Perspectives from Higher Education: Applied Sciences University Teachers on the Digitalization of the Bioeconomy

Essi Ryymin

“ If we don't change, we don't grow.”
Gail Sheehy

The bioeconomy is being disrupted due to global trends of digitalization and automation. Knowledge-intensive businesses and sustainable solutions in carbon-smart food production have resulted in various consequences for the professionals working in and for bioeconomy. This paper examines bioeconomy teachers’ perceptions of digitalization. It draws on research data from semi-structured focus-group interviews that were conducted with bioeconomy teachers in applied sciences higher education. The theoretical frame for the analysis was Mishra and Koehler’s (2006) teacher knowledge framework for technology integration called *Technological Pedagogical Content Knowledge* (TPACK). The results suggest that although applied sciences university teachers have strong *Technological Pedagogical Knowledge* (TPK), they need more systematic approach and support to develop *Technological Content Knowledge* (TCK) in a disruptive field. Teaching in a rapidly transforming discipline, like bioeconomy, requires continuous co-development of all TPACK knowledge components by teachers.

Introduction

The term “bioeconomy” covers multiple scientific fields and interrelated perspectives highlighting biotechnology, bio-resources, and bio-ecology (Bugge et al., 2016). Several national and global policy papers (European Commission, 2012; Ministry of the Environment, Finland, 2014; Klitkou et al., 2017; OECD, 2020) have reflected on how the bioeconomy can meet digitalization as a catalysing process that results in a kind of “new industrial revolution”. Digitalization in the bioeconomy is connected to applications of digital technologies, digitalized data, new and changing business models. This is happening alongside of a revolution in consumer behavior, for example, with the critical emergence of a circular economy (Klitkou et al., 2017; Satpute et al., 2017; Lamberg et al., 2020), which is important because it aims at eliminating waste and the continual use of resources by employing reuse, sharing, repair, and recycling.

The role of smart and sustainable solutions is often combined with tackling the effects of climate change and population growth. However, equally important is the connection of digital disruption with human resources and the world of work: reshaped industries require new kinds of competencies and increase the level of required skills which emphasises learning, education and training (Autor et al., 2020).

For example, in agriculture, new data-driven processes including various kinds of digital applications, smart machines, and sensors, have changed farmers’ decision-making, as well as knowledge and learning needs (Ingram & Maye, 2020).

According to Klerkx and colleagues (2019), digitalization in agriculture is expected to provide technical optimization of agricultural production systems, value chains, and food systems. Further, it may help address societal concerns around farming. Klerkx and

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colleagues have investigated several recent studies on the digitalization of agriculture. They offer as examples of its societal implementation the provenance and traceability of food (Dawkins, 2017), animal welfare in livestock industries (Yeates, 2017), the environmental impact of various farming practices (Balafoutis et al., 2017), enhancing knowledge exchange and learning, using ubiquitous data (Baumüller, 2017), and improving the monitoring of crises and controversies in agricultural chains and sectors (Stevens et al., 2016).

Mulder (2017) discussed how farmers need to cope with data-driven, knowledge-intensive changes in their ecosystems. They require new solutions that create a balance between people, planet, and profit-related objectives. Some farmers may also eventually feel pressed to create new business models because of the lack of future opportunities. In the midst of these infrastructural changes, learning competence becomes crucial (Mulder, 2017). Education and teaching need to stay up to date for future professionals as the various fields, disciplines and industries rapidly develop in society.

This paper aims at examining how applied sciences university teachers in Finland perceive digitalization in the field of bioeconomy and as a part of their profession, in particular at a university of applied sciences. In Finnish, the word "professor" denotes the highest non-administrative position or rank at the universities focusing on scientific research. This paper thus instead refers to "teachers" working at a University of Applied Sciences. Such universities of applied sciences offer professionally oriented higher education on bachelor's and master's level and have strong ties with working life and regional development.

The goal of this paper is to investigate applied sciences bioeconomy teachers' perceptions of digitalization in their work. The study aims to find out answers to the following research questions: 1) What kind of meanings do teachers give to digitalization in their work? 2) How does the digitalization of the bioeconomy connect with teachers' *Technological Pedagogical Content Knowledge* (TPACK)?

The study wishes to contribute to a discussion of holistic impacts of digitalization on higher education teachers' profession. In this case, we look especially at bioeconomy teachers to consider the importance for them of transforming substantial knowledge to align with pedagogical methodology.

Teachers' Competence in the Digital Age

Digitalization challenges the work of applied sciences university teachers as well as their competences in many ways. The researcher From (2017) described a new dimension in teachers' pedagogical skills and competences as Pedagogical Digital Competence (PDC). This relates to knowledge, skills, and attitudes that are needed to plan, conduct, evaluate, and revise ICT-supported teaching, It takes into account theory, subject and context, and supports effective student learning.

Ilomäki and colleagues (2016) investigated how digital competence is described in educational research through an analysis of 76 research articles. Based on their investigation, they suggested defining digital competence as consisting of (1) technical competence, (2) the ability to use digital technologies in a meaningful way for work, study, and in everyday life, (3) the ability to evaluate digital technologies critically, and (4) motivation to participate and commit in the digital culture.

Pozos and Torelló (2010) offer a more holistic view of applied sciences university teachers' digital competences. They suggest these teachers' digital competences in the integration and use of ICT means building broader capacities and abilities for new knowledge construction, knowledge management, and innovation. According to their view applied sciences teachers are agents of change, research, and innovation, who are committed to generating, applying and sharing new knowledge across society in a critical and responsible way.

The Technological Pedagogical Content Knowledge (TPACK) Framework

According to Gartner's glossary (n.d.), "digital disruption" is "an effect that changes the fundamental expectations and behaviors in a culture, market, industry or process that is caused by, or expressed through, digital capabilities, channels or assets". Skog and colleagues (2018) proposed the following definition of "digital disruption": "The rapidly unfolding processes through which digital innovation comes to fundamentally alter historically sustainable logics for value creation and capture by unbundling and

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recombining linkages among resources or generating new ones". The "disruption" therefore refers generally to the emergence of digital products, services, and businesses that "disrupt" the current market and cause a need for re-evaluation (Kenney et al., 2015; Udovita, 2020).

Digital disruption shapes teachers' work in many ways. It requires the re-creation of teaching and learning methods with digital tools, and therefore also challenges the teaching content. Mishra and Koehler (2006, as well as Koehler et al., 2013) have developed a teacher knowledge framework for technology integration called *Technological Pedagogical Content Knowledge* (TPACK) (Figure 1). The framework incorporates three core components: *Content* (C), *Pedagogy* (P), and *Technology* (T). The more the three main domains coincide, the greater the opportunities for effective teaching with digital tools (Koehler et al., 2013; Amhag et al., 2019). Equally important are the interactions between and among bodies of knowledge covered by professors in their classrooms, represented as *Pedagogical Content Knowledge* (PCK), *Technological Content Knowledge* (TCK), *Technological Pedagogical Knowledge* (TPK), and *Technological Pedagogical Content Knowledge* (TPACK).

The framework defines *Content Knowledge* (CK) as applied sciences university teachers' knowledge about a given subject matter to be learned, which is of critical importance for teachers. This knowledge includes concepts, theories, ideas, evidence, and established practices toward developing knowledge. Inquiry and

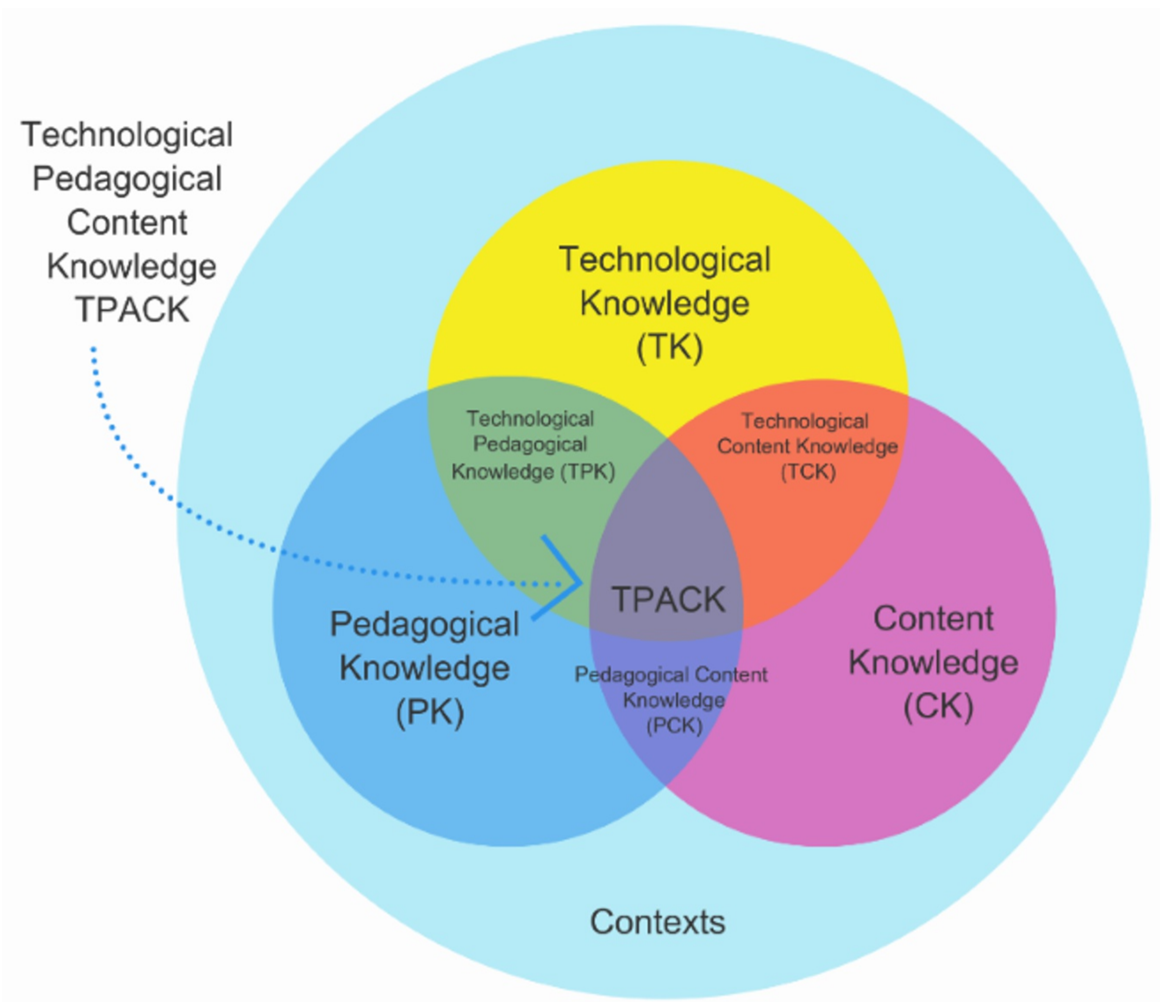

Figure 1. The TPACK framework and its knowledge components (Mishra & Koehler, 2006; Koehler et al., 2013).

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knowledge differ between fields, though in each case teachers should understand their discipline's fundamentals. A second type of knowledge, *Pedagogical Knowledge* (PK) is defined as teachers' knowledge about the methods and models of teaching and learning. This form of knowledge applies to understanding how students learn, the learning process and lesson planning, assessment, and general classroom management skills. The third type, *Pedagogical Content Knowledge* (PCK) designates teachers' knowledge of pedagogy applicable to teaching specific content. PCK covers the core business of teaching, learning, curriculum, and assessment. (Mishra & Koehler, 2006; Koehler et al., 2013; Amhag et al., 2019.)

According to the framework's developers, *Technology Knowledge* (TK) is always in a state of flux; more so than the other two core knowledge domains in the TPACK framework (Koehler et al., 2013). "Technology" here can apply to all technological tools and resources, and requires mastery of information technology for information processing, communication, and problem solving. It does not posit an end state, but instead develops over a lifetime of generative, open-ended interaction with other technology. *Technological Content Knowledge* (TCK) signifies an understanding of how technology and content influence and constrain each another. Applied sciences university teachers need to understand which specific technologies are best suited for dealing with content and addressing subject-matter learning in their discipline.

Technological Pedagogical Knowledge (TPK) defines the understanding of how teaching and learning can be promoted with particular technologies in various ways. This includes knowing the pedagogical principles and constraints of a range of digital tools appropriate for pedagogical designs and strategies.

The framework treats *Technological Pedagogical Content Knowledge* (TPACK) as an emergent form of knowledge that goes beyond all three core components. It constitutes an understanding that emerges from continuous interactions among content, pedagogical, and technological knowledge. Underlying the truly meaningful and deep skill of teaching with digital tools, TPACK differs from the knowledge of each of the three concepts individually. Applied sciences university teachers should learn how pedagogical, technological, and content knowledge can interact and compensate for some of the problems students face (Koehler et al., 2013; Amhag et al., 2019). The outer circle in the framework (Figure 1) emphasizes the realization that technology, pedagogy, and content do not exist in a vacuum, but are instantiated in specific learning and teaching contexts.

Porras-Hernández and Salinas-Amescua (2013) further developed the concept of context of the TPACK-model and differentiated its levels into macro, meso, and micro contexts. The macro level context includes the social, political, technological, and economic conditions. These include the rapid technological developments worldwide, which require constant learning, as well as institutional and national policies that, in the case of technology integration by teachers, have become especially relevant. The meso context marks the social, cultural, political, organizational, and economic conditions established in the local community, as well as in the educational institution itself. The micro level context concerns in-class conditions for learning. The micro level involves resources for learning activities, norms, and policies, as well as the expectations, preferences, and goals of applied sciences university teachers and students as they interact in classrooms.

Kyllönen (2020) suggested in her recent dissertation of teachers' pedagogical use of technologies that changes in all three levels of context shape teachers' TPACK, and must therefore be given careful attention. Kereluik and colleagues (2013) commented on TPACK from the point of view of 21st century skills. They emphasized that the base of disciplinary knowledge (*Content Knowledge*, CK) encompasses both traditional content knowledge and concepts forwarded in modern frameworks, such as students having strong communication skills integrated across content areas, being metacognitive in an iterative process, engaging with complex texts, and complex problem solving. Further, they stress that knowing the technology (*Technology Knowledge*, TK) is important, but that knowing when and why to use it is more important (*Technological Pedagogical Knowledge*, TPK). Basic digital literacy skills are thus essential for both applied sciences students and teachers. Knowing when to use a particular technology for activities such as collaboration, or why to use a certain technology for acquiring specific disciplinary knowledge, constitutes an important, transferable, highly relevant type of knowledge that will not quickly become antiquated with ever-changing technological trends (Kereluik et al., 2013).

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Data Collection and Methodology

Data originate from three (3) semi-structured online focus-group interviews with bioeconomy teachers from one university of applied sciences in Finland. An open call was made, then enrollment to online focus-group sessions for interested bioeconomy teachers. The teachers were encouraged to form multidisciplinary groups with the aim of representing several disciplines. The interview offered teachers an opportunity to debate and share knowledge across the boundaries of several degree programs. Sixteen (16) interviewees in the focus-groups represented a broad range of disciplines and variety of degree programs involving the bioeconomy, for example, agriculture, bioprocess%and automation engineering, environmental engineering, forestry and horticulture. The interviewees' average working experience related to the bioeconomy was 24.3 years, and in teaching positions, 20.6 years. Every focus-group had two interviewers.

The key themes of the interviews included bioeconomy teachers' continuous learning and competence development at work, as well as their considerations related to digitalization and sustainable development in the bioeconomy. The interview themes were connected to the theoretical approaches of competence development in higher education institution teachers (Tigelaar et al., 2004; Gilis et al., 2008). Rintala and colleagues (2021) are also introducing all the interview themes from this research in more detail in an article describing bioeconomy teachers' challenges and possibilities for continuous learning at work. This paper focuses primarily on bioeconomy teachers' considerations of digitalization.

The interviews were recorded, transcribed, and analyzed.% The qualitative data analysis implemented a thematic analysis, as introduced by Braun and Clarke (Braun & Clarke, 2006; Terry et al., 2017) in the interview data analysis, which was an iterative and both theory- and data-driven process conducted by the interviewers. The theoretical framework of specific interest in the analysis was the TPACK Framework and its knowledge components.

Results

Changes in contexts support teachers' Technological Pedagogical Knowledge (TPK) development

The interviewed applied sciences university teachers connected their understanding of the meaning of digitalization to the pedagogical use of technologies. They described their methods and models in implementing digital tools in teaching, as well as student interaction, and in guiding the learning processes.

Quote 1:

> *"I think we have rather good digital competences in the degree programs of bioeconomy here. For instance, transformation to distance education (online education) was quick and flexible. We (teachers) have kind of a manner to act and think digitally. I think we bring this kind of digital know-how to our students as well. I think we are already on a good track."*

The interviewees felt that they had good *Technological Pedagogical Knowledge* (TPK): they knew how teaching and learning can be promoted with technologies, were familiar with the relevant pedagogical principles, and applied a range of digital tools for pedagogical designs and strategies. In line with Koehler and colleagues' (2013) idea of *Technological Pedagogical Knowledge* (TPK), the interviewees seemed to own a "forward-looking, creative, and open-minded mindset" in seeking to use technology for the sake of advancing student learning. Their experienced competence in TPK seemed to be linked to strong *Pedagogical Knowledge* (PK) in general. This included their understanding of how students learn, how to guide learning processes, and their general educational management skills. As the interviewees were quite experienced applied sciences teachers, they were also very familiar with their curricula, the subject matters of the discipline to be learned, and the theories, ideas and established practices of their disciplines. This mirrored good *Content Knowledge* (CK).

In line with the suggestion of Kyllönen (2020), the changes in the contexts we discovered seemed to play a crucial role in teachers' *Technological Pedagogical Knowledge* (TPK) development. The discussion in the focus-groups revealed that applied sciences university teachers received important support to their digital competence development from the meso level context, their educational institution. The university of applied sciences offered long-term support in the pedagogical use of technologies by mentoring, in-service training, and investing in technologies designed for pedagogical purposes.

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Quote 2:

> *"We are offered very good chances (for digitalization) in our university. I have had possibilities to work as a teacher online ... I think it's over 20 years now … I mean totally in distance education."*

The macro level context also has an impact. National digitalization policies for education (Higher Education Institute's Digivision 2030) offer a vision, guidelines, and resources for HE institutions in fostering digitalization and improving teachers' digital skills.

Digital disruption of bioeconomy challenges teachers' Technological Content Knowledge (TCK)

The interviewees in our study connected the meaning of digitalization strongly to the on-going digital transformation of their discipline; the application of digital technologies and digitalized data in the bioeconomy. In line with the description of Satpute and colleagues (2017), bioeconomy teachers were aware that rapidly innovative technologies offer many new possibilities for data-driven knowledge creation in the bioeconomy, for example, in the production of renewable biological resources and their conversion into food, feed, and bio-based products. They also mentioned digital monitoring and data flow systems, digital networks and supply chains, and social media as examples of current digital disruption in their discipline.

Quote 3:

> *"If I think (digitalization) on my own subject area, I would mention geographical information systems and management of different applications. Collecting geographical information, digital data gathering and sharing, and data flows. For instance, in different phases of forestry … from the woods to the factories to the ready-made products."*

Although applied sciences teachers' perceptions of digitalization in pedagogy were quite positive, one common view amongst the interviewees in relation to digitalization in their field or in the industry was slightly worrisome. They expressed their concerns, that there will soon be an urgent need to update not only their *Content Knowledge* (CK), but especially their *Technological Content Knowledge* (TCK), due to the rapid digital disruption in the bioeconomy.

The discussion of this theme echoed that digitalization in the bioeconomy has a strong impact on both teachers' CK and TCK, and that these two cannot be separated. Instead, they are intertwined because technology-enhanced working methods are in a complex interaction with content of the bioeconomy. Accordingly, Koehler and colleagues (2013) also highlight that:

> *"technology and content knowledge have a deep historical relationship. Progress in fields as diverse as medicine, history, archeology, and physics have coincided with the development of new technologies that afford the representation and manipulation of data in new and fruitful ways. Consider Roentgen's discovery of X-rays or the technique of carbon-14 dating and the influence of these technologies in the fields of medicine and archeology. Consider also how the advent of the digital computer changed the nature of physics and mathematics and placed a greater emphasis on the role of simulation in understanding phenomena".*

Many of the interviewees speculated that applied sciences university teachers may have quite limited opportunities for updating their discipline's CK and TCK during the rapid changes. When the teachers were asked how they currently develop their substantial knowledge, they described several proactive methods related mainly to informal activities, like knowledge sharing with colleagues and following research and development in the field and relevant businesses. Despite these initiatives, the interviewees seemed to wish for a more systematic and strategic approach, along with support for continuous development of CK and TCK. A common view amongst the interviewees was that the profession of a bioeconomy teacher is currently in a flux.

The teachers also recognized that their meso level context was positively "nudging" their CK and TCK development. This is because the university had recently chosen smart and sustainable bioeconomy as a strategic emphasis, and founded several RDI-projects on the topic (Ryymin et al., 2020). One applied sciences teacher also highlighted the importance of the micro level context for developing teachers' knowledge, as teachers may learn from their students, for example, via project-based learning and in shared problem-solving.

Conclusions

The goal of this paper was to find answers to the following research questions: 1) *What kind of meanings*

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do teachers give to digitalization in their work? and 2) *How does the digitalization of the bioeconomy connect with teachers' Technological Pedagogical Content Knowledge (TPACK)?*

The profession of an applied sciences university teacher in the field of bioeconomy is in a flux due to rapid current digital disruption of the industry. Following the framework of TPACK (Mishra & Koehler, 2006; Koehler et al., 2013), the teachers in this study considered themselves quite competent in their *Technological Pedagogical Knowledge* (TPK), *Pedagogical Knowledge* (PK), and CK related to current (university) curricula. However, they expressed concerns about updating in the near future their CK, and especially their TCK. Despite having many proactive initiatives to update their knowledge, they longed for a more strategic approach to develop their disciplinary knowledge, intertwined with technological innovations. Research, development, and innovation activities, along with stronger partnerships and collaboration with the bioeconomy industry and businesses were mentioned as important activities for teachers in embracing digital disruption. Also, the micro, meso and macro level contexts were deemed as meaningful for applied sciences teachers' development. Positive changes in these contexts may accelerate positive development in teachers' knowledge components. Hence, the strategies of HE institutions play an important role in teachers' knowledge development and adaptation to global changes.

The TPACK-framework states that the core components of teachers' knowledge are in continuous interaction and co-development. Challenges and changes in one core component, sooner or later, effect the other components. Therefore, when supporting teachers to reconcile changes in a disruptive industry, one must pay attention to the co-developing all of the knowledge components. Especially, teachers should have strategies and approaches to develop systematically their *Content Knowledge* (CK) and *Technological Content Knowledge* (TCK) as related to their rapidly transforming discipline.

An applied sciences university teacher can become an agent of change by systematized development, as suggested by Pozos and Torelló (2012). They can commit to generate and share new knowledge in a critical and responsible way. In future research, it will be important to find out what kinds of possibilities and challenges bioeconomy teachers face in their continuous learning and content knowledge development at work. Likewise, questions arise about how to support teachers' development efficiently and optimally during transformations in the digital age.

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References

Amhag, L., Hellström, L. & Stigmar, M. 2019. Teacher Educators' Use of Digital Tools and Needs for Digital Competence in Higher Education. *Journal of Digital Learning in Teacher Education*, 35(4): 203-223. DOI: 10.1080/21532974.2019.1646169

Autor, D., Mindell, D., & Reynolds, E. 2020. The Work of the Future: Building Better Jobs in an Age of Intelligent Machines. *MIT Task Force on the Work of the Future*. https://workofthefuture.mit.edu/wp-content/uploads/2021/01/2020-Final-Report4.pdf

Balafoutis, A., Beck, B., Fountas, S., Vangeyte, J., Van der Wal, T., Soto, I., Gómez-Barbero, M., Barners, A. & Eory, V. 2017. Precision Agriculture Technologies Positively Contributing to GHG Emissions Mitigation, Farm Productivity and Economics. *Sustainability,* 9(8): 1339. DOI: 10.3390/su9081339

Baumüller, H. 2018. The little we know: an exploratory literature review on the utility of mobile phone enabled services for smallholder farmers. *Journal of International Development*, 30(1): 134-154. DOI: doi.org/10.1002/jid.3314

Braun, V. & Clarke, V. 2006. Using thematic analysis in psychology. *Qualitative Research in Psychology*, 3(2): 77. DOI: 10.1191/1478088706qp063oa

Bugge, M.M., Hansen, T., &%Klitkou, A. 2016. What is the bioeconomy? A review of the literature. *Sustainability*, 8(7): 691. %DOI: 10.3390/su8070691%%

Dawkins, M. 2017. Animal welfare and efficient farming: Is conflict inevitable? *Animal Production Science*, 57(2): 201. DOI: 10.1071/AN15383

European Commission. 2012. Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions. *Innovating for Sustainable Growth: A Bioeconomy for Europe*. Retrieved January 8, 2021 from: http://ec.europa.eu/research/bioeconomy/pdf/official-strategy_en.pdf

From, J. 2017. Pedagogical Digital Competence — Between Values, Knowledge and Skills. *Higher Education Studies*, 7(2): 43-50. DOI: 10.5539/hes.v7n2p43

Gartner glossary (n.d.). Digital disruption. Retrieved February 1, 2021 from: https://www.gartner.com/en/information-technology/glossary/digital-disruption

Higher Education Institutes Digivision 2030. (n.d.) Retrieved January 8, 2021 from: https://digivisio2030.fi/wp-content/uploads/HEI-Digivision-2030.pdf

Ilomäki, L., Paavola, S., Lakkala, M. & Kantosalo, A. 2016. Digital competence —an emergent boundary concept for policy and educational research. *Education and Information Technologies*, 21(3): 655-679. DOI: 10.1007/s10639-014-9346-4

Ingram, J., & Maye, D. 2020. What Are the Implications of Digitalisation for Agricultural Knowledge? *Frontiers in Sustainable Food Systems*. DOI: 10.3389/fsufs.2020.00066

Kereluik, K., Mishra, P., Fahnoe, C. & Terry, L. 2013. What Knowledge is of Most Worth. *Journal of Digital Learning in Teacher Education*, 29(4): 127-140. DOI: 10.1080/21532974.2013.10784716

Klerkx, L., Jakku, E. & Labarthe, P. 2019. A review of social science on digital agriculture, smart farming and agriculture 4.0: New contributions and a future research agenda. *NJAS - Wageningen Journal of Life Sciences*, 90-91: 100315. DOI: 10.1016/j.njas.2019.100315

Klitkou, A., Bozell, J., Panoutsou, C., Kuhndt, M., Kuusisaari, J. & Beckmann, J.P. 2017. Bioeconomy and digitalization. Background paper. *MISTRA The Swedish Foundation for Strategic Environmental Research*. Retrieved January 8, 2021 from: https://www.mistra.org/wp-content/uploads/2017/12/Bilaga-1-Bakgrundsdokument-Bioeconomy-and-Digitalisation.pdf

Koehler, M.J., Mishra, P. & Cain, W. 2013. What is technological pedagogical content knowledge (TPACK)? *Journal of Education*,193(3): 13-19. DOI:10.1177/002205741319300303

Kyllönen, M. 2020. Teknologian pedagoginen käyttö ja hyväksyminen. Academic dissertation. University of Jyväskylä. Retrieved January 9, 2021 from: http://urn.fi/URN:ISBN:978-951-39-8057-3

Lamberg, L., Ryymin, E. & Vetoshkina, L. Forthcoming. Value Dimensions in Interdisciplinary Research: Facilitating Research Problem Formulation in Smart Bioeconomy. *Manuscript submitted for publication.*

Ministry of the Environment Finland. 2014. The Finnish Bioeconomy Strategy. Retrieved January 8, 2021 from: https://www.biotalous.fi/wp-content/uploads/2014/08/The_Finnish_Bioeconomy_Strategy_110620141.pdf

Mishra, P. & Koehler, M.J. 2006. Technological pedagogical content knowledge: A framework for teacher knowledge. *Teachers College Record*, 108(6): 1017-1054. DOI: 10.1111/j.1467-9620.2006.00684.x

Mulder, M. 2017. A Five-Component Future Competence (5CFC) Model. *The Journal of Agricultural Education and Extension*, 23(2): 99-102. DOI: 10.1080/1389224X.2017.1296533

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OECD. 2020. Digitalisation in the bioeconomy: Convergence for the bio-based industries. *The Digitalisation of Science, Technology and Innovation: Key Developments and Policies.* Paris: OECD Publishing.
DOI:10.1787/bd16d851-en

Porras-Hernández, L.H. & Salinas-Amescua, B. 2013. Strengthening TPACK: a broader notion of context and the use of teacher's narratives to reveal knowledge construction. *Journal of Educational Computing Research*, 48(2): 223-244.
DOI: 10.2190/ec.48.2.f

Pozos, K. & Torelló, O. 2012. The Digital Competence as a Cross-Cutting Axis of Higher Education Teachers' Pedagogical Competences in the European Higher Education area. Procedia - Social and Behavioral Sciences, 46: 1112-1116.
DOI: 10.1016/j.sbspro.2012.05.257

Rintala, H., Ryymin, E., Postareff, L. & Lahdenperä, J. Forthcoming. Higher Education Teachers as Continuous Learners: A Mixed Methods Study on Learning Needs and Informal Workplace Learning in a University of Applied Sciences in a Field of Bioeconomy. *Manuscript in preparation.*

Ryymin, E., Lamberg, L., & Pakarinen, A. 2020. How to Digitally Enhance Bioeconomy Collaboration: Multidisciplinary Research Team Ideation for Technology Innovation. *Technology Innovation Management Review*, 10(11): 31-39.
DOI: doi.org/10.22215/timreview/1401

Satpute, S.K., Płaza, G.A., & Banpurkar, A.G. 2017. Biosurfactants' Production from Renewable Natural Resources: Example of Innovative and Smart Technology in Circular Bioeconomy. *Management Systems in Production Engineering*, 25(1): 46-54.
DOI: doi.org/10.1515/mspe-2017-0007

Skog, D.A., Wimelius, H. & Sandberg, J. 2018. Digital Disruption. *Business & Information Systems Engineering*, 60(5): 431-437.
DOI: doi.org/10.1007/s12599-018-0550-4

Stevens, T.M., Aarts, N., Termeer, C.J.A.M. & Dewulf, A. 2016. Social media as a new playing field for the governance of agro-food sustainability. *Current Opinion in Environmental Sustainability*, 18: 99-106.
DOI: /10.1016/j.cosust.2015.11.010

Terry, G., Hayfield, N., Clarke, V. & Braun, V. 2017. Thematic analysis. In Stainton Rogers, W. & Willig, C. (Eds.), *The SAGE Handbook of Qualitative Research in Psychology* (2nd edition), London: SAGE Publications: 17-37.
DOI: /10.4135/9781526405555.n2

Yeates, W.J. 2017. How Good? Ethical Criteria for a "Good Life" for Farm Animals. *Journal of Agricultural and Environmental Ethics*, 30: 23-35.
DOI: /10.1007/s10806-017-9650-2

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