



ABSTRACT

Major developments such as the AI and the green transition are shifting global skill demands. VET graduates may be particularly vulnerable to these changes, given their specific training as compared to more broadly trained non-VET graduates. Lifelong learning (LLL) activities can help prevent skill deficits. This paper examines differences between VET and non-VET graduates in LLL participation and skills, using PIAAC Cycle 2 data from 24 OECD countries. When comparing graduates from the same educational level, differences in LLL participation are generally larger between OECD countries than between VET and non-VET graduates within countries. Multilevel regression analyses show that VET graduates score lower in numeracy and adaptive problem solving compared to non-VET graduates. Training participation is positively associated with skills across all age groups, although effects are smaller for older adults. LLL participation is associated with a higher likelihood of feeling underskilled. No differences between VET and non-VET graduates were found in the association between LLL and skills or feeling underskilled. The association between training and skills was weaker for individuals with VET in their educational pathway.

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Skills2Capabilities, a Horizon Europe study, is about understanding how skills systems need to develop if they are to assist people to make labour market transitions – i.e. between jobs, employers or sectors – and thereby reduce the level of skill mismatch which might otherwise arise.

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Introduction

The world of work is changing rapidly, driven by factors such as the arrival of generative artificial intelligence (AI), increased flexibility of the labour market, the green transition, and automation (e.g. Acemoglu, 2024; Arntz et al., 2016). At the same time, many OECD (Organisation for Economic Co-operation and Development) countries are confronted with challenges related to demographics such as an aging population (André et al., 2024) and the arrival of migrant groups such as refugees. All these shifts lead to the demand for new skills, as well as to skill obsolescence — a decline in the value or level of existing skills — creating skill mismatches that harm productivity and employability. Lifelong learning (LLL) activities can help prevent these skill deficits by updating, repairing, and enhancing skills (Künn-Nelen, 2025). Indeed, governments worldwide focus on keeping the skills of their workforce up to date and introduce policy interventions to support reskilling in response to the evolving demands of work. A common strategy of countries in this regard is to stimulate LLL.

The importance of LLL has been widely discussed in the scientific literature. Early work demonstrated that education is positively related to earnings through higher productivity (e.g., Becker, 1962; Ben-Porath, 1967), and more recent studies generally highlight positive relations with overall skill level (Ferreira et al., 2017), employability, productivity, and job quality (Borghans & Golsteyn, 2008; Field, 2012; McMahon, 1998). De Grip and Sauermann (2012) confirm these findings through a field experiment. LLL also relates to non-economic benefits, such as better health, lower crime incidence, and greater civic participation (McMahon, 1998; Borghans & Golsteyn, 2008; Field, 2012). At the societal level, higher skill levels are associated with increased GDP, reduced poverty and crime, improved life satisfaction and health, and broader social benefits (McMahon, 1998; Krueger & Kumar, 2002).

However, a substantial share of the population is not taking part in LLL activities. Especially individuals that are most at risk in terms of a reduction of their employability, such as workers in routine occupations, low-educated individuals, and the unemployed lag behind in terms of their LLL participation (e.g., Ferreira et al., 2017; Kalenda et al., 2022). Another group that is relatively vulnerable to the changing skill demands, are the Vocational Education and Training (VET) graduates.

According to Bol and Forster (2025), *‘vocational education can generally be described as highly occupation-specific education that provides students with an educational qualification that is clearly tied to a narrow position in the labor market’* (p. 37). For a long time, VET graduates were shown to have better labour market outcomes, especially early in their career (Breen, 2005; Forster et al., 2016; Hanushek et al., 2017; Middeldorp et al., 2019; Ryan, 2001; Wolbers, 2007). However, since specific skills tend to depreciate faster, and are more susceptible to technological change than general skills (Brunello & Rocco, 2017b; Hanushek et al., 2017; Woessmann, 2018), VET graduates are now facing potential downsides of being educated for a niche, putting them at risk (Ter Weel et al., 2021). Indeed, Dicks et al. (2024) show that starting wages of VET graduates that

are educated for highly automatable occupations are lower than those of VET graduates that are educated for other occupations.

Compared to VET graduates, general graduates possess more general (or academic) skills which are not occupation-specific (Brunello & Rocco, 2017a). This might have two advantages. First, due to the wide applicability of general skills (Golsteyn & Stenberg, 2017; Woessmann, 2018), there is a wider variety of jobs graduates can apply for. Second, general skills can serve as ‘steppingstones’ for further learning. General skills, such as literacy or numeracy, can be applied to a wide range of tasks and jobs, while specific skills can be applied to fewer tasks or jobs (Becker, 1962; Golsteyn & Stenberg, 2017). Specific skills also tend to be less flexible than general skills, in regard to changing tasks within occupations (Krueger & Kumar, 2002; Forster et al., 2016). Accordingly, specific skills depreciate faster than academic or general skills, and are more susceptible to technological change (Borghans & Golsteyn, 2008; Brunello & Rocco, 2017b; Woessmann, 2018). Those with more specific skills – VET graduates – will therefore have to update their skills sooner than those with more general skills in order to remain in employment and competitive in the labour market later in life (Dicks et al., 2024). This is, however, easier said than done: VET graduates tend to participate less in training and adult learning activities (Schwerdt et al., 2012; Golsteyn & Stenberg, 2017; Hanushek et al., 2017; Woessmann, 2018; Hornberg et al., 2021).

This paper contributes to previous research that investigated differences in engagement in LLL activities and skill levels between VET and non-VET graduates. We explore the associations between participation in LLL activities and key information-processing skills and skill mismatch across these two groups. Specifically, we address the following research questions:

- To what extent do graduates with a VET degree engage in various LLL activities compared to graduates with a non-VET degree of the same educational level across OECD countries?
- To what extent do graduates with a VET degree have different levels of key information-processing skills and self-perceived skill mismatches as compared to graduates with a non-VET degree of the same educational level across OECD countries?
- To what extent are the associations between LLL activities and key information-processing skills and self-perceived skill mismatch different for graduates with a VET degree versus graduates with a non-VET degree within the same educational level across OECD countries?

Our contributions are threefold. First, unlike previous studies, we focus on the type of study within the same educational level, specifically upper secondary education. As noted by Bol and Forster (2025), the distinction between the type of study and the educational level is often not made, with entire educational levels being categorized as either vocational or general. This makes it impossible to distinguish the influence of vocational versus general education, as the difference might entirely be driven by the effect of educational level. Most evidence on the association between participation in LLL and skill development for VET graduates is indirect, i.e., training participation and key information-processing skills are found to be lower among vulnerable groups who have characteristics that can be linked to vocational graduates by proxy, but differences between VET graduates and non-VET graduates are not measured directly.

We are able to link skills and LLL activities directly to vocational education across multiple countries. Second, when analysing LLL activities, we not only focus on non-formal training participation, but also on informal learning at the job. This is particularly relevant, as most learning in the workplace happens informally through daily tasks, interactions, and problem-solving, rather than through structured training programmes (De Grip, 2024). Third, we broaden existing knowledge by performing two additional analyses. We apply a life course perspective by investigating the associations between LLL activities and skill levels among VET graduates and non-VET graduates across age groups. While VET graduates may have fewer incentives to engage in LLL early in their careers due to strong job-skill matches and higher opportunity costs, their need for upskilling is likely to increase later in life as their vocational skills become outdated. However, their participation often remains low, potentially due to limited key skills, leading us to examine how the associations between LLL, skills, and vocational education unfolds across age groups. These insights can help to reveal which specific groups to focus on in policy. Additionally, we broaden the definition of VET graduates by considering whether individuals have ever followed vocational education at any point in their educational pathway, regardless of the type of study of their highest qualification.

To answer the research questions, we utilize the novel PIAAC Cycle 2 dataset, collected in 2022-2023, including adults between 16 and 65 years old in 31 OECD countries. These adults were assessed on their key information-processing skills in the domains of literacy, numeracy, and adaptive problem-solving. Additional information on their education, work status, informal learning and training participation was collected through a background questionnaire.

The remainder of this paper is structured as follows: we begin with a literature overview, followed by a description of the data, measurements and methodology. Next, the results are presented. Finally, we conclude by discussing the results and offering directions for future research.

Literature overview

Differences in LLL participation between VET and general graduates

Despite the importance of LLL, and the different skills set that VET versus general graduates possess when entering the labour market, research on the participation in different types of LLL activities often does not make a clear distinction between VET and general graduates. This does not mean that there is no research about LLL participation of VET graduates (see e.g., Schwerdt et al., 2012; Woessmann, 2018; Tobback et al., 2024). Instead, as also mentioned by Bol and Forster (2025), the type (VET versus general) and level of education are often conflated, resulting in many studies that distinguish between vocational (upper secondary) or general (tertiary) education. This means that in estimating the effect of vocational education, the counterfactual can be different things: it can be general education at the same level but sometimes also general education at a different (higher) level.

There are only a few studies that compare the training participation of vocationally and generally educated workers, while also accounting for underlying differences in educational level between vocational and general graduatesⁱ. For example, Woessmann (2018) states that the vocationally

educated are less likely to participate in LLL activities than generally educated individuals. Similarly, Tobback et al. (2024) demonstrate that vocationally educated individuals are less likely to participate in on-the-job training and other training directly after graduation, relative to general graduatesⁱⁱ. Additionally, Brunello and Rocco (2017b) state that general graduates participate more often in work-related training courses early in their career, while Hanushek et al. (2017) find that they are more likely to receive this training as they become older (when residing in apprenticeship countries). In our study, we focus specifically on differences between vocational and general graduates within the same educational level, providing more direct evidence.

Differences in skill levels and skill mismatch between VET and general graduates

Individuals who followed a vocational path generally possess more specific skills and less general skills than their generally educated counterparts (Krueger & Kumar, 2002; Brunello & Rocco, 2017a; Choi et al., 2019; Hampf & Woessmann, 2017). This is not surprising, as the focus of the two educational paths is generally different; vocational programs are more closely linked to jobs, while general graduates are taught a more widely applicable skill set (Hanushek et al., 2017). Brunello and Rocco (2017a) explain that even when vocational and general education are taught at the same educational level (ISCED), general programme graduates have a higher proficiency in foundational skills. To what extent this also holds for adaptive problem-solving skills has not yet been researched.

These differences in the type of skills between vocational and general graduates also lead to differences in skill mismatches, i.e. differences in the skills that are required for a job and the skills that a worker possesses. Hanushek et al., (2017) argue that vocational graduates experience fewer skill mismatches than general graduates, as vocational graduates are more closely matched to jobs in the labour market than general graduatesⁱⁱⁱ. Coenen et al. (2014; 2015) look at the difference in the extent of mismatch between broad and narrow vocational programmes in the Netherlands and find that graduates from narrow vocational programmes have a higher likelihood of being mismatched (Coenen et al., 2014; 2015)^{iv}.

Relation between LLL participation and skills Now that the literature has been explored on possible differences in LLL participation and skill levels and mismatches between VET and general graduates, the next step is to examine what previous research has found regarding the role of LLL in skill development. After all, investing in LLL is especially meaningful when it results in measurable gains in skills. In this study, we are particularly interested in whether this association is different for VET versus general graduates. However, prior research directly addressing this comparison is scarce. Therefore, we first provide a general overview of studies examining the associations between LLL participation and skill development, to better understand the broader context of this relationship.

In the literature there is in general evidence that adult education and skill proficiency are positively related. Cross-national research (e.g., Desjardins, 2015; Desjardins & Kim, 2023) has, for instance, shown a consistent association between participation in LLL and literacy proficiency. Due to the cross-sectional nature of the data used in these studies, causality is not directly explored, but it is

shown that those who participate more frequently in adult education tend to have higher literacy skills, while the opposite holds for those with lower levels of participation. This pattern is also influenced by employer support, with more literate adults generally receiving more support for their LLL participation in most countries (Desjardins & Kim, 2023).

Ferreira et al. (2017) investigate how initial skill mismatches affect work-related learning and skill development in Europe. They find that both training and informal learning improve skills, with informal learning having a stronger impact. However, the benefits of work-related learning depend on the initial skill match: workers with lower skills relative to their job requirements gain the most, as learning helps to bridge the gap. In contrast, overskilled workers experience less skill development, with learning mainly preventing skill depreciation.

National skill surveys, such as the Dutch Skills Survey (Ter Weel et al., 2025) and the British Skills Survey (Henseke et al., 2025, Davuesm et al., 2025), show the increasing demand in many job tasks among which computer use and analytical tasks. Recent evidence in the Dutch surveys shows moreover that workers who participate in formal training or engage in informal learning through their jobs are more likely to report improvements in relevant skills, such as problem-solving, literacy, and adaptability. In the Netherlands, those who frequently acquire new skills at work tend to be higher-educated and better able to respond to changing task demands.

Heterogeneity in relation between LLL participation and skills across VET status

With our study we contribute to this stream of literature by investigating the associations between LLL activities and skill levels among VET graduates and non-VET graduates. Theoretically, there is reason to expect heterogeneity. General skills provide a better foundation for learning later in life, as they can be used as a ‘steppingstone’ for further learning (Cörvers et al., 2011; Golsteyn & Stenberg, 2017; Heckman, 2007; Woessmann, 2018). Cunha et al. (2005) explain this using the terms self-productivity (i.e., the skill level one possesses at one moment in the life cycle, increases the skill level later in the life cycle) and complementarity (i.e., skill begets skill; investments at early moments in the life cycle increase the productivity of later investments). Also Brunello and Rocco (2017a) state that the proper command of basic (foundational) skills is fundamental for updating and improving advanced skills and competencies. Whether the returns to LLL participation among VET and general graduates indeed differs, has not yet been researched. However, as Fouarge et al. (2013) find that those with a lower educational level have lower economic returns, which could be explained by the self-productivity mechanism as well, it is worth analysing whether LLL affects skill formation different for VET and non-VET⁷.

Data and measurements

Data

To answer the research questions, we use cross-national data from the second cycle of PIAAC (PIAAC-II). This is the largest international survey on adult skills, held every ten years. Data for PIAAC-II was gathered between 2022 and 2023. A representative group of respondents between the ages of 16 and 65 were assessed on their key information-processing skills in three domains:

literacy, numeracy, and adaptive problem-solving skills. Additional information on the respondents was collected through a background questionnaire. In total, 31 countries participated in PIAAC-II. Due to data restrictions in the public use files, we exclude five countries—Austria, Denmark, Italy, Norway, and Sweden. Additionally, we exclude the United States and Ireland because there is no variation between VET and non-VET graduates in upper secondary education. This results in a final sample of 24 countries included in the main analyses.

Since our interest is in lifelong learning and skills at work, we drop respondents that are currently enrolled in formal education. We include respondents that are employed and aged 25 years or older. This is to exclude people in our analytical sample who are taking a gap between educational programs, and thus did not leave formal education yet.

As noted before, the type (VET versus general) and level of education are often conflated, resulting in many studies that cannot clearly distinguish between vocational versus general education and upper secondary versus tertiary education (Bol & Forster 2025). PIAAC-II offers a unique possibility to disentangle the level and orientation aspects: we focus in our main analyses on respondents with an upper secondary qualification (i.e., ISCED3 in the UNESCO ISCED 2011 educational classification) and can distinguish VET and non-VET graduates within this educational level.

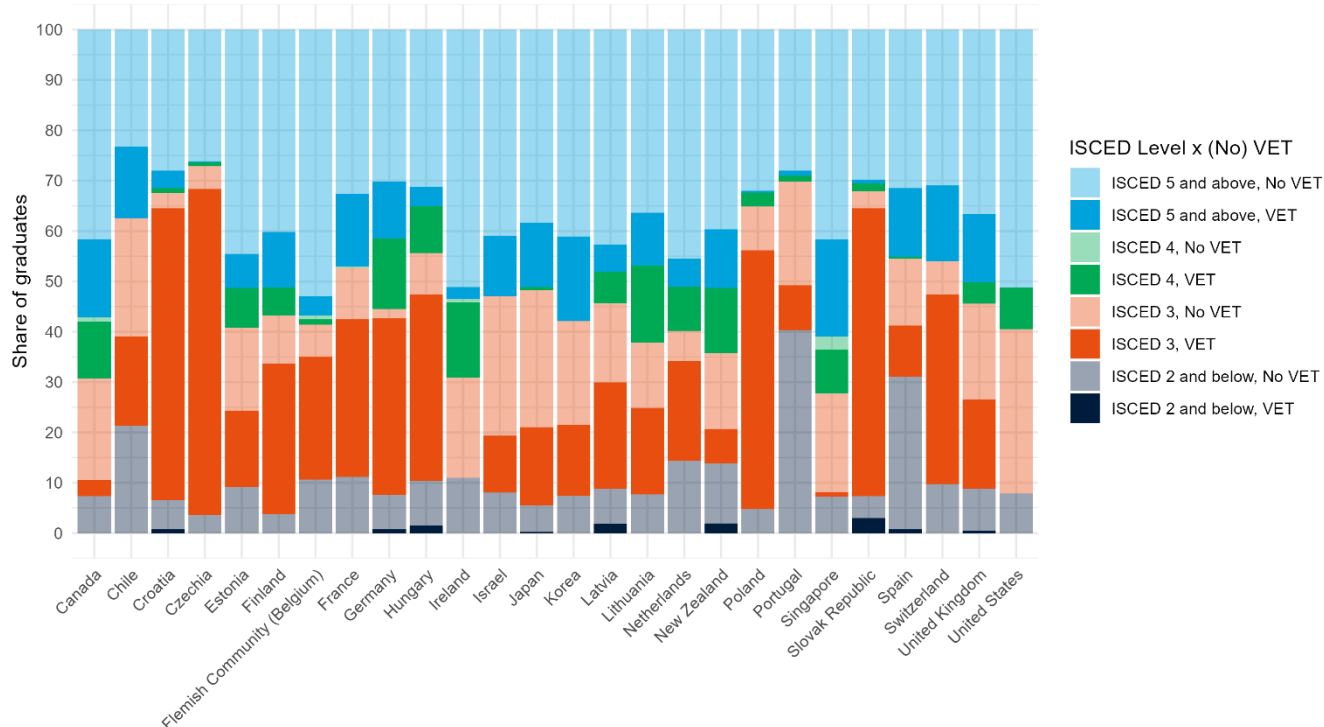


Figure 1: ISCED level and VET orientation of highest qualification. Source: Pooled PIAAC cycle 2 data; own calculation

In Figure 1 the shares of different groups of graduates are reported per country. For each educational level (ISCED), we distinguish between VET and non-VET graduates. Most variation between VET and non-VET programs within countries exists at ISCED-3 level. While for some countries like Croatia, Czechia, and Slovak Republic, we observe very high shares of VET graduates

within this education level, for other countries like Latvia, Lithuania, and Spain, the shares are more balanced. There are also countries, like Canada and Singapore, where VET shares are very small. Focusing on ISCED-3 graduates leads to a total of 28,987 respondents in 24 different countries in our main analyses.

Measurements

Skills measures

The key information-processing skills assessed in PIAAC-II cover three domains. While adaptative problem-solving concerns a new skill domain, literacy and numeracy were already covered in PIAAC-I. These skills are closely linked to the competences needed in work and everyday life, and can be generally applied. The skills are measured on a scale that ranges from 0 to 500. Since item-response theory is applied, each skill domain is measured with ten Plausible Values (PVs). In accordance with other studies (Hanushek et al., 2015; Esping-Andersen & Cimentada, 2018), for simplicity we use the first PV in our multilevel analyses.

For skill mismatch the following question is used: ‘Overall, which of the following statements best describes your skills in relation to what is required to do your job?’. Respondents had the following answering categories: ‘My skills are higher than required by my job’, ‘My skills are matched to what is required by my job’ or ‘Some of my skills are lower than what is required by my job and need to be further developed’. Based on this, we distinguish respondents who feel that some of their skills are lower than required in the job (underskilled) versus respondents who feel their skills are matched or higher than required.^{vi}

Vocational orientation

Vocational orientation of the highest qualification is based on the UNESCO ISCED 2011 educational classification. This defines vocational education as follows: education programmes that are designed for learners to acquire the knowledge, skills and competencies specific to a particular occupation, trade, or class of occupations or trades (UNESCO, 2012, p. 14). In PIAAC-II, there is an indicator on vocational orientation of the highest qualification, which we include in our analyses, as a binary variable (0 versus 1).

The advantage of this indicator is that it is based on an official international definition. This makes it possible to perform country comparisons. The disadvantage is that nuances in national education systems are not always visible or captured. This insight also emerged from discussions with some country experts that we had during the preparation of this study. By selecting individuals with upper secondary education, we ensure that the effect of educational level is to some extent isolated. However, distinguishing between VET and non-VET education at this level is challenging in some countries. This means that in some countries, the non-VET track at upper secondary education is not always a final stage of formal education or applies only to a highly specific group of graduates.

Lifelong learning activities

We include measurements for both non-formal and informal LLL. Non-formal LLL activity is measured by training participation in the 12 months preceding the survey. During the survey, respondents were prompted to consider training activities such as courses, webinars, workshops, lectures, or private lessons.^{vii} These activities can be job-related or pursued for personal interest. Respondents indicated whether they followed any training in the past 12 months (1) or not (0).

Informal LLL is captured by the extent to which respondents experience learning-by-doing in their job, ranging from never to every day.

Control variables

In our analyses we include the following control variables: age groups, sex, migration background, parental education, working hours and contract type. Age groups are divided into: '25 to 34 years old', '35 to 44 years old', '45 to 54 years old' and '55 to 65 years old'. Sex is measured by distinguishing 'males' (0) and 'females' (1). Migration background consists of the following four categories: 'first generation immigrants', 'second generation immigrants', 'non-first or -second generation immigrants', and 'non-immigrant and one foreign-born parent'. Working hours distinguishes parttime (<32 hours) versus fulltime workers (≥ 32 hours). Finally, contract type distinguishes permanent versus fixed term contracts.

Table 1 presents the descriptives of the variables included in our analyses.

Table 1: Descriptives statistics

	N	Mean	SD	Min	max
VET education	28,987	0.65	0.48	0.00	1.00
Numeracy scale score - PV1	28,987	252.92	50.46	16.67	473.96
Adaptive Problem Solving scale score - PV1	28,987	240.11	42.77	19.73	397.54
Feeling underskilled	28,987	0.08	0.27	0.00	1.00
Training participation last 12 months	28,987	0.33	0.47	0.00	1.00
Learning-by-doing (at least once a week)	28,987	0.42	0.49	0.00	1.00
Gender	%				
Men	0.53				
Women	0.47				
Age categories	%				
25-34	19.69				
35-44	24.35				
45-54	29.61				
55 plus	26.34				
Migration background	%				
1st generation immigrants	8.50				
2nd generation immigrants	3.88				
Non 1st or 2nd generation immigrants	81.34				
Non-immigrant and one foreign-born parent	6.28				
Parental education	%				
Parents have ISCED 0 to 2	29.60				
At least one parent has ISCED 3 or 4	52.24				
At least one parent has ISCED 5 to 8	15.73				
Missing	2.43				
Contract type	%				
Temporary	8.01				
Permanent	54.16				
Missing values	37.83				
Working hours	%				
< 32 hours	11.67				
>= 32 hours	84.42				
Missing values	3.92				

Source: PIAAC cycle 2 data; own calculation.

Methods

To investigate differences in LLL participation and skills development among VET and non-VET graduates across OECD countries, descriptive figures are presented separately for these variables. This provides insights into the differences between OECD countries for these outcomes.

We then go a step further by looking at associations between these variables. The key information-processing skills, numeracy and adaptive problem-solving, are measured on a continuous scale, which means that we perform multilevel linear regression analyses. Multilevel analysis takes into account that respondents are clustered within countries. In the first model, we include training participation in the past 12 months (i.e., formal learning) as well as the indicator on informal learning. In the second model, the association between having a VET qualification and skills is explored. In the third model, both the LLL variables and the VET indicator are added to the model. The fourth and final model examines whether the association between LLL and skills is different for VET versus non-VET graduates by adding interaction terms between the LLL variables and the VET indicator.

Next to the key-information processing skills we also investigate the probability of feeling underskilled. Since this is a binary outcome variable, we perform multilevel logistic regression analyses. The construction of the models is the same as for the key information-processing skills. We calculate Average Marginal Effects (AMEs) to ease interpretation. When multiplied by hundred, these coefficients can be interpreted as percentage points increase in the probability to be underskilled.

We also performed two additional analyses. In the first additional analysis, the previously described analyses are repeated by age groups. The second additional analysis considers whether respondents have ever completed a VET qualification as part of their formal educational pathway. This analysis uses the full sample, without restricting to those with upper secondary education only, and includes a VET variable indicating whether a respondent has completed a VET qualification at any point, regardless of whether it is their highest qualification. In these models, we control for respondents' highest attained qualification.

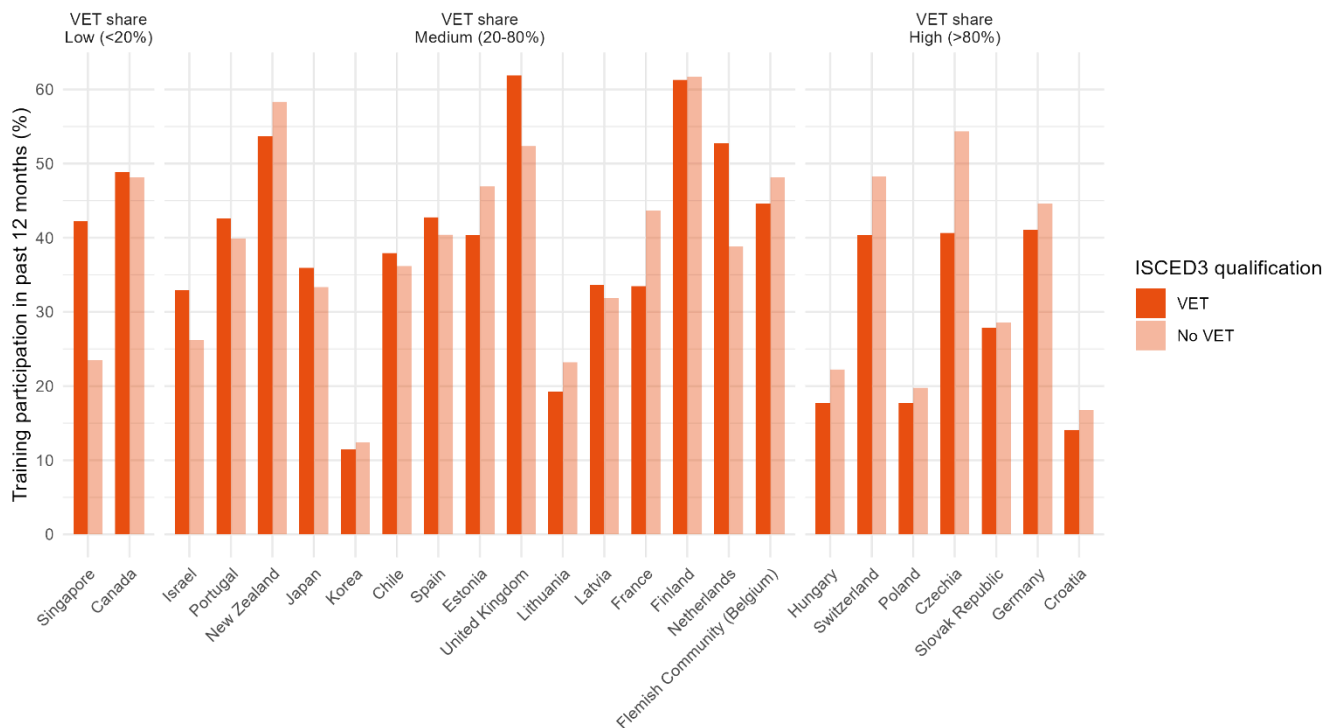
In all multilevel analyses, control variables are included and the provided replicate weight are used. Note that this is cross-sectional data, meaning that strict causal interpretation is not possible.

Results

1. Lifelong Learning and Skills: VET vs non-VET graduates with highest obtained degree at ISCED 3

1.1 Descriptive results: Lifelong learning and VET

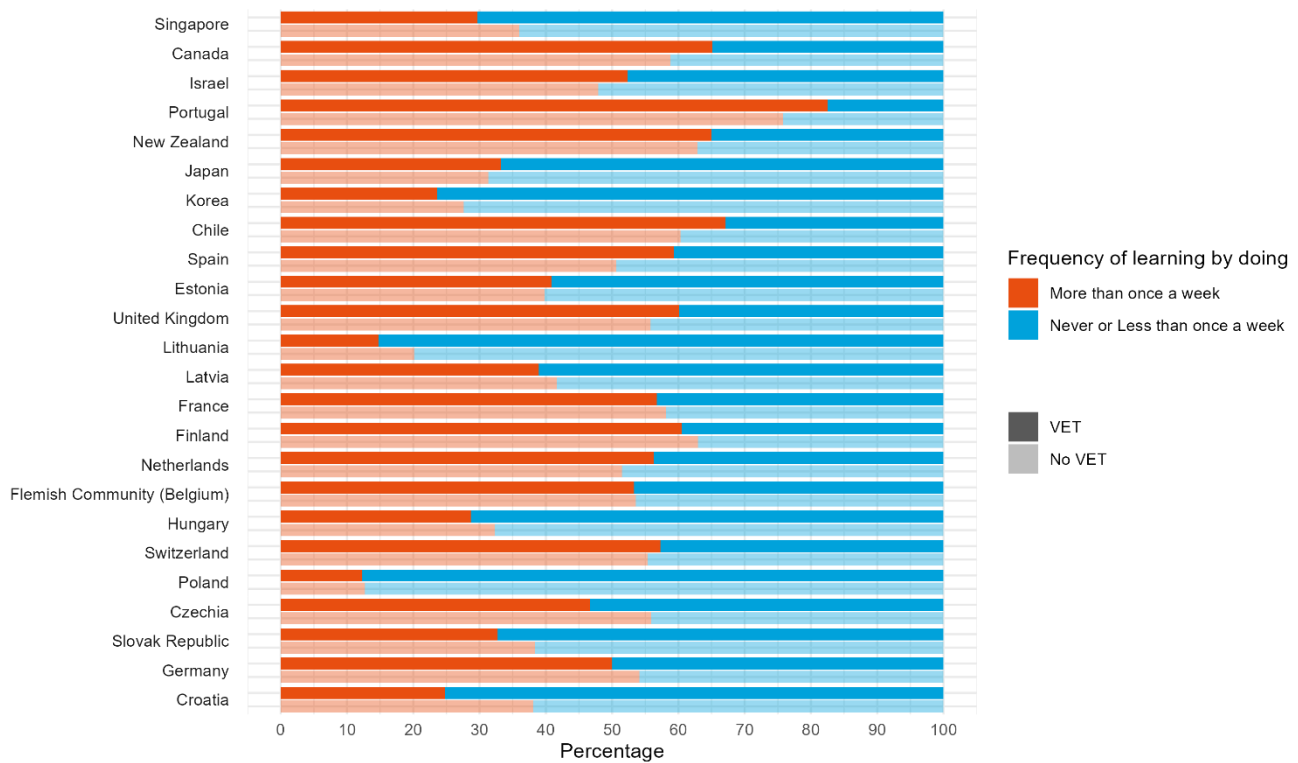
Figure 2: Percentage of training participation in the past 12 months across countries.



Source: Pooled PIAAC cycle 2 data; own calculation

Figure 2 shows the percentage of ISCED3-educated workers that indicate to have participated in training in the past 12 months. The percentages are shown separately for VET and non-VET graduates, and the 24 countries displayed are ordered by the share of VET-graduates among their ISCED3-educated workers. The percentage of training participation in the past 12 months varies between 11% (in South Korea) and 62% in Finland and the United Kingdom. Differences in training participation are generally larger between different countries than between VET and non-VET graduates within countries (at the same educational level). A pattern is visible where in countries with a high share of VET graduates at ISCED3 level, VET graduates less often indicated to have engaged in training than their non-VET educated counterparts. In countries with lower shares of VET graduates, the reverse pattern is often visible. In countries that have more balanced shares of VET graduates within the ISCED3 level, there is no clear pattern.

Figure 3: Frequency of learning-by-doing across countries.

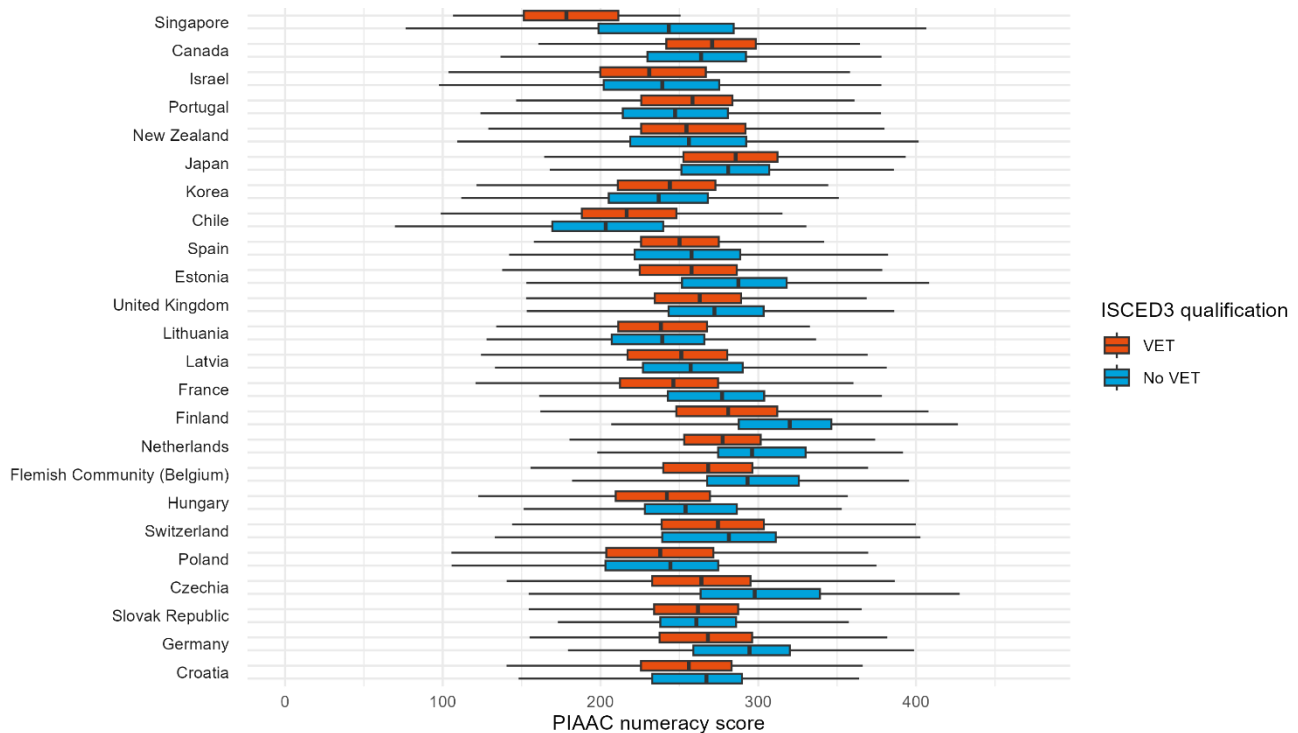


Source: Pooled PIAAC cycle 2 data; own calculation

Figure 3 shows the share of ISCED3-educated workers engaging in learning-by-doing more than once a week (in orange) or less than once a week/never (blue) across countries. Dark-coloured bars represent VET graduates, while transparent bars indicate non-VET graduates. Although the pattern is more mixed than in figure 1, also here in countries with high VET shares (towards the top of the graph) learning-by-doing is generally higher among non-VET graduates than in countries with lower VET shares. In seven countries the share of workers participating in learning-by-doing more than once a week is higher among VET than non-VET graduates, while the reverse is true in eight countries. In the remaining nine countries displayed here, the difference is less than three percentage points.

1.2 Descriptive results: Skill levels, underskilling and VET

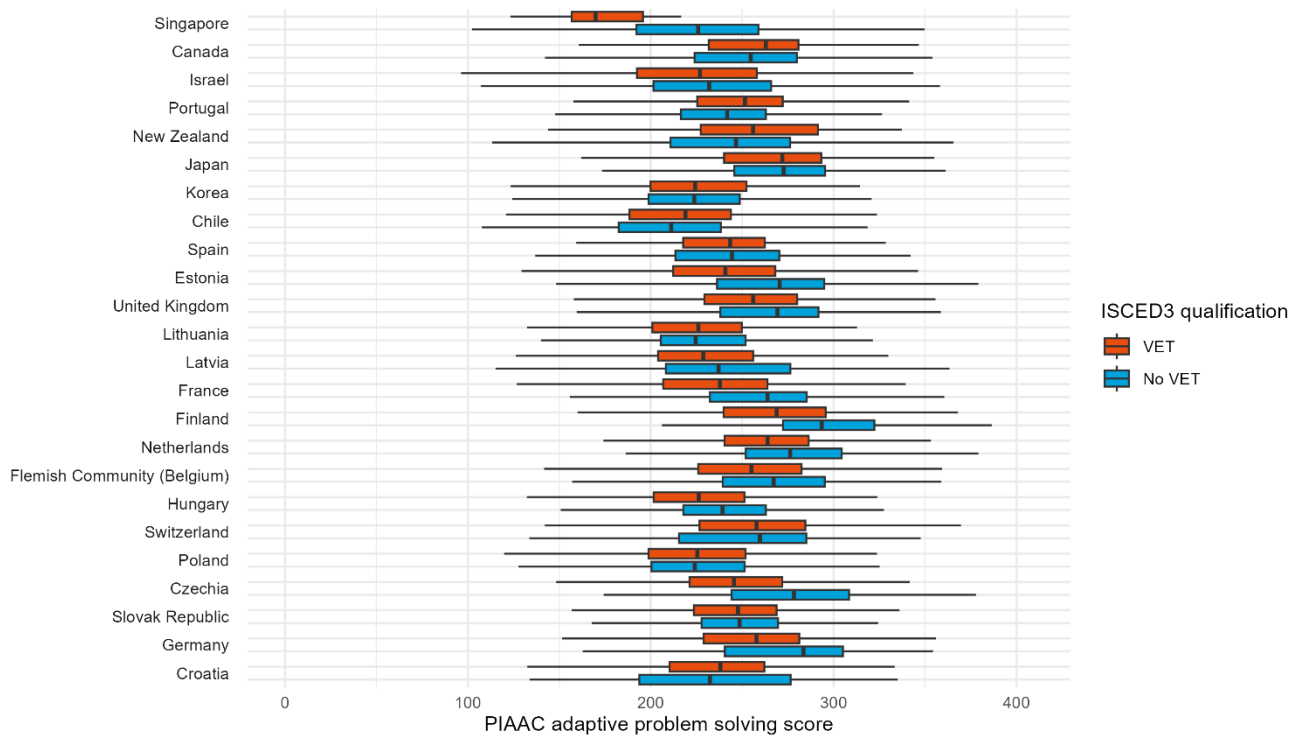
Figure 4: PIAAC numeracy scores (in boxplots) across countries.



Source: Pooled PIAAC cycle 2 data; own calculation

Figure 4 shows the Tukey boxplots for the numeracy scores of ISCED3-educated workers, separately for VET and non-VET graduates across 24 countries. Only in Finland, Netherlands, Japan and Switzerland the median score for both VET and non-VET graduates is more than 270 points. In a majority of the observed countries median numeracy scores are lower for VET graduates than for non-VET graduates. This is in line with the (expectations from the) literature. Chile, Portugal, Korea, Canada, Japan, and the Slovak Republic form an exception to this pattern, although the score-advantage of the VET graduates is smaller than 15 points in all these countries. Note that this is below one skill level on the PIAAC scale, which corresponds to 50 points. More substantial differences exist in countries where non-VET graduates have higher median scores, particularly in Singapore. Also in Finland, Czechia, France, Estonia, Germany and Flanders the difference between the two groups is larger than 20 points. When we relate these findings to the shares of VET graduates across countries, we observe relatively high test scores among VET graduates in most countries with relatively low shares of VET graduates among the ISCED3-educated, whereas the reverse is true for countries with relatively low shares of non-VET graduates.

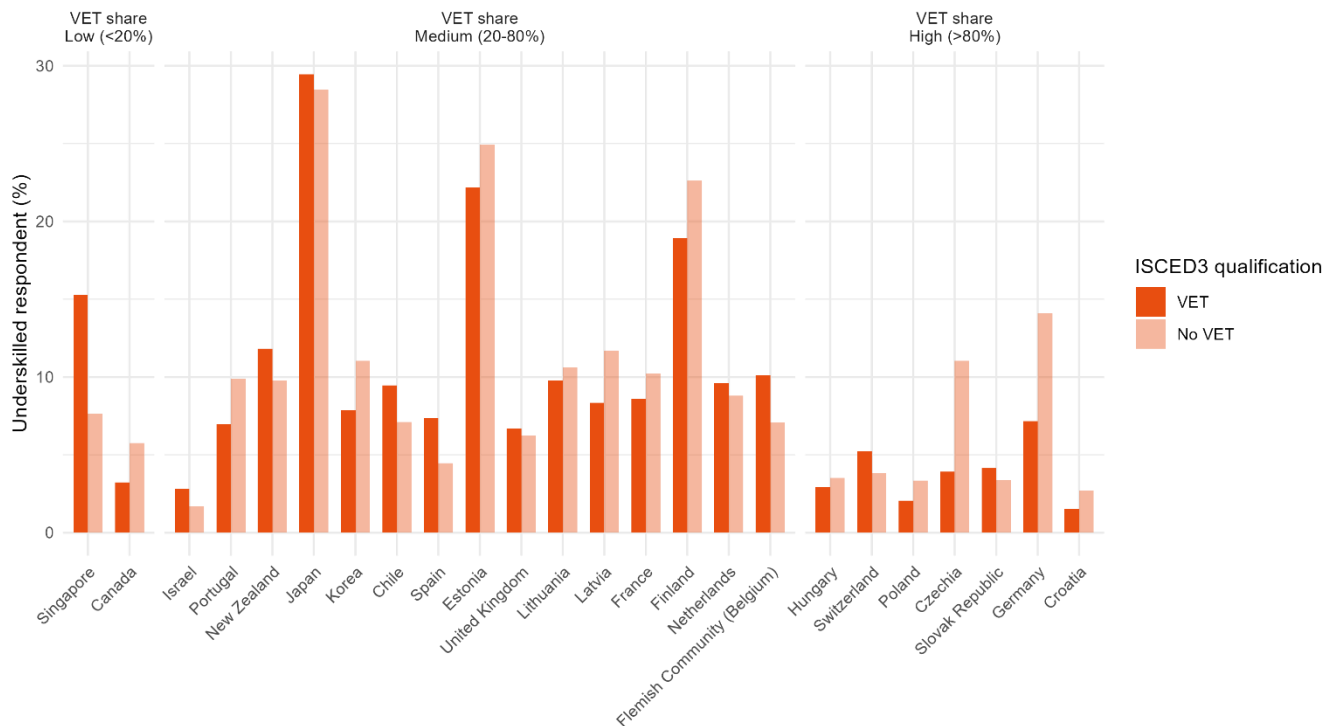
Figure 5: PIAAC adaptive problem solving scores (in boxplots) across countries.



Source: Pooled PIAAC cycle 2 data; own calculation

Figure 5 replicates the information from figure 4 for adaptive problem solving scores. The highest median adaptive problem solving scores for VET graduates are found in Japan, Finland, the Netherlands and Canada. The score pattern for adaptive problem solving across countries is quite similar to that for numeracy. However, for adaptive problem solving there are more countries where VET graduates have a higher median than non-VET graduates. In addition, the differences in medians between VET and non-VET graduates are on average smaller for adaptive problem solving.

Figure 6: Percentage of underskilled across countries.



Source: Pooled PIAAC cycle 2 data; own calculation

Figure 6 displays the percentage of workers that indicated feeling underskilled for their jobs, separately for ISCED3 VET graduates and non-VET graduates. The share of respondents indicating to feel underskilled is generally low: in most countries less than 15%. Notable exceptions are Japan, Estonia and Finland, where both VET and non-VET graduates are significantly more likely to feel underskilled. In Singapore, Czechia and Germany the difference between VET and non-VET graduates is particularly large. In Singapore, a country with very few VET graduates, these VET graduates indicate to feel underskilled more often, while the opposite is observed in Czechia and Germany. There seem to be no systematic differences in feeling underskilled among VET and non-VET graduates depending on the share of VET graduates within ISCED-3 level. These findings contrast with those of Hanushek et al. (2017), who found that VET graduates experience fewer skill mismatches than non-VET graduates.

1.3 Multilevel analyses: Associations between skills, self-perceived skill matching, LLL activities and VET

In the main analyses we investigate the associations between skills, self-perceived skill matching, LLL activities and VET. We first present the regression results for our main models with numeracy and adaptive problem solving as the dependent variables. Numeracy and adaptive problem solving scores in PIAAC range from 0 to 500 points, with 50 points being equal to one skill level. Subsequently, we present the results with self-perceived skill mismatch as the dependent variable. As indicated in the method section, all regressions include control variables, although we do not present these coefficients for reasons of brevity.

Table 2: Main model estimation results for numeracy and adaptive problem solving.

Panel A: Numeracy				
	(1)	(2)	(3)	(4)
VARIABLES	LLL only	VET only	LLL and VET	Interactions between LLL and VET
Training participation	10.030*** (1.019)		10.039*** (1.008)	11.160*** (1.704)
Learning-by-doing	-2.911** (1.302)		-2.849** (1.288)	-1.174 (1.563)
Vocational education		-8.875*** (2.974)	-8.870*** (2.929)	-7.126** (3.210)
Learning-by-doing * VET				-2.619 (2.091)
Training participation * VET				-1.741 (1.558)
Constant	255.330*** (4.284)	263.804*** (5.617)	261.265*** (5.640)	260.094*** (5.665)
Observations	28,987	28,987	28,987	28,987
Number of groups	24	24	24	24
Panel B: Adaptive problem solving				
VARIABLES				
Training participation	10.231*** (1.001)		10.239*** (0.988)	11.188*** (1.636)
Learning-by-doing	-2.404** (0.968)		-2.358** (0.963)	-0.495 (1.319)
Vocational education		-6.620*** (2.238)	-6.622*** (2.196)	-4.845** (2.344)
Training participation * VET				-1.470 (1.680)
Learning-by-doing * VET				-2.916* (1.708)
Constant	245.024*** (3.723)	252.302*** (4.703)	249.453*** (4.657)	248.260*** (4.733)
Observations	28,987	28,987	28,987	28,987
Number of groups	24	24	24	24

Notes: Robust standard errors in parentheses; *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$; Models are weighted; controls include age categories, gender, migration background, parental education, working hours and contract type.

Source: Pooled PIAAC cycle 2 data.

Table 2 presents the associations between PIAAC skill scores, LLL participation and having a VET qualification at ISCED3 level. The coefficients in model 1 can be interpreted as average differences in skill scores for respondents that participated in LLL activities as compared to those who did not.^{viii} The coefficients of training participation in the last 12 months are statistically significant at the 1% level and indicate a positive association with both numeracy scores (panel A) and adaptive problem

solving (panel B). Workers who indicated to have participated in training in the last 12 months have, on average, both numeracy and adaptive problem solving scores that are 10 points higher than workers who did not participate in training in the last 12 months. This corresponds to approximately 0.2 SDs, or 20% of the difference between two PIAAC skill levels. These results are in line with the literature discussed in the literature overview showing that training relates to skill development (Ferreria et al. 2017).

When we look at the association between skills and learning-by-doing, we find a significant but negative association with numeracy and adaptive problem solving. Workers who indicate to engage in learning-by-doing at work more than once a week have, on average, lower skill scores than those who learn by doing less than once a week. Specifically, more often engaging in learning-by-doing is associated with a 2.9 points lower score on numeracy and a 2.4 lower score on adaptive problem solving, significant at the 5% level. While these associations are small, they seem to indicate that workers with lower skill levels, participate more in informal learning. Over time, it is expected that their skill levels rise, though given the cross-sectional data at hand, we cannot test this. Another possible explanation is related to the type of jobs. Jobs that require relatively low levels of numeracy and adaptive problem-solving skills, are likely to be more routine based jobs (Görlitz & Tamm, 2016a, in which informal learning is less possible).

Model 2 demonstrates the association between skills scores and VET as highest qualification. Having a VET degree is negatively associated with numeracy and adaptive problem solving. VET graduates have, on average, a numeracy score that is 8.9 points lower than non-VET graduates. The association between VET and skills is slightly smaller for adaptive problem solving than for numeracy: VET graduates score, on average, 6.6 points lower than non-VET graduates. As with training participation, these results are in line with the literature discussed in the overview: VET graduates tend to possess fewer general skills, such as numeracy and adaptive problem solving, than general graduates, while they do possess more specific skills.

In model 3, we include both LLL participation and VET in the model. When adding VET to our baseline model 1, training participation and learning-by-doing remain statistically significant and the effect sizes remain similar. This also holds for the association between VET and skill levels compared to model 2.

In model 4, we include an interaction with each of the LLL variables and VET. Therefore, the coefficients related to LLL activities now show the association between LLL and skill levels of non-VET graduates. We observe that non-VET graduates who have participated in training in the last 12 months have on average a numeracy and adaptive problem solving score 11.2 points higher than that of non-VET graduates who did not participate. As the interaction effect between training participation and VET is not significant, the associations described above between training participation and skills also hold for VET graduates. The association between the skills and learning-by-doing is not statistically significant for non-VET graduates, nor for VET-graduates.^{ix} Overall, we can conclude that the association between LLL activities and skills is not different for VET than for non-VET graduates.

Table 3: Main model estimation results for self-perceived skill mismatch.

VARIABLES	Feeling underskilled			
	(1)	(2)	(3)	(4) Interactions between LLL and VET
	LLL only	VET only	VET and LLL	
Training participation	0.021*** (0.006)		0.021*** (0.006)	0.018** (0.007)
Learning-by-doing	0.042*** (0.007)		0.041*** (0.007)	0.042*** (0.009)
Vocational education		-0.005 (0.004)	-0.005 (0.004)	-0.007 (0.006)
Training participation * VET				0.005 (0.008)
Learning-by-doing * VET				-0.002 (0.006)
Observations	28,987	28,987	28,987	28,987
Number of groups	24	24	24	24

Notes: Standard errors in parentheses; *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$; Average Marginal Effects; Models are weighted; Controls include age categories, gender, migration background, parental education, working hours and contract type. Source: Pooled PIAAC cycle 2 data.

Table 3 presents the associations between self-perceived skill mismatch, LLL participation and having a VET qualification at ISCED3 level. The coefficients can be interpreted as the average marginal effects indicating the probabilities of being underskilled. When we look at the results of model 1, we find that workers who indicated to have participated in training in the last 12 months have 2.1% higher probability of perceiving themselves as underskilled, compared to their counterparts. We find a similar association between learning-by-doing and self-perceived skill mismatch: the probability of feeling underskilled is 4.2% higher for workers who indicate to engage in learning-by-doing at work more than once a week than workers who indicate to engage in learning-by-doing less than once a week. These results are in line with the literature discussed in the overview. These results could indicate that those who feel underskilled respond by taking part in training and informal learning to match their skill levels to the required ones. Alternatively, the results could also indicate that a relatively low level of foundational skills prevents workers from up- and reskilling needed to match their own skill levels to the required ones at work.

In model 2, we do not see a statistically significant association between having a VET qualification at the ISCED3 level and self-perceived skill mismatch. This implies that we do not find evidence for the suggestion often made in the literature that non-VET graduates might be less prepared for the labour market than VET graduates.

When we look at the LLL variables and having a VET qualification together in model 3, the associations between training participation and learning-by-doing and self-perceived skill mismatch remain the same. Likewise, the association between having a VET qualification at the ISCED3 level and self-perceived skill mismatch remains statistically insignificant.

Similar to Table 2 focusing on skill levels, we do not observe significant differences in the association between LLL activities and mismatch probabilities, depending on the type of education (VET versus non-VET) in model 4.

2. Further Examination I: Patterns across the life course: the role of age groups and VET

In the first additional analysis, we focus on differences across age groups. We repeat our analyses separately for the following age groups: 24–34, 35–44, 45–54, and 55 and older. To keep the analysis manageable, we report the results for models 3 and 4 only (see Table B1 in the appendix).

The additional analyses on the key information-processing skills, numeracy and adaptive problem solving show that for all age groups, training participation in the past 12 months is positively associated with the key information-processing skills. Nevertheless, the association with numeracy is about half as strong in the oldest compared to the youngest group. As in the main findings, learning-by-doing shows small negative associations with numeracy and problem solving skills, but only in the 45–54 age group. One possible explanation is that learning-by-doing at this age may be more common among lower-skilled workers, whereas higher-skilled individuals might engage in such learning earlier in their careers and subsequently shift toward supporting others in their learning processes. VET graduates have lower skill levels compared to non-VET graduates, except within in 45-54 age group. We do not observe differences in the associations between participation in LLL activities and skills for VET versus non-VET graduates across the age groups.

The analyses of perceived underskilling show that participation in LLL is positively associated with feeling underskilled in all age groups, even though the strongest associations are found within the 25-34 age group (3.8%) and the smallest within the 55 plus age group (1.7%). A negative association between VET degree and underskilling was found only among 25–34-year-olds. This may reflect that VET graduates who recently left formal education have specific skills that better match the job requirements. In the youngest age group (25-34), we find that the positive association between learning-by-doing and feeling underskilled is less positive for VET graduates. The main effect of VET is, however, not significant. Among the 55 plus group, the positive association between training participation and feeling underskilled is less strong for VET graduates compared to non-VET graduates, but again the main effect of VET is not significant. These results broadly align with the main findings and do not suggest substantial deviations in patterns, even though this was expected based on theoretical reasons.

3. Further Examination II: Patterns across the educational pathways: the role of VET in the pathway

In the second additional analysis, we repeat the main analyses, but now focus on whether respondents have VET in their pathway and/or as highest qualification. Note that in these analyses we do not only select respondents who obtained upper secondary education as their highest qualification, but include the full sample^x and control for highest qualification obtained.

Table 4: Results of further examination II for numeracy, adaptive problem solving and underskilling

VARIABLES	Numeracy		Adaptive problem solving		Feeling underskilled	
	LLL and VET	Interactions between LLL and VET	LLL and VET	Interactions between LLL and VET	LLL and VET	Interactions between LLL and VET
Training participation	9.422*** (0.468)	18.125*** (1.095)	9.200*** (0.650)	15.237*** (0.758)	0.024*** (0.004)	0.023*** (0.005)
Learning-by-doing	-3.660*** (1.019)	-0.533 (1.298)	-2.781*** (0.754)	-0.632 (1.070)	0.041*** (0.005)	0.036*** (0.005)
VET in pathway	-6.786*** (1.681)	-11.224*** (2.630)	-4.899*** (1.390)	-7.665*** (2.026)	-0.001 (0.003)	-0.009 (0.006)
Learning-by-doing * VET in pathway		-2.731** (1.307)		-1.963 (1.224)		0.012*** (0.004)
Training participation * VET in pathway		-5.372*** (1.333)		-4.069*** (1.123)		0.003 (0.005)
Constant	263.341*** (4.955)	272.852*** (5.408)	251.131*** (4.155)	257.278*** (4.521)		
Observations	76,640	76,640	76,640	76,640	76,640	76,640
Number of groups	26	26	26	26	26	26

Notes: Robust standard errors in parentheses; *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$; Models are weighted; controls include highest qualification (ISCED), age categories, gender, migration background, parental education, working hours and contract type. Source: Pooled PIAAC cycle 2 data.

Table 4 presents the results from model 3 and 4 for numeracy, adaptive problem solving and feeling underskilled. The associations between LLL and skills are comparable to the main analyses in model 3 (LLL and VET). Workers who indicated to have participated in training have, on average, numeracy and adaptive problem solving scores that are roughly 9 points higher than those workers who did not participate in training in the last 12 months. Additionally, more often engaging in learning-by-doing is associated with a 3.7 points lower score on numeracy and a 2.8 lower score on adaptive problem solving, significant at the 1% level. On the other hand, the association between having had VET in the pathway and skills is slightly smaller than that of VET as highest qualification in the main analyses. Respondents who have had VET in their pathway have, on average, a numeracy score that is 6.8 points lower and an adaptive problem solving score that is 4.9 points lower.

The interaction model for numeracy shows that the positive association between training participation and numeracy is significantly weaker for VET graduates ($18.125 - 5.372 = 12.753$) compared to non-VET graduates (18.125). The same hold for adaptive problem solving: $\beta = 15.237$ for non-VET graduates versus $\beta = 11.168$. This may indicate that non-VET graduates gain more, in terms of key skills, from training participation than VET graduates. The interaction term between learning-by-doing and VET is non-significant for both domains.

The results on perceived underskilling of model 3 (LLL and VET) are not different from the results in the main model: having had VET anywhere in the pathway is not significantly associated with the

probability of feeling underskilled, while participation in LLL is. When we look at the model including the interactions, we observe that the positive association between learning-by-doing and feeling underskilled is significant stronger for VET graduates. The main effect of VET is, however, not significant, nor is the interaction between training participation and VET.

Conclusions and Discussion

The world of work is changing rapidly, due to developments such as the arrival of AI, the green transition and automation. At the same time many OECD countries are confronted with demographical challenges, such as an aging population. These shifts make it crucial to keep the labour force as productive as possible, though this is increasingly difficult. The demand for new skills, alongside skill obsolescence, contributes to mismatches that harm productivity and employability. LLL activities can help prevent these deficits by updating, repairing, and enhancing skills (Künn-Nelen, 2025). Many countries, therefore, focus on stimulating participation in LLL. Certain groups are vulnerable in this respect, such as VET graduates. These graduates are trained in specific skills in their formal education, while non-VET graduates are taught more general skills.

In this paper, we addressed three research questions. First, we examined the extent to which VET graduates engage in various LLL activities compared to their non-VET counterparts at the same educational level across OECD countries. Second, we explored whether VET graduates have different levels of key information-processing skills and self-perceived skill mismatches compared to non-VET graduates within the same educational level across OECD countries. Third, we investigated whether the associations between LLL activities and information-processing skills, as well as self-perceived skill mismatches, differ for VET graduates versus non-VET graduates within the same educational level across OECD countries.

This paper made three key contributions. First, we addressed the gap in the literature by focusing on comparing VET and non-VET graduates within the same educational level, specifically upper secondary education. This approach allowed us to better isolate the effect of vocational versus general education, without the confounding effect of educational level. Second, we broadened the scope of LLL activities by including both non-formal training participation and informal learning at work. By examining both structured and informal learning, we provided a more comprehensive view of how VET and non-VET graduates engage with learning opportunities. Third, in additional analyses we applied a life-course perspective, exploring how these associations vary across age groups. In additional analyses we also expanded the definition of VET graduates to include those who have ever followed vocational education at any point in their educational pathway, regardless of whether it is their highest qualification. This allowed us to capture a fuller picture of the LLL experiences and skill outcomes of individuals with a vocational background.

To answer the research questions, we used the novel PIAAC Cycle 2 dataset, collected between 2022 and 2023, which included adults aged 16-65 from 31 OECD countries. The dataset includes information on key information-processing skills in literacy, numeracy, and adaptive problem-solving, alongside background information on education, employment status, and participation in informal learning and training activities.

Our descriptive results showed that in most OECD countries most variation in the share of VET and non-VET education within educational levels exists at upper secondary education. Differences in participation in LLL activities are generally larger between OECD countries than between VET and non-VET graduates within countries at the same educational level. In countries with a high share of VET graduates, VET graduates engage less in LLL activities compared to non-VET graduates, while the reverse is often observed in countries with fewer VET graduates. In countries with a more balanced distribution of VET graduates, no clear pattern emerged. Regarding key information-processing skills, VET graduates typically have lower median skill scores than non-VET graduates in the majority of countries, which is in line with previous theoretical and empirical literature (e.g., Brunello & Rocco, 2017a; Cunha et al., 2005; Woessmann, 2018). However, in countries with fewer VET graduates, VET graduates tend to have higher skills. This pattern is consistent for both numeracy and adaptive problem solving, although differences in adaptive problem solving are smaller on average. Finally, the share of respondents who feel underskilled is generally low across OECD countries, with some differences observed. Specifically, in certain countries, VET graduates are more likely to feel underskilled compared to non-VET graduates, but no systematic association is found. This implies that we do not find evidence for the suggestion often made in the literature that VET graduates might be more prepared for the labour market than non-VET graduates.

In the next step, we performed multilevel linear and logistic regression to look at the associations between LLL activities, VET education and skills. We clustered respondents within countries and performed linear or logistic regression analyses, depending on the outcome measure (i.e., key information-processing skills or feeling underskilled). We found that participation in training in the last 12 months was positively associated with higher skills in numeracy and adaptive problem solving. Workers who participated in training scored on average 10 points higher than those who did not. Given the cross-sectional character of the data, this can either mean that training increased skills, or that high skill levels make it easier to participate in training. In contrast, more frequent learning-by-doing at work was negatively associated with skill levels, with workers engaging in this informal learning more than once a week scoring slightly lower in both numeracy and problem solving. This could suggest that workers with jobs that provide less learning-by-doing opportunities have lower skills to begin with. Across education levels, Görlitz and Tamm (2016a) have shown that this is the case. We are not aware of studies that show this within educational levels. VET graduates generally scored lower in both numeracy and adaptive problem solving compared to non-VET graduates, which aligns with the pattern that VET graduates tend to have fewer general skills but more specific skills (Brunello & Rocco, 2017a; Cunha et al., 2005; Woessmann, 2018). We did not find evidence that the association between LLL activities and skills was different for VET versus non-VET graduates.

Participation in LLL activities was associated with a higher probability of feeling underskilled, with those participating in training or learning-by-doing reporting higher mismatch probabilities. Again, this suggests that those who feel underskilled are more likely to feel the need to and actually participate more in learning activities. However, no significant differences were found between VET and non-VET graduates in terms of feeling underskilled, and we also show no indication that the associations between LLL activities and feeling underskilled was different for VET versus non-VET

graduates. Building on the theoretical literature that suggests that higher key skills make later skill investments more productive (Cunha et al., 2005), this is an unexpected result. However, we again need to be aware of the cross-sectional character of the data at hand disabling a causal interpretation of learning activities on skill levels and perceived mismatches.

Two additional analyses were performed. The first additional analysis by age group confirmed the main findings. Training participation is positively associated with skills across all age groups, though the effect size was weaker in older adults. VET graduates generally had lower skills compared to non-VET graduates, except for 45–54-year-olds. Participation in LLL was associated with a higher likelihood of feeling underskilled in all age groups, but no significant differences were found between VET and non-VET graduates, except in the youngest group, where VET graduates felt less underskilled. This latter finding is in line with previous research highlighting the good transition from school to work among VET graduates (Woessmann, 2018).

In the second additional analysis, we expanded the main analyses by examining whether or not individuals had VET somewhere in their educational pathway or as their highest qualification. In this analysis, in which workers from all educational levels are included, we also found that participation in LLL is associated with higher skill levels and a lower probability of perceiving a skill gap. However, in contrast to our findings for ISCED-3 workers only, we did find that the relation between LLL and skill levels is smaller if workers had VET experience at some point in their educational pathway. This suggests that those without any VET experience may benefit more from training in terms of skill development. However, as VET experience is strongly related to educational levels, in this additional analysis it is again (as in the earlier literature) difficult to disentangle the education type and level in these associations.

Our main contribution to the literature and take-away for policy makers should therefore be seen in our analyses within ISCED-3 level. Here, due to the unique PIAAC data, we are able to disentangle the education level and type aspects of workers' educational background. Based on the results of this sample, we found a strong and positive association between participation in nonformal and informal LLL on the one hand, and skill levels and perceived skill gaps on the other. Importantly, these associations do not depend on the VET status. However, the level of both key information-processing skills and numeracy skills does appear to be lower for workers who finished ISCED-3 education in a VET track compared to those in a general track. Our descriptive analyses showed no clear relation between participation in LLL activities between workers with a VET or general educational background. In a next study, we will go more in depth in explaining participation in LLL activities among VET graduates by national educational and training policies.

While this study has offered a first exploration using newly available cross-national data on key information-processing skills and LLL among VET versus general graduates, there are also several limitations that require further investigation in future research. One limitation of our study is its cross-sectional nature, which, as noted throughout the paper, limits our ability to draw causal conclusions, meaning that our study does not account for reverse causality. Our focus on upper secondary education, where the VET-general distinction is most pronounced, also entails a notable limitation. In several countries, general graduates at this level have not yet completed their formal

education, either progressing to higher education or representing a select group that exits the system early. The heterogeneous nature of this general graduate group raises the question of whether it is the most appropriate comparison group. However, we have tried to disentangle the influence of the type of educational program and its level, which can be expanded in future research. Moreover, in some countries, there is significant variation within the VET track, with a distinction between workplace-based and school-based training. These differences may complicate cross-country comparisons. We also expanded on previous research by not only looking at training participation, but also considering learning-by-doing. The former measure can be extended by looking for instance at the content of training participation and examining how that might be connected with skill development.

For future research, given the findings from the additional analyses, it would be interesting to explore a combination of the life course perspective and the broader measure of VET. This approach could provide a clearer understanding of the impact of VET and potentially account for changes in educational systems over time. Lastly, it would be valuable to examine how OECD countries differ in their policies regarding for example LLL and how these policies relate to the findings presented in this paper. For instance, we observe differences in LLL participation and skill development based on the share of VET graduates in a country. By incorporating policy indicators, policymakers could gain valuable insights to better foster LLL and skill development among VET graduates.

References

- Acemoglu, D. (2024). Harms of AI. In J. B. Bullock, Y.-C. Chen, J. Himmelreich, V. M. Hudson, A. Korinek, M. M. Young, & B. Zhang (Eds.), *The Oxford Handbook of AI Governance* (pp. 660–706). Oxford: Oxford University Press.
- Allen, J.P., Levels, M., & Van der Velden, R.K.W. (2013). *Skill mismatch and skill use in developed countries: Evidence from the PIAAC study*. ROA. ROA Research Memoranda No. 017 <https://doi.org/10.26481/umaror.2013017>
- André, C., Gal, P., & Schief, M. (2024). *Enhancing productivity and growth in an ageing society: Key mechanisms and policy options*. Paris: OECD Publishing.
- Arntz, M., Gregory, T., & Zierahn, U. (2016). *The Risk of Automation for Jobs in OECD Countries: A Comparative Analysis*. Paris: OECD Publishing.
- Bassanini, A., Booth, A.L., Brunello, G., De Paola, M., & Leuven, E. (2005). *Workplace training in Europe*. IZA Discussion papers, No. 1640. Institute for the Study of Labor (IZA), Bonn. Retrieved from <https://hdl.handle.net/10419/33575>
- Becker, G. S. (1962). Investment in Human Capital: A Theoretical Analysis. *Journal of Political Economy*, 70(5, Part 2), 9-49.
- Ben-Porath, Y. (1967). The Production of Human Capital and the Life Cycle of Earnings. *Journal of Political Economy*, 75(4, Part 1), 352-365.
- Bol, T., & Forster, A. (2025). Vocational education and labor market outcomes. In M. H. J. Wolbers & D. Verhaest (Eds.), *Handbook of Education and Work* (pp. 37-51): Edward Elgar Publishing.
- Borghans, L., & Golsteyn, B. (2008). Modernising vocational education and training: the importance of information, advice and guidance over the life-cycle. In Cedefop, *Modernising vocational education and training: Fourth report on vocational training in Europe: Background report* (vol. 1, pp. 279-318). Luxembourg: Office for Official Publications of the European Communities.
- Breen, R. (2005). Explaining Cross-National Variation in Youth Unemployment: Market and Institutional Factors. *European Sociological Review*, 21(2), 125-134. <https://doi.org/10.1093/esr/jci008>
- Brunello, G., & Rocco, L. (2017a). The effects of vocational education on adult skills, employment and wages: What can we learn from PIAAC? *SERIEs: Journal of the Spanish Economic Association*, 8(4), 315-343. doi:10.1007/s13209-017-0163-z
- Brunello, G., & Rocco, L. (2017b). The Labor Market Effects of Academic and Vocational Education over the Life Cycle: Evidence Based on a British Cohort. *Journal of Human Capital*, 11(1), 106-166. doi:10.1086/690234

- Choi, S., Jeong, J., & Kim, S. (2019). Impact of vocational education and training on adult skills and employment: An applied multilevel analysis. *International Journal of Educational Development*, 66, 129-138. <https://doi.org/10.1016/j.ijedudev.2018.09.007>
- Coenen, J.B., Heijke, J.A.M., & Meng, C.M. (2014). *Narrow versus broad vocational education: labour market position and curriculum characteristics of specialised versus less specialised vocational education programmes in the Netherlands*. ROA. ROA Technical Reports No. 004 <https://doi.org/10.26481/umarot.2014004>
- Coenen, J.B., Heijke, J.A.M., & Meng, C.M. (2015). The labour market position of narrow versus broad vocational education programmes. *Empirical Research in Vocational Education and Training*, 7(9), 1-31. <https://doi.org/10.1186/s40461-015-0020-x>
- Cörvers, F., Heijke, J.A.M., Kriechel, B., & Pfeifer, H. (2011). *High and steady or low and rising?: life-cycle earnings patterns in vocational and general education*. Researchcentrum voor Onderwijs en Arbeidsmarkt, Faculteit der Economische Wetenschappen. ROA Research Memoranda No. 7 <https://doi.org/10.26481/umaror.2011007>
- Cunha, F., Heckman, J.J., Lochner, L., & Masterov, D.V. (2005). Interpreting the evidence on life cycle skill formation. In Hanuchek, E., & Welch, F. (eds), *Handbook of the Economics of Education*. Oxford: North Holland.
- Davuesm R., Felstead, A., Gallie, D., Green, F., Henseke, G. & Zhou. Y. (2025). *Are Skill Requirements Still Rising? Findings from the Skills and Employment Survey 2024*. Cardiff: Wales Institute for Social and Economic Research and Data, Cardiff University.
- De Grip, A. (2024). *The importance of informal learning at work*. IZA World of Labor 2024: 162 doi: 10.15185/izawol.162.v2
- De Grip, A., & Sauermann, J. (2012). The Effects of Training on Own and Co-worker Productivity: Evidence from a Field Experiment. *The Economic Journal*, 122(560), 376-399. <https://doi.org/10.1111/j.1468-0297.2012.02500.x>
- Desjardins, R. (2015). Participation in adult education opportunities: Evidence from PIAAC and policy trends in selected countries. *UNESCO*. <https://unesdoc.unesco.org/ark:/48223/pf0000232396>
- Desjardins, R., and Kim, J. (2023). Inequality in adult education participation across national contexts: is growing employer support exacerbating or mitigating inequality in participation? In M. Schemann (Ed.), *International yearbook of adult education 2023*: 75–98. New York, NY: Portico.
- Dicks, A., Künn-Nelen, A., Levels, M., & Montizaan, R. (2024). Automation risks of vocational training programs and early careers in the Netherlands. *Acta Sociologica*, 67(4), 507-528. <https://doi.org/10.1177/00016993241250277>

- Esping-Andersen, G., & Cimentada, J. (2018). Ability and mobility: The relative influence of skills and social origin on social mobility. *Social Science Research*, 75, 13-31. <https://doi.org/10.1016/j.ssresearch.2018.06.003>
- Ferreira, M., De Grip, A., & Van der Velden, R. (2018). Does informal learning at work differ between temporary and permanent workers? Evidence from 20 OECD countries. *Labour Economics*, 55, 18-40. <https://doi.org/10.1016/j.labeco.2018.08.009>
- Ferreira, M., Künn-Nelen, A., & De Grip, A. (2017). Work-Related Learning and Skill Development in Europe: Does Initial Skill Mismatch Matter? In *Skill Mismatch in Labor Markets* (Vol. 45, pp. 345-407). <https://doi.org/10.1108/S0147-912120170000045010>
- Field, J. (2012). Is lifelong learning making a difference? Research-based evidence on the impact of adult learning. In Aspin, D., Chapman, J., Evans, K., & Bagnall, R. (eds), *Second International Handbook of Lifelong Learning. Springer International Handbooks of Education* (vol. 26). Springer: Dordrecht. https://doi.org/10.1007/978-94-007-2360-3_54
- Forster, A., G. , Bol, T., & Van de Werfhorst, H., G. (2016). Vocational Education and Employment over the Life Cycle. *Sociological Science*, 3(21), 473-494. doi:10.15195/3.a21
- Fouarge, D., Schils, T., & De Grip, A. (2013). Why do low-educated workers invest less in further training? *Applied Economics*, 45(18), 2587-2601. <https://doi.org/10.1080/00036846.2012.671926>
- Golsteyn, B., & Stenberg, A. (2017). Earnings over the life course: General versus vocational education. *Journal of Human Capital*, 11(2), 167-212. <https://doi.org/10.1086/691798>
- Görlitz, K., & Tamm, M. (2016a). Revisiting the complementarity between education and training – the role of job tasks and firm effects. *Education Economics*, 24(3), 261-279. <https://doi.org/10.1080/09645292.2015.1006182>
- Görlitz, K., & Tamm, M. (2016b). The return to voucher-financed training on wages, employment and job tasks. *Economic of Education Review*, 52, 51-62. <https://doi.org/10.1016/j.econedurev.2016.01.004>
- Hampf, F., & Woessmann, L. (2017). Vocational vs. General education and employment of the life cycle: New evidence from PIAAC. *CESifo Economic Studies*, 63(3), 255-269. <https://doi.org/10.1093/cesifo/ifx012>
- Hanushek, E. A., Schwerdt, G., Wiederhold, S., & Woessmann, L. (2015). Returns to skills around the world: Evidence from PIAAC. *European Economic Review*, 73, 103-130. <https://doi.org/10.1016/j.euroecorev.2014.10.006>
- Hanushek, E.A., Schwerdt, G., Woessmann, L., & Zhang, L. (2017). General education, vocational education, and labor-market outcomes over the lifecycle. *Journal of Human Resources*, 52(1), 48-87. <https://doi.org/10.3368/jhr.52.1.0415-7074R>

- Heckman, J.J. (2007). The economics, technology, and neuroscience of human capability formation. *Proceedings of the national Academy of Sciences*, 104(33), 13250-13255. <https://doi.org/10.1073/pnas.0701362104>
- Henseke, G, Felstead, A, Gallie, D and Green, F (2025). Degrees of demand: a task-based analysis of the British graduate labour market. *Oxford Economic Papers*, 77, 144-165. <https://doi.org/10.1093/oep/gpae020>
- Hornberg, C., Dos Santos, S., Ehlert, M., & Solga, H. (2021). *Training for the future: How to increase participation among vulnerable workers*. TECHNEQUALITY Policy Brief, No. 3. ROA: Maastricht. Retrieved from <https://technequality-project.eu/media/154>
- Kalenda, J., Vaculíková, J., & Kočvarová, I. (2022). Barriers to the participation of low-educated workers in non-formal education. *Journal of Education and Work*, 35(5), 455-469. <https://doi.org/10.1080/13639080.2022.2091118>
- Krueger, D., & Kumar, K.B. (2002). Skill-specific rather than general education: A reason for slow European growth? *USC FBE Working paper*, No. 02-7. <https://dx.doi.org/10.2139/ssrn.310628>
- Künn-Nelen, A. (2025). Employability: the race between skills obsolescence and lifelong learning. In M. H. J. Wolbers & D. Verhaest (Eds.), *Handbook of Education and Work* (pp. 293-316). Cheltenham, UK: Edward Elgar Publishing.
- McMahon, W.W. (1998). Conceptual framework for the analysis of the social benefits of lifelong learnings. *Education Economics*, 6(3), 309-346. <https://doi.org/10.1080/09645299800000022>
- Middeldorp, M. M., Eldzes, A. J. E., & van Dijk, J. (2019). Smoothness of the School-to-Work Transition: General versus Vocational Upper-Secondary Education. *European Sociological Review*, 35(1), 81-97. <https://doi.org/10.1093/esr/jcy043>
- Ryan, P. (2001). The School-to-Work Transition: A Cross-National Perspective. *Journal of Economic Literature*, 39(1), 34-92. DOI: 10.1257/jel.39.1.34
- Schwerdt, G., Messer, D., Woessmann, L., & Wolter, S.C. (2012). The impact of an adult education voucher program: Evidence from a randomized field experiment. *Journal of Public economic*, 96(7-8), 569-583. <https://doi.org/10.1016/j.jpubeco.2012.03.001>
- Ter Weel, B., van den Berg, E., Pritsch, D., Fouarge, D., Künn, A. & Lansink, X. (2025). *Taken en vaardigheden op het werk, 2012-2024; Ontwikkeling van vraag en aanbod van werktaken op basis van de Nederlandse Skills survey [Tasks and skills at work, 2012-2024: Development of demand and supply of work tasks based on the Dutch Skills Survey.]*. Amsterdam: SEO Rapport.
- Ter Weel, B., Zwetsloot, J., & Bisschop, P. (2021). Technologie verslechtert arbeidsmarktkansen van mbo'ers [Technology worsens labor market opportunities for vocational education graduates]. *ESB*, 106(4797), 226-229. <https://esb.nu/technologie-verslechtert-arbeidsmarktkansen-van-mboers/>

- Tobback, I., Verhaest, D., Baert, S., & De Witte, K. (2024). Vocational education, general education, and on-the-job learning over the life cycle. *European Sociological Review*, 40(2), 189-207. <https://doi.org/10.1093/esr/jcad015>
- UNESCO (2012). *International Standard Classification of Education ISCED 2011*. Montreal: UNESCO Institute for Statistics.
- Woessmann, L. (2018). *Effects of vocational and general education for labor-market outcomes over the life-cycle*. Luxembourg: Publications Office of the European Union.
- Wolbers, M. H. J. (2007). Patterns of Labour Market Entry: A Comparative Perspective on School-to-Work Transitions in 11 European Countries. *Acta Sociologica*, 50(3), 189-210. <https://doi.org/10.1177/0001699307080924>

Appendix

Table B1. Multilevel regression on key information processing skills and underskilling by age group

	Panel A: Numeracy							
	M3: LLL and VET				M4: Interactions between LLL and VET			
	25-34	35-44	45-54	55+	25-34	35-44	45-54	55+
Training participation	14.704*** (1.884)	9.061*** (2.281)	8.958*** (1.134)	7.754*** (1.514)	15.300*** (3.509)	9.955** (4.244)	11.350*** (2.198)	7.799*** (2.860)
Learning-by-doing	-2.431 (1.979)	-2.462 (2.053)	-4.333*** (1.182)	-2.036 (1.700)	-1.261 (2.629)	-1.175 (1.639)	-5.263*** (1.880)	1.740 (2.546)
Vocational education	-10.996*** (3.495)	-9.471*** (3.259)	-5.816 (3.762)	-9.156*** (2.984)	-9.687** (4.374)	-8.075** (3.564)	-5.125 (4.424)	-6.835** (3.211)
Learning-by-doing * VET					-1.862 (3.706)	-1.972 (2.648)	1.416 (2.571)	-6.123** (3.075)
Training participation * VET					-0.937 (3.572)	-1.354 (3.779)	-3.647 (3.240)	0.040 (3.165)
Constant	254.462*** (5.939)	263.575*** (6.324)	257.094*** (6.132)	248.828*** (5.408)	253.619*** (6.054)	262.669*** (6.429)	256.629*** (6.451)	247.252*** (5.472)
Observations	5,708	7,059	8,584	7,636	5,708	7,059	8,584	7,636
Number of groups	24	24	24	24	24	24	24	24
	Panel B: Adaptive problem solving							
Training participation	12.431*** (1.939)	9.132*** (1.836)	10.124*** (1.189)	9.244*** (1.506)	14.833*** (3.285)	9.771*** (3.443)	10.774*** (1.531)	9.266*** (2.419)
Learning-by-doing	-1.745 (1.519)	-1.634 (1.376)	-3.950*** (1.132)	-1.749 (1.639)	0.305 (2.180)	1.820 (1.652)	-3.762* (2.099)	-0.617 (2.584)
Vocational education	-8.816***	-6.540***	-3.843	-7.454***	-5.662	-3.781	-3.384	-6.754**

Learning-by-doing * VET	(2.870)	(2.472)	(2.518)	(2.292)	(3.631)	(2.318)	(3.125)	(2.783)
					-3.261	-5.321***	-0.289	-1.836
Training participation * VET					(2.935)	(2.008)	(2.545)	(3.015)
					-3.789	-0.947	-0.992	-0.001
					(3.447)	(3.227)	(2.359)	(2.334)
Constant	244.534***	248.268***	239.030***	230.647***	242.476***	246.459***	238.715***	230.172***
	(5.401)	(5.616)	(4.425)	(4.162)	(5.413)	(5.492)	(4.711)	(4.458)
Observations	5,708	7,059	8,584	7,636	5,708	7,059	8,584	7,636
Number of groups	24	24	24	24	24	24	24	24
Panel C: Underskilled								
Training participation	0.038***	0.020**	0.020***	0.017**	0.037**	0.018	0.004	0.027**
	(0.010)	(0.010)	(0.008)	(0.009)	(0.017)	(0.014)	(0.010)	(0.012)
Learning-by-doing	0.051***	0.056***	0.035***	0.027**	0.070***	0.052***	0.036***	0.019
	(0.012)	(0.010)	(0.008)	(0.011)	(0.014)	(0.014)	(0.013)	(0.015)
Vocational education	-0.022**	-0.005	-0.007	0.004	-0.003	-0.011	-0.018*	0.003
	(0.008)	(0.008)	(0.006)	(0.006)	(0.011)	(0.015)	(0.011)	(0.008)
Training participation * VET					0.002	0.004	0.030*	-0.014*
					(0.020)	(0.015)	(0.015)	(0.008)
Learning-by-doing * VET					-0.031***	0.008	-0.001	0.015
					(0.009)	(0.016)	(0.017)	(0.013)
Observations	5,708	7,059	8,584	7,636	5,708	7,059	8,584	7,636

Notes: Robust standard errors in parentheses; *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$; Models are weighted; controls include age categories, gender, migration background, parental education, working hours and contract type. Source: Pooled PIAAC cycle 2 data.

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ⁱ Especially when the difference between VET and non-VET graduates is overlapping with differences in educational levels, there is indirect evidence that suggests that VET graduates might have different LLL-participation than non-VET graduates because of the difference in jobs (routine vs non-routine, skill depreciation rates of occupations, working hours, contract types) and personal and personality characteristics. See for example: Bassanini et al. (2005), Choi et al. (2019), Ferreira et al. (2018), Görlitz & Tamm, 2016a/b, Wolbers (2007).

ⁱⁱ Tobback et al. (2024) create a VET dummy, to indicate whether a study programme is vocational or not. They explain that they use two different dimensions: (1) whether a programme is linked to a specific job or trade and (2) whether the programme includes work-based learning. Educational attainment is used as a control variable. Moreover, Tobback et al. (2024) select a sample of respondents with an upper secondary (ISCED 3), post-secondary (ISCED 4), or first-level tertiary education (ISCED 5) qualification.

ⁱⁱⁱ The extent (or direction) of skill mismatches is, in turn, related to participation in LLL activities. In particular, Ferreira et al. (2017) explain that underskilled and overskilled workers have different reasons to participate in LLL activities. Underskilled workers need, on average, more informal learning (on-the-job) to perform their job at the required level compared to well-matched workers, while overskilled workers use training as a means to keep their skills up-to-date. Ferreira et al. (2017) explain that overskilled workers underutilize their skills on the job, which results in these workers being less able to maintain their cognitive level and being more vulnerable to skill decline. Similarly, Allen et al. (2013) find that workers are more likely to participate in training when they are underskilled. They find that being underskilled in literacy results in a 14% increase in training participation compared to well-matched workers and that being underskilled in numeracy results in a 4% increase. Allen et al. (2013) also investigate the effect of overskilling: being overskilled in literacy results in a 16% decrease in training participation and being overskilled in numeracy in a 3% decrease. The effects of skill mismatches tend to be largest for literacy use.

^{iv} Graduates from narrow vocational programmes also have a higher likelihood of being unemployed, often earn less, and are more dissatisfied with their job than graduates from broad programmes (Coenen et al., 2014; 2015).

^v Although it should be noted that in this paper we can only look at heterogeneous relations between training and skills and cannot infer causality.

^{vi} While we acknowledge that also the difference between matched and overskilled workers is interesting to look at, the data at hand does not allow for a further differentiation of the mismatch variable.

^{vii} In the rest of the paper, we will use the term training participation.

^{viii} We also ran models allowing for random slopes, but these did not significantly change the conclusions of our analysis.

^{ix} The size of the coefficient of learning-by-doing is comparable to that in models 2 and 3.

^x Here we can include Ireland and the United States as there is variation in VET versus general graduates across educational levels.