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Entrepreneurship education, entrepreneurship competencies and entrepreneurial activities of alumni: A comparison between the engineering and other graduates of Estonian University of Life Sciences

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Abstract. Entrepreneurial mind-set, knowledge and skills to recognise opportunities and implement ideas are vital competences for achieving success in the midst of rapid global changes. The main purpose of the entrepreneurship education is to foster those competencies. The present paper focuses on the role of the university education in developing various entrepreneurship competences, and the share of entrepreneurs among the alumni. The aim is more specifically to examine the relationship between entrepreneurship education and entrepreneurship competence development in university and the later entrepreneurial activities of the engineering alumni. The analysis is based on a questionnaire survey of alumni entrepreneurship conducted in 2016 as a part of a programme 'Edu ja Tegu- Development of entrepreneurial education throughout all educational levels'. *Chi-square tests, t-tests* are used to compare the engineering alumni of Estonian University of Life Sciences with graduates from other fields. The overall share of entrepreneurs among the engineering alumni was 35.6%. The entrepreneurial activities were impacted by the time of graduation. It had also impact of whether the graduates had received entrepreneurship courses during their studies. In comparison with other alumni, the engineering graduates assessed that their university education helped them develop significantly better problem-solving skills, critical thinking, self- evaluation skills, ability to develop new ideas and solutions and leadership skills and obtained significantly less entrepreneurial and financial knowledge during their studies. However, in case of engineering alumni, entrepreneurship education did not have significant impact on their entrepreneurial activities and assessments of competences, thus indicating that other factors are in play.

Key words: engineering education, entrepreneurship competencies, entrepreneurship education, graduates, university.

INTRODUCTION

Many studies have argued that providing entrepreneurial learning opportunities in universities and secondary schools has a favourable effect on entrepreneurship and innovation (Peterman & Kennedy, 2003; Kuratko, 2005; Van Praag & Versloot, 2007). The promotion of entrepreneurship is seen as a crucial source of economic growth and the educational system is more and more committed to honing entrepreneurial skills of the students. This can be illustrated by the prioritisation of the entrepreneurship education and training and its role in supporting business growth by the European Commission (2013) in 'The Entrepreneurship 2020 Action Plan'. Universities are increasingly seen as central actors, whose role is to contribute to entrepreneurship and economic development and provide their students with the skills they need to create and lead technology-rich entrepreneurial ventures (Barr et al., 2009).

Entrepreneurship has been identified by the European Commission as one of the eight key competences necessary for every citizen in modern society (Council Recommendations … 2018). Entrepreneurship as a competence can be understood as a transversal set of knowledge, skills and attitudes that enable to act upon opportunities and ideas and to turn those into action while creating value for others (Bacigalupo et al., 2016). Gibb (2008) emphasizes that those behaviours, skills and attributes help individuals and organisations to create and to adjust to changes in uncertain and complex situations.). The competence is based on '*creativity, critical thinking, problem solving, taking initiative and perseverance and the ability to work collaboratively'* (European Commission 2019, p. 13).

Entrepreneurship education describes the methodological approaches, educational content and activities that address the development of students' competences for entrepreneurial value creation (Moberg et al., 2014). Fayolle et al. (2006) emphasise that entrepreneurship education is pedagogy or a process that does not exclusively focus on new business creation, but on the development of specific attitudes and skills, including personal qualities. Education provides the opportunity to practice those behaviours (Gibb, 2008). Kirby (2004) argues that the entrepreneurship education should not focus only on new venture creation or small business management, but on the development of particular set of skills, attributes and behaviours necessary for successful entrepreneurship. This sets it aside from business education that focuses more narrowly on business creation. The competences developed through entrepreneurship education should increase individuals' employability and venturing as well as complement application of professional competencies while working as an employee or being entrepreneur (Mets et al., 2017). Entrepreneurship education is expected to increase entrepreneurial intentions and entrepreneurial self-efficacy that refers to the ability to carry out various tasks and roles connected with entrepreneurship (Bae et al., 2014).

Many authors (Katz, 2003; Kuratko, 2005; Matlay & Carey, 2007; Fayolle, 2013; Nabi et al., 2017; Neck et al., 2018) have noted that in the recent decades the provision of entrepreneurship education has rapidly increased. This includes the significant growth of entrepreneurship education programmes in universities (Morris et al., 2013). This has been followed by increase in the research on the effects of the entrepreneurship education. An increasing body of research has focused on the linkages between the entrepreneurship education and entrepreneurial intentions of students (e.g. Pittaway & Cope, 2007; Bae et al., 2014; Karimi et al., 2016; Maresch et al., 2016). The meta-

analyses by Martin et al. (2013) and Bae et al. (2014) conclude that there is a positive effect of entrepreneurship education to entrepreneurial intentions. However, as Pittaway & Cope (2007) emphasize, the link between entrepreneurship education and outcomes in terms of actual enterprise creation has been under-researched.

Duval-Couetil et al. (2012), Maresch et al. (2016) have noted that the research on the impact of entrepreneurship education on engineering students has been relatively limited, although the number of publications on the topic have grown rapidly in the last years, as demonstrated by the analysis of Reis et al. (2019). Traditionally engineering education has focused on theoretical knowledge and prescribed content delivery, and less on entrepreneurial mindsets and creativity (Täks et al., 2016). However, it is acknowledged that there is a need to change the educational practices with putting more emphasis on developing students' creativity, innovativeness, mindsets and attitudes (Täks et al., 2014).

A review by Reis et al. (2019) on the research trends in engineering entrepreneurship education summarises that the effect of entrepreneurship education on entrepreneurial intentions and definition of entrepreneurship education have been the topics that dominate research. For example, Maresch et al. (2016) compared the impact of entrepreneurship education on entrepreneurial intentions of engineering and sciences students with outcomes in the group of business students. Their results demonstrated that entrepreneurship education had a positive effect on the entrepreneurship intentions in both groups, but also indicated to a potential 'Matthew effect', where business students with their prior background and education in business may benefit more from the entrepreneurship education. The positive impact of entrepreneurship education on intentions of engineering students was also suggested in the studies by Souitaris et al. (2007), Barba-Sánchez & Atienza-Sahuquillo (2017). Duval-Couetil et al. (2012) measured the outcomes of entrepreneurship education in terms of students' attitudes and perceptions, including self-evaluation of skills and abilities connected with entrepreneurship. The analysis of the latter demonstrated that engineering students who had received entrepreneurship education evaluated fifteen skills related to venturing and technology self-efficacy, and their general traits such as risk tolerance and ability to evaluate business ideas, significantly higher than those who had not received entrepreneurship education.

The outcomes of entrepreneurship education in terms of proceeding from intention to action by a subsequent enterprise creation has received more limited attention. One example is a study by Menzies & Paradi (2003), who compared groups of Canadian engineering graduates and demonstrated significantly higher business ownership rate after the graduation among those, who had received elective entrepreneurship courses. The results also indicated that those graduates established their enterprises sooner after the graduation in comparison with those who had not received entrepreneurship courses. An example of a longitudinal study on graduate entrepreneurship is provided by Matlay (2008), whose results indicated a positive relationship between entrepreneurship education and outcomes as graduates interested in entrepreneurship at the time of university studies progressed from self-employment to SME ownership and partnership in the following ten years.

The present research aims to contribute to the filling of the research gaps in research on the actual entrepreneurial activities of the graduates, and on the role entrepreneurship education played in the development of entrepreneurship competences. The analysis is

based on a cross-sectional study of Estonian University of Life Sciences' alumni. The university is in the process of reforming its entrepreneurship education offering, and the main motivation for the study was to collect information on the entrepreneurship activities of graduates, because the university has not studied this before, and to collect feedback on the competences developed in order analyse the outcomes and shortcomings of education provided, and potential for improvement.

The main focus of the present analysis in on the engineering alumni and their entrepreneurship outcomes as they are expected to be the main creators of high growth entrepreneurship and technological innovation. Also, as entrepreneurship education has historically not been highly prioritised in the engineering curricula of particular university, the entrepreneurship rate of the alumni is a question of interest for the university. The main objective of the present research is to examine the relationship between entrepreneurship education and development of entrepreneurship competences in the university and the later entrepreneurial activities of the engineering alumni. The research questions are as follows:

- What is the share of entrepreneurs among engineering alumni in comparison with alumni of other fields?
- Did engineering graduates receive entrepreneurship education during their university studies and how did this affect their entrepreneurial activities later?
- How did the entrepreneurship education impact development of the entrepreneurship competencies of engineering graduates?
- How did engineering graduates who become entrepreneurs evaluate the development of entrepreneurship competences during their university studies in comparison with non-entrepreneurs?

The present paper is divided into four section. The introduction is followed by overview on materials and methods in the second section. The third section discusses the main results. The conclusions are presented in the fourth section.

MATERIALS AND METHODS

The present research is based on a cross-sectional study conducted in 2016. The data used was collected with an alumni survey that was part of the program 'Edu Tegu– Development of entrepreneurial education throughout all educational levels'. The entrepreneurial education programme was initiated by Estonian Ministry of Education and Research and was co-funded by the European Social Fund of the European Union. The present analysis focuses on the data collected from the graduates from Estonian University of Life Sciences (EULS). EULS is fourth in size among six Estonian public universities. With teaching and research going on in variety of fields representing both STEM fields and social sciences (economics), data from the alumni provides a good opportunity for comparing engineering graduates to the other fields.

The survey was conducted as a web-based questionnaire survey. The overall aim was to collect information about the graduates' entrepreneurial activities, the entrepreneurship education they received during their studies, and on their self-evaluation of different entrepreneurship competencies obtained during their studies, assessments on what kind of knowledge and skills should be emphasised more in curricula. For the university, this was an important feedback on the strengths and

shortcomings of the education provided and on the activities of the students after their graduation. The sample consisted of the EULS graduates from the years 1951 to 2016. In total, the link to the survey was disseminated to the e-mail address of 6,496 persons. The study made use of the contacts of the graduates that registered for a university reunion event, university's information system's data on personal email addresses and on advertising the study in university's website and social media. 1,457 responses were obtained (Põder et al., 2016), however, some of those responses are also partial with missing data in case of some of the variables.

In the survey respondents were asked to name their field of studies. In the analysis engineering graduates refers to respondents who graduated from agricultural and production engineering, husbandry engineering and ergonomics, energy engineering and technology curricula and attended the university's present-day Institute of Technology or its predecessor Faculty of Agricultural Mechanisation. The other alumni refer to the graduates of agriculture, forestry, fisheries; life sciences; veterinary science and animal husbandry; business and administration and other curricula of other institutes of the EULS. The field of studies question was completed in case of 1,417 respondents that are used in this analysis. The number of engineering graduates in the analysis was 195 (13.4% of the respondents). The engineering graduates' average age at the time of the study was 41.31 years [$SD = 14.74$; for other alumni $M = 39.45$; $SD = 12.88$; $t(1,133) = 1.651$, $p = 0.099$]. Share of men among engineering graduates was 93% [35.6% among graduates of other institutes; $\chi^2(1, N = 1,131) = 180.96$, $p < 0.001$]. The higher share of men among the engineering students is common across countries (e.g. as reported in the studies of Menzies & Paradi 2003; Duval-Couetil et al., 2012). One question of interest in the study was the change in the provision of entrepreneurship education over time. Thus, for the analysis, respondents are also divided into two groups on the basis of their graduation time: from 2006 to 2016 (ten years from the time of study at 2016 and a period of relative stability in terms of curriculum reforms) and before 2006. 60.6% of engineering graduates and 61.6% of other graduates had graduated from the university between 2006–2016 [$\chi^2(1, N = 1,404) = 0.016$, $p = 0.898$].

In the survey, entrepreneurs were operationalized as graduates who were self-employed or owners and managers of commercial enterprises or non-profit organisations. Entrepreneurship education was surveyed with the question on whether the respondents participated in any entrepreneurship courses during their university studies. Entrepreneurship competencies was studied with a list of 22 competencies (Table 2). The list was compiled on the basis of literature and analysis of learning outcomes of EULS entrepreneurship courses and supplemented by the feedback from entrepreneurship lecturers. Respondents were asked to evaluate in a Likert-type of scale of 5 (5- certainly yes …. 1- certainly not) whether their studies helped them to obtain those competencies.

Chi-square tests was used to compare the share of entrepreneurs among engineering and other alumni and if different groups of alumni had received entrepreneurship education. *Independent sample t-tests* were used for studying mean age upon the person became an entrepreneur and compare the mean assessment on entrepreneurship competences between different groups (Table 2 to Table 6). The data was checked for the assumptions of *chi-square* and *t-tests* (using 95% confidence interval). There were no violations in the assumptions of *chi-square* tests. In the *independent sample t-tests* presented in Table 2, the homogeneity of variance

assumption was broken in case of 7 comparisons, so for those comparison *Welch t-test* is reported in the table. Also, in the Tables 3 to 6, if the variance between the two comparison groups was unequal, results of *Welch t-test* is presented.

RESULTS AND DISCUSSION

Share of entrepreneurs

The share of entrepreneurs among all respondents at the time of the study in 2016 was 31%. That is relatively close to the current enterprise ownership rate reported, for example, in the Menzies & Paradi's (2003) study. The overall share of entrepreneurs among the engineering alumni was 35.6%; in other alumni 30.2%, but the difference not statistically significant [$\chi^2(1, N = 1{,}389) = 2.23$, $p = 0.135$]. However, the differences were significant, if the time of graduation and average age of the graduate at the time when the enterprise was established were considered. At the time of study, the share of entrepreneurs among the engineering alumni that graduated before 2006, was significantly higher [53.9% vs. 39.3%, Fig. 1, $\chi^2(1, N = 189) = 20.25$, $p < 0.001$]. Although the share of entrepreneurs was lower among the other alumni, the association with the period of graduation before or after 2006 was also significant [$\chi^2(1, N = 1{,}187) = 32.08$, $p < 0.001$].

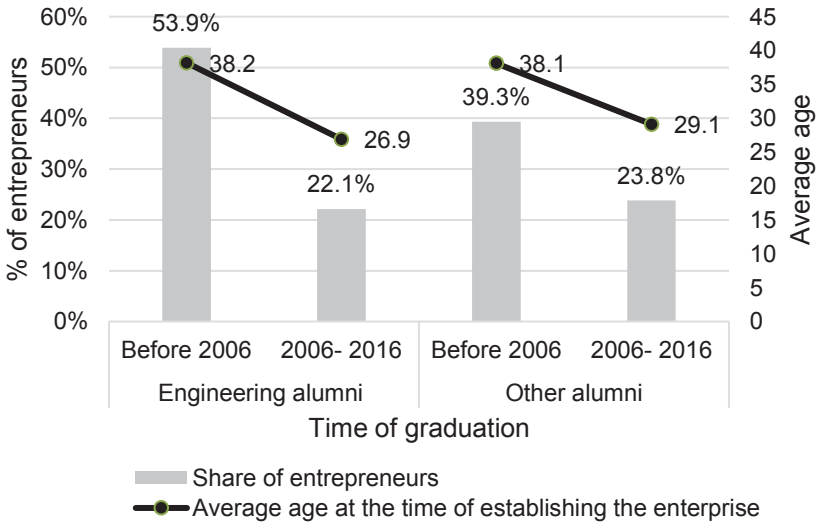

Figure 1. Share of entrepreneurs among the alumni and average age of the graduate at the time of establishment of the enterprise.

One possible explanation for the considerably higher share of entrepreneurs among engineering graduates is also the socioeconomic context of the period. The group of those earlier graduates includes those, who worked as engineers in the 1990s that is the transition period from socialist economy to the market economy in Estonia. This time period is characterized by the collapse of previous economic relations and industrial restructuring and considerable changes in labour demand (Viira et al., 2009; Põder et al.,

2017). The activities of EULS and the engineering education it provides has historically been strongly connected with agriculture, thus the developments in agriculture have had considerable impact on its graduates. With the decline and restructuring of Soviet era large scale industries and agro-industrial complexes the demand for engineers dropped and this drove necessity-based entrepreneurship by forcing the graduates previously employed in those industries and large-scale organisations set out on their own and become entrepreneurs. At the same time re-establishment of private entrepreneurship after Soviet period in which private entrepreneurship was officially forbidden in Estonia, the transition period offered also new entrepreneurship opportunities that also drove opportunity-based entrepreneurship.

The increase of entrepreneurs among the graduates over time indicates also to the time lag between the graduation and entrepreneurship activities discussed by Lüthje & Franke (2003) and Souitaris et al. (2007). However, the analysis of survey data also shows that on average the graduates became entrepreneurs in the age of 33.5 years [engineering graduates $M = 33.67$, $SD = 9.47$; other alumni $M = 33.47$, $SD = 9.32$; $t(356) = 0.149$, $p = 0.882$], but there is clear tendency that more recent graduates start their enterprises at younger and younger age. In both alumni groups respondents who graduated in the period of 2006–2016, were significantly younger when getting involved in entrepreneurship (Fig. 1). For engineering graduates the average age when becoming an entrepreneur was higher for those who had graduated before 2006 ($M = 38.17$, $SD = 9.17$) in comparison with graduates from period 2006 and later ($M = 26.92$, $SD = 4.78$), $t(55) = -6.19$, $p < 0.001$. The trend in similar in the group from other fields of study as earlier graduates started their entrepreneurial activities at a later age ($M = 38.06$, $SD = 9.47$) than the entrepreneurs in the group that graduated university after 2006 ($M = 29.12$, $SD = 6.79$), $t(260) = -9.33$, $p < 0.001$.

This could be explained by the increased integration of entrepreneurship education to secondary and higher education in Estonia that has been going on in the last decade (Täks et al., 2014; Raudsaar & Kaseorg, 2016). The educational efforts and increased public attention would provide the graduates with necessary skills and knowledge and encouragement for becoming an entrepreneur. But an additional factor that may explain the younger start-up age is another institutional change for entrepreneurship start-up process. Since 2011, the legal requirements for the share capital while setting up a private limited company have been relaxed in Estonia and this has played the role encouraging enterprise creation (Põder et al., 2017).

Entrepreneurship education

Share of alumni, who had received entrepreneurship courses during their university studies, was significantly lower among engineering alumni (44.5%) in comparison with in other alumni (57.9%), [$\chi^2(1, N = 1{,}147) = 9.232$, $p = 0.002$].This differs from the results of Maresch et al. (2016), in case of which engineering graduates had received more entrepreneurship courses than business students.

As more attention is paid to entrepreneurship education, in case of engineering alumni who graduated after 2006, 59.8% had entrepreneurship courses in their curricula in comparison with 24.2% of engineering alumni, who had graduated before 2006 [$\chi^2(1, N = 158) = 17.216$, $p < 0.001$]. The trend of increase of entrepreneurship courses for engineering students is similar to that reported by Menzies & Paradi (2003).

The significant difference characterised also other alumni as 42.9% of those graduating before 2006 reported entrepreneurship courses, while in case of those who graduated later in 2006–2016, their share had increased to 67.6% [$\chi^2(1, N = 979) = 57.919, p < 0.001$]. This demonstrates the expansion of entrepreneurship education in higher education as in the last decade several programs and governmental efforts have concentrated on increasing the number of entrepreneurship courses in different education levels in Estonia as well as creating start-up programs and competitions and other similar opportunities (Täks et al., 2014).

In case of engineering alumni, entrepreneurship courses did not impact entrepreneurial activities (43.8% of engineering alumni entrepreneurs had taken entrepreneurship courses vs. 45.8% of those who were not entrepreneurs, Table 1), $\chi^2(1, N = 160) = 0.679, p = 0.795$. The comparison by the time of the graduation shows that 26.3% of entrepreneurs among the engineering graduates from the period before 2006 had received entrepreneurship courses. In case of non-entrepreneurs, 20.8% of them had received entrepreneurship courses, but the difference with entrepreneurs was not significant [$\chi^2(1, N = 62) = 0.241, p = 0.623$]. For the engineering alumni, who graduated in 2006 to 2016, 70.8% of entrepreneurs and 55.6% of non-entrepreneurs had received entrepreneurship education, however the difference was also not significant [$\chi^2(1, N = 87) = 1.687, p = 0.194$].

Table 1. Share of alumni, who received entrepreneurship education during their university studies

Time of graduation		Engineering alumni	Other alumni	TOTAL
Before 2006	Entrepreneurs	26.3%	52.3%	46.9%
	Non- entrepreneurs	20.8%	35.4%	35.1%
	Total	24.2%	42.9%	40.5%
	p	n.s	**	**
2006 to 2016	Entrepreneurs	70.8%	78.1%	77.2%
	Non- entrepreneurs	55.6%	63.7%	62.8%
	Total	59.8%	67.5%	66.7%
	p	n.s	**	***
TOTAL	Entrepreneurs	43.8%	65.4%	61.8%
	Non- entrepreneurs	45.8%	54.2%	53.9%
	Total	44.5%	57.9%	56.7%
	p	n.s	**	**

**p < 0.05; **p < 0.01; ***p < 0.001; n.s- not significant.*

However, in case of other graduates, entrepreneurship courses had significant impact (65.4% of graduates who became entrepreneurs had received entrepreneurship courses as part of their studies vs. 54.2% of those who were not entrepreneurs, $\chi^2(1, N = 980) = 10.920, p < 0.01$). The comparison by the time of graduation shows the among those, who graduated before 2006, 52.3% of entrepreneurs had received entrepreneurship education in comparison with 35.4% of non-entrepreneurs who had entrepreneurship courses [$\chi^2(1, N = 343) = 9.859, p < 0.01$). Similar significant difference occurred also in the group of other alumni, who graduated in the period of 2006 to 2016.

Thus, while in non-engineering alumni entrepreneurship education had positive impact on later entrepreneurial activities, this was not the case for engineering alumni. In the period before 2006 more than half of engineering alumni had become

entrepreneurs, despite of the fact that most of them had not received any entrepreneurship education. For those, who had received entrepreneurship education, it failed to have significant impact on whether they become entrepreneurs or not. It can be assumed that in case of the engineering alumni the choice to become an entrepreneur was impacted by other factors than entrepreneurship education. In the present study the group of non-engineering alumni did not include only business students, but also other fields of studies, so our results are not comparable with those of Maresch et al. (2016) in one-on-one. However, with the lack of effect of entrepreneurship education in engineering students, but impact on other graduates, it is possible that there is a similar effect as suggested in their research, where different groups (in their case business students) may benefit more from the entrepreneurship education.

Assessments on the development of entrepreneurship competencies

In the questionnaire survey the graduates were asked to assess 22 different knowledge and skills connected with entrepreneurship in a Likert type of scale of 5 (Table 2). Overall, the highest scores were given to the development of ability to continuously work of self-improvement, independence, oral and written expression skills and communications skills. Entrepreneurial knowledge and financial knowledge received the lowest scores. The engineering alumni on average gave higher scores to the competences studied.

Table 2. Comparison of the assessment on how did university studies help to develop the following competences

	Engineering alumni		Other alumni		*t-value*	*df*	*p*
	M	*SD*	*M*	*SD*			
Continuous self-improvement	4.09	0.74	4.08	0.74	0.059	1,134	n.s
Independence	4.10	0.89	3.98	0.88	1.64	1,129	n.s
Oral and written expression skills	3.88	0.87	3.94	0.87	-0.843	1,134	n.s
Communication skills	3.85	0.91	3.89	0.89	-0.505	1,130	n.s
Teamworking	3.91	0.77	3.85	0.89	0.952	230.74	n.s
Planning skills	3.85	0.81	3.83	0.85	0.178	1,126	n.s
Ability to work on long-term goals	3.79	0.95	3.84	0.88	-0.681	1,125	n.s
Problem-solving skills	4.09	0.77	3.74	0.95	5.121	240.65	***
Critical thinking	3.94	0.83	3.71	0.89	3.09	218.04	**
Critical evaluation of own skills	3.89	0.81	3.72	0.88	2.447	222.82	*
Ethical behaviour	3.84	0.86	3.73	0.92	1.410	210.86	n.s
Self-confidence	3.75	0.84	3.72	0.87	0.385	1,126	n.s
Need for achievement	3.61	0.93	3.56	0.97	0.542	1,123	n.s
Networking ability	3.59	0.96	3.49	1.04	1.198	1,124	n.s
Developing new ideas and solutions	3.80	0.83	3.42	0.95	5.162	228.54	***
Creativity	3.68	0.98	3.43	0.96	3.058	1,121	**
Initiative	3.53	0.91	3.42	0.97	1.292	1,122	n.s
Risk taking	3.48	1.00	3.34	0.99	1.667	1,125	n.s
ICT skills	3.39	1.09	3.35	1.09	0.359	1,125	n.s
Leadership skills	3.37	0.99	3.17	1.05	2.214	1,130	*
Financial knowledge	2.70	1.01	3.13	1.18	-4.800	230.31	***
Entrepreneurial knowledge	2.87	1.06	3.10	1.16	-2.265	1,122	*

**p < 0.05; **p < 0.01; *** p < 0.001; n.s.- not significant.*

The comparison between engineering alumni and other alumni indicated that in case of 8 competences the difference between the scores of two groups were statistically significant. In comparison with other alumni engineering alumni gave considerably higher assessments to the development of problem-solving skills, critical thinking, critical evaluation of own skills, ability to develop new ideas and solutions, but also to creativity and leadership. The scores were significantly lower in case of entrepreneurial knowledge and financial knowledge. On the basis of the results in can be concluded that in the opinion of the engineering alumni, the university education generally provided them with a mix of skills critical for engineering profession and for acting upon different opportunities. Given the nature of engineering work, it can be expected that they developed better competences than other alumni in problem solving, critical thinking, and finding new solutions as this also requires creativity, but interesting aspect was also the better outcomes in leadership skills.

T-tests were also used to study whether entrepreneurship education had impact on the evaluations on the development of various competencies (Table 3 and 4). In case of the engineering alumni, entrepreneurship courses were connected only with three competencies: entrepreneurial knowledge, financial knowledge and ICT skills. Engineering alumni, who had attended entrepreneurship courses, gave statistically significantly higher assessments on whether the studies helped to acquire those skills and knowledge.

Table 3. Mean scores of engineering alumni on the assessments on how did university studies help to develop the following competences on the basis of whether they received entrepreneurship courses (EC) or not

	EC		No EC		*t-value*	*df*	*p*
	M	*SD*	*M*	*SD*			
Continuous self-improvement	4.12	0.75	4.03	0.73	-0.492	156	n.s
Independence	3.99	0.94	3.96	0.85	-0.400	155	n.s
Oral and written expression skills	4.00	0.88	3.85	0.85	1.019	156	n.s
Communication skills	3.93	0.89	3.82	0.92	1.179	155	n.s
Teamworking	3.91	0.82	3.76	0.72	0.060	156	n.s
Planning skills	3.91	0.79	3.73	0.82	0.168	155	n.s
Ability to work on long-term goals	3.92	1.04	3.72	0.88	-0.716	133.16	n.s
Problem-solving skills	3.78	0.82	3.68	0.72	-0.566	156	n.s
Critical thinking	3.74	0.80	3.66	0.86	0.100	155	n.s
Critical evaluation of own skills	3.73	0.73	3.69	0.86	1.113	156	n.s
Ethical behaviour	3.71	0.86	3.75	0.85	1.155	151	n.s
Self-confidence	3.81	0.90	3.59	0.79	-0.265	153	n.s
Need for achievement	3.64	0.92	3.44	0.94	-0.680	155	n.s
Networking ability	3.59	0.99	3.32	0.95	0.321	155	n.s
Developing new ideas and solutions	3.46	0.83	3.36	0.84	-0.309	156	n.s
Creativity	3.41	0.96	3.43	0.99	-0.421	154	n.s
Initiative	3.49	0.86	3.32	0.95	-0.232	154	n.s
Risk taking	3.35	0.96	3.32	1.04	-0.820	154	n.s
ICT skills	3.61	0.96	3.00	1.16	2.595	155	*
Leadership skills	3.25	0.99	3.04	1.00	0.284	155	n.s
Financial knowledge	3.53	0.97	2.57	1.00	2.952	155	**
Entrepreneurial knowledge	3.49	0.86	2.54	1.09	4.306	154	***

***p < 0.05; **p < 0.01; *** p < 0.001; n.s.- not significant.*

In the assessments of the alumni from other fields (Table 4), the entrepreneurship education had considerably more impact. Respondents from other fields gave significantly higher scores to more than half of the competences in the list (to 12 competences out of 22). Besides the entrepreneurial and financial knowledge and ICT skills that were significantly different also in case of engineering alumni, such competences as networking skills, self-confidence, leadership skills, ability to work for long-term goals, need for achievement, planning, taking initiative, written and oral expression skills, teamwork were impacted by entrepreneurship courses the alumni of other fields had received during their studies. Thus, it can be assumed that while those skills are typically emphasised as transversal competences that all courses in the university should help to develop, the entrepreneurship education has a significant role in contributing to the development of certain skills.

Table 4. Mean scores of other alumni on the assessments on how did university studies help to develop the following competences on the basis of whether they received entrepreneurship courses (EC) or not

	EC		No EC		*t-value*	*df*	*p*
	M	*SD*	*M*	*SD*			
Continuous self-improvement	4.12	0.73	4.03	0.75	1.771	964	n.s
Independence	3.99	0.87	3.96	0.89	0.558	962	n.s
Oral and written expression skills	4.00	0.86	3.85	0.87	2.705	965	**
Communication skills	3.93	0.89	3.82	0.89	1.922	961	n.s
Teamworking	3.91	0.84	3.76	0.93	2.507	813.79	*
Planning skills	3.91	0.83	3.73	0.84	3.291	958	**
Ability to work on long-term goals	3.92	0.86	3.72	0.89	3.428	841.06	**
Problem-solving skills	3.78	0.93	3.68	0.97	1.683	996	n.s
Critical thinking	3.74	0.88	3.66	0.90	1.443	957	n.s
Critical evaluation of own skills	3.73	0.89	3.69	0.87	0.840	958	n.s
Ethical behaviour	3.71	0.95	3.75	0.87	-0.654	889.66	n.s
Self-confidence	3.81	0.85	3.59	0.88	3.941	960	***
Need for achievement	3.64	0.96	3.44	0.97	3.092	955	**
Networking ability	3.59	1.04	3.32	1.01	4.009	956	***
Developing new ideas and solutions	3.46	0.98	336	0.91	1.473	899.02	n.s
Creativity	3.41	0.97	3.43	0.93	-0.209	954	n.s
Initiative	3.49	0.97	3.32	0.94	2.740	955	**
Risk taking	3.35	1.01	3.32	0.97	0.516	958	n.s
ICT skills	3.61	0.98	3.00	1.15	8.821	957	***
Leadership skills	3.25	1.05	3.04	1.04	3.140	962	**
Financial knowledge	3.53	1.08	2.57	1.07	13.642	961	***
Entrepreneurial knowledge	3.49	1.06	2.54	1.06	13.581	955	***

**p < 0.05; **p < 0.01; *** p < 0.001; n.s.- not significant.*

Another question of interest in the study was whether those, who later became entrepreneurs, have different opinion on how did university education contribute to the development of various competences. Table 5 provides comparisons for the engineering graduates. As it can be seen from the comparisons, the entrepreneurs among the engineering graduates did not report significantly different development of various skills and knowledge. Entrepreneurs gave statistically different assessments to only two

competences. Networking ability received higher scores and ICT skills lower scores from entrepreneurs than non-entrepreneurs among engineering alumni (Table 5).

Networking is connected with skills for social interaction and with creation, maintenance and using of social relationships to advance individual goals (Morris et al., 2013). While the other competences did not make difference for the engineering alumni, it seems that those, who built up relationships during their university studies, were in a better position to use those for their entrepreneurship activities. As one of our takes from the analysis has been that the entrepreneurship activities of engineering graduates were also induced by the economic climate and contraction and restructuring of large-scale industries, it can be expected that those individuals with good networks were in particularly favourable position for accessing various resources during a period of economic and social turmoil.

Table 5. Mean scores of engineering alumni on the assessments on how did university studies help to develop the following competences on the basis of whether they are entrepreneurs

	Entrepreneurs		Non-entrepreneurs		*t-value*	*df*	*p*
	M	*SD*	*M*	*SD*			
Continuous self-improvement	4.08	0.67	4.11	0.80	-0.256	141.05	n.s
Independence	4.13	1.02	4.13	0.80	0.013	141	n.s
Oral and written expression skills	3.86	0.96	3.93	0.80	-0.467	142	n.s
Communication skills	3.84	0.97	3.85	0.84	-.0057	141	n.s
Teamworking	3.90	0.85	3.91	0.69	-0.068	142	n.s
Planning skills	3.83	0.75	3.89	0.79	-0.475	141	n.s
Ability to work on long-term goals	3.81	1.03	3.81	0.89	-0.023	139	n.s
Problem-solving skills	4.11	0.82	4.10	0.76	0.093	142	n.s
Critical thinking	3.94	0.87	3.99	0.83	-0.355	141	n.s
Critical evaluation of own skills	3.86	0.87	3.90	0.78	-0.318	142	n.s
Ethical behaviour	3.87	0.87	3.81	0.85	0.430	138	n.s
Self-confidence	3.76	1.10	3.76	1.02	0.039	139	n.s
Need for achievement	3.56	0.91	3.66	0.89	-0.702	141	n.s
Networking ability	3.79	1.03	3.48	0.84	2.031	141	*
Developing new ideas and solutions	3.84	0.78	3.80	0.87	0.276	142	n.s
Creativity	3.84	0.94	3.55	0.99	1.756	140	n.s
Initiative	3.68	0.94	3.43	0.85	1.662	140	n.s
Risk taking	3.56	1.01	3.42	0.98	0.820	140	n.s
ICT skills	3.19	1.10	3.65	1.02	-2.578	141	*
Leadership skills	3.56	1.04	3.28	0.88	1.704	121.54	n.s
Financial knowledge	2.79	1.09	2.63	0.90	1.008	141	n.s
Entrepreneurial knowledge	2.98	1.16	2.79	0.96	1.098	140	n.s

$*p < 0.05$; $**p < 0.01$; $*** p < 0.001$; n.s.- not significant.

The lack of difference in the engineering alumni scores indicates relatively uniform opinions on what kind of education the university provided them with. Engineering alumni developed same kind of entrepreneurship competencies throughout their studies regardless of whether they later become entrepreneurs or not. This could indicate that the competences developed during studies should be sufficient base if the graduate later decides to become an entrepreneur. Also, those who later become entrepreneurs did not necessarily seek out the development of very specific competences during the studies.

The entrepreneurs from other alumni also displayed same kind of patterns in their assessments (Table 6). But besides those two competences, also problem solving, risk taking, leadership and financial knowledge received higher scores from entrepreneurs than non-entrepreneurs.

Table 6. Mean scores of other alumni on the assessments on how did university studies help to develop the following competences on the basis of whether they are entrepreneurs

	Entrepreneurs		Non-entrepreneurs		*t-value*	*df*	*p*
	M	*SD*	*M*	*SD*			
Continuous self-improvement	4.11	0.74	4.08	0.73	0.656	910	n.s
Independence	3.95	0.96	4.01	0.82	-0.954	908	n.s
Oral and written expression skills	3.90	0.90	3.97	0.84	-1.078	912	n.s
Communication skills	3.89	0.89	3.91	0.88	-0.394	910	n.s
Teamworking	3.82	0.91	3.87	0.86	-0.783	909	n.s
Planning skills	3.80	0.89	3.86	0.82	-0.984	571.88	n.s
Ability to work on long-term goals	3.87	0.90	3.83	0.88	0.565	906	n.s
Problem-solving skills	3.83	0.96	3.70	0.93	2.020	913	*
Critical thinking	3.71	0.95	3.74	0.86	-0.438	904	n.s
Critical evaluation of own skills	3.75	0.92	3.73	0.87	0.269	905	n.s
Ethical behaviour	3.68	0.93	3.77	0.90	-1.457	901	n.s
Self-confidence	3.74	0.87	3.71	0.86	0.554	906	n.s
Need for achievement	3.59	0.96	3.57	0.97	0.334	903	n.s
Networking ability	3.60	1.04	3.44	1.03	2.308	903	*
Developing new ideas and solutions	3.48	0.93	3.40	0.95	1.276	909	n.s
Creativity	3.47	0.95	3.43	0.96	0.722	903	n.s
Initiative	3.51	0.97	3.38	0.96	1.836	905	n.s
Risk taking	3.44	1.02	3.30	0.97	1.991	907	*
ICT skills	3.31	1.12	3.39	1.07	-1.144	904	*
Leadership skills	3.31	1.03	3.08	1.05	3.129	908	**
Financial knowledge	3.26	1.21	3.07	1.65	2.322	907	*
Entrepreneurial knowledge	3.20	1.17	3.04	1.42	1.916	903	n.s

**p < 0.05; **p < 0.01; ***p < 0.001; n.s- not significant.*

Problem solving skills, networking and leadership skills were among those competences that other alumni had scored significantly lower in comparison with engineering alumni (Table 2), and those skills seem to be particularly critical for encouraging entrepreneurship among the graduates from other fields. For networking ability and leadership as well as for financial knowledge and ICT, the entrepreneurship education made difference (Table 4). While the problem solving and risk-taking ability were important in becoming an entrepreneur, the entrepreneurship education did not build up particular skills during the entrepreneurship courses.

Limitations of the survey

The present research has several limitations as the analysis is relatively descriptive in its nature and the data collected with the questionnaire was based on the respondents' self-reports and not on the actual measurement of performance. This included reports on whether the graduates had received any entrepreneurship courses as part of their university studies. The shortcoming of the survey is that the questionnaire did not specify

the amount of entrepreneurship courses, including the number of courses or credit hours in detail, or their specific content. The collection of detailed data on how many and which kind of courses were part of the particular curricula was beyond the scope of this survey, because the aim was to collect data on the activities of graduates from all programs spanning over several decades. This included dozens of different study programs and curricula that have been subjected to profound changes. The changes over the span of time, including in the definition of credit hours, make it impossible to measure the workload, exact number of courses or detailed content of the course reliably on the basis of the graduates' recall.

Also, as entrepreneurs were operationalised on the basis of the question on whether the respondent was a sole proprietor and owner and manager of a commercial enterprise or non-profit; thus it is impossible to differentiate on whether they fit criteria for a classic Schumpeterian definition of entrepreneur or a regular everyday business owner.

CONCLUSIONS

Engineering alumni is expected to be in the forefront of a knowledge-based society by contributing to the new venture creation and technological developments and solutions for modern problems. With just over a third of engineering alumni involved in entrepreneurial activities, the research on the role of entrepreneurship education in their entrepreneurship activities provides valuable feedback on how to improve the attainment of knowledge and skills necessary for university students later in their life.

The entrepreneurial activities were impacted by the time of graduation that also had impact of whether the graduates had received entrepreneurship courses during their studies. We associate the significantly higher share of entrepreneurs among engineering graduates from the period before 2006 with the considerable economic restructuring that was taking place in the transition period. Part of this process was the collapse of Soviet era argo-industrial complexes and contraction of newly privatized industrial and agricultural enterprises (Viira et al., 2009; Põder et al., 2017). This was accompanied by considerable decrease in engineering jobs in the industry and agriculture. The ongoing economic and institutional changes created both opportunity and necessity-based entrepreneurship in the field of engineering that could explain the higher entrepreneurial activity of engineering graduates in comparison with other fields.

The socioeconomic context can also explain the lack of impact on entrepreneurship education on entrepreneurial activities of engineering alumni. While the share of engineering alumni who had received entrepreneurship education during their university studies was two times lower in comparison of alumni of other fields that graduated before 2006, the share of entrepreneurs was considerably higher in engineering alumni. Thus, they became entrepreneurs despite of lack of education in the field of entrepreneurship. This is also demonstrated by the assessments on the entrepreneurship competencies as the engineering alumni indicated that they had less financial knowledge and entrepreneurial knowledge than those in other alumni. While the entrepreneurship courses helped to build those competences, better skills in those areas did not impact whether the engineering graduates became entrepreneurs. This also indicates the possibility that the socioeconomic developments in their particular field were the primary drivers for entrepreneurship activities. For example, among those who

graduated after 2006, the difference in the share of entrepreneurs between engineering and other alumni disappears.

The entrepreneurship education had more important role in developing different competencies in other alumni than in engineering graduates. However, the evaluation on the competences indicates that the engineering education of EULS provided a well-rounded development of transversal competences throughout the different subjects even without the entrepreneurship courses. With higher scores on most of competences studied in comparison with other alumni from different fields, the competences such as problem-solving abilities, critical thinking, creativity, development of new ideas and solutions served the engineering alumni well in solving the issues related with their entrepreneurship activity.

Another result that indicates to this direction mentioned in above, is the lack of significant differences between the scores of engineering alumni who had received entrepreneurship courses in comparison with those who had not participated in any. In the interpretation of this results, the limitations of the present study have to be considered. As the study does not provide information on the actual content and on how much entrepreneurship education was received, the lack of impact of entrepreneurship education on the development of competences of engineering alumni can be related with very limited access to entrepreneurship courses. As entrepreneurship courses have not traditionally been prioritized in the Estonian engineering education and less than half of engineering alumni had participated in any entrepreneurship courses, it is highly likely that the entrepreneurship education in the engineering programs consisted of a single obligatory course and/or a random elective course. In case of other alumni the entrepreneurship education increased the likelihood of them later becoming an entrepreneur and the other alumni included graduates from the fields (e.g. business and administration) which study programs have traditionally contained an integrated set of entrepreneurship courses. Thus, the actual content and volume of entrepreneurship education and how it impacts the entrepreneurial activities after the university graduation requires further research attention.

Typically, most of university graduates do not set up their enterprise right after finishing the university, but in somewhat older age after working as an employee and building up experience and network. Present results demonstrated that in the last decade the graduates have started to become entrepreneurs at younger and younger age. This could be explained by institutional changes in legislation and the effort of the government to encourage entrepreneurship by simplifying the administrative processes for setting up enterprises as well as by expansion of entrepreneurship education. But it also indicates that entrepreneurship education in higher education requires further attention from policymakers and researchers. When considerable share of graduates become entrepreneurs sooner after their university graduation as in previous decades, the entrepreneurship education they received will have more direct and quicker impact on their actual entrepreneurial activities.

Despite the methodological shortcomings of the present survey, we find that our results indicate to some useful implication for the further research. While the impact of entrepreneurship education on the formation of entrepreneurial intentions has been the subject of increased amount of research, the question of how does it translate into action and when, should receive more attention.

Another question that our study failed the address, is how the competences erode over time and which kind of competences turn out to be more critical for different paths later in life. This particular study looked back and asked the graduates to assess their education years after they received it. However, a longitudinal study would provide means to collect data on the students' views on their competences at the time of university studies and contrast those with assessments collected later in life and affected by experience of implementing those competences in real life. This kind of methodology would help to address the time lags between the university studies and entrepreneurial activity. Our study indicated decrease in the average age for entrepreneurship and we interpret that it is partially caused by increased access to entrepreneurship education, incubators, accelerators etc. that encourage entrepreneurship. But another question of interest is whether this results in better performance in comparison with entrepreneurs who build up experience and networks with working for a longer period as an employee in industry, before setting up their entrepreneurial endeavours.

Our interpretation of some of the results was tied to the institutional changes in the society. The future studies should account for the institutional context of the entrepreneurship activities and entrepreneurship education. Many studies have integrated the perception of social norms, societies' attitudes towards entrepreneurship into their study. However, in particular fields of economic activities, the rapid contraction or expansion of particular industry and its labour demand is likely to be more primary driver of entrepreneurship activities.

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