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Study on Hackathons for New Innovation Seed and Business Model Development Needs in Digitalization Driven Sustainability, Circularity and Environmentally Friendly Solutions Demanding Digitalizing Societies

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ABSTRACT

In developed countries, companies face constant growing legal enforcement and pressure from governments and local municipalities to become more environmentally friendly. Nowadays, sustainability is a business advantage and a clear competitive edge as an integral part of some front-line companies' business models too [1-3]. In this complex environment, several options are available for companies to become more sustainable in terms of their services and products, operative actions and business models. For example, this can be achieved by reducing income inequality [99] and minimizing the negative environmental impact [4]. Companies can hire expensive consultants and study step by step guidebooks for making less waste and running their operations more environmentally friendly, or they can innovate and jump new level of sustainable production. In the innovation strategy, different organizations typically do collaborate with higher education institutions, with the goal to acquire and implement new sustainable solution seeds for the business operations. Such collaborations exist in the form of hackathons, code camps and similar events which have been proven to be powerful and successful sources of innovation seeds. The study objective was to map different strategies in hackathon event collaboration to achieve better results in sustainability matters in company – university collaboration relationship. This study is based on published materials and experience-based evidence of successful creation of new business ideas by several companies in Russia, Finland and Estonia. In addition to the gained sustainability in operations, the companies have also minimized energy consumption and reduced own and their customers CO₂ emissions and carbon footprint.

Keywords: *Hackathon; student; sustainability; social event; team work; code camp; business model; innovation; circular economy; environment; environmentally friendly; industry hack; organizing; smart solution; gamification.*

1. INTRODUCTION

Over the last decades, the critical issues of energy and resource over-consumption, including the environmental impact of greenhouse gas emissions have been a focus of discussions by practitioners and academics. In the academic world, the growing interest towards waste reduction, decarbonization

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[77], circularity [78-80], making industries more aware of newest sustainability technologies [101] and sustainable business models is evidenced by the increased number of area-specific conferences and special issues of scientific journals, like the special issues in the Journal of Cleaner Production (Vol. 45, April 2013) and Organisation and Environment (Vol. 29, Iss. 1, March 2016). Both of these special issues do discuss multiple important aspects of sustainability and provide a comprehensive overview into the topic of how to achieve sustainable innovations, business sustainable business and economic performance [74] and e.g. the history of Business Models for Sustainability [73].

Business owners and entrepreneurs' point of view to different sustainability, circular economy and waste reduction focused business models should be that those are really valuable source of 2020s competitive advantage achieving tools [1, 2] and could help them move from product manufacturer role towards a larger player in their own markets as solution provider [86]. On the other hand, lot of SMEs do tend to struggle to be able to minimize their carbon footprint [75], when the larger companies focus on bigger picture issues, like optimizing the warehousing processes [81], reducing energy use, material waste and costs through operation synchronization [82, 83]. Fortunately, this challenge can be conquered through careful adjustment of business strategies, services and products, as well as by fine-tuning of supply chains [84], warehousing and logistics. Such adjustments are often based on innovations that can be introduced by companies themselves or imposed by authorities. While some companies try to reduce greenhouse gas emissions through automation and robotization [5,87], other search for new ideas and solutions in the wider world.

2. BACKGROUND & RESEARCH FOCUS

The goal of the study is to find out positive aspects between universities and companies' cooperation in the form of short term study camp events, hackathons. Hackathons are events, which are aimed to develop ideas and concepts that e.g. support sustainable development and the circular economy, MVPs (Minimum Viable Product) and business model concept creation. All cooperation projects in hackathons should address a challenge, which all partners can relate to and/or can see benefits for themselves of using their resources for the participation, plus people should feel safe and able to trust each other [68,69]. This research is based on long-term experience from multiple disable hackathons and development of inclusive technology, software and solution innovation events organized as LUT code camp and hackathon events. LUT, working in educational development and practical word connectivity with its own area software development organizations, started hackathons in the summer of 2003 (then known as code camp events). At that time, the goal was to build Symbian OS platform based new software solution innovations. Based on the gained experience, academic studies and educational development efforts, the first published work [6] was released in 2007. For several years after this, we collaborated with professionals and academics to develop new engaging methods for teaching, innovation seed creation and encaging learning to be able to share knowledge and experiences from these hackathon-type open and inclusive collaboration models between different types of actors such as universities, companies, municipalities, and nonprofit organizations [7-13]. The following sections describe the different forms of hackathon events and explain the multiple ways in which the se events could and has been organized. Also, in the following we will be touching sustainability and eco-friendly hackathons.

2.1 Industry 4.0 Movement, Digital Transformation of Society and Exponentially Developing Technology is Challenging HEIs, Municipalities and Companies

When we have been seeking for explanations for hackathon events popularity, in addition of their ability to generate new innovation seeds, it is clear that the exponentially speeding up development of technology and need to adapt processes and education of masses has it's won contribution to this, in the modern companies. When new technology solutions are constantly emerging and entering into markets, the companies face the pressure to adjust their working models and processes to compensate for the change. The changes will force the employees to adjust and learn new skills and ways to work and how to interact with technology. Some examples for this are the digitalization of processes [14], changes in the traditional/typical roles of participating actors in collaborative and networked models [16] and acceleration of decision making for managing assets and their data [17]. Rapid technological changes present multiple challenges for education units in different levels, but

specially in the level of higher education institutes (HEIs), because of their long educational programs (e.g. anything from three and half to six years). The long time it takes to educate the new generation in these programs partially hinders the capability HEIs have to develop their curricula's and to make them evolve fast enough to be able to adjust to constantly changing and more digital and mobile information access based "new" society. As a consequence, HEIs and their students have to face the challenges that are built around extremely fast evolving and changing demands for new competencies, skills and knowledge [13] and both the students and teachers should keep themselves knowledgeable what should be known of the technologies in trend at any given time, e.g. how to correctly take into account global positioning systems (GPS) limitations and satellite tracking capabilities [92-93], when building programs based on the location data collected from GPS systems. As an example, topics that have developing role in computer sciences (CS) and software engineering (SE) curricula's are digitalization, crowd sourcing, (big) data-analysis, (quantum) computational sciences and different forms of social media related topics [18]. Additionally, topics like these are the drivers for new data and knowledge-based sustainability related development efforts. They connect sustainability and artificial intelligence utilization to product design processes, which will help to enhance the circularity of the products [19].

In the similar manner, as the teachers can be somewhat challenged in front of constantly developing and changing technology stack, also many organizations do experience same sort of digitalization and speed of change related growth and change pains. New legislation-based requirements for waste and emission reduction, speeding up competition and client base based sustainability and circularity related demands do push companies to continuously find ways to evolve with new business models. Depending on companies' markets, this can mean a need to utilize digitalization and industry 4.0 in new and novel ways, and steer traditional product-based models, towards service and knowledge-based business models [20] and to be able to innovate for the need to keep the business up and running, while at the same time the company needs to focus on consistency and stable productivity. The time pressure is known to be a factor which can enhance the productivity, as shown in the study made at LUT University [21], with a large group of intensively studying students, under the time and productivity pressure to create a huge set of ideas, in small amount of time to do it.

2.2 Multiple Hackathon and Code Camp Flavors and Utilized Approaches

Under the pressure from the global markets to embrace novel and newest technologies, workforce skills, technical tools and talent development opportunities, HEIs and companies have turned towards events like code camps and hackathons as a practical catalyst. During the previously mentioned code camps and hackathons the participants are presented with a challenge to study and learn how to use new technologies, how to approach "the newest trend with neutral mind set", what to think about automation and robotization just introduced into markets, and so on. In this sort of environment, talented teacher can step out from lecturer's role and take more mentor and learning challengers role. Depending on where and for what situations the students might struggle, the teacher can adapt the learning environment on demand and as needed. In traditional lecturing environment, the teacher does not know how well students understand the content. In hackathon, teacher sees the struggles through observation of student's actions and results of those actions. Teacher can provide some real-life cases, which are good candidates to be tested with new technology driven possibilities. In other words, hackathons form an alternative environment and format/approach to collaboration, emphasizing participation of everyone part of the event [22], and an event where everyone learns something new about the technologies and processes under investigation [13].

Hackathons are time-bounded events, where teams engage in intensive collaboration to work on a project they are interested in [23]. As an innovation event, Hackathons can foster the innovativeness potential of a team or a small focus group and at the same time, these events keep the resource burden minimal for the participating companies (both monetary and man hour burden) [24]. Additionally, working with the public sector, civic hackathon named events can be organized as participatory events, with a target to make innovative service prototypes through engineers and citizens collaboration work, for the goal to achieve sustainability and social matters related issues solutions [100]. Also, hackathon like events can be a great means to get people to participate to different sort of co-creation and solution developing initiatives [102]. For novel new ideas and solution

innovations, hackathons can be seen to be a breeding ground for product / solutions idea development efforts, networking option for students and industry, approach for brainstorming capability boosting and innovation inspiring and support tool. So, in short, the hackathons as events provide opportunities for new kind of outcomes and they can be built to include new businesses and entrepreneurial activities generation [26].

Typically, hackathons last from 24 hours up to a week or two. They often take place over the course of a weekend (i.e. over 48 hours), but there are also events that take place during a whole week e.g. from Monday to Friday. More details on the duration of hackathons can be found in the paper by Porras et al. [13]. Participation in a hackathon event, from participants point of view, can be divided into three phases: pre-event, event and post-event [27]. During these phases organizers have to navigate a multitude of decisions regarding when and how to engage participants, mentors and stakeholders [88]. During the pre-event phase for example, organizers often propose small preparatory tasks such as studying background material related to the theme of the event. In some cases, event facilitators / mentors / technology experts / challenge case owners and other stakeholders deliver pre-lectures [28] or ask participants to think about which project they would like to work on prior to an event [29]. As part of the preparation organizers also sometimes ask participants to form teams prior to an event. During events, organizers utilize different approaches to form teams, help them develop a suitable idea for their project and support them to achieve their goals [28, 30-32]. It should be noted in this context that each participant can have different motivations to participate in an event and that their goals are not always aligned to each other or to goals of the organizers [33] and as such, it would be important to be able to understand to ask from yourself, are you doing the right things, if the hackathons are not producing the proper results [25].

There are limited insights in existing work related to the sustainability of hackathon outcomes. Most prior work focuses on individual experiences (including student / participant related benefits [34], different positive aspects experienced by the stakeholders together [35] and networking benefits [36])[91]. Studies on continuation activities are still rare. Existing work in this area covers project continuation [89] in the context of entrepreneurial [26], civic [37] and corporate hackathons [38]. Moreover, there is also work reporting on the reuse of software code created during an event [90]. All of these studies report that continuation after a hackathon mainly depends on the efforts of individual participants. There is limited insight into whether and how hackathon organizers or other involved parties such as mentors, event facilitators and event sponsors currently foster continuation. Given the findings of those studies, additional research on post-hackathon activities is necessary.

In the following sections, we will briefly discuss hackathon organizers that specialize in supporting the collaboration between participants and stakeholders and help to plan and run events focusing on various topics including those that might not be too familiar to companies that aim to address them (e.g. a new focus on sustainability and circularity features of products and services the company / municipality would like to develop further).

2.3 Research and Innovation Collaboration with Hackathon Organizers and HEIs

Many hackathons are organized or supported by universities. The largest hackathon league registers more than 65,000 students and more than 200 events per year (<https://mlh.io/about>). However, despite those events often being organized with the aim to foster civic engagement [37] or student entrepreneurship [26], there are limited insights into how to sustain the hackathon outcomes beyond a singular event. This lack of insight appears surprising given the resource contribution of organizers and participants to hackathons. Moreover, it seems unreasonable to expect students to develop meaningful and sustainable products and services within the short time span of an event. Thus, it is important to provide support for them that foster continuation, especially when projects are not likely to continue despite individual intentions [39]. It is also essential to understand which factors contribute to project continuation and how this continuation can be supported. In these sorts of cases, as described in this publication, the support can be based on HEIs in collaboration with companies that support hackathons such as Estonian based Garage48¹.

¹ <http://garage48.org/>

In the following, we are providing hackathons examples, from events designed to build circular economy, circularity and eco-friendly operations models contributing solutions. In other words, authors are presenting hackathons, which were facilitated by hackathon organizing enterprises or HEIs and which were events-based challenges coming from industry driven contexts. In these specific cases, the goal was to drive up service sustainability, create more ecological products or help the challenge giving companies customers to run their business operations in more sustainable manner.

3. CASE EXAMPLES

In this section, we present examples from hackathon experiences, related to events and methods used to support promotion and inspiring to sustainable development. These examples will help to illustrate how hackathons can be used as a tool to help companies and municipalities to develop their sustainability actions. Each case is described from the perspectives of different actors. Generally speaking, we show cases from the point of view of the universities, companies and event facilitating commercial organizations. The cases presented in the article provide a depth view, examples of special arrangements and will provide a clear picture of how well-thought-out setups, clearly described tasks and sufficient time to prepare solutions can provide a basis for the development of innovative projects related to sustainability and the circular economy. Thorough event preparation also offers participants and challenge that provides a foundation for companies to accelerate future idea development, on visited challenge context. For example, if the challenge giving company makes decision to take further actions, they know to who to turn to for first follow up steps. On the other hand, if e.g. the students get later on new business ideas they most like know where to go to talk as first possible customers.

3.1 Savonia University of Applied Sciences – Game Development due Hackathons

Savonia University of Applied Sciences' starting point in gamification was on 2013-2014 in Health Propeli –project with an idea to research digital games and gamification methods in health, performance and rehabilitation development context. Gamification methods across non-game industries have taken place through digital transformation due engaging users to improve personal health care taking motivation and enhancing problem solving capabilities [40]. For example, to motivate to healthier eating habits, to support independent rehabilitation or activating games for cerebrovascular disorder patients. The Health Propeli project focused on piloting new ways to produce economically sustainable digital health games and to map different business model ideas with health care professionals, researchers and companies. In the project different health gamification business models were built around rehabilitation school for kids, rehabilitation center, around Premium and Kunnonpaikka game demos and also for learning -and rehabilitation environments with workshop methods, for companies and operators in North Savo region. Back in 2013, it was actually estimated, that Finnish game industry would develop into 1,5 billion euros business ecosystem by 2020 [42]. In actuality, the growth has been even faster, and the Finnish game industry stabilized into around 2 billion euros annual industrial turnover rate. This development happened, even though there were couple years of decline in the Finnish game industries business operations [43].

When analyzed, these workshops did show lot of promising results within different new business model combinations. The next phase for the project was to build on top of these business promises. The idea was to use the workshop result as an input, and then to develop gamification solutions to visionary business opportunities. For this goal, hackathon [7,13,15] method was chosen for being effective, fast and fun way for participants to answer into the set development goal. After Health Propeli -project, Savonia continued gamification theme in the project called 'Health Game Lab', which created innovative solutions in health- and wellness industry during 2016-2019. In this time period, circa 70 games with different themes were developed by utilizing the hackathon method (Table 1.). Due the good experiences from the Health games sector the hackathon method was also applied into other themes, like sustainable water challenges [44] and recruiting. Addition to previous positive experiences from hackathons, it is easy to find out, that the current research on hackathons is also supporting positive outcomes expectation value for health, and sustainability related hackathons [41] and positive organizational culture development from university industry collaborative actions [46]. This is advancing networking and mentoring, engaging different sort of participants to environmental

activity and society development efforts [67] and involving people into community development activities [45].

Table 1. Savonia: Circa 70 games developed in Health themed hackathons during 2016-2019

<i>Date</i>	<i>Event</i>	<i>Theme</i>	<i>Description</i>	<i>Games produced</i>	<i>No of participants</i>
29.-31.1.2016	Global Game Jam	Rituals	Global game event, which purpose is to progress game development skills. 48 hours time to create the game from beginning untill the end in given theme. Savonia organized physical space to participate Global Game Jam event.	8	30
10-12.6.2016	Health Game Jam	Health application or game	48 hours time to create the game from beginning untill the end in given theme.	4	11
14-16.10.2016	Health Game Jam	Health application or game	48 hours time to create the game from beginning untill the end in given theme.	7	25
20-22.1.2017	Global Game Jam	Waves	Global game event, which purpose is to progress game development skills. 48 hours time to create the game from beginning untill the end in given theme. Savonia organized physical space to participate Global Game Jam event.	9	33
19-21.4.2017	eHealth Game Jam	eHealth	Orderer: Suomen Telelääketieteen ja eHealth Society	3	7
19-21.5.2017	Health Game Jam	Physiotherapeutic application	48 hours time to create the game from beginning untill the end in given theme.	13	60
15-17.9.2017	Water Wonderlab Game Jam	Water safety challenges	48 hours time to create the game from beginning untill the end in given theme.	5	17
27-28.9.2017	Lääketiede Game Jam	Recognizing emotions	12 hours time to create the game from beginning untill the end in given theme.	1	3
8-9.12.2017	Rekry Game Jam		24 hours time to create the game from beginning untill the end in given theme.	1	4
26-28.1.2018	Global Game Jam	Transmission	Global game event, which purpose is to progress game development skills. 48 hours time to create the game from beginning untill the end in given theme. Savonia organized physical space to participate Global Game Jam event.	8	23
15-17.3.2018	eHealth2018 Hackathon	eHealth	18,5 hours time to create the game from beginning untill the end in given theme.	5	18
27-29.4.2018	Health Game Jam	Health application or game	48 hours time to create the game from beginning untill the end in given theme.		
25-27.2019	Global Game Jam	What home means to you	Global game event, which purpose is to progress game development skills. 48 hours time to create the game from beginning untill the end in given theme. Savonia organized physical space to participate Global Game Jam event.	6	

Inspired of previous hackathon experiences, Savonia organized a 2-day 'Design Sprint' student hackathon on 2018 to support Zambian handicraft women to gain more skills for gaining better income possibilities. Hackathon was organized with combination of 17 business and design students to create jewelry designs for mixing Nordic preferences with Zambian idiom with sustainability and social unity themes. Jewelry design prototypes were made in 2 days and marketing plans and posters students finished in one-week time. Students were provided a video regards from Zambian handicraft women, short informative presentations about entrepreneurship in Africa, global design thinking and background information about conditions and available tools in manufacturing place. Students also had business and jewelry design teachers guidance along the process. Savonia had previous project Sustainable Mining Networks in Zambia to increase innovational activities, networking, welfare and human security issues through business development in mining areas, where most raw materials are

not processed into goods, but materials are exported with low value from Zambia. These handicraft women wanted to convert recycled metals and gemstones into affordable mid-price jewelries, but women entrepreneurship in poorest countries in the world is not a piece of cake. According to research, women face many challenges as entrepreneurs e.g. in similar conditions in South Africa, where they have a lack of training, financing, resources, gender discrimination and negative attitudes [47]. Student groups were willing to participate in socially responsible project and made 4 prototypes, one per each student group, with marketing plans in Nordic markets getting 2 credits per person for progressing their studies. Jewelries are made in Zambia and posted by mail into Europe. Sales are still small in Nordic countries, compared to Africa and USA, even though sustainability is growing trend globally and rising star element for the luxury brands [48]. Surprisingly challenges in the project concentrated around the topic of different organizational cultures, the ways of work and supply chain development, but unexpectedly less around national cultures even though Finland is one of the highly developed countries [49] and Zambia despite of recent strong development, still one of the poorest countries in the world [50]. In the workshops, handicraft women were worth of trust, friendly and hardworking even though they had very little of anything and most of them supported their 5 to 12 children with jewelry manufacturing. The challenges they face are very basic level issues about health, safety, tools and ergonomics, but also larger about financing to build networks, actual methods and skills in jewelry manufacturing, business and entrepreneurship skills.

At the beginning of the project Finnish students were provided with information that Zambian women have very basic tools and skills in jewelry manufacturing. According to Zambian handicraft women's organization leader, they would have needed even more handicraft skills training and financing to get all the designs into productions. On the other hand, it is a part of charity organizations culture to receive this type of support, so the outline of the project needs to be clarified at the beginning and reminded along the way. Students had 48 hours hackathon in Savonia premises in Kuopio, Finland was intense couple of days beginning early in the morning continuing late at night in jewelry workshop and only one week to finish marketing plans and posters, but they were happy to help less fortunate people. Zambian handicraft women put some of the simplest designs into their production and obviously training need appeared in the project for RDI staff in Savonia University of Applied Sciences.

Table 2. 3R Game Jam partners. 2018 event for gamified sustainability solution boosting event.

Implementing party	Sustainable development values	Example of projects
City of Kuopio	Resource wisdom is one of the most important strategies of the city. The goal is to have zero waste and pollution, sustainable consumption and well-being by 2050.	Transformation towards sustainable energy, smart solutions, traffic and road solutions (e.g. electric bikes first in Nordic county cities), recycling, business smart city solutions, citizens health and wellbeing, etc.
Jätekukko Oy (municipal waste management)	A municipally owned service company providing daily waste management services for property owners. Services include waste transportation, waste management consultation, sorting stations, the Kuopio Waste Center and ecopoints complementing the Rinki ecopoint network. The area of Jätekukko covers 15 municipalities and has 215,000 inhabitants.	Organizing easy and intelligent waste management, intelligent mobile solutions for waste collection and recycling; waste management and sorting advisory service for schools, associations, communities, housing associations, road cooperatives and other groups and companies, etc. environmental education for schools.
Kuopas Oy (student housing organization)	Kuopas offers student housing in the city of Kuopio. Goal is to support comfortable studies progress. Housing is secured for the entire study period for about 3,000 residents.	Heating and electricity produced 100 % with biofuel, renewable energy e.g. solar panels, electric car for students, smart solutions for heating and temperature variations, etc.

Implementing party	Sustainable development values	Example of projects
KierRe EAKR - project	The project will develop solutions that support urban resource wisdom and low carbon in cities, municipalities and communities.	A creation of a roadmap to archive goals to become a resource-wise city. Manure ecosystem for farms, sales promotion and survey of gas cars in North Savo, minimization of water leaks, urban farming, user-friendly waste collection station near the horse arena, etc.
SmaRa EAKR - project	Development and research about smart solutions in North Savo, Savilahti Kuopio area.	Service design for waste management, smart energy networks & future user profiles for sustainable solution.
Savonia University of Applied Sciences	Strategy's main goal is to be the most influential university of applied sciences in Finland by 2020. Values: reliability, courage, influential, communality.	Sustainable solutions in Africa, water monitoring development, bioeconomy education model, smart health and gamified solutions, sustainable food production sustainable and creative business development etc.

Also 2018 City of Kuopio, student apartments, regional waste management and recycling company and Savonia University of Applied Sciences created an event 3R Game Jam to create motivational games for recycling activity boosting purposes (partners are presented with more details, in the table 2). The game with name Fox the Recycler was the one that won 3R Game Jam. City of Kuopio and waste company Jätekuukko found the game solution functioning and motivating, it got selected to be supported to go ahead into the next development and case study phase. This case study would be a pilot study, done with the student apartments organization of the Kuopio area. The main reason why the whole concept of building gamified solutions to boost interest and motivation to recycle more in individual level was pursued, was the problem in the current time amounts recycling, happening with e.g. wood waste, which mostly ended to be used as energy waste, and not to be used as raw material for re-use purposes. Additionally, it was found out in background studies, that in Kuopio area the mixed household waste does not generate well enough recyclable material stream and gamified solutions with small educational parts was hoped for to be a solution to educate younger generation study participants to start to improve source separation and recycling actions. Following Table 3, depicts the yearly Finnish recycling tonnages and how they are utilized in circularity sense.

Participants (250 students from student housing units) installed the game in the experiment on Sep 17th - Nov 30th 2018. Monthly user's highest unique user rate was 235 users and the typical daily unique users' rate did fluctuate between 30 to 50 persons. Recycling results were phenomenal, and participants found the game to be very motivating. For example, the rate for biowaste recycling was 76 % before the start of the experiment. After the pilot experiment study, the game had increased the rate of biowaste recycling up to 97 % level. Additionally, plastic recycling rates did rise from 25 % level up to 84 % level. [51] Experiment showed due hackathon produced gamification solution is it possible to motivate and boost recycling rates, but the gamification project should be repeat around 4 years cycle according to students' average study time in their degrees.

Gamification as a phenomenon is here to stay also as a part of our work life as improving efficiency, increasing bringing up new ideas or improving learning and formal organizations can learn about gamified solution to bring more enthusiasm into business life [52]. Games have amazing ability to catch peoples' attention, advance networking, develop creativity and enhance motivation [53]. Would gamification be serious option for organizations facing these challenges? Gamification can support shift of renewing organizational culture and according to research simulation games increase change processes in education organizations [54]. Gamification still divides opinions, because not all managers and employees are convinced about gamified solutions in business context [55] and one reason can be the reputation of games as connected in younger generation activities and not in serious work life. Gamification also requires certain skills of using digital platforms and mobile applications and solutions may not suitable for target group with weaker digital skills. Digitalization has already brought enormous changes from everyday social life to market changes and various new

business models, which change business environments dramatically with disruptive technologies [56-58]. Based on previous research and experimentations from hackathons, gamification may be something we have needed for effective implementation in supporting organizational culture change, changing behavior of residents or enhance study motivation of students and it is worth for further investigation and research.

Table 3. Finnis yearly waste generation in tons, including the separation to energy, incineration, material usage and landfill streams

Waste	Utilization Energy	Disposal Incineration	Material Utilization	Landfill and other disposals	Total
Chemical wastes	16	32	98	149	295
Metal waste	0	0	173	1	174
Glass waste	0	0	72	0	72
Waste paper and paperboard	69	0	552	0	621
Plastic and rubber wastes	71	0	35	2	108
Wood waste	2948	7	45	1	3001
Animal and vegetable waste	101	5	423	6	535
Household and other misc. waste	2019	1	122	84	2226
Sludges	334	2	125	137	597
Mineral waste	336	0	5361	103 258	108 995
Other wastes	300	13	843	175	1332
Total	6195	62	7848	103 812	117 917
Of which hazardous waste:	134	46	97	1166	1443

3.2 Stora Enso HackThePack Sustainability Hackathon

As a background information on the scale Stora Enso and similar sized companies work in daily basis and to explain the magnitude of their operations, we start by shortly presenting the problem of tracking one of unique logs from forest, up until the wood processing process. This is one of the challenges given for young students on 2017 by Stora Enso. On that time the goal was to give students a chance to show their innovativeness and problem-solving skills, in a challenge setting that was connected into more traditional university course, in Finland. After this operations scale related example, a detailed description will be given for cardboard packing and sustainability related hackathon challenge, which works as case example in this research study. So, in the wood tracking context, the challenges are in the timber tracking and origin verification directions, where things are currently based on a wood batch IDs (wood batch is an operational unit, it is a bundle of wood which is located at the front of the roadside timber stack). Ideally, forest industry would like to track down every single log and every single movement it makes, i.e. to track GPS coordinates of every tree from forest, up until the point it already is part of some final products. But within the current process constraints, this is not possible. For example, wood origin ID gets lost as soon as a wood batch arrives at a mill terminal. A factory knows exactly, where one truck load of wood is unloaded, but there is no information on where and when it goes after that. As the wood usage is dictated by the individual factories, the Stora Enso corporations Wood Supply enterprise resource planning (ERP) system, does not have decision power on specific wood usage inside the factories. The end result is that the corporation might lose the trace of unique logs and then they start to track logs at the truck load level. And to understand why e.g. RFID (Radio-frequency identification) tracking all the logs might not be the wisest solution, the fact is that in just for the year 2016, total round wood volume harvested by the unit of Wood Supply Finland was 9,074,684 m³ (solid over the bark) consisting of a total of 49,465,308 logs cut. Even if the costs of whole RFID tag processing would be only one euro per log, that would cost annually almost 50 million euros. So, in short, as one can see from these figures, any development activities Stora Enso plans on their main operations, ends up working out big in scale and in euros.

Considering the above example from Stora Enso log tracking challenge shows, the scale of operations is truly huge. In fact, compared to most other companies in Finland, they operate in top 1%, when we consider the company size. In Finland, SMEs cover almost the whole commercial

company sector, only 0,2% (651 companies) are part of the large corporation's size group [59]. On another words, this sort of huge operational scale is rare for most of the people, in the country. So, scale of the operations in mind, let us take a look into the case example from spring 2017, Stora Enso HackThePack sustainability hackathon event. This one was organized by professional hackathon events building company named Industry hack, an innovative event building company of 10 creative people, who develop, facilitate and organize hackathon for companies and municipalities. Industry Hack people worked in close collaboration with Stora Enso through the whole process, starting from transforming the development need / the original hacking idea into a feasible hack challenge. They continued to collaborate all the way up until the end, when the winner of the event was finally nominated. The process started in 2016, from an idea seed generated by Stora Enso innovation days / internal development actions used to speed up RDI activities. In these internal action rounds, an idea was generated to pursue sustainability development goals by building a Hackathon focused specifically on sustainability issues. The company wanted to take this internal development idea outside the company walls and try to find fresh solutions, concept, approaches, tools as well as operational models to address the packing industries sustainability needs (e.g. to decrease the environmental impact, different cardboard packets create and to improve the image of cardboard packets in the eyes of the consumers), in close collaboration with Stora Enso. In August – September 2016, Stora Enso started to look for partners to organize the hackathon. It took a while to select a few most promising options, and finally in September-October 2016 Stora Enso was making a good progress negotiating with the event organizing company and at the same time learning new operational models for large corporation – SME collaboration operations, as this sort of approach (i.e. for giving the “show” for outsiders to run and to boost their own solution innovation cases) was new experience for the large corporation, at the time. One remarkable learning point was happening within the legal unit of big corporation as the Industry hack, an innovative but relatively young company at that time, wasn't actually ready to go forward with standard templates. Despite the young age of the company, the people inside Industry hack had a wide experience and a good eye on legal texts and for the “small print” in case the results would not be as expected (which is good point for any company organizing these events, as in the end it all comes down to the companies and people who participate to make the events successful in challenge giving company's eyes). All in all, this experience did lead Stora Enso to start to build more open approaches towards SMEs and nowadays Stora Enso can proudly state, that it currently works openly and efficiently with a large number of SMEs and startups. So, in fact, this event exercise to organize their first hackathon did “hack” the large company's operations into more flexible directions too. In the following figure 1, the usual outline of this sort of events is divided to 4 main parts, starting from definitions and finally ending to pilots started after the actual Hackathon event.

The large-scale event preparation started in November 2016. The challenge was officially made in writing, the time frame and location of the event was discussed, reservation for spaces and personnel time tables were booked. Social media advertising started in the end of 2016 / beginning of 2017 (one example shown in Fig. 2). The call for applications inviting companies to take part in the hackathon and to compete for an opportunity to build a future collaboration with Stora Enso and collect the monetary prize was open from the period of the mid of January and the beginning of February 2017.

While Stora Enso started an open public marketing campaign, Industry hack used its own tools, networks and startup seeking skills to find potential and promising participants for the challenge. Among the applicants were more than 30 companies, from recent startups to large scale coalitions and big corporations. After rigorous qualification rounds, eight most promising companies were selected in February 2017. Then Stora Enso recruited eight internal mentors, one for each participating team. The mentors and teams met two weeks before the actual event weekend, which was set to be on March 3-5, 2017 (Friday – Sunday). The meeting with the teams and mentors, and team preparations were in a form of a teleconference, reducing participants need to travel. In the morning of March 3, Stora Enso arranged a bus transfer for some of the participants from the capital of Finland (Helsinki) to Imatra (around 260km bus drive) to make it easy for the participants to arrive at the event with fresh minds and full of energy. At Imatra, the finer details of the challenge were presented for all participants (part of the challenge description is shown in the following Fig. 3).



Fig. 1. Generic view into the 4-step model for Hackathon flow, used by Industry Hack and Stora Enso to derive their event specific program

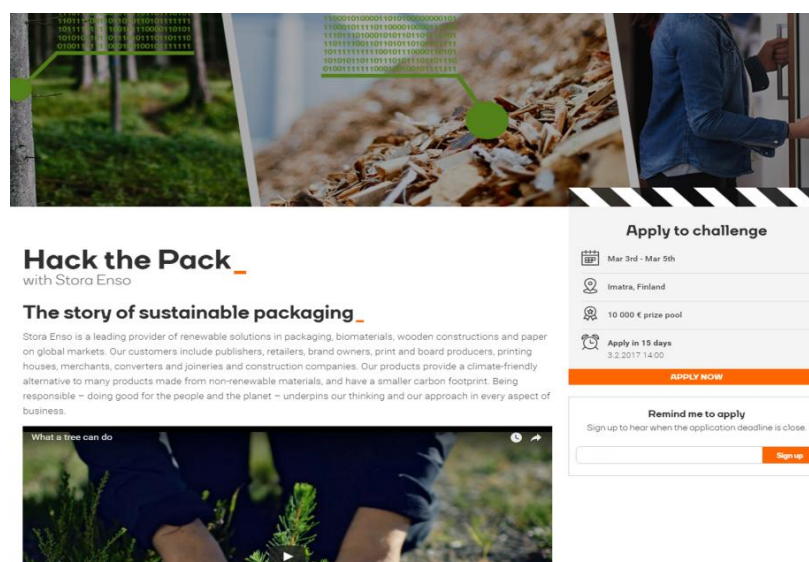


Fig. 2. Example from events social media marketing materials

The company was presented in a broader context with one of the long-term final product customer of Stora Enso, who took part in the event. The customer opened up a wider view on the value chain starting from trees in the forest, continuing through paper pulp, paperboard and other packing materials, and ending with products for commercial packaging. First event day included a visit to Stora Enso Imatra Kaukopää mills, with a practical introduction to production and presentations about the industrial-size machines transforming raw wood to pulp and then to paperboard materials with the next machines in the production process. Participants ended the friday with a dinner party with Stora Enso representatives and their customer. The party was built as a shared relaxed evening session, to give the Hack event teams access to full value chain view and knowledgeable people who work with different steps in the chain. The dinner took place at Scandic Imatran Valtionhotelli Hotel. The participation of the customer was one of the key components in this hackathon, as the hackathon promoted the use of huge data amounts, both the Stora Enso, but also their customers collect from

their operations. In short, big sustainability boosting possibilities might be hiding on that data, but the challenge is how to connect the raw data correctly into the value chains and build enough data transparency, to boost the sustainability goals. When teams work ethics is considered, many of the teams worked through the Friday night. On Saturday morning, teams were collected from the hotel and transferred to the place named Officer Club, near Stora Enso Imatra mills where teams. On Saturday, the customers presentative gave motivational presentation and opened up some additional specifics. All teams had their personal mentor, but mentors also visited other teams to boost the competitors. The rest of the day was dedicated to intensive work with the Hackathon challenge, In the late evening, all participants went back to hotel for a buffet dinner, which was also available through the night, in case some teams choose to continue working to get ahead of the competitors.

The Challenge

Stora Enso wants to make the whole value chain of the packaging product, from harvesting wood in a forest to a final product in the consumer's hand, more transparent. This way we can tell Stora Enso's customers and consumers the story of the product, emphasizing its' sustainability. Collecting and visualizing all data from the value chain also enables the creation of new business and service ideas.

- **Data collection and visualization challenge**
 How could Stora Enso better collect and visualize production and sustainability related data from the whole value chain of the product and somehow show it with the product to illustrate (and potentially improve) the product's sustainability?
- **Storytelling and service design challenge**
 Using the collected data, how could Stora Enso tell its customer and consumer the story of the product (and it's sustainability), in an engaging and compelling way, perhaps even customizing the story to different target groups or individuals?
- **Open challenge**
 What new business ideas for Stora Enso can you come up with using the data?

Fig. 3. Content from the challenge description

On Sunday, all teams went to Officers Club for the final presentations. The teams had three to five minutes to present their idea followed by a brief discussion in Stora Enso Research Center, near the Officer Club. After two days experience knowledge and final presentation experience, the judges went to make the final decisions, at the same time the teams had ca 45 minutes to relax and wait for the results. The judges were free to choose the solution that fit best to Stora Enso case requirements, however Industry hack provided them with clear evaluation criteria and a framework:

- How well does the idea match the challenge given?
- The potential of the idea to improve the sustainability in the value chains of Stora Enso
- Novelty and creativity of the idea
- Quality of the demonstration and presentation of the idea
- Overall experience related to the idea
- Reproducibility of the idea.

The winning demo

1: The logs have arrived by train to the mill. Information shown about making pulp and board

2: A truck is driving a way from the mill with the rolls safely loaded....

3: The truck arrives at Tetrapak and information from Tetrapak is shown. And then the story goes on for each step....

Link to the winning pitch: <https://www.youtube.com/watch?v=7p9n7kxwz0s>

The two runner-ups

Team WareSign – a startup company

EACH LOG HAS A UNIQUE FINGERPRINT.

WE USE IMAGING TO IDENTIFY EACH LOG AND BLOCKCHAIN TO TRACK THEM THROUGH THE SUPPLY CHAIN.

- No need to tag each log with an RFID tag.

Team Proximity combining IBM and Ixonos

Tree as a service

// LET PETER PLANT A TREE AND CREATE A NEW STORY OF WHAT TREE CAN DO

Fig. 4. The winner and the two runner ups

Finally, the judges revealed the winning team and two high-quality runner-ups (visualized in Fig. 4.). Idea was that most potential solutions would be given Stora Enso mentor and project boosting company contact to get the ideas in next level. In reality, the implementation of the idea was in fact not as easy as expected. The implementation challenge did end up being a good learning point for both Stora Enso and Industry hack. Companies did learn, that if they would have given direct access for the results presentations for wider audience, the presentation of the end results would have inspired more people who have access to key resources to implement the follow up pilots, which would have made the next steps easier. Especially when the winning team's idea connected augmented reality ideology to aerial context, which were not that traditionally well-known things inside Stora Enso. In terms of the results achieved, it was said by Stora Enso representative, that the amount of resources invested in the hackathon generated more innovative insights and ideas that could have been produced by the company's own teams. One positive impact of the hackathon was the way it transformed the image of Stora Enso and give the corporate participants form large company, new things to think about too.

Hackathons are currently used by Stora Enso as an innovative supporting tool alongside with the Stora Enso accelerator program, which is built for the leadership training purposes and provides the new leaders in training an opportunity to connect directly with innovative startups. When it comes to the ownership of results, at the start of the process an NDA (non-disclosure agreement) was signed between the innovators and Stora Enso. It was agreed that the ideas and solutions were owned by their inventors, however, the data remained the property of Stora Enso.

3.3 Helping the Customer to be more Sustainable Successful – The Enerkey Case

This is a University industry hackathon collaboration, which aimed to innovate new energy saving solutions for B2B market clients. The aim was to improve e.g. reporting and find ways to utilize more self-service consumption analysis tools. The hackathon event was collaborative event with ICT4S conference. The ICT for sustainability conference was organized in summer 2019, the last one before covid-19 social distancing limitations [94-95], which has made this type of hackathons with get-together time quite challenging for quite a time and has raised the need to organize virtual hackathons [96-98]. The collaboration with conference made the conference presentations and materials also available for the students too. The hackathon participants were able to enjoy from the newest ICT and sustainability knowledge and discuss with the area specialists who were the best of the nest in their own research areas of digitalization and sustainability front. In addition to the special conference collaboration, the whole hackathon was organized utilizing an exceptional way. The design of the event was built around 3 different cities virtual and hybrid participation model. The main Hub was in Finland, Lappeenranta. Two other cities were northern Finland city Kuopio and more central city Lahti. There 3 hubs were connected to each other through online communication tools (tools like Zoom and Adobe Connect Pro).

In addition to the hybrid mode way how this event was organized, the participation had inbuilt special structure too. The students had the possibility to do a full 14 days (1-14 June 2019) day intensive camp. Or shorter 7-day version (8-14 June 2019). In case of 14 days participation, students had to generate two different solutions and in case of 7 days camp, they were only required to produce one. In case of the long intensive two weeks version, the special details of the hackathon were revealed for the students on Friday 1st of June 2019. Then, on Monday 3rd of June, time slots were reserved for case-based details. The following Tuesday was reserved for students to show their mock-ups, first designs and to get feedback from the company. Then the Thursday was the day, when company specialists were available for technical details discussions (e.g. to clarify any specialties the students might have found on their data). Then the 8th of June was the 14 days long sessions first presentation day. It was also the time, when 7-day camp participants were joining to this hackathon event.

So, on 8th of June, everyone participating to the event were working to produce best possible ideas for the competition and to win the promised prices for the winning team. The second half did mostly follow the base structure of the first week. Including mockup/demo presentations, support days, technical specialist's session and finally in 13th of June the participants made their presentation

rounds with the challenge owners of the company. The winning team had the special chance to present their solution in front of the ICT4S conference audience.

To be able to do all this, in April and May, the facilitators used time to promote the event in different social media channels, through e-mail lists and notification boards to get as many participants to join as possible. To give the participants some preparation / area of application pre-study possibility, we did announce the general context area of this hackathon, before the event truly started. In this special case, we promoted the thematic of energy usage reduction and corporation's sustainability goals. Around a week before the event, the participants received a pre-event message, a message which explained the event practical arrangements (what to expect) and overall explanation of the data the participants would get into their hands. Later on, the participants got access to the actual large data. This data had multiple different parameters, which would explain the reasons for the backgrounds to the basic consumption patterns. The data included fields like the time of date, the opening hours of the specific commercial building, the area and volume of the building, area code in Finland, current temperature outside the building and few other supportive data and meta data information to explain the cross-connections between the given data points and shown energy consumption in electricity, HVAC (heating, ventilation, and air conditioning), water consumption and so on.

For maximum participation, the event was available to all students, in the partnering schools. We recommended to consider of having one mathematics and/or IT specialist student to the team, to handle the data analysis and database material handling. It was not mandatory but seemed to be good suggestion at the time. As the event was run on hybrid mode, distance participating was promoted for students, who did not have possibility to participate to any of the previous, on-site hackathons. In the distance mode, students received clear set of instructions how to use the remote communication channel (Adobe Connect Pro tool in this particular case).

For inclusive participating, for many different age and life situation groups, we had all of our information sessions in the evening time. For example, people in summer jobs, this was one of the facilitators pre-designed feature in this intensive study camp. For local participation, all events were arranged in pre-agreed hackathon hubs. This was the case for all presentations given by the participants, all the milestone sessions and final presentations given for the challenge owners and also for on-site information lectures too.

By the reviewed feedback, received from the participants, the hybrid model did allow the company specialist to smoothly participate, on a convenient time for them and the participants too. Also, the feeling was that the event was arranged so that it did not interrupting anyone's everyday personal life or business routines and operations. Even when we are talking about the pre covid-19 time, when the assumption was, that people really prefer to have nice accommodations and physical setups for hackathons, students actually informed to be really pleased for the distance participation possibility. In our special event, all presentations had the chance to be given from remote participation mode, all information and company specialist sessions, the goal explanations and support sessions too. This was especially important for the participants with impossible life situations for any sort of onsite participation.

The challenge itself was build around machine learning solutions (ML), AI (Artificial Intelligence) utilization to find energy usage expectations and new algorithms to help make energy suggestions for the B2B customers. The general guidance for participants was to "play with the data", visualize the ideas the participants had and try to map patterns on the data, find outliers and consider of data in fleet level [85]. For this, the participants received information packet on how the corporations consume energy in general in their facilities. This was done to help the participants to find special energy saving potentials, to be able to spot energy consumption anomalies or any irregular building energy consumption patterns. Overall, the challenge owner was looking for the participants to show their vision about "Virtual Energy Manager" and the future of the company. They were looking special kind of novel insight where the non-obvious energy consumers were and to find new ways to educate the industry to be more sustainable and less energy dependent.

In the participation form side, the team side for the event was quite flexible. We were open for anything between 2 to 6 person per team, but based on our experience, we would suggest considering focusing on 3 to 4 persons per team to help everyone to really contribute to the end results and have similar intensive participation experience. Also, for higher productivity levels, it was evident that the detailed description of the data and bit by bit meaning of it is important for participants success on time limited challenges. On one hand, it minimizes the time to get familiar with the data the participants work on with, and on the other hand this maximizes the time for the participants has time to get deep into the idea and solution testing for the given challenge. Additionally, any typical expected outliers one could find with the data and error sources the seen data could include could be useful too. This will save the time for the team on getting familiar with the data, which will give them more resources to answer to the given challenge.

In the side of results, the team who won the event, did produce a solution for database based highly technical approach with a partly automated and partly manual tool, which would help the company to focus on potential locations of energy saving potentials with their consumers, in specific energy consuming locations. This tool was a frontline support utility to pinpoint the outlier points to save energy. In bigger picture the idea was to help to find special outliers that could be generalized to customers asset fleet to start energy saving sustainability program deployment activities.

All in all, the event was a special exception in post vocid-19 time, with all the remote participation options. It did include multiple twists outside of the traditions of hackathons for the time and the event was able to produce highly more applicable solutions than what was the general history-based expectation of the event facilitators.

3.4 All-Russia University Megahackathon

Considering hackathons word wide, and given historical differences between East and West, it is quite interesting to take a look at the way hackathons are run in Russia and to compare them with similar events in Finland and Estonia. After all, in geographic terms, the Finnish cities of Helsinki, Kuopio, and Lappeenranta, the Estonian city of Tallinn, and the Russian city of St. Petersburg are all only some hundreds of kilometers apart. For this purpose, we used the St. Petersburg largest Hackathon event, MegaHackathon (<http://hackuniversity.ru>) annual competition of Russian university graduates and undergraduates organized in St. Petersburg as an example. In this event, each team represents their own university, and universities, in turn, support their representatives by providing scholarships and covering their travel expenses, if teams are not formed by St Petersburg resident universities. The candidates have to fill in an on-line questionnaire with some basic questions, upload a CV and explain their motivation in 3-5 sentences. The programming skills are not obligatory and can be very basic, as long as participants can demonstrate their expertise in a certain field. The age of participants is limited to 18-45 years. Students or graduates can form teams of four and apply as a team, but they can also apply individually and join a team at the event. As part of the event program, a number of workshops are organized where invited experts give lectures; in addition, expert support is available for the duration of the event. The topics (or cases) are generated by companies who are interested in participation in the event and provide sponsorship. In return they get solved cases or/and can meet some talented students as potential future employees.

In April 2019, MegaHachathon was organized in St Petersburg, Russia for the second time. Within 48 hours, teams of four solved cases presented by real customers, among those MTS, BIOCAD, RighTech, Unilever and HERE Technologies (Table 4). They offered tasks in the areas of primary importance to the new age business, including Big Data, Virtual Reality and Augmented Reality (VR/AR), blockchain, Internet of things (IoT) and Robotics, Linux and open source software, Audio, social services, logistics, information protection, as well as personal data security. The main prizes were internships with the participating companies and various gadgets. The organizers of the hackathon were the Polytechnic Design Office UMGEn, the Russian Association of Students for the Development of Science and Education (RASNO), and HERE Technologies.

Table 4. Sponsors of MegaHackathon

Company acronym	Description	Website
MTS	With over 100 million subscribers in Russia, Ukraine, Armenia and Belarus. MTS is the largest mobile network operator in Russia with the largest market share (31% in 2017).	www.mts.ru
BIOCAD	A leading biotechnology company in Russia compliant with international standards, founded in 2021. BIOCAD combines world-class research & development center with ultra-modern pharmaceutical and biotechnological manufacturing facilities, utilizing their preclinical and clinical research infrastructures.	https://biocad.ru/
RighTech	The company provides a hybrid cloud SaaS-solution for projects in the field of Internet of Things, at all levels of complexity. RighTech was founded in 2016.	https://rightech.io/en/main-page/
Unilever	The 7 th most valuable company in Europe. Headquarters in London (UK) and Rotterdam (The Netherlands). Produces cleaning agents, food & beverages, plus some beauty & personal care products.	www.unilever.com
HERE Technologies	HERE Technologies were founded in 1985. The products HERE technologies company does produce re related to mapping, location data and also to services which focus on location data in context of companies and individuals.	www.here.com
HH.ru	Russian database: Vacancies and CVs for job seekers and employers.	https://hh.ru
REG.ru	A Russian hosting and domain provider.	https://www.reg.ru
Unified Entrepreneurs hip Center	A St. Petersburg (Russia) - based multifunctional organization to support entrepreneurs and business start-ups.	https://www.crpp.ru/

The event started on a Friday night when the teams were formed, and cases distributed and finished on a Sunday night by the award ceremony. The students could stay overnight in a hostel, but the majority preferred to sleep for two or three hours at the premises using their own sleeping bags. The students were not “chained” to their laptops but could attend presentations whenever they wanted and also get a hot meal. For two days, the teams worked on their projects, then presented their solutions to the jury who evaluated them and selected top solutions for the final presentation. Out of 100 participating teams, only 20 were selected. Among the members of the jury were independent experts, representatives of universities and large companies. When making their decisions, the jury took into account the novelty and feasibility of the proposed solutions, as well as the level of competence of the team. For the jury members, it was especially important to understand whether students were enthusiastic about their project. The most important criteria for the jury were the usefulness (i.e. applicability) of the result, and the completeness of the task (i.e. a ready-to-use code).

Among the winners, there was a team from the St. Petersburg based ITMO university (University of Information Technologies, Mechanics and Optics (ITMO)), who worked on a solution for the case “Smart conveyor for sorting waste using neural networks” (<http://news.ifmo.ru/ru/news/8436/>). According to Alexei Ustinov, second-year student of the Faculty of Information and Communication Technology and the team leader, the team participated in MegaHackaton for the second time, but in 2019 the event was even more ambitious than in the previous year. Their task was to teach a robot how to interact with the camera so that it could determine the coordinates of a particular object on the conveyor. The company Yota Lab, which offered the case, was not so much interested in a technological solution, but rather in identification of talented students. So, as a reward, all four members of the winning team received an invitation to join the open Yota Lab as interns.

Building on the success of the previous years, HackUniversity has already announced the topics for 2020 MegaHackaton. Some of them will be the same as in 2019, including Big Data, VR/AR, IoT and Robotics, Audio, and Logistics. However, there will be new topics, too, among them:

- Drones: creating solutions for various societal needs (agriculture, cartography, etc.);
- Neurointerface: development of software applications using the latest neuroprogramming technologies for educational tracks, and to be used in biology and robotic;
- 3D prototyping: creating industrial facilities based on 3D printing technology;
- Start-up: participation with your own idea.

One of the problems identified by the participants of the previous events was lack of clarity in formulation of some of the cases presented by companies; hopefully, this issue will be successfully addressed by HackUniversity in 2020.

3.5 Hackathons Organizing Companies – Case Garage48 & Africa

The Estonian based for-profit organization Garage48 (<https://garage48.org/>) has organized more than 100 hackathons across 25 countries on three continents since their inception in 2010. During this time span more than 155 ideas were pitched, 1500+ prototypes built, 12 teams have successfully acquired venture capital, and many have developed their prototypes into working businesses. Garage48 is currently run by 5 people that organize more than 25 hackathons per year which are attended by an average of about 100 participants over the last few years. They specialize in organizing hackathons that are aimed at fostering entrepreneurship. Starting out as an Estonian focused organization they have subsequently expanded into the other Baltic states and beyond while staying firmly rooted in the ever-growing Estonian start-up scene which boasts more than 500 start-ups. Four of those start-ups have reached unicorn status (a privately held startup company valued at over \$1 billion) until this point. Garage48 organize events in various domains including but not limited to education, cybersecurity, defense, robotics and others. This diversification is mainly driven by the close connection between Garage48 and the Estonian entrepreneurial scene. In recent years they also included hackathons that focus on civic and environmental innovation into their portfolio, for diversification. One example of such events was the Re-Invent hackathon (<https://garage48.org/events/garage48-re-invent>) which took place in Kigali, Rwanda (10-12 May 2019). This particular event was 48 hours long Hackathon with prototypes as end goal. It was conducted in cooperation with E-Estonia and NetGroup. The event focused on the creation of prototypes for sustainable development and the solution of civic problems. Registration for the event was available on their official website. The website also included the full agenda, recommendations for participants about what they should bring to the hackathon, the format of the initial pitching, the procedure of team formation, food and drinks, sleeping facilities, FAQ, and final demo presentation. Detailed information was available for potential participants to set participant's expectations and ensure that their essential needs would be covered. The hackathon was also marketed as an event on Facebook. The target audience for Garage48 events typically are students or (young) professionals that are interested in the topic of the event and / or in creating their own business. For some events Garage48 also teams up with universities which can incentivize students by offering study credits (ECTS) for participation.

Garage48 events typically have a high retention rate with some individuals attending more than 10 different events. This can partly be attributed to their strong focus on Tallinn and Tartu (Estonia's largest and second largest cities) where most of their events take place. They are not only close geographically (the trip takes about 2 to 2.5 hours by bus or train) but also economically with many companies having offices in both cities and the universities running joint programs e.g. in the area of cybersecurity.

Garage48 hackathons typically start in the afternoon with opening remarks by the organizers before the mentors are introduced. Afterwards participants can pitch project ideas they would like to work on during the hackathon. Each pitch included a short description of the overall project idea, initial goals for the duration of the hackathon and suggestions for which skills would potentially be needed to

complete the pitched project. Participants are asked to explicitly look for designers, marketers, developers and entrepreneurs since the aim of the hackathon typically is to develop innovative prototypes that can later be turned into sustainable start-ups. Participants can pitch ideas they had developed prior to the hackathon or ideas they had just thought of e.g. while listening to the pitches of others. Teams are then formed around pitched ideas based on the personal interest of the other participants that had not pitched. Participants which have pitched ideas but do not receive sufficient interest for a team to be formed join other teams. After the teams are formed, they begin to work which typically is at or around late evening time 22:00. In the following day, students in this course did continue their hacking efforts with the support provided by their mentors. There typically is a group of mentors on site that covers different fields of expertise including design mentors, business mentors, technical mentors and domain mentors. The job of the mentors is to ensure that each team member has a task s/he works on, that present skills are taken advantage of and that the teams stay on track for the final presentation which included the presentation of a prototype and an initial business plan. Presentations are conducted in the form of a business pitch and typically last less than 10 minutes. In order to prepare for their final pitch each team sends at least one person (typically the idea owner) to multiple separate pitch training sessions where they are coached by professional trainers. During these sessions, participants receive feedback about their pitches and learn how to talk about their idea and product. These sessions are typically very hands on with a short introduction that is followed by hands-on coaching. To share the current state of their projects all teams also have to present their respective progress during three separate checkpoints at in the morning of the second and third hacking day and in the evening on the second hacking day. Events conclude after 48 hours with the final presentations, judging and the handing out of prizes all of which are broadcasted live online. During the 48 hours of the hackathon the mentors typically meet multiple times to discuss the progress and potential issues of each team and decide which mentor(s) would be the most helpful for teams to overcome identified problems. That mentor or mentor team would then approach the team with the challenges and supported them to overcome potential issues.

Projects the participants worked on during the Re-Invent hackathon included a project involving small sensors to track pollution levels, a blockchain verification platform, a counselling app and an embeddable survey. Notably, one of the teams aimed to create e.g. phone cases from banana trunks. The hackathon was organized as an international event attracting participants from five countries, such as Ukraine and Japan.

As part of their follow-up strategy the organizers include individuals that run incubators and accelerator programs into the organization to support project continuation after an event has ended [60]. Moreover, they offer prizes to the winning teams which in the case we studied included tickets to the local startup summit and a pitching opportunity for Africa Demo.

4. LESSONS LEARNED FROM SUSTAINABILITY SUPPORTING HACKATHONS

By comparing of different events, we are able to build base framework for typical success factors, in sustainability boosting hackathon event context. All company representatives present at the events mentioned that as a whole the events were thought-provoking, while some ideas were worth further discussion. Additionally, the companies looking for opportunities to minimize their energy consumption expressed their surprise at the thoroughness of the analysis performed by the students.

The clear indication these event results offer, is the fact that the both in-process and product development experiences in hackathons have been mostly positive. Sometimes this might not be the case, but with the extensive positive experiences background and stream of academic publications offering same line of proof about the productivity and power of hackathons in supporting the goals of getting more sustainable at corporations, municipalities, universities and NGOs. Hackathons are able to boost forming of more sustainable and circular societies, but it does not happen by itself. To be successful, we need to be able to define properly, 1) how to keep enhancing the hackathon ideation efficiency and brainstorming productivity, 2) who should be running these events and how to keep up delivering this sort of results, 3) what are the needed new and novel practices to support the sustainability of new ideas and solutions created in hackathons, so they stay alive and find their way to open markets and 4) ways to generally support participation with properly thinking the premises

that will work with the set goals and facilitation models. To put it shortly, especially in the context of sustainability hackathons, there are multiple options to proceed with the good ideas and promising MVP solutions, to get these to next level, after given hackathon events. Current hackathon practices in academic setting do tend to leave (too) good ideas to never-ending development pipelines. One could say, as defense of the teacher, this is because “something more urgent” did pop up, but in reality, the MVPs and ideas are mostly the result of hard work done by the students. We have made the hypothesis, that the teacher / facilitator might notice the potential of the idea, but does not say it aloud, as he/she does not think it is ground breaking idea, but on the other hand, the participants might lack the years of academy and industry experience to be able to notice, when they have something special in their hands.

5. CONCLUSION

Based on the limited amount of the current hackathons academic based knowledge, especially taking into account, that most of the research has been conducted and published after the year 2010 [13], it is quite clear there is still lot of room to add knowledge on this context and do e.g. practical hands on hackathon related research. Specially there is space to add novel knowledge to hackathons and sustainability front. Fortunately, there are already some signs of research picking up speed in hackathon events and sustainability research in academic studies [23,61]. In the on commercial hackathon front, we do know some cities / municipalities have started to use hackathons, the current literature actually mostly only explains and reveals entrepreneurship and company-focused hackathon events. The research gap in literature, in the field of municipality / public sector organized / or sustainability focused open hackathons events, suggest somewhat limited utilization of hackathons in past, for the purpose of generating new novel ideas to public sector operations sustainability context. As hackathons are typically a tool for innovation, new research streams should also take into account different research streams related to front end innovation [62] studies to pinpoint specialties different style of hackathons e.g. face-to-face physical events, hybrid hackathons and 100% virtual events have, when it comes to ways of facilitating these and to be successful in supporting new novel idea and innovation seed generation work. And the formalization work [76] should take ideas also outside of the context, what is the specific focus, in any given hackathon event itself. By enhancing the front-end innovation part of hackathons, adding knowledge on public – university collaboration activities and continuing boosting the research in hackathon results long term sustainability front, the development of new environmentally acknowledging business models and creation of sustainability and circularity related innovations, can be taken to new levels. Additionally, to the research which focuses to the process and facilitation, also different analytical and innovation work supporting tools like MCDS and business model generation activities [63] should be taken into account too.

Based on the positive experience-based feedback from hackathon participating companies, challenge owners and academics) educational units, professors, researchers, unit leaders and teachers), and after seeing these, case example based positive results made for the benefit of our global ecosystems, it's logical to recommend others to continue pursuing to same directions. For this, we suggest considering e.g. social media to boost the creativity of the participants (building common understanding on the topic and using social media from brainstorming as a help tool [64]). Technical companies, who participate or build hackathons, could consider studying different success factors for collaborative product development [65], to use these for pilots builds as continuation efforts, which should follow the hackathon events. And new style of collaboration partners should also be considered, to boost special sort of creativity, like it was in the experiment where artist collaborated with technical engineers and researchers to generate new style of art form [66]. And finally, more effort should be put to the understanding of why people do participate to different events and social activities [70], what drives the participation of different genders [71] and what are the technological possibilities to achieve improved sustainability levels [72].

Generally speaking, it is beneficial for hackathon results, if the challenge owners (e.g. companies, NGOs, municipalities, University etc.) can build a gender neutral and inspiring environment for the young participants with desire to build more sustainable world and bring to the event their own pool of resources, long-term area expertise-based experience data, access to technology and client base knowledge. As an example, higher education unit / partnering municipality / nonprofit organization with

sustainability development goals can run open data [103] based opportunity-seeking datathons for the goal of developing society knowledge base widening information services or aim to make new novel business models based on data [104], or e.g. designthon to generate tools and interpretation models to a data streams which are already open to everyone, but hard to interpret by non-technical people, people without programming skillset or for example for a person who has not previous experience in data-analytics.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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Ari Happonen

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Research, Academic and Educational Experience: He is an Associate Professor at the LUT University, Finland, and project manager, principal investigator and University - Industry collaborator at LUT School of Engineering Science. His research takes place at the intersection between Software engineering for entrepreneurial attitude and corporation RDI efforts, Digital transformation with business development and Digitalization, Robotization and automatization, Electrification with sustainability and waste reduction, ICT for Sustainability and society development by also cross connecting all these fields to education with University - industry collaboration and Hackathon events. His research has contributed e.g. to the software engineering, ICT & sustainability, supply chain and global logistics development, AI solutions & RPA studies, EV & big data analysis, 3D printing state-of-the-art technology application areas and hackathon & education related research areas. He has more than 100 academic publications in indexed journals, conferences and books, around the world. Furthermore, he is a Guest Editor of the Special Issues in "Digital Services, Design and Cost Implications for Electric Vehicles Data Based Services and Fleet Management Systems for the Energies journal. He is supervising several doctoral theses and has already supervised over 150 theses. He has 20 years of teaching experience and he also has extensive industrial and academic collaboration network. Moreover, he is a member of the Allied ICT Finland (largest ICT network in the Nordics). His current interests are specially in software solutions to fight against climate change, enhancement of sustainability, automatization and cross industrial innovation. In 2020, he started to lead an international 4 HEI unit collaborative team of the EU funded Finnish-Russian project AWARE (Against Waste: Activate Research and Education) as project manager and principal researcher.

Special Award:

10/2020 Organizing of EIT Raw Materials education innovation hackathon
4/2020 Organizing South Carelia local "Kaikille kone" -campaign
11/2019 Judge on Taylors University yearly Engineering fair event
5/2019 Organizing SkinnARila project competition for LTKY 50 year event
3/2019 Organizing chair for Workshopping a Data Equity Manifesto
2/2019 – 7/2019 ICT4S Lappeenranta conference Company collaboration & Hackathon Master
11/2018-> LUT Nominee for Allied ICT Finland (AIF) Growth Mill activities representative
05/2018 The Finnish Cultural Foundation 11 000 eur Grant for Civic engineering
12/2016 LUT representative in Imatra municipality Digitalization & DT group
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International Conference on Software Engineering, and others. His research has received multiple awards including an ACM SIGSOFT Distinguished Paper Award.



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She is a scientific associate with the Natural History Museum, London, UK. Her research so far has been primarily collection-based and focused on the consequences of climate change for terrestrial biodiversity. She is particularly interested in statistical design and modeling applications for the analysis of species distribution information. Some of her most-cited research is on distribution and conservation status of forest bamboo biodiversity, and biogeography and evolution of ferns, including scaly tree ferns. In 2005, she acted as a contributing author for a major assessment of the human impact on the environment, The Millennium Ecosystem Assessment. Since 2012, she has been an Associate Editor for Systematic and Biodiversity published by Taylor & Francis. In 2019, she became a member of the Useful Plants and Fungi of Colombia (UPFC) project implemented by The Royal Botanical Gardens, Kew. In 2020, she joined the project team of the EU funded Finnish-Russian project AWARE (Against Waste: Activate Research and Education) which allowed her to focus her research activities on more general issues of sustainability.



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She is working in international RDI operations, business development and project manager in the field of Bio and Circular Economy. Her research Interest areas in business development, organizational culture research connected to sustainable technologies. During her career she has worked in international field as export director, marketing manager and hr-manager. She has research articles in the national and international journals.



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He is an Operations Manager at Stora Enso Forest Division, Forest Finland. He also holds a Docent professorship in Forest Technology at the University of Helsinki and a Docent professorship in Forest Operations, especially Forest Energy Supply Systems at the University of Eastern Finland. He has over 20 years of experience in teaching at the University of Eastern Finland, University of Helsinki, and Lappeenranta University of Technology. Moreover, he is a member of the Bioenergy Association of Finland, the Finnish Society of Forest Science, and the Society of Finnish Industrial Foresters. His current interests are digitalization in forest operations and logistics, as well as climate change and sustainability. He has supervised several doctoral and M.Sc. theses at the University of Eastern Finland, University of Helsinki, University of Jyväskylä, Aalto University, and Lappeenranta University of Technology. The total number of his publications is more than 400 consisting of the

peer-reviewed and non-refereed scientific articles, scientific books, publications intended for professional communities and the general public, and audiovisual material. Furthermore, he is a member of Editorial Board in the *Metsätieteen Aikakauskirja* journal and has been a Guest Editor of the Special Issues in “Advances in the Green Circular Economy: Forest and Agriculture Industry” and “The Impact of Forest Industry Operations and Comparison of Greenhouse Carbon Emissions” for the *Sustainability* journal.

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