Lessons learned from FITech Turku, a 18 million euros university collaboration project to complement the regional demand for Master degree engineers

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***Abstract*— This Innovative Practice Full Paper presents a nationwide university collaboration project to complement regional demand for Master degree engineers. Technology industry with sufficient ability and investment in research, development and innovation is in the core of economic growth and success at both national and regional level. Higher education institutions should produce the needed new engineering professionals and serve as platforms for university-industry collaboration in research and innovation. Due to phenomena such as globalisation of industrial activities and growing demand for sustainable energy solutions, the regional development of different technology industry sectors, e.g. marine technology, telecommunications and battery technologies, can take diverting directions and change the need for skillsets of new engineers. While innovation activity of a local higher education institution can on long term provide the platform for new growth businesses, investment-heavy industries often have other drivers for the location of their activities. Establishing new degree programs, or even further, new educational institutions, contains its potential challenges, financial and in availability of qualified researchers, teachers and students. Furthermore, these efforts are not sufficiently fast to address the fairly rapid changes in the need for the workforce.**

FITech (Finnish Institute of Technology) has been a five year project to address the demand of qualified engineers in Southwestern Finland, the region with the fastest growing technology industry in the country. The project consortium contains the seven Finnish universities providing engineering education, with the budget for the 5-year project period (from 2017 to 2021) being 18 million euros, from which 70% is funded by the Finnish Ministry of Education and Culture, and the 30% is covered by the universities themselves, This paper analyzes the quantitative (e.g. master thesis elaborated in companies in the region, plans and agreements to take the collaboration forward after the funded project period) of the project. In addition to reflect upon the follow up, three new education projects (FITech ICT, FITech Energy Storage and FITech 5G), materialized from the collaboration within FITech consortium, are introduced. The discussion summarizes the detected challenges and areas for improvement to enhance the success of such systematic university collaboration at a national scale.

Keywords—engineering education, university network, FITech, academy-industry collaboration

I. INTRODUCTION

Access to skilled engineering professionals is a valuable asset for countries worldwide. Engineers support the growth and economic development of the country while simultaneously improving the citizens quality of life [1]. Governments have an important role in the growth of national engineer talents by supporting the development of quality engineering education, providing finance and resources to infrastructure projects and research. The national investment required to support quality engineering education is considerable in terms of money and time. The return of a nation's investment in engineering education takes several years, or decades, to be seen, because the process to support the growth of talented individuals and enable them to create the impact in our societies requires time. Consequently, to benefit a country, governments build long time strategies addressing forecasted needs.

In contrast, industry requirements for engineer talents are dynamic. Due to the fast pace in innovation and global market needs, industry requires different engineering knowledge at different times in distinct locations. Furthermore, industry is flexible to allocate itself where commercial opportunities are most suitable for their business. As a result, sometimes companies might establish themselves in different locations than the ones offering the engineering education.

It is of national interest to be able to produce the engineering knowledge and talents that the local industry requires. A relevant question on national level, is: how to develop frameworks to balance an unbalanced supply-demand of engineering graduates in a country?

In this paper, the authors analyze upon the outcomes delivered by the Finnish national project entitled FITech (Finnish Institute of Technology) Turku after 5 years of its implementation. The aim of FITech Turku is to address the supply-demand challenge of engineers graduating in Finland, with a specific focus in meeting the skill demand in Southwestern Finland.

II. BACKGROUND

A. Engineering education in Finland.

Finland has an estimated population of 5,537,116 inhabitants by March [2]. As any other nation, Finland needs to invest its resources in university education wisely to support its economy.

The university system in Finland is steered and its degree education funded by Finnish government, while most of the university research depends on external funding [3], [4].Ideally, the universities should provide degree programs and call for research activity in the fields relevant to their surrounding economy and industry.

Fig. 1. Region in Finland and location of university partners in FiTech [5]

Since the 1980's the region of Southwestern Finland (Figure 1) has been in need of master level engineer graduates due to its industry growth. In 2014 there was a significant boost in the maritime industry which emphasizes the demand for master level engineering graduates. An example of this supply-demand for master level engineers is illustrated in Table 1.

The existing university programs in Southwestern Finland, during this time, were focused and limited to information technology, biotechnology and process engineering. Wide range of other engineering education programs are offered by five different universities, located in other regions of the country.

To address the supply-demand imbalance for master level engineers, the Finnish Ministry of Education and Culture (MoEC) chose to fund the project of FITech (Finnish Institute of Technology). FITech is a network of seven Finnish universities providing technology degree programs across Finland [5].

TABLE I. SUMMARY OF NATIONAL TECHNOLOGY PRODUCTION OUTCOMES GIVEN BY THE FINNISH CENTER OF ECONOMICAL DEVELOPMENT

2017	Turn-over of tech. Industry (Mrd€)	% of national volume	Personnel in tech industry (person)	Export of products from tech industry %	MSc. or higher in Tech (ICT&Eng)
Uusimaa	27.0	37.1	101 500	55	42 053
Pirkanmaa	6.6	9.1	32 500	54	12 996
Southwestern Finland	5.7	7.8	28 600	51	4 720
Northern Ostrobothnia	5.7	7.8	23 100	67	6 458
Ostrobothnia	4.7	6.5	18 300	59	1 940
Southeastern Finland	2.4	3.3	10 800	19	3 412
Whole Finland	72.7		299 600		83 793

B. FITech

In 2017, a new higher education and research collaboration structure, FITech network was established between the Finnish universities offering engineering, MoEC and the industry and labour organizations in the field of technology.

The first project implemented by FITech collaboration network is FITech Turku, with the aim to support the need of master level engineer graduates in Southwestern Finland. The MoEC, together with the following seven universities, committed to fund the 5-year project:

- Aalto University (Aalto), co-ordinator of this consortium.
- Lappeenranta-Lahti University of Technology (LUT)
- University of Oulu (Oulu)
- Tampere University (UTA)
- University of Turku (UTU)
- University of Vaasa (Vaasa) and
- Åbo Akademi University (ÅA).

Out of the seven universities, UTU and ÅA are located in Southwestern Finland, while their offerings in engineering are very limited compared to the other ones. Through collaboration, the universities aimed at providing a concrete and economically efficient solution to the educational challenge [6], [7].

C. Objectives of FITech Turku

1. Common platform of offerings. FITech will launch a common platform for higher education and research in engineering for its partner universities. (https://fitech.io/)
2. Concrete interventions. The following measures are expected to support Southwestern Finland (based on the 2017 MoEC report [8]):

a. Promoting and increasing graduation theses, summer internships and course projects in mechanical engineering, materials engineering, energy technology, electrical engineering and electronics, information technology, industrial engineering and management, targeting at economical activities in Southwestern Finland.

b. Expanding the study possibilities of students in the University of Turku and Åbo Akademi University by offering complementary engineering minors provided by the other partner universities.

c. Upgrading or complementing degrees of engineers within the current workforce of the region.

d. Lowering the threshold of moving to Southwestern Finland.

3. Sustainability of actions. Organization of collaborative structures will secure the above-mentioned activities in the long term:
   a. The establishment of FITech emphasizes the joint potential of universities and companies in the field of engineering to promote sustainable and visionary collaboration between academia and industry.
   b. Creation and establishment of mechanisms that enable universities to work seamlessly with each other and with industry. By 2022, no external funding should be needed to continue successful operations.

D. Organisation and resources

FITech Collaboration network organized itself by creating governing and acting bodies as following:

- Board of FITech – top level representation of the founding universities, industry and labour associations. responsible for strategic decision-making in the network. The board has the authority to found new FITech projects and nominates executive groups for these projects.
- FITech Turku Steering group – representation of the participating universities and local companies. The Steering group monitors project progress and reports to the Board.
- FITech Turku project manager
- FITech Turku Operative group – academic coordinators of participating universities. This group collects the academic offerings of each university, organizes events and reporting and acts as university contact persons in questions related to the project.
- Communications, study administration service designer and support for developing online courses. These common support functions plan and operate the FITech communications (e.g. via website fitech.io), promoting academic offerings for their target audience, developing common student enrollment practices for studies provided by a group of universities with various internal systems and support teachers in the process of re-designing their courses to be delivered online.

III. METHODS

Due to the nature of this study, we utilize retrospective analysis. For this analysis we utilize the quantitative data available, e.g. academic offerings, master thesis completed to the region and other company collaboration by the Fitech network.

The data analyzed is mainly administrative outcomes gathered from 2017 to first half of 2021 during the FITech Turku project (Figure 2). According to diverse authors [9], [10], a retrospective analysis is a research method utilized when the outcomes of an event are already known at the moment of the study, and the data available is analyzed to understand what could have led to the study outcome or how similar studies can be improved in the future.

The data was collected in two parallel processes. The academic offerings were reported before their execution, at the time those offerings were published available for the network. The materialized results of activities, such as student enrollment in courses arranged and master thesis completed, were reported twice a year after the end of each academic semester.

IV. OUTCOMES

This section summarizes the quantitative results delivered during the FITech Turku project. It is organized according to the metrics utilized to measure the impact of the project against its objectives, specifically concrete interventions 2.a - 2.d, during its execution.

A. Academic offerings

The academic offerings within FITech Turku project include:

- **Full Master programs**. These were offered by LUT and TAU. (Table 2) These programs offered to the workforce with existing undergraduate degree in engineering (obj 2.c)
- **Minors**. Thematic collections of courses offered (obj 2.b) as an academic minor for an academic year. (Table 3) Some courses within the minors were offered also as individual courses, to extend the flexibility of the offering.
- **Individual courses** on topics of high interest (obj. 2.b), such as managing large projects. (Table 4)
  Two thirds of minors and Individual courses were also suitable for the non-degree students, the workforce of the industry in Southwestern Finland. (obj. 2.c)
- FITech summer schools and summer courses were offered. Branded as **Fitech Summer Boost**.

B. Master of Science in Technology Programs

The number of M.Sc (Tech) programs in execution is presented in table 2. LUT started a new master program in several domains of engineering each year in 2018-2021. The 2-year master programs were extended to 3 calendar years to allow students to study while they work. Blended learning methods were applied, and modules that require use of in-campus equipment were primarily offered during weekends. Due to the increased amount of remote studies in these programs, applicants with an undergraduate degree from any region in the country could apply for these programs, decreasing the actual impact in the region in focus, but serving the national need for engineers.

Prior to FITech Turku, as co-operation between UTU and UTA, UTA had started an in-campus master program in mechanical engineering, using premises and teaching equipment of local institutions. These 2-year programs started in 2016, 2017 and 2018 and contribute to UTA numbers in chapter 4.2.

TABLE II. MASTER (MSC TECH) PROGRAMS UNDER FITECH TURKU. 'X' INDICATES A NEW START OF THE PROGRAM. THE NUMBER IS THE COUNT OF ANNUAL BATCHES AND INTAKE IS THE NUMBER OF STUDENTS STARTING THE PROGRAM IN A BATCH.

Program/Year	17	18	19	20	21
Energy Technology - Efficient Energy Usage and Energy Economics (LUT)		X 1	X 2	X 3	X 3
Intake / students		20	23	24	
Electrical Engineering / ELEC programme (LUT)	X 1	X 2	X 3	X 3	X 3
Mechanical Engineering / MEC programme (LUT)	X 1	X 2	X 3	X 3	X 3
Intake / students (MEC&ELEC)	80	46	40	50	
Mechanical Engineering (UTA) (This program initiated in another project).	X 2	X 3	2	1	
Total programs running	4	4	4	4	3
Total of batches	4	8	10	10	9

The academic offerings were collected from the participating universities. Each of the universities independently decided the academic minors and individual courses they offered based on their existing specializations, matching some of the knowledge gaps identified in the region. For each course and minor, there was a responsible person at the university providing or organizing the course. However, the link of these academics and the FITech project remain often rather nominal than active. Responsible academics had no or only modest incentive for the success of their "FITech minor", providing courses to degree students of other universities.

TABLE III. ACTIVE MINORS BY YEAR

Name of the minor	18	19	20	21
Materials Engineering (UTA)	x	x	x	x
Automation Engineering (UTA)	x		x	x
Energy Technology (Vaasa)	x	x	x	x
Use and Characteristics of Steel (Oulu)	x	x	x	x
Marine Technology (Aalto)	x	x	x	x
International Design Business Management (Aalto)	x	x	x	x
Chemical Engineering for Manufacturing Industry (ÅA)	x	x	x	x
Safety -Critical and Autonomous Systems (ÅA, UTU)	x	x		
Production Planning, Control and Optimization (ÅA)	x	x	x	x
Co-creation and Platform Economy (UTU, ÅA)	x	x	x	x
Industrial ICT (UTU,ÅA)	x	x	x	x
Project and Industrial Management (ÅA,UTA, Oulu, Aalto)	x	x	x	x
Process Design for Energy Efficiency (ÅA)	x	x	x	x
Environmental Engineering (Oulu, ÅA)	x	x	x	x
Commercialization of Medical Devices and Software (UTA)		x	x	x
High-growth Operations		x	x	
Industrial Robotics (UTA)		x	x	x
Smart and Sustainable Maritime Business (UTU, Aalto)		x	x	x
Total:	14	17	17	16

By June 2021, 20 students studying their master degree in a university in Turku region (15 in UTU, 5 in ÅA) had completed a FITech minor. These students were distributed as follow: the minor 'Project and Industrial Management' was registered for 9 students, minor 'Environmental Engineering' for 6 students, minor 'Industrial ICT' for 2, and minors 'Marine Technology', 'Energy Technology' and 'Co-creation and platform Economy' each for 1 student. Since the minor is typically formally registered to the system at the time of graduation, the total number of minors can be collected only after the end of FITech Turku project.

TABLE IV. ACTIVE INDIVIDUAL COURSES BY YEAR

Course name	18	19	20	21
Principles of Chemical Reaction Engineering (ÅA)	x			

Project Management, Basic Course (ÅA collaboration with UTA, Oulu, Aalto)	x			
Project Management , Advance course (ÅA in collaboration UTA, Oulu, Aalto)	x			
Process optimization (Oulu)	x			
Tolerance Design (Oulu)		x	x	x
Simulation and Modelling of Machines (Oulu)		x	x	x
Signal analysis in mechanical engineering (Oulu)		x	x	x
Fracture Mechanics (Oulu)		x	x	x
MSc course: Optimization of ship energy systems (Aalto)	x			
Neural Networks (ÅA, UTU)				
Automation summer course (TAU)			x	
Hydraulic Machines (UTA)			x	
Product Innovations (Oulu)		x	x	x
Introduction to engine laboratory research (Vaasa)				x
Strength of materials (TAU)				x
Use of high strength steels in mechanical engineering (Oulu)			x	x
Total	5	5	8	8

C. FITech Summer Boost

- 2018: Technology and Business Models of Autonomous Ships (Aalto)
- 2019: Additive Manufacturing and 3D printing (Aalto)
- 2020: One vessel, six sustainable aspects (Aalto)
- 2021: Strategic project management (Aalto, ÅA, Oulu, UTA)

D. Master Thesis

Master thesis is traditionally seen as a means connecting companies and engineering students as future workforce. 76% of cases the student is, at the time of graduation, working in the company where the thesis was done [11, p. 40]. Addressing objective 2.a, the master thesis completed by students in FITech universities with a topic provided by a company in the Southwestern Finland region were reported. The quantitative target for the project was to increase the number of master degree graduates in engineering by 200 per year [11, p. 39]

By February 2021, there were a total of 537 Master's thesis completed in the region . Due to the typical duration of a thesis project, 4-6 months, the thesis count for year 2017 should be considered as a baseline for impact of Fitech activities (Table 5).

For Aalto, the 2017 count is exceptionally high, since 2017 was the last year of execution in old master programs, urging students to finish their prolonged studies. For UTA, the numbers contain 31 thesis done in the programs started in a regionally targetted project before Fitech program. For Vaasa, the number for 2020 contains thesis done for topics by companies that have operations both in Vaasa area and Southwestern Finland.

TABLE V. MASTER THESIS COMPLETED PER YEAR AND PARTICIPATING UNIVERSITY

	2017	2018	2019	2020	Total (18-20)
Aalto	46	17	17	10	44
LUT	2	8	19	14	41
Oulu	0	3	7	6	16
UTA	45	47	45	78	170
UTU	8	22	16	30	68
Vaasa	0	1	1	13	15
ÅA	16	25	16	25	66
Total	117	123	121	176	420

E. Course feedback student

FITech carried out a bi-annual course feedback survey in 2019 and 2020. In this survey we measured the Net Promoter Score (NPS) of FITech Turku studies and in H2 2020 it was 56, which it is considered excellent (Table 6). Additionally, within the open ended question of the survey, we discovered that the students will appreciate if the course would be remote and if we could improve the flexibility of the course schedules and thus increase their suitability for adult learners.

TABLE VI. NPS OF STUDENTS STUDENTS FEEDBACK BY SEMESTER

Semester	n	NPS
H1 2019		9
H2 2019	43	42
H1 2020	26	27
H2 2020	36	56

F. Collaboration agreements between universities

Project objective 3. requires sustainability of the actions. In 2020 FITech universities started to work towards long term cross-institutional agreements to provide selected minors to the students of the other university. First agreements were set up to supplement the offering of University of Turku with essential know-how needed in the area.

The preparation for these agreements has involved evaluation of the courses in current programs. This is to ensure that students taking a foreign minor will fulfill its pre-requirements for a successful completion of it. Long term cross institutional agreements have been signed from Marine Technology, Project Management and Materials Engineering. There are on-going negotiations on more agreements (Table 7).

TABLE VII. COLLABORATION AGREEMENTS

Organization	Area	Status
UTU & Aalto	Marine Technology	Signed
UTU & Aalto	Mechanical Engineering	Signed
UTU & Aalto	Material Engineering (courses)	Signed
UTU & ÅA & Turku University of Applied Sciences	Project Management (20ECT)	Signed
Vaasa & Aalto	Energy Technology	Negotiation
Aalto & UTU & ÅA	Smart and Sustainable Maritime Business	Negotiation

G. Industry collaboration

Collaboration with the industry in Southwestern Finland was one of the key actions to increase the effectiveness of FITech Turku project (objectives 2.a and 3.). Since establishment of the project various kinds of events and means have been carried out and collaboration has been developed to educational cooperation, such as visiting lectures and student project topics offered by the industry, under a greater part of the FITech Turku minors.

Different types of collaborations between the industry and academia have been promoted under the FITech Turku project. These collaborations range from: guest lectures, seminars, meetings, master's thesis discussions, master's thesis, summer training discussions, recruitment events, company visits, course materials (e.g. case examples, videos, interviews, lecture slides from and for industry), course projects. Also a completely new Industry Seminar course was designed and implemented into the academic offering to emphasize and accelerate the collaboration with companies in Turku region.

Each university reported their company collaboration activities during the reporting periods. By April 2021 a total of 186 companies were reported to have collaborated with academics under FITech Turku.

H. Continuous learning initiatives

FITech consortium has after its initiation addressed other skill caps in the field of technology and engineering. Linked with Fitech objective 2.c, but with a national perspective, there has been growing discussion - followed by MoEC attention and public funding - to further educating the current workforce. Several initiatives, called as continuing education have been set to provide university courses to persons whose current or expected professional profile requires updating their knowledge. As a working consortium of all Finnish universities providing engineering and technology degree programs, FITech has been an effective actor to organise such education efforts. The consortium has started a new project, with MoEC funding, for 3 focused themes: FITech ICT to provide both basic and advance ICT courses to the workforce meeting the challenges of digitalisation. FITech Energy Storage FITech offers courses on modern energy storage and conversion technologies to support industrial activity mitigating climate change. FITech 5G focuses in courses on 5G communication technology and industrial products and services enabled with that.

V. DISCUSSION

To discussion of this work, we will be focusing on group of outcomes.

A. Academic offerings (master programs, minors, courses and summer schools).

The outcomes show that opening access to parts of specialized degree programs and thematic modules from the participating seven universities produces a wide academic offering that would be exorbitant expensive and resource demanding to implement by a single university. No question, such co-operative effort can increase specialization options for engineering graduates. To maximize the impact of such effort, more coordination in planning and implementing academic offerings would be needed, to match the offerings with the themes most in demand, even in cases requiring new course development. Academic collaboration, in initiative such as the FITech project, would benefit from clear incentives for the faculty. This might enhance motivation and engagement for the collaborative design and fast implementation of relevant courses, aligned with industry needs, which would serve remote and adult learners. This coordination and commitment to maintain same academic offering over several academic years would have supported students in planning their studies over all years of their degree program.

The relatively low number of foreign minors completed by the students, reported in this manuscript, and student feedback suggests that while the academic offerings were generally found interesting, truly remote learning possibilities would have been needed. Thus, in courses that require contact teaching, such as laboratory exercises, the laboratory should be arranged where the majority of the students are. Several of the Fitech universities were mainly using traditional, on-campus teaching methods at the early part of the project. This had an impact on the volume of cross-university participants on the courses. For degree students, the situation improved when universities moved to online teaching due to covid-19 in 2020. For the current workforce, the courses arranged in academic calendar, bound to the 8 week period system, was found demanding while not studying as a full-time student.

B. Thesis

Impact of increased focus in the target region can be seen in the positive development of volume of master thesis completed to the region. Fitech universities Oulu, LUT and Vaasa have successfully increased their input to the region. This work has benefitted from the industry collaboration activities of the project. In total, comparing the annual volume

to the pre-project baseline and initial target [11] the impact of the project is, while growing, still below 50% of the target. The project has created new opportunities for thesis meanwhile from the student viewpoint these opportunities compete with existing alternatives at the home region of the university, and the final choice remains with the student.

C. Company collaboration

Industry collaboration has a value to the universities as well as to the companies. The thesis topics represent a concrete activity, while industry-academia connections created in the project may materialize in a variety of new co-innovation efforts.

D. Collaboration agreements between universities and continues learning

Finnish universities are expected, by their funding MoEC, to form unique profiles for their research and education. Opening the curriculum to partner universities in Fitech has encouraged discussion about these profiles on practical level and has materialized in bipartial arrangements to continue after the project. The result helps to avoid unnecessary competition between the universities. The experience from the project shows that commitment to co-operation needs to extend over several years allowing students to plan their degree contents with these options in mind.

Further, the pre-requirements of studies at the receiving university need to be taken into curricula planning at the sending university.

To benefit from the rich offering such as the minors provided by the FITech network, the receiving region should have a sufficient student population in its engineering programs.

VI. Conclusions

Sufficient funding, focused common support functions and partners sharing same goals at executive level serve the success of a project like FITech Turku. Taking such a project from a group of co-operating institutions into team of collaborative academics would however benefit from better motivating the individual academics. The value of collaboration, creating and providing courses to a distributed student population, needs to be recognized by all the actors. From university executives to the academic actors.

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