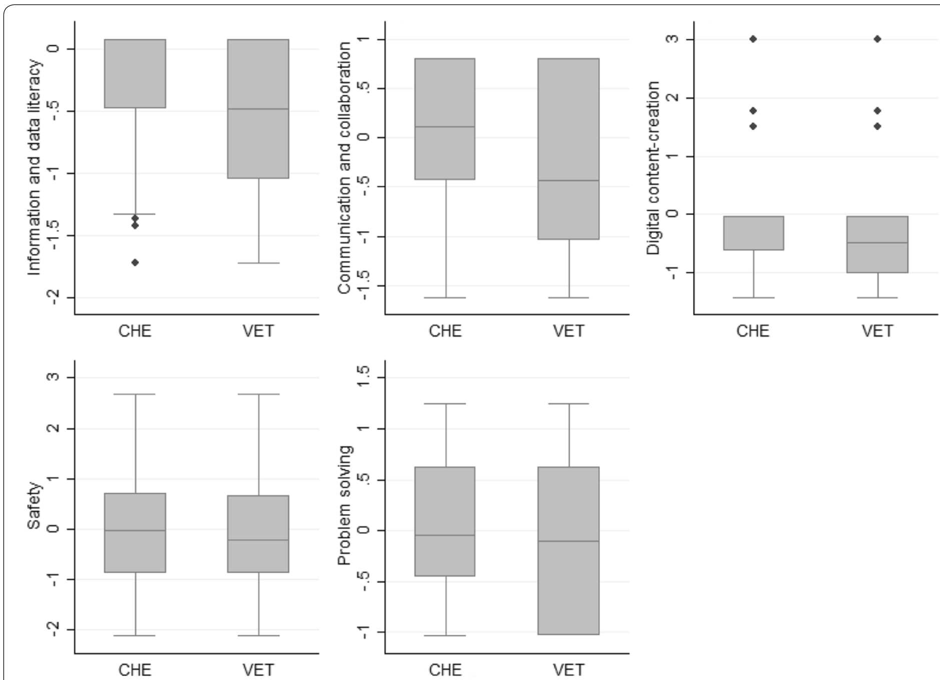

Fig. 1 Digital competences of cooperative student concept by *CHE* Cooperative higher education and *VET* Vocational education and training (standardized Score of Theta)

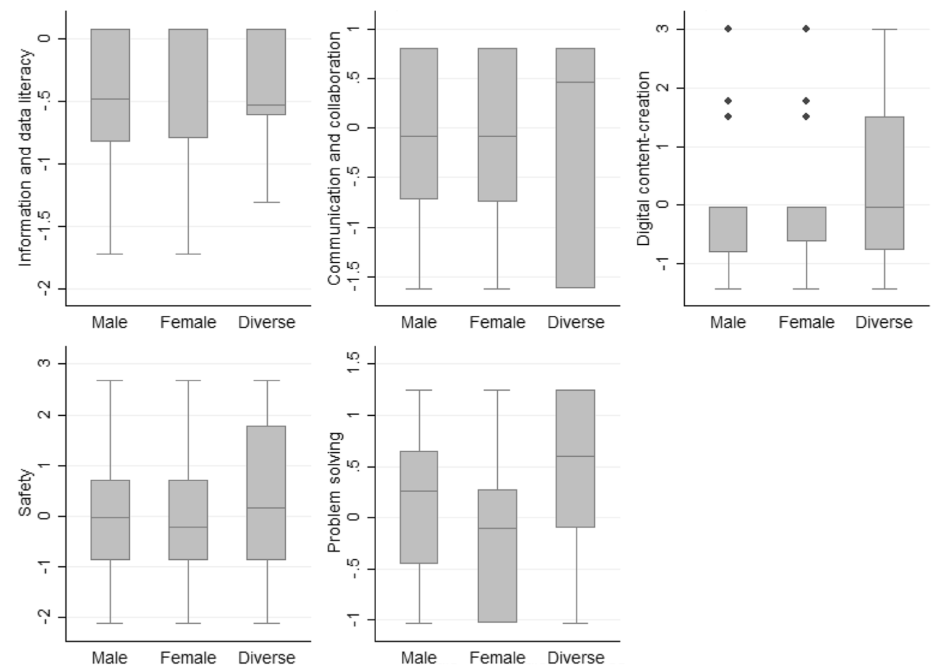

Fig. 2 Digital competences and gender (standardized Score of Theta)

Table 4 Results of multilevel analysis of the digital competences in formation and data literacy and communication and collaboration

	Information and data literacy *β*	Communication and collaboration *β*
Class-level variables (level 2)		
Cooperative higher education (ref = vocational training)	.26 (.07)***	.33 (.10)**
Individual-level variables (level 1)		
Female (ref = male)	.02 (.04)	−.10 (.06)#
Diverse (ref = male)	.06 (.17)	.03 (.25)
Social background	−.01 (.01)	.01 (.02)
Age	.01 (.01)	−.01 (.01)
Year of schooling graduate	.01 (.01)*	.00 (.00)
Degree of vocational training (ref = no degree of vocational training)	.10 (.06)#	.02 (.08)
University entrance qualification (ref = no university entrance qualification)	.04 (.05)	.04 (.08)
Level 2 R^2	.91	.08
Level 1 R^2	.51	.28
N (classes)	37	37
n (individuals)	869	869

β unstandardized beta weight, standard errors in parenthesis

# $p<0.10$, * $p<0.05$, ** $p<0.01$, *** $p<0.001$

Hypotheses testing

As mentioned previously, we employed a multilevel analysis to analyse the digital competences "information and data literacy" and "communication and collaboration". Table 4 shows the results of this analysis. In our study, the competence "information and data literacy" was influenced by the cooperative student format on the class level (Level 2). Students from cooperative higher education programmes reported more advanced competences than did their counterparts from vocational training programmes ($\beta = .26$; $p < .001$), and gender and social background appeared to have no effect on these dimensions. The variables "biography of education" showed a significant effect in terms of the year of completion of secondary school ($\beta = .01$; $p < .05$) and the possession of previous vocational training qualifications ($\beta = .10$; $p < .10$). The model fit was good with results of $R^2 = .91$ (Level 2) and $R^2 = .51$ (Level 1). The results of the multilevel analysis for the digital competence "communication and collaboration" likewise shows a significant effect for students of cooperative education, who reported better competences than did those from vocational training programmes ($\beta = .33$; $p < .01$). The male participants showed significantly better results than the female participants in this respect ($\beta = -.10$; $p < .10$). The model fit for Level 1 ($R^2 = .28$) and Level 2 ($R^2 = .08$) was questionable.

Table 5 shows the results of the robust regressions for the dependent variable "digital content creation". While for the OLS there were no discernible differences between the two student groups ($\beta = .03$; $p = .78$), the cooperative higher education students had significantly better results for LAV ($\beta = .44$; $p < .10$), M95 ($\beta = .16$; $p < .10$) and MM85 ($\beta = .26$; $p < .001$). There was also a significant effect for participants who had no degree of vocational training at M95 ($\beta = -.05$; $p < .05$). But this effect was not robust.

The results for the dimension "safety" are presented in Table 6. There are relatively robust effects for the three variables: cooperative student, gender and age. Looked at in detail, we see that students from cooperative higher education programmes show higher competences in "safety" in OLS ($\beta = .20$; $p < .10$) and LAV ($\beta = .19$; $p = .14$). This effect increased with the estimation of M95 ($\beta = .27$; $p < .05$) and MM85 ($\beta = .34$; $p < .01$). In addition, the male participants scored better results in all four estimations. In terms of age, older participants generally had more advanced competences. This estimation was confirmed in all four estimations. Furthermore, there was a significant effect for participants who had no degree of vocational training at M95 ($\beta = -.11$;

Table 5 Results of regression analysis for digital content-creation (n = 869)

	OLS	LAV	M95	MM85
Cooperative higher education (ref = vocational training)	.03 (.11)	.44 (.24)#	.16 (.09)#	.26 (.08)***
Female (ref = male)	− .08 (.08)	− .01 (.03)	− .04 (.07)	.03 (.05)
Diverse (ref = male)	.38 (.47)	.36 (.67)	.26 (.40)	.11 (.22)
Social background	.01 (.03)	.01 (.01)	.01 (.02)	.01 (.02)
Age	.03 (.02)	.01 (.01)	.02 (.02)	.01 (.02)
Year of schooling graduate	.01 (.01)	.01 (.01)	.01 (.01)	.03 (.04)
Degree of vocational training (ref = no degree of vocational training)	− .09 (.01)	.01 (.02)	− .05 (.10)*	.04 (.08)
University entrance qualification (ref = no university entrance qualification)	− .01 (.10)	.01 (.13)	.03 (.09)	.09 (.07)

Unstandardized beta weight are presented, robust standard errors in parenthesis (LAV: Bootstrap standard errors)

OLS ordinary least squares, *LAV* least-absolute value, *M95* Huber-M-Estimator with a 95% efficiency of a normal distribution, *MM85* MM-Estimator of 50% breakdown point a 85% efficiency of a normal distribution

# $p < 0.10$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 6 Results of regression analysis for safety (n = 869)

	OLS	LAV	M95	MM85
Cooperative higher education (ref = vocational training)	.20 (.11)#	.19 (.13)	.27 (.11)*	.34 (.12)**
Female (ref = male)	− .16 (.08)*	− .21 (.10)*	− .20 (.09)*	− .23 (.09)*
Diverse (ref = male)	.40 (.50)	1.15 (1.05)	.27 (.58)	.01 (1.17)
Social background	.02 (.02)	.02 (.02)	.01 (.02)	.01 (.03)
Age	.06 (.02)**	.05 (.02)*	.07 (.02)**	.06 (.03)*
Year of schooling graduate	.01 (.01)	.01 (.01)	.01 (.01)	.01 (.01)
Degree of vocational training (ref = no degree of vocational training)	− .11 (.12)	− .07 (.12)	− .11 (.12)*	− .09 (.13)
University entrance qualification (ref = no university entrance qualification)	− .02 (.11)	− .07 (.13)	− .02 (.11)	− .02 (.12)

Unstandardized beta weight are presented, robust standard errors in parenthesis (LAV: Bootstrap standard errors)

OLS ordinary least squares, *LAV* least-absolute value, *M95* Huber-M-Estimator with a 95% efficiency of a normal distribution, *MM85* MM-Estimator of 50% breakdown point a 85% efficiency of a normal distribution

# $p<0.10$, * $p<0.05$, ** $p<0.01$, *** $p<0.001$

Table 7 Results of regression analysis for problem solving (n = 869)

	OLS	LAV	M95	MM85
Cooperative higher education (ref = vocational training)	.13 (.08)#	.17 (.13)	.14 (.08)#	.16 (.09)#
Female (ref = male)	− .35 (.05)***	− .42 (.08)***	− .39 (.06)***	− .41 (.06)***
Diverse (ref = male)	.29 (.27)	− .19 (.61)	.30 (.29)	.30 (.41)
Social background	− .01 (.02)	− .01 (.02)	− .01 (.02)	− .01 (.02)
Age	.04 (.01)**	.06 (.02)**	.04 (.02)**	.05 (.02)**
Year of schooling graduate	.01 (.00)	.01 (.01)	.01 (.00)*	.01 (.00)**
Degree of vocational training (ref = no degree of vocational training)	− .02 (.07)	− .06 (.10)	− .01 (.08)	− .01 (.09)
University entrance qualification (ref = no university entrance qualification)	− .03 (.07)	− .02 (.12)	− .04 (.08)	− .04 (.09)

Unstandardized beta weight are presented, robust standard errors in parenthesis (LAV: Bootstrap standard errors)

OLS ordinary least squares, *LAV* least-absolute value, *M95* Huber-M-Estimator with a 95% efficiency of a normal distribution, *MM85* MM-estimator of 50% breakdown point an 85% efficiency of a normal distribution

# $p<0.10$, * $p<0.05$, ** $p<0.01$, *** $p<0.001$

$p<.05$), which is also shown in Table 5. The other results shown in this table for this competence show no significant differences between the two groups.

Table 7, below, shows our analysis of the digital competence “problem solving”. The results yield significantly higher values for cooperative higher education students at OLS ($\beta=.13$; $p<.10$), M95 ($\beta=.14$; $p<.10$) and MM85 ($\beta=.16$; $p<.10$) than for those in the other group. Female participants showed significantly lower results than male ones in all estimations. Age also had a positive significant effect in all of these estimations. Finally, the participant’s number of year of schooling has a positive effect on the estimation M95 ($\beta=.01$; $p<.05$) and MM85 ($\beta=.01$; $p<.01$).

Discussion

The results of the study confirm Hypothesis one: In all dimensions, students of cooperative higher education show more advanced abilities than do students of vocational training programmes. Hypothesis two must rejected. Male participants tend to show better values relative to female participants in the dimension “problem solving and safety”. Hypothesis must also be rejected, as we found no perceivable link between digital competences and social background. Further results show that age is a positive robust significant predictor for the dimensions “safety” and “problem solving”.

Based on the empirical results, one can make the following statements. A higher ability level among students from cooperative higher education programmes can be seen in the companies’ selection criteria (Kupfer 2013). Furthermore, a study in a higher education institution has got a scientific claim that possibly has an effect on the digital competences between these two groups.

We would argue for the effect of different digital competences in these two groups based on a possibly indirect effect of social background, with the student’s school degree acting as a mediator variable to achievement within the education system. Large-Scale Assessments show findings that correlate social background and school achievement (Ehmke and Jude 2010; Müller and Ehmke 2016; Hußmann et al. 2017). Based on the findings that correlate digital skills and student achievement in school (Skryabin et al. 2015), it possible to argue that such skills differ already in secondary school, and are possibly undertaught there. These differences in digital competences remain until the end of secondary schooling and during the transitional period into higher education. Further research to test these thoughts would be welcome.

Many developmental tasks take place during young adulthood (Nurmi 2004; Salmela-Aro 2011; Shanahan 2000). For example, Havighurst’s classic work (1974) classifies eight developmental tasks in young adulthood between the ages of 19 and 30: (1) deciding on a partner, (2) living with a partner, (3) starting a family, (4) raising children, (5) maintaining a (family) household, (6) starting a professional career, (7) taking societal responsibility, and (8) finding an adequate social network. These duties for developing can be conceptualized as achievement- and affiliation-related developmental tasks (Schulenberg et al. 2004). Such development could explain that there is a gender and age effect in different digital competences. Because we could assume correlation between these development tasks and digital competences.

The effect of gender is seen critically, because male participants have a higher self-assessment and subjective self-efficacy as female participants (Cooper et al. 2018). Objective performance tests are recommended for further analysis. The theories associated with the digital divide are not supported in this research. First, it is possible that participants’ self-measurement is not reliable and that the chosen measuring instruments are inaccurate, for this reason. Secondly, we can assume that Germany is a highly technological country, where access to technology, such as the Internet, is relatively easy for everyone, regardless of his or her background (Frees and Koch 2018). Based on Destatis (2020) it can be seen that 99% of people in the age cohort between 10 to 15 years and 16 to 24 years use internet in the year 2019. Implications for practice can be drawn from this study. For example, the results show that digital skills should be taught at vocational schools and included in the curriculum. Thus, one also faces the challenge to train teachers on digitalisation. Furthermore, the subject didactics at the vocational and higher education institutions have to address strategies how the desired digital competences are specifically integrated and instructed in the classroom. Approaches for VET can be found in Wilbers (2019) or in computer science education (Zendler 2018). Here, motivation-based learning environments—for example, those based on self-determination theory (Deci and Ryan 2002)—should be developed and used. For co-op students, the findings of Wild and Neef (2019) and Schulze Heuling and Wild (in review) are useful. For future research there is an apparent need to develop and try out other research design models related to digital competence, such as longitudinal studies to examine the concept both as a dependent and an independent variable (Brüderl and Ludwig 2014), or experimental designs.

This study raises new research questions. As research shows that in academic fields differences exist (Georg et al. 2009; Engler 1997), future studies are challenged to explore differences in digital competence with other academic fields. Especially in science, technology, engineering and mathematics (STEM), where the student dropout rate is high (Heublein and Schmelzer 2018), there is a need for research to explore the correlation between digital competence and, for example, the dropout rate. There is also a need to research special groups with their corresponding competence profiles. Researchers have the opportunity to analyse the special digital competence profiles of individuals in different groups, how these differ from others, and what factors affect these competence profiles.

To conclude, this study explores digital competences among cooperative education and vocational training students. Results show that students in cooperative higher education institutions have more advanced digital competences than do those in vocational training programmes, with male students show slightly higher abilities than female ones. Further research is needed to learn more about the learning conditions for digitalisation and how digital competences influences students' ability.

Strengths and weaknesses of the study design

The present study has several strengths. The sample size for the data analysis was large, and data collection was completed during a transitional phase in which the survey participants were actively integrating themselves into their new institution, drawing on their experience and knowledge of previously visited institutions. To the best of our knowledge, this is the first time research on digital competences was conducted on this population.

This research did present some limitations. As we collected data from only one German federal state, our research was limited to the field of economics, it is difficult to generalise from the results to assess their relevance to other academic majors. Since we used a cross sectional design, causal interpretation of this data can also be difficult (Brüderl and Ludwig 2014).

We used self-reports rather than objective tests to collect data for digital competences. While self-reports present some disadvantages such as social desirability, or participants may not be able to accurately assess themselves (Döring and Bortz 2016; Klieme et al. 2002) nevertheless stress that it is possible to obtain a valid picture of central aspects of "competencies" based on self-reports.

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The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

Competing interests
The authors declare that they have no competing interests.

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