TERTIARY STEM FIELDS EDUCATION IN THE CONTEXT OF THE BALTIC STATES

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Abstract. Engineering and other STEM fields education is the activity which involves both theoretical knowledge and highly practical skills. The Baltic States evidence the strength in the field of human resources with a very high level of tertiary education among the employed population. The quality and professionalism of the labour force improve with the increase in the proportion of people with higher education. The research aim is to evaluate the tertiary STEM fields education and its demand in the labour market. The research applies the monographic method, methods of analysis and synthesis, data grouping, logical and constructional methods. The analysis of statistical data shows a high demand for engineering specialists. The share of Latvia's population studying in the STEM fields (science, technology, engineering and mathematics) at a tertiary level has reached the OECD level; though, it is slightly below the EU average rate. The employment rates evidence high demand for STEM graduates both in the Baltic States and the OECD and the EU on average. In 2018, the employment of all fields of the STEM graduates in all Baltic States is higher than the respective figure in the OECD countries and the EU on average. The highest rates of employment fluctuating between 91.8% (Latvia) and 93.7-93.8% (Estonia and Lithuania) are observed in the field of information and communication technologies. Nevertheless, agriculture, forestry, fisheries and veterinary are lowly demanded by young people and produce low proportions of graduates (around 2-3.5% of all tertiary graduates), the employment rates are quite high exceeding 85%.

Keywords: STEM, tertiary, entrants, graduates, employment, Baltic States.

Introduction

It is generally recognised that the STEM sciences are potentially new study and research powerhouse which integrate not only technical knowledge and skills, but they are even considered as a philosophy and STEM education is viewed through a philosophical lens [1]. Chachasvilli-Bolotin S. et al. analysing factors that predict secondary school students continue STEM education in HEIs conclude that studying of science subjects has declined at the secondary school level [2]. Many researchers have focused their studies on the gender representation in STEM study programmes and related jobs [3; 4]. Jansons E. and Rivza B. [5] have paid particular interest on transformation of tertiary education in the Baltic States and concluded that insufficient supply of STEM tertiary graduates results from enrolment rates in the fields.

Restructuring of the state support for higher education is one of the medium-term targets of education policy in Latvia as well as other countries. The Cabinet Regulations No 561 (16.08.2016) "Regulations Regarding Implementation of the Specific Aid Subjective 8.1.1 "To Increase the Number of Upgraded STEM Study Programmes, Including Medicine and Creative Industries" of the Operational Programme "Growth and Employment"" prescribe that the STEM study programmes are higher education study programmes which include natural sciences, mathematics and information technology; engineering, manufacturing and construction and agriculture [6]. Therefore, the present research encompasses the analysis of the following study fields consistent also with the OECD classification: 1) natural sciences, mathematics and statistics; 2) information and communication technologies (ICTs); 3) engineering, manufacturing and construction and 4) agriculture, forestry, fisheries and veterinary [7].

The research aim is to evaluate the tertiary STEM fields education and its demand in the labour market. The following research tasks are advanced to reach the research aim: 1) to assess the population data in the Baltic States and the proportion of youth as candidates for the STEM studies; 2) to analyse various breakdowns of tertiary STEM fields entrants and graduates; 3) to analyse the employability indicators of the STEM fields graduates.

The topicality of the present research lies in the increasing demand for STEM skilled graduates and analytical evidence of low unemployment rates among the STEM graduates. The research novelty is a detailed study of the new entrants in and graduates of the STEM fields in the Baltic States and their performance in the labour market.

Materials and methods

The research encompasses the analysis of statistical data compiled by the OECD, the World Economic Forum, Eurostat as well as scientific publications and other materials. The research is based on the monographic method to study and describe the research phenomenon (STEM field), methods of analysis and synthesis to explain the data obtained during the research as well as to make conclusions, data grouping to clearly display the compared and analysed data, logical and constructional methods are used to formulate regularities. The mentioned methods are applied to better reveal the situation between the new entrants and graduates of the STEM study programmes in the Baltic States and discuss research results of other researchers. The research period covers the years from 2013 to 2019, while the employment data are analysed for the only year available in the OECD statistics (2018).

Results and discussion

The number of population varies among the Baltic States ranging between 1.3 million (Estonia) and 2.8 million (Lithuania) in 2019. The difference in the number of population is closely linked with the number of young people, i.e. potential students of HEIs and those who could choose the STEM study fields (Table 1).

Table 1

Total number of population and population aged 15-19 in the Baltic States, 2013-2019 [8]

Country	Population	Year							2019 vs 2013, %
		2013	2014	2015	2016	2017	2018	2019	
Estonia	total population	1317997	1314545	1314608	1315790	1317384	1321977	1326855	0.67
	population aged 15-19	62666	60576	59890	59742	59859	60700	62072	-0.95
	Youth of total, %	**4.75**	**4.61**	**4.56**	**4.54**	**4.54**	**4.59**	**4.68**	**-0.07 pp**
Latvia	total population	2012647	1993785	1977523	1959535	1942247	1927170	1913826	-4.91
	population aged 15-19	95734	89814	87036	86040	86315	87879	89225	-6.80
	Youth of total, %	**4.76**	**4.50**	**4.40**	**4.39**	**4.44**	**4.56**	**4.66**	**-0.10 pp**
Lithuania	total population	2957689	2932366	2904908	2868234	2828398	2801541	2794135	-5.53
	population aged 15-19	182450	173797	166269	157597	142376	140259	133873	-26.62
	Youth of total, %	**6.17**	**5.93**	**5.72**	**5.49**	**5.03**	**5.01**	**4.79**	**-1.38 pp**
Baltic States	total population	6288333	6240696	6197039	6143559	6088029	6050688	6034816	-4.03
	population aged 15-19	340850	324187	313195	303379	288550	288838	285170	-16.34
	Youth of total, %	**5.42**	**5.19**	**5.05**	**4.94**	**4.74**	**4.77**	**4.73**	**-0.69 pp**

In absolute figures, Lithuania has the largest number of population, it constitutes around 46-47% of total population in the Baltic States, followed by Latvia with 32% and Estonia with 21-22%. Though, Estonia is the only country among the Baltic States where the number of population has slightly grown over the period analysed. In 2019, the population has increased by 0.67% compared with 2013, while the average annual growth is only 0.11%. Unfortunately, the number of population has declined in the

other Baltic States – Latvia and Lithuania (by 4.91% and 5.53% respectively). Annually, the number of population has decreased quite moderately, just by 0.84% in Latvia and 0.94% in Lithuania. It is very important to analyse the number of population aged 15-19 as they are the potential entrants in higher education institutions. Lithuania has the worst indicators in this aspect as the number of young people has decreased by 26.62% comparing the figures of 2019 and 2013. The annual decrease is also the highest among the Baltic States – 5%, while Estonia and Latvia experience considerably lower annual declines, i.e. 0.14% and 1.13% respectively.

The number of population shall be analysed in the context of new entrants in tertiary education and the STEM study programmes as well as graduates to show the fluctuating tendencies (Fig. 1).

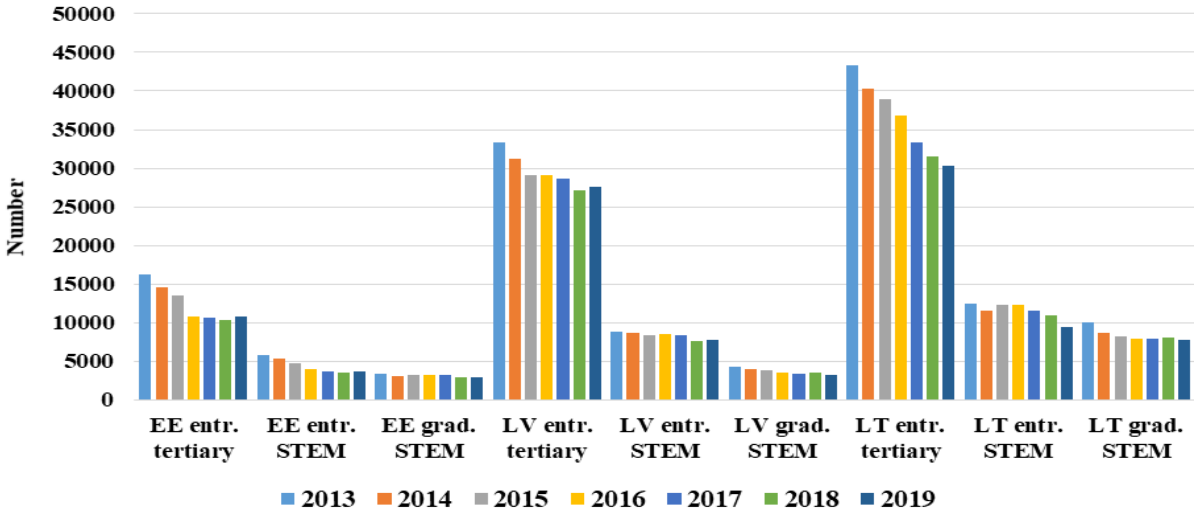

Fig. 1. **Total number of new entrants in tertiary education and entrants in and graduates of the STEM study programmes in the Baltic States in 2013-2019 [7; 9]**

In absolute figures, here again Lithuania has the largest number both in terms of new entrants in tertiary education and entrants in the STEM study programmes. This might be explained by the largest number of total population and the population aged 15-19. However, the number of new entrants in the STEM programmes has sharply decreased in the latest year analysed (2019) comparing with the previous year, where the decrease is 13.33%. All Baltic States have experienced a decline in the number of students from 2013 to 2018 with the exception of Lithuania which continues to produce a decline also in 2019. The average annual decrease in the number of new entrants in tertiary education is the highest in Estonia (33.93%) and Lithuania (30%), while Latvia shows a moderate decline (17.01%). In 2019, the number of new entrants in tertiary education has increased in Estonia and Latvia by 4.21% and 1.93% respectively. In 2016, the number of new entrants in the STEM study programmes grew by 0.86% in Latvia probably due to the increase of the state financed budget places in the STEM study programmes. The Ministry of Education and Science of the Republic of Latvia envisaged the promotion of population to study STEM courses by increasing financing; thus, the number of state financed budget places grew by 2.35% (2017) and 0.30% (2018) with a decrease in 2019 (by 0.30%) [10]. Unfortunately, this did not enforce people to choose STEM study programmes, as the number of new entrants increased only in 2019 by 2.15%. Consequently, it may be concluded that the increase in the number of state financed budget places in the STEM study programmes does not correlate with the increase in the number of new entrants in these programmes.

In Estonia, the number of STEM study programme graduates has slightly increased in 2015 and 2017 when the growth was 3.81% and 0.22% respectively. In Latvia, the number of graduates has grown by 4.86% in 2018 compared with the previous year, which could slightly be linked with the increase in the state financed budget places from 2016. Though, the number of graduates evidenced negative results in the other years analysed with the largest decrease in 2017 (7.17%) and 2019 (7.34%). In Lithuania, the number of new entrants has grown in 2015 (6.44%) followed by the increase in the number of graduates in 2017 (0.69%) and 2018 (1.79%).

The analysis of male and female proportion in the STEM study programmes shows a dominance of male students in all Baltic States over the analysed period. The highest dominance of male students is observed in Latvia and Lithuania, which exceeds 70% among new entrants. The average proportion of male entrants is 73.57% in Latvia, followed by Lithuania (71.93%) and Estonia (64.13%). The drop-out of students also influences the number of graduates; here, the proportion of male students is lower. The average proportion of male graduates is the highest in Lithuania (67.40%), followed by Latvia (66.65%) and Estonia (59.05%). This means that the STEM sciences are dominantly male chosen, since females choose less and less science subjects at schools and universities. This conclusion coincides also with the conclusions of Vooren M. [11] that these study programmes are less popular among females. According to the UNESCO Science Report, females are under-represented in the STEM fields like engineering, computing, mathematics and physics [12]. Scientists worldwide see various reasons to explain the low representation of women in the STEM fields. For example, Vooren M. and Haelermans C. [11] believe that girls have lower school performance results in mathematics than boys. Jouini E., Karehnke P. and others [13] see women under-representation in these fields due to lower self-confidence in mathematics arisen from negative stereotypes.

Complicated study courses resulting from specific theory and heavy practical tasks, overestimation of own capabilities, entering study programmes with the state financed budget places could be some of the reasons for lower and very low proportion of graduates versus new entrants in the STEM study programmes in the Baltic States (Fig. 2).

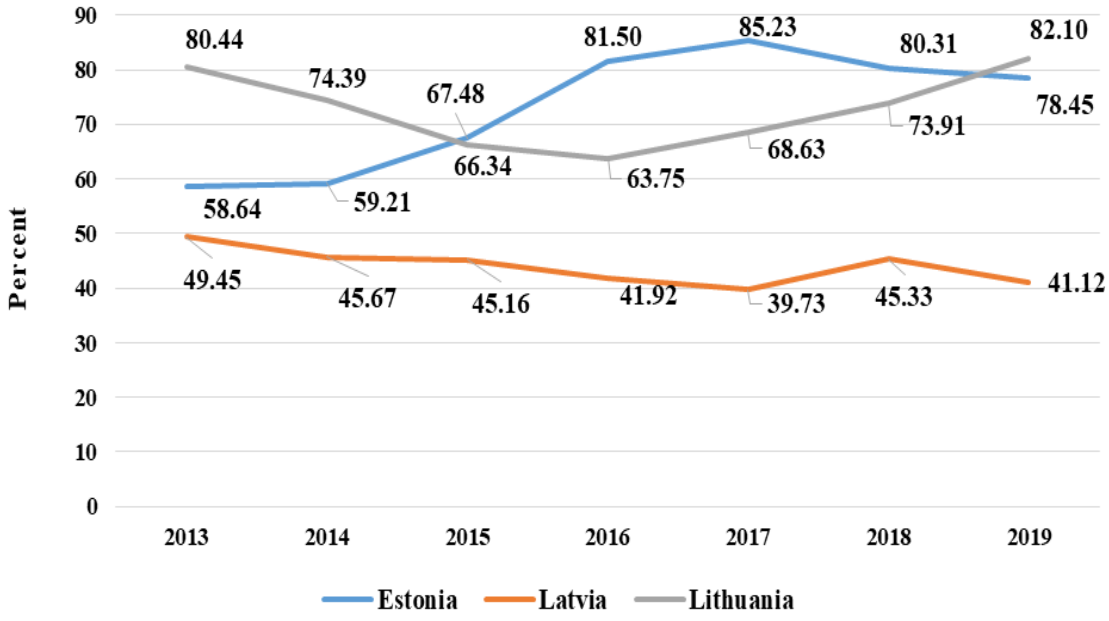

Fig. 2. **Proportion of graduates of STEM study programmes vs new entrants in the Baltic States in 2013-2019 [7; 9]**

Latvia has the lowest proportion of the STEM study programme graduates against new entrants. On average, only 44.05% of entrants have graduated tertiary STEM study programmes. Much better situation is seen in Estonia and Lithuania where the average attainment is 72.97% and 72.80% respectively. In Lithuania, the proportion of graduates has started to grow from 2017; thus, reaching the highest point in 2019 (82.10%). One of the reasons might be the decreasing number of new entrants supported by those who are strongly encouraged to complete their studies. In Latvia, the largest gap between new entrants and graduates is seen in 2017 when the share of graduates against new entrants is 39.73%.

The proportion of new entrants and graduates in the STEM study programmes of total number of entrants and graduates reveals the demand for individual STEM study programmes (Table 2).

Table 2

Proportion of new entrants in and graduates of STEM study programmes by field of total number of entrants and graduates in tertiary education in the Baltics States for 2013-2019 [7; 9]

Study field	Country		Year							Avr. 2013-2019
			2013	2014	2015	2016	2017	2018	2019	
Natural sciences, mathematics and statistics	EE	entr.	5.30	5.90	6.28	7.67	7.84	7.42	6.58	6.71
		grad.	7.47	6.13	6.76	6.63	6.13	6.03	6.12	6.47
	LV	entr.	3.10	3.06	3.14	3.36	3.27	3.26	3.28	3.21
		grad.	2.31	2.69	3.41	3.04	2.99	2.61	2.41	2.78
	LT	entr.	3.85	3.59	3.93	4.23	4.35	4.76	4.89	4.23
		grad.	3.20	3.60	3.82	4.07	3.82	4.06	4.20	3.28
Information and Communication Technologies	EE	entr.	9.89	9.95	8.91	8.53	8.73	9.36	10.42	9.40
		grad.	4.27	4.96	4.69	6.08	7.08	6.35	7.60	5.86
	LV	entr.	5.84	6.06	6.58	7.06	7.24	7.67	7.63	6.87
		grad.	3.54	3.85	4.27	4.65	4.73	4.47	3.48	4.14
	LT	entr.	2.42	3.05	3.79	4.36	5.86	6.88	6.64	4.71
		grad.	2.08	2.02	1.74	1.94	2.61	2.96	3.49	2.41
Engineering, manufacturing and construction	EE	entr.	18.46	17.97	18.30	17.48	16.27	15.87	14.93	17.04
		grad.	15.68	15.90	15.79	14.98	16.11	15.75	14.24	15.49
	LV	entr.	15.91	16.70	17.57	17.22	17.19	15.86	15.96	16.63
		grad.	12.58	14.18	12.09	12.13	12.21	12.15	9.95	12.18
	LT	entr.	20.05	19.75	20.92	21.63	21.31	20.23	17.07	20.14
		grad.	17.48	17.11	16.53	16.76	18.00	18.50	18.18	17.51
Agriculture, forestry, fisheries and veterinary	EE	entr.	2.20	2.25	2.13	2.52	2.24	1.97	1.97	2.18
		grad.	2.60	2.24	2.18	2.08	2.44	2.10	2.37	2.29
	LV	entr.	1.55	2.04	1.69	1.65	1.48	1.46	1.45	1.62
		grad.	1.05	1.54	1.88	2.01	1.76	2.33	1.40	1.71
	LT	entr.	2.46	2.44	3.06	3.17	2.92	2.70	2.49	2.75
		grad.	1.99	2.25	2.24	2.50	2.72	3.59	3.47	2.68

Engineering, manufacturing and construction field is the most demanded study field among the STEM study programmes in all Baltic States. On average, 16-20% of new entrants have chosen this study field and it also has the highest proportion of graduates (12-17%). The demand for engineering, manufacturing and construction varies by years and countries. Hence, the demand is the highest in Lithuania, especially in 2016 (21.63%) followed by a slight decrease in the following years and reaching the lowest ratio (17.07%) in 2019. However, in absolute figures, the largest number of new entrants was enrolled in 2013 (8688 students), but this is the year with the largest number of new entrants in and graduates from the STEM fields in general. Unfortunately, Latvia has the lowest results both in terms of new entrants and graduates in all STEM fields with the exception of new entrants in information and communication technologies (6.87% of all STEM fields on average). The increase in state financed budget places has not fostered the increase of new entrants in the STEM study fields either in 2017 or 2018. Agriculture, forestry, fisheries and veterinary is the least demanded field in the Baltic States with the average proportion around 2.2%.

In Latvia, the restructuring of education policy to provide more state financed budget places for the STEM study programmes and consequently to satisfy the labour market demand for these specialists was one of the main targets envisaged by the Guidelines for Science, Technology Development of Innovation 2014-2020 [10]. Though, it has not encouraged the desire of young people to choose exact sciences as seen from the previous analysis.

The attainment of tertiary education graduates and especially those graduated from the STEM study programmes is reflected in the employment possibilities and employment rates in the Baltic States (Table 3 and Fig. 3).

Table 3

Employment by tertiary education attainment in the Baltic States between 2013 and 2020 [14]

	2013	2014	2015	2016	2017	2018	2019	2020
Estonia	80.8	84.1	84.4	82.8	86.9	85.4	87.4	85.4
Latvia	83.3	83.4	85.0	86.8	88.5	88.7	89.2	86.9
Lithuania	88.0	88.0	89.0	90.6	89.9	90.8	91.4	89.5
EU-28	81.8	82.3	83.0	83.5	84.3	84.7	85.1	84.1

Employment of tertiary-level graduates indicates the innovative potential of a country as well as the capacity of the country's labour force. Latvia alongside with Estonia and Lithuania evidences the strength in the field of human resources as on average more than 85% of population have higher education among the employed ones.

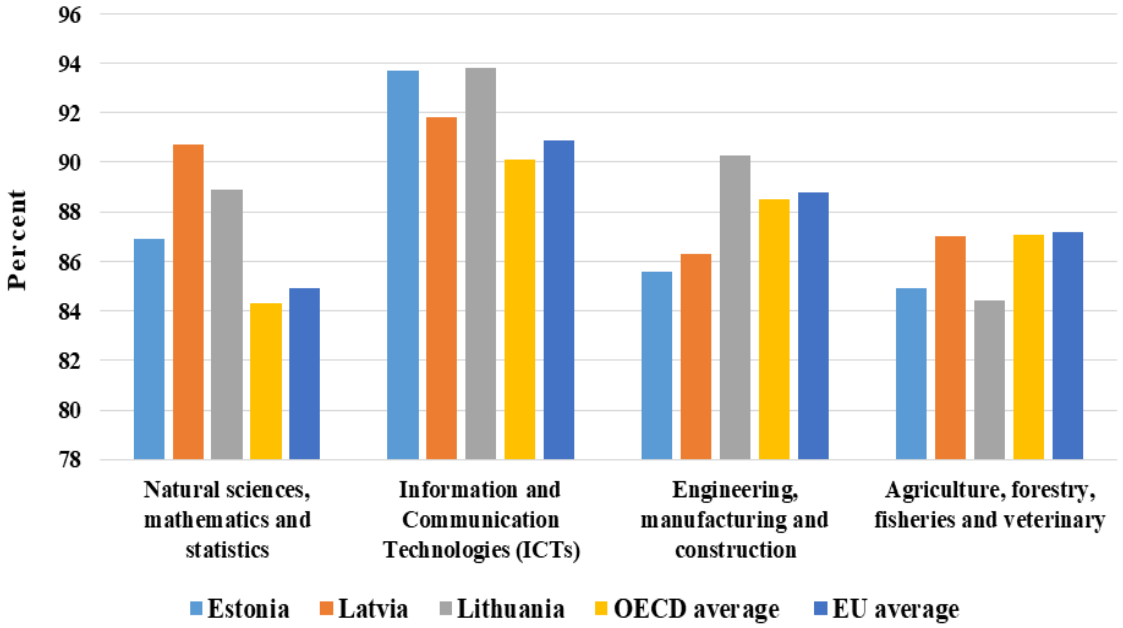

Fig. 3. **Employment rates of the STEM graduates in 2018, as percentage of employed 25-64 years-olds among all 25-64 year-olds [15]**

The OECD statistics provides data on the employment rates of the STEM graduates only for 2018; thus, it is the year analysed in detail. The highest rates of employment fluctuating between 91.8% (Latvia) and 93.7-93.8% (Estonia and Lithuania) are observed in the field of information and communication technologies. In Lithuania, the high employment rate of IT specialists has a negative correlation with the low proportion of IT graduates (2.96%). This means that the employment of IT graduates is urgently topical which is also revealed by other scientists and practitioners. In contrast, high proportion of graduates from engineering, manufacturing and construction study programmes (15.75% in Estonia, 12.15% in Latvia and 18.50% in Lithuania) results in employment rates between 85.6% (Estonia) and 90.3% (Lithuania). Nevertheless, agriculture, forestry, fisheries and veterinary are lowly demanded by young people and produce low proportions of graduates (around 2-3.5% of all tertiary graduates), the employment rates are quite high, reaching even 87% in Latvia.

In general, the analysis of employment rates evidences high demand for STEM graduates both in the Baltic States and the OECD and the EU on average. In 2018, the employment of all fields of the STEM graduates in all Baltic States is higher than the respective figure in the OECD countries and the EU on average. The only exception is in agriculture, forestry, fisheries and veterinary where Latvia has a 0.1-0.2 percentage points lower rate. However, according to the World Economic Forum [16], the future jobs include exactly the STEM fields.

Conclusions

1. Lithuania has the largest number of population constituting 46-47% of total population in the Baltic States and it also has the largest share of youth aged 15-19. However, the number of young people in Lithuania has decreased by 26.62% comparing the figures of 2019 and 2013, while Estonia and Latvia experience considerably lower declines, i.e. 0.95% and 6.80% respectively.
2. The analysis of graduates of the STEM study programmes measured as a proportion of population shows that Latvia has the lowest performance, i.e. 0.17% compared with 0.22% in Estonia and 0.28% in Lithuania.
3. In all Baltic States male students show a dominance in the STEM study programmes. The highest dominance of male students is observed in Latvia and Lithuania, which exceeds 70% among new entrants. The average proportion of male graduates is the highest in Lithuania (67.40%), followed by Latvia (66.65%) and Estonia (59.05%).
4. Latvia has the lowest proportion of the STEM study programme graduates against new entrants (44.05%). In Estonia and Lithuania, the average attainment is 72.97% and 72.80% respectively.
5. The employment rates evidence high demand for STEM graduates where the demand for IT specialists is the highest between 91.8% (Latvia) and 93.7-93.8% (Estonia and Lithuania), which is also one of the fields for future jobs. The employment rates evidence high demand for STEM graduates both in the Baltic States and the OECD and the EU on average.

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