Empowerment for Digitalization Skills in Agriculture with the TERRATECH Education Approach

George Katranas[1], Ruth Pereira[2], Sofia Oliveira[2], Andreas Riel[3,4](✉), Theodoros Kosmanis[5], Péter Féjer[6], Susana Carvalho[2], Matteo Gatti[7], and Nicoleta Alina Suciu[8]

[1] Cerca Trova Ltd., 1000 Sofia, Bulgaria
katranasg@ctrova.eu
[2] GreenUPorto, Faculty of Sciences, University of Porto, Porto, Portugal
{ruth.pereira,susana.carvalho}@fc.up.pt,
up201101605@edu.fc.up.pt
[3] Univ. Grenoble Alpes, CNRS, Grenoble INP, G-SCOP, 38000 Grenoble, France
andreas.riel@grenoble-inp.fr, Riel_Andreas@ecqa.org
[4] ECQA GmbH, 3500 Krems, Austria
[5] International Hellenic University, Thessaloniki, Greece
kosmanis@ihu.gr
[6] University of Debrecen, Debrecen, Hungary
fejerp@gmail.com
[7] DI.PRO.VE.S, Università Cattolica del Sacro Cuore, 29122 Piacenza, Italy
matteo.gatti@unicatt.it
[8] DiSTAS, Università Cattolica del Sacro Cuore, 29122 Piacenza, Italy
nicoleta.suciu@unicatt.it

Abstract. The agricultural IoT infrastructure transformation is enabling crop producers to receive status information from interconnect farms, crops, crop/field, equipment, storage and livestock. Agricultural corporations down to small family farms are now able to monitor the entire plantation ecosystem, spanning from: crop field physical parameters (temperature, light, humidity, soil moisture etc.), plants phenotyping, crops vigour, local climatic conditions and control of operations such as its irrigation and fertilisation through automation solutions (greenhouses). The TERRATECH approach presented in this paper aims to develop an advanced interactive MSc course related to Agriculture IoT Engineering that will train individuals with the necessary skills and knowledge to work in the rising "Smart Agriculture" industry. The course is also formulated to stimulate transversal competences such as the increased sense of initiative and entrepreneurship.

Keywords: Internet of Things · Agriculture · Agrotechnology · Education · Training

1 Introduction

Considering that the world population is set to reach 9.7 billion by 2050 [1], and adding to the equation the ever so frequent extreme weather conditions, rising climate change and

M. Yilmaz et al. (Eds.): EuroSPI 2022, CCIS 1646, pp. 224–238, 2022.
https://doi.org/10.1007/978-3-031-15559-8_17

the environmental impact from intense farming [2], then the need for agriculture optimisation is rapidly becoming a necessity. Moreover, several countries are experiencing an overall shortage of skilled workers in agriculture [3]. It is this need for food security and environmental protection that smart precision farming systems, based on IoT technologies, are attempting to satisfy [4]. The agricultural IoT infrastructure transformation is enabling crop producers to receive status information from interconnect farms, crops, crop/field, equipment, storage and livestock. Agricultural corporations down to small family farms are now able to monitor the entire plantation ecosystem, spanning from: crop field physical parameters (temperature, light, humidity, soil moisture etc.), plants phenotyping, crops vigour, local climatic conditions and control of operations such as irrigation and fertilisation through automation solutions (greenhouses). The information is now gathered, processed and visualised through web-based or mobile application user interfaces directly to the stakeholders for decision making at any stage of the production process, from planting and cultivation up to storage and logistics (End-to-End farm management systems) [5]. Now, asset management is possible; farming companies can finally receive live information, optimise their production while at the same time maintain energy and resources efficient procedures. Overall IoT systems are set to reduce inefficiencies, risks and overall cost and provide an unparallel ease of connectivity that stakeholders can exploit for decision-making.

This paper presents the masTERs course on smArt Agriculture TECHnologies (TERRATECH) Erasmus+ project which aims at developing an advanced interactive MSc course related to Agriculture IoT Engineering that will train individuals with the necessary skills and knowledge to work in the rising "Smart Agriculture" industry. The course is designed to follow the European Credit Transfer and Accumulation System (ECTS) credit standards for certification recognition across the EU. This postgraduate course is also formulated to stimulate transversal competences, such as the increased sense of initiative and entrepreneurship.

2 Significance of IoT in the Agricultural Sector

Today, there is clear evidence that ICT solutions can play a critical role in enabling companies and farmers worldwide to optimise their production, reduce the operating costs, while protecting the environment and increasingly sustainable use of natural resources. Penetration of relevant solutions to the market has been progressively increasing (mostly in smart metering solutions); creating huge opportunities but also significant threats to the stakeholders in the agricultural industry that still follow traditional techniques. Among those most severely impacted, by the advent of such solutions, are the agricultural producers who are facing a new business reality. This reality dictates that the majority of farmers, especially operating in Southern Europe, are likely to have near zero tertiary education and they have to learn to use highly sophisticated ICT solutions in order to be competitive in the near future. In contrast, engineers with expertise in ICT solutions have in general near zero understanding on agronomy in order to cater these needs. To sustain growth, improve competitiveness and drive business value, the industry must transform and take advantage of business opportunities that arise arising from using adoption of IoT-based solutions.

At EU level, the European Commission in February 2020 has defined its vision for EU digital transformation to achieve an inclusive use of technology that works for people and respects the core values of the EU [6]. The White Paper on Artificial Intelligence [7] and the European Data Strategy [8] are, in fact, the first two pillars of the Commission's new digital strategy [9, 10].

Furthermore, as highlighted by Araujo et al. [11], Agriculture 4.0, part of EU Green Deal Program, is playing a central role in shaping the future of the agri-food sector, by having the three main dimensions of sustainability as pillars. These aim at providing economic, social, and environmental benefits, in an ethical and fair manner. In terms of economic benefits, Agriculture 4.0 involves applying modern technologies to generate data and use them for real-time processing, analysis, and decision-making purposes.

Farming applications supported by sophisticated ICT solutions and intelligent controls can effectively alter the traditional agronomic practices used so far and empower users to achieve significant benefits through increased yield, lower the costs, strive for environmental protection, and ignite entrepreneurship. Different benefits arising from the use of agricultural IoT are further described in the case studies below:

- A case study by Libelium [12] showed an 18% increase in milk production by changing the feeding pattern of cows as based on monitoring of environmental conditions. This was a custom solution based on COTS products applied in a new market;
- Facing the farmers' need to measure water consumption at the farms scale, Knode [13] was launched as a high technology start-up providing solutions for collecting, storing, and analysing asset and resource data on farms.
- Kurt Bantle [14], a retired engineer and now farmer, used IoT to reduce the water consumption in his avocado farm by 75%.
- The use of remote and proximal sensing solutions to create a heat/vegetation map allowing the user to activate the irrigation system [15] or performing more efficient variable rate fertilization [16].
- IoT solutions for early pest detection can reduce yield loss by up to 20–40% [17]; likewise, other IoT-based solutions allowed more efficient plant protection leading to similar productivity with 40–50% less spray [18].

Since there is no *EU-wide* formal agricultural training at a MSc level, in all cases the engineers have to comprehend in depth the farmers' needs in order to be able to provide effective and problem-based solutions; contrariwise, farmers and agronomists have to invest in understanding and growing their knowledge on IoT. IoT and the digitalization of agricultural processes, tools and business will influence agricultural related personnel as they will need to have either an insight of the systems capabilities for corporate decisions, design/service this ecosystem or process/analyse the acquired data.

We investigated across Europe through our partner's network, to a sample of 100 farmers that were asked to share their views on this rapidly emerging new technology and the results are:

- The vast majority (90%) prefer to examine optimising their production using IoT as opposed to traditional techniques;
- the preferred system to achieve the goal was: software for production optimisation (32%), sensing and monitoring (23%), automation and control (21%), smart greenhouse hardware (15%), livestock monitoring (9%);
- only 1 out of 10 had any knowledge in using any type of IoT systems and none on designing or installing it.

Similar were the responses from a questionnaire developed under the SMARTAKIS Horizon2020 project (Grant Agreement 696294) on the interest and adaptation of smart farming technologies [19]. Plus, a recent survey carried out in the scope of DEMETER Horizon2020 project, which involved 484 farmers from around the globe, revealed that farmers were generally aware of the benefits associated with smart farming. According to this survey, the biggest drivers to farmers using smart farming technologies were [20]:

- To provide information to better manage the farm.
- To simplify work.
- To improve environmental impact.
- To increase profitability.

In addition, 14% and 13% of the farmers that replied to DEMETER's questionnaire stated that the main reasons preventing them from adopting these technologies were the fact that they did not possess enough skills and that the technologies were too complex, respectively [20].

The TERRATECH project team identified that at least 21 occupations within the engineering and agricultural sector requiring knowledge on IoT solutions, at various levels as reported in Table 1.

Table 1. IoT influence on agricultural positions.

No	Job responsibility	Main duties	IoT influence
1	Agricultural Equipment Operator	Drive and control farm equipment to till soil, to sow and, harvest crops	Operates ICT/IoT enabled equipment to collect information
2	Agricultural Engineer	Apply knowledge of engineering technology, biological and agronomic sciences to agricultural problems	Responsible for installing the IoT systems on farms to support the data measurement

(*continued*)

Table 1. (*continued*)

No	Job responsibility	Main duties	IoT influence
3	Agricultural Inspector	Inspect agricultural equipment, facilities and operations to ensure compliance with regulations and laws	Receives detailed and vital information from the inspection
4	Agricultural Sciences Teachers	Teach courses in the agricultural sciences	Responsible for teaching agricultural professionals with the IoT systems ecosystem
5	Agricultural Technician	Set up or maintain laboratory equipment and collect samples from crops or animals	IoT system maintenance and installation
6	Aquaculture Managers	Manage activities relating to fish hatchery production	Receives vital information on fishery status
7	Farmer	Manage small to medium crop and livestock farms	Receives vital information on farm status
8	Computer Engineer	Develop and maintain systems software and hardware for farming applications as well as performing data analysis	Develop the IoT software
9	Electro Technical Officer	Deals with maintaining electrical equipment and systems on crops	IoT system maintenance
10	Farm/Crop Manager	Plan, direct and coordinate the operations within the agricultural company/farm	Receives vital information on crop status
11	Geospatial Scientists and Technologists	R&D of geospatial tech-nologies also involved in producing/using intelligent databases, and program-ming, development of Farm Management Information Systems	Receives and analyses Remote Sensing and GIS data to extract crop parameters such as health information

(*continued*)

Table 1. (*continued*)

No	Job responsibility	Main duties	IoT influence
12	IT Specialist	Provide technical assistance to equipment users, maintenance of intranet and data flow	Maintains the IoT data flow through the corporate intranet and satellite communication systems
13	Food Distribution Manager	Organise the storage and distribution of goods	Consults the IoT systems database to monitor the status and location of goods (stored or in in transit)
14	Nursery and Greenhouse Manager	Plan, organize, direct, control, and coordinate activities in propagating, cultivating, and harvesting horticultural specialties	Receives vital information on nursery/greenhouse status
15	Livestock/Stable Manager	Manages the animal welfare and stable status	Receives information IoT systems on livestock health and condition
16	Precision Agriculture Technician	Apply geospatial technologies, including Remote Sensing, GIS and GPS, to agricultural production	Receives information from the IoT system and installs the sensors on the farms
17	Remote Sensing Technician	Apply remote sensing technologies to assist scientists in areas such as agricultural and natural resources	Operates ICT/IoT enabled equipment and drones for data acquisition, processing and analysis
18	Soil and Plant Scientist	Conduct research in breeding, physiology, production, yield, management of crops and agricultural plants or trees, shrubs, and nursery stock, management of soil conditions and fertilization	Uses the IoT systems to get centralised information on changes on soil physical composition and chemical properties
19	Sanity/Waste/Irrigation Engineer	Deals with the engineering aspect of water lines and waste management for agricultural crops	Responsible for installing the IoT systems on crop fields to support the irrigation and waste management

(*continued*)

Table 1. (*continued*)

No	Job responsibility	Main duties	IoT influence
20	Electrician	Installs, maintains and repairs electrical wiring, equipment, control systems and fixtures	Installs, maintains and repairs the IoT system
21	Structural Engineer	Involves designing crop/field and buildings	Receives information on crop/field condition from the IoT system and installs the sensors on the crop fields and equipment

Table 1 lists job responsibilities in the agricultural sector that require upskilling to integrate the new advances on farming, crop-related technologies, and their benefits. Occupations affected by the growth of IoT technologies will be requested by farmers, food industries, equipment manufacturers, as well as by thousands of private companies dealing with agricultural productions. In fact, some of the listed positions were already identified by SFATE Erasmus+ Project as new job opportunities that would arise from the adoption of smart farming technologies [21].

The authors' own desk-research and educational networks revealed that hands-on IoT courses dedicated to the application of these systems to the Farming industry are still rare in the currently 137 Agriculture educational institutions inside the EU. Some engineering educational institutions mainly in Northern Europe have begun offering general ICT/IoT courses or Precision Agriculture courses of a few days duration, that are unable to convey solutions to practical and technical problems that are faced within the farming industry and do not offer a hands-on training on agricultural related companies and farms, at least not on a European scale.

Our mission is to provide a novel academic program in the theme of Agriculture IoT systems and land-based infrastructure that includes interactive teaching methods and partnerships with major educational and industrial organizations, giving students a solid grounding for starting a fruitful career in the corresponding industry or enable professionals to gain extra skills and knowledge and at the same time prompting local communities and authorities to embrace the new technologies and their benefits. Hence, the output of the partnership is to design a Master program providing additional skills to those interested in an agricultural career and allow the partners to create an ongoing course that will be implemented beyond the duration of this project. Table 2 shows the project partnership per organization type.

Table 2. Partners in the TERRATECH consortium.

Org. type	Consortium partners	Partner acronyms	Country	Skills
Universities	University of Porto	UPorto	PT	Academic institutions, course development
	International Hellenic University	IHU	GR	
	University of Debrecen	DEB	HU	
	University Pompeu Fabra	UPF	ES	
	Università Cattolica del Sacro Cuore	UCSC	IT	
	Vidzeme University of Applied Sciences	VIA	LV	
SMEs	Cerca Trova Ltd	CT	BG	Technology development, applied research, analysis and optimization
	ECQA GmbH	ECQA	AT	Degree certification
	Evolutionary Archetypes Consulting SL	EA	ES	e-Learning Platform development
	Ktima Filippou-Schoinoplokakis	KF	GR	Industrial partner and market insight
	AgriWatch	AW	NL	Industrial partner and market insight
	Agroop Lda	AGP	PT	Industrial partner and market insight
	Regional Federation of CUMA of the West	CO	FR	Industrial partner and market insight
Research Centre	Mediterranean Agronomic Institute of Chania	MAICh	GR	Research institution

The consortium gathers 6 Universities (DEB, IHU, UCSC, UPorto, UPF, VIA) from 6 European Union countries (Greece, Hungary, Italy, Latvia, Portugal, Spain), 1 SME for technology solutions from Bulgaria (CT), 1 SME for the MSc course certification (ECQA – Austria), 1 research centre from Greece (MAICh) and 4 other partners: 1 olive tree and vineyard farm (KF – Greece), 1 farming cooperation (CO – France) 1 communication company specialized in IT solutions and e-learning (EA – Spain), and 2 SMEs specialist in Geospatial technology and IoT solutions (AW – Netherlands and AGP – Portugal) to act as end-users/industrial partners for hosting the students for their practice and also for providing knowledge and market insight. All organizations have long-standing, established experience in their field. In addition, the consortium comprised from individuals that have a vast experience in EU projects, research and technology diffusion.

3 Curriculum Design

The main activity of the project is the development and execution of the academic curriculum. Based on the needs at European level and the technology trend IoT, the latter is composed of twenty-four (24) courses appropriately divided into two semesters. The course titles are listed in Table 3. Both time periods include, besides the courses, two university visits for the students, one at the International Hellenic University, Greece and one at the University of Debrecen in Hungary. The curriculum focuses on applied engineering concepts and provides industry insights in order to immerse the students in Agriculture ICT core components, functionality, maintenance, safety & sustainability. Two of the courses are characterised as large experiments that will lead to the development of drones, sensor clusters & IoT/Virtual Reality (VR) based measurement system. These subjects will be taught in person during the university visits and will include lab/practice work. Half of these subjects will be taught via blended classroom, where the DEB/IHU lecturers will co-teach with lecturers from partners (UPorto, CT, UPF, UCSC, VIA, MAICh, ECQA), which are experts in the respective subjects. The other half of these subjects will be taught remotely by the respective partners.

The TERRATECH curriculum is innovative also in the fact that it encompasses interactive teaching methods and partnerships with expert academic and farmers organizations to give to the students a solid background for starting a fruitful career in the industry. For example, the knowledge centres cooperate with business partners for the development of joint laboratory demonstrator exercises using CoSpectroCam sensor [22] developed by AW in three courses (Data Acquisition & Sensors, Agricultural Drone Systems, IoT Platforms & Systems). The duration of the MSc program is nine months. During the execution of the program, three mobility periods are programmed. For the first two periods (duration: 14 days) the students and two educators from one university will travel to the other, and vice-versa, to participate in large-scale laboratories. The third period (duration: 1 month) is reserved for an industrial placement, an agronomic on-the-job experience. Students will produce a report during the placement.

Although the postgraduate will be taught in English, local language lessons (in Hungarian and Greek) will be provided to enable the participants to immerge in the local culture during the exchange periods. The master's degree will be open for participation for anyone with a basic agronomic, electrical or mechanical engineering, or physics background. Priority will be given according to their academic performance.

Table 3. TERRATECH academic curriculum structure.

Code	Course title	Course authors	Working hours	Estimated teaching method						
				Lecture		Lab	Blended	Exams	Home work	Practice
				In-Class	Web					
TS1.1	Plant Pathology	UPorto/DEB	50	10	20	–	–	5	15	–
TS1.2	Data Acquisition and Sensors	IHU	50	24	–	10	–	4	12	–
TS1.3	NI LabVIEW Training	CT	50	10	8	20	Y	3	9	–
TS1.4	Geographic Information Systems	MAICh	50	–	30	–	Y	5	15	–
TS1.5	Remote Sensing and Wireless Sensor Networks	UPF	50	–	30	–	Y	5	15	–
TS1.6	Greenhouse and Soilless Culture	UPorto	50	–	30	–	–	54	15	–
TS1.7	Soil Quality and Health	UPorto/DEB	50	10	20	–	–	5	15	–
TS1.8	IoT Platforms and Systems	IHU	50	10	8	20	Y	3	9	–
TS1.9	Precision Soil Cultivation and Sowing	DEB	50	10	20	–	Y	5	15	–
TS1.10	Precision Nutrient and Irrigation Management	UCSC/MAICh	50	–	30	–	Y	5	15	–
TS1.11	Local Culture and Language	IHU/DEB	50	30	–	–	–	5	15	–
TS1.12	Intermediate Project	IHU/DEB	60	20	–	40	–	–	–	–
TS2.1	Precision Crop Production and Protection Systems	DEB	50	30	–	–	–	5	15	–

(*continued*)

Table 3. *(continued)*

Code	Course title	Course authors	Working hours	Estimated teaching method						
				Lecture		Lab	Blended	Exams	Home work	Practice
				In-Class	Web					
TS2.2	In-Silico Models for Integrated Environment and Human Risk Assessment	UCSC	50	8	10	20	Y	3	9	–
TS2.3	Precision Plant Farming Management	DEB	50	30	–	–	–	5	15	–
TS2.4	Agricultur-al Drone System	IHU	50	24	–	10	Y	4	12	–
TS2.5	Data processing and Blockchain	IHU/CT	50	24	–	10	–	4	12	–
TS2.6	Renewable Energy in Agriculture	IHU	50	–	30	–	Y	5	15	–
TS2.7	Modern Technologies to Mitigate the Impact of Agricultural Activities	UCSC	50	–	30	–	Y	5	15	–
TS2.8	Augmented/Virtual Reality	VIA	50	–	30	–	Y	5	15	–
TS2.9	Innovation and Entrepreneurship Management	ECQA	50	–	30	–	Y	5	15	–
TS2.10	Business Administration	ECQA	50	–	30	–	Y	5	15	–

(continued)

Table 3. (*continued*)

Code	Course title	Course authors	Working hours	Estimated teaching method						
				Lecture		Lab	Blended	Exams	Home work	Practice
				In-Class	Web					
TS2.11	Local Culture and Language	IHU/DEB	50	30	–	–	–	5	15	–
TS2.12	Developing Tool Demonstrator	IHU/DEB	60	20	–	40	–	–	–	–
–	Industrial Practice	KF/AW/AGP/CO	280				–	–	120	160
Total Hours			**1500**	**290**	**356**	**170**	–	**101**	**423**	**160**
Total ECTS Credits			**60**							

4 Conclusion and Outlook

The Industry 4.0 revolution is bringing to our everyday lives the concept of creating networks of smart interconnected objects via the IoT, with direct applications in almost all major sectors, including the agricultural one. Confronted with hard-to-face challenges associated with socioeconomic, economic, and climatic crises, the latter is increasingly adopting the new sensing and data exchange technologies, placing them ahead in the transition towards ICT and IoT adaptation. This market will rapidly require skilled individuals to design, develop, install, service and maintain these new systems.

Building on the success of a similar initiative in the maritime domain [23], the objective of the TERRATECH Joint Master's Degree in Agriculture ICT/IoT systems presented here is to facilitate the qualification of current and future workforce in IoT-enabled agrotechnology and processes, both in initial and continuous education and training. The rapid market growth will demand that this postgraduate program will become an integral part of academic institutions and agriculture academies in Europe and beyond.

The first edition of the program (pilot program) will be financed by the European Commission. Financial sustainability of subsequent editions will be ensured by collecting student fees and through the scholarships that industrial companies will offer to train their personnel and stay competitive in this emerging field. The fees will cover the participant's training, laboratory apparatus and demonstrator equipment maintenance. It will also cover the student's mobility between academic institutions and to the industrial partners for their practice. Furthermore, the objective is to create a synergetic partnership with agriculture industry key players for co-financing the education program. Their return on invest will be clearly visible and measurable in terms of highly qualified students and professionals that can significantly help drive digitalization forward in the agriculture sector.

At this stage, the training modules and platform are being set up. The first deployment cycle will start in autumn 2022, allowing the consortium to have an initial basis for validation and improvement.

5 Relationship with the SPI Manifesto

Europe-wide qualification and certification of modern, digital skills has been one of the backbones of EuroAsiaSPI[2] ever since its creation. In particular, the integration of diverse competences in product, services, and systems design has been identified as a key principle and success factor [24–26]. The SPI manifesto [27, 28] created in this community defines the values and principles required to deploy SPI efficiently and effectively.

The principle "**Create a learning organization**" means that organizations need to continuously qualify and re-qualify personnel to strengthen and re-new core competences in rapidly evolving contexts of the digital era. While agriculture has net ben a domain EuroSPI has been focussing on so far, the increasing predominance of digital technologies to face difficult challenges such as climate change and workforce depletion makes this domain particularly interesting and challenging for the SPI community.

Acknowledgements. This project is a highly collaborative endeavour requiring intense contributions of a huge number of individuals. We regret that we cannot cite all their names here and want to express our thanks to them in this way. Some of them, however, gave particularly valuable input to the work programme published in this article without being cited as co-authors. Special thanks are therefore due to Anabela Cachada, Verónica Inês Nogueira, Tânia Caetano, Ettore Capri, Stefano Poni, Tito Caffi and Maura Calliera, Ali Abkar.

The TERRATECH project [29] is financially supported by the European Commission in the Erasmus+ Programme under the project number 21568-EPP-1-2020-1-PT-EPPKA2-KA. This publication reflects the views only of the authors, and the Commission cannot be held responsible for any use which may be made of the information contained therein.

References

1. United Nations, Population Division, World Population Prospects, 2019 Revision, Medium Variant. https://population.un.org/wpp/Download/Standard/CSV/. Accessed 16 Apr 2022
2. OECD – Agriculture and Climate Change. https://oecd.org/tad/sustainable-agriculture/agriculture-climate-change-september-2015.pdf. Accessed 16 Apr 2022
3. Eurostat. Performance of the agricultural sector. Accessed 27 Dec 2021. https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Performance_of_the_agricultural_sector#Agricultural_labour_productivity. Accessed 23 Apr 2022
4. De Clercq M., Vats A., Biel A.: Agriculture 4.0: The Future of Farming Technology (2018). https://www.marshmclennan.com/insights/publications/2018/mar/agriculture-4-0.html. Accessed 19 Apr 2022
5. Berginsight: M2M/IoT Applications in the Agricultural Industry. https://berginsight.com/ReportPDF/ProductSheet/bi-agriculture-ps.pdf. Accessed 12 Apr 2022
6. European Commission. Shaping Europe's Digital Future (COM 2020). https://ec.europa.eu/info/sites/info/files/communication-shaping-europes-digital-future-feb2020_en_3.pdf. Accessed 1 Mar 2022
7. European Commission. The White Paper on Artificial Intelligence (COM 2020). https://ec.europa.eu/info/sites/info/files/commission-white-paper-artificial-intelligence-feb2020_en.pdf. Accessed 19 Apr 2022
8. European Commission. A European Strategy for Data (COM 2020). https://ec.europa.eu/info/sites/info/files/communication-european-strategy-data-19feb2020_en.pdf. Accessed 19 Apr 2022
9. European Commission. Digital Economy and Society Index 2020 Thematic Chapters; Available on the Digital Economy and Society Index (DESI) (europa.eu); European Commission, Bruxelles, Belgium (2020)
10. European Commission. Digital Economy and Society Index 2020 Italy; Available on Italy Shaping Europe's Digital Future (europa.eu); European Commission, Bruxelles, Belgium (2020)
11. Araújo, S.O., Peres, R.S., Barata, J., Lidon, F., Ramalho, J.C.: Characterising the Agriculture 4.0 landscape—Emerging trends, challenges and opportunities. Agronomy **11**, 667 (2021). https://doi.org/10.3390/agronomy11040667
12. Libelium case study: How a dairy farm increased their milk production 18% with IoT and Machine Learning. http://www.libelium.com/how-a-dairy-farm-increased-their-milk-production-18-with-iot-and-machine-learning/. Accessed 16 Apr 2022
13. Losant and Knode. https://www.losant.com/client-case-studies/knode. Accessed 16 Apr 2022
14. Spirent: IoT in Agriculture. https://www.spirent.cn/-/media/case-studies/iot/iot-in-agriculture_case-study.pdf. Accessed 25 Mar 2022

15. Mobodexter: Drones in Agriculture. https://www.mobodexter.com/wp-content/uploads/2018/07/Application-of-Drones-in-Agriculture-using-PAASMER-IoT-Platform-casestudy.pdf. Accessed 16 Apr 2022
16. Gatti, M., et al.: Effects of variable rate nitrogen application on cv. Barbera performance: vegetative growth and leaf nutritional status. Am. J. Enol. Viticult. **69**(3), 196–209 (2018). https://doi.org/10.5344/ajev.2018.17084
17. Agrivi: Farm Revolution Sensors for Crop Pest Detection. https://blog.agrivi.com/post/farm-revolution-sensors-for-crop-pest-detection. Accessed 16 Apr 2022
18. Rossi, V., Salinari, F., Poni, S., Caffi, T., Bettati, T.: Addressing the implementation problem in agricultural decision support systems: the example of vite.net®. Comput. Electron. Agric. **100**, 88–99 (2014)
19. SMARTAKIS Project: Deliverable D2.2 Report on farmer's needs. https://www.smart-akis.com/wp-content/uploads/2017/02/D2.2.-Report-on-farmers-needs.pdf. Accessed 03 Apr 2022
20. DEMETER H2020 project. The Farmer's Voice (2022). https://h2020-demeter.eu/the-farmers-voice-demeter-survey-and-webinar/. Accessed 20 Apr 2022
21. SFATE Erasmus+ Project. SFATE Report: Adapting curricula to smart farming technologies and new job opportunities (2019). http://sfate.eu. Accessed 20 Apr 2022
22. CoSpectroCam is an optical coaxial assembly of an RGB Camera and a Spectrometer. https://www.agriwatch.nl/projects/cospectrocamproject. Accessed 23 Apr 2022
23. Katranas, G., Riel, A., Corchado-Rodríguez, J.M., Plaza-Hernández, M.: The SMARTSEA education approach to leveraging the Internet of Things in the maritime industry. In: Yilmaz, M., Niemann, J., Clarke, P., Messnarz, R. (eds.) EuroSPI 2020. CCIS, vol. 1251, pp. 247–258. Springer, Cham (2020). https://doi.org/10.1007/978-3-030-56441-4_18
24. Riel, A., Tichkiewitch, S., Draghici, A., Draghici, G., Messnarz, R.: Integrated engineering collaboration skills to drive product quality and innovation. In: Proceedings of the EuroSPI^2 2009 International Conference, Madrid, September 2009, pp. 2.11–2.20 (2009)
25. Riel, A.: Integrated design – a set of competences and skills required by systems and product architects. Keynote paper. In: Riel, A., O'Connor, R., Tichkiewitch, S., Messnarz, R. (eds.) EuroSPI 2010. CCIS, vol. 99, pp. 233–244. Springer, Heidelberg (2010). https://doi.org/10.1007/978-3-642-15666-3_21
26. Tichkiewitch, S., Riel, A.: European qualification and certification for the lifelong learning. Keynote paper. In: Fischer, X., Nadeau, J.-P. (eds.) Research in Interactive Design, pp. 135–146. Springer, Paris (2011). https://doi.org/10.1007/978-2-8178-0169-8_10
27. Korsaa, M., et al.: The SPI Manifesto and the ECQA SPI manager certification scheme. J. Softw.: Evol. Process **24**(5), 525–540 (2012)
28. SPI Manifesto. https://conference.eurospi.net/images/eurospi/spi_manifesto.pdf. Accessed 12 June 2022
29. TERRATECH – M.Sc. course related to Agriculture IoT Engineering (2021). https://www.terratechmsc.eu/. Accessed 16 Apr 2022