

Quality of Sustainable Experience (QoSE)

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Abstract

This report documents the program and the outcomes of Dagstuhl Seminar 23042 “Quality of Sustainable Experience (QoSE)”. The seminar aimed to bring together people from different fields, perspectives and backgrounds. The participants discussed how experiences – as the main selling point of products and services – in various ICT-related domains can be made more sustainable, how they can contribute to relevant sustainable development goals, and how the quality and degree of sustainability of such experiences may be evaluated and be better understood. The main objectives of the seminar were to foster new alliances, to inspire, to trigger scientific renewal, as well as to identify future opportunities and research challenges through a hands-on approach.

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1 Executive Summary

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In line with the shift towards a more experience-centered paradigm in product and service design, Information and Communication Technology (ICT) is seen as an important enabler of immersive, and potentially transformative digital experiences. As such, ICT has a huge potential to address fundamental human needs (e.g., experiencing pleasure, relatedness); to tackle “slow-change problems” (e.g., adopting a sustainable lifestyle) and to keep up important social functions also in times of crisis (e.g., distance education, communication, entertainment) through experiences. However, two non-negligible downsides of ICT are its potential negative impact on wellbeing (e.g., addiction, blurring online/offline identities), and its growing ecological footprint, with ever-increasing demands to satisfy the Quality of Experience (QoE) of increasingly spoiled users.

* Editor / Organizer



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On this background, this Dagstuhl Seminar set out to discuss the topic of “Quality of Sustainable Experience”, and hence the challenge of how to transform existing physical and digital experiences into more sustainable (ideally fossil-free), yet human-centered and well-appreciated ones. The aim was to bring together experts from different fields addressing the multi-faceted topic from their own perspective, using their distinct tools and methods. The main objectives with the seminar were to foster new alliances, inspire, trigger scientific renewal, as well as to identify future opportunities and research challenges through a hands-on approach. The participants discussed how experiences – as the main selling point of products and services – in various ICT-related domains can be made more sustainable, how they can contribute to relevant sustainable development goals, and how the quality and degree of sustainability of such experiences may be evaluated and be better understood. The seminar adopted a bottom-up approach to identify key areas for future work within the outlined scope and converged into four topics that were further discussed in smaller groups, with the aim of better understanding current knowledge gaps and challenges and to identify topics and areas where the represented disciplines could – in the short to longer term future – make a genuine impact towards more sustainable ICT-based experiences.

The group discussions during the seminar centered around four main topics, namely (1) collaborative XR and remote attendance, (2) quantification / measures of QoSE, (3) ICT as a means to drive sustainability and (4) Needs versus greeds. During the discussions, the groups identified a set of challenges and generated “NOW”, “WOW” and “HOW” ideas [1], which are described further in Section 5.

The seminar has already resulted in a number of spin-off activities, for example at the 15th International Conference on Quality of Multimedia Experiences (QoMEX 2023), having a particular focus on the transition towards more inclusive and sustainable multimedia experiences. More concretely, the conference is hosting a special session involving several seminar participants and organizers entitled “Towards the design and evaluation of sustainable multimedia experiences”, and one of the seminar participants was invited to give a keynote at the conference. Another concrete outcome is the initiative to apply for funding of a COST Action in order to build a community on the topic of QoSE. Finally, a video trailer has also been compiled to put focus on and raise awareness of the topics discussed at the seminar [2].

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3 Overview of Talks

3.1 Let's talk about designing Sustainable Interactions through Accessibility

Stepanie Arevalo Arboleda (TU Ilmenau, DE)

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 Stepanie Arevalo Arboleda

My current research focuses on experiences in immersive environments (augmented and virtual reality) together with the use of robotic systems to enhance communication for the aging population. Designing for sustainable interactions could be approached from an inclusive perspective, where technology is conceived and designed to allow for adaptable experiences. Sustainability through accessibility can be approached methodologically by understanding the current experiences of people with disabilities and the aging population using participatory design and experience-driven design. I consider that Sustainable HCI and QoSE could also include Disability Interaction and accessibility when conceptualizing sustainable experiences that go beyond designing for sustainable technology but invite reflection on technologies' uses and evoke self-evaluation of intentions and behavior. I would like to encourage discussions on how to include Disability Interaction and Accessibility in the QoSE agenda.

3.2 The user experience of assessing ethical issues of AI systems

Emma Beauxis-Aussalet (VU University Amsterdam, NL)

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 Emma Beauxis-Aussalet

The users are tasked with assessing the ethical issues of AI systems, at different phases of a system life cycle. The users have very diverse backgrounds, e.g., with technical expertise or domain expertise(s) – but are generally Dutch. A most characteristic element of the user experience is the knowledge gap(s) between users, between users and the technology, or between users and the domain (e.g., poverty prevention, fraud detection, resource allocation). It makes collaboration between diverse stakeholders essential to succeed with the task. Misunderstandings and miscommunication are key issues in such collaboration. Fear and stress are also inherent to the user experience, due to the many impacts of AI on society – some of which already had devastating consequences. Conflicts of interests also arise, e.g., between technology suppliers (especially contractors) and policy makers. Our work relates to many societal aspects of sustainability, especially considering the many impacts of AI on sustainability. But energy consumption is outside of our scope.

The specificity of our approach is not to design new user interfaces, visualisations, or tutorials. Instead, we first focus on designing the assessment techniques (e.g., the appropriate metrics, statistics, sampling method), and designing the human organisation that is needed for assessing AI (e.g., gathering people with the right set of skills and responsibilities). But to do so, user-centered design may prove harmful (sometimes) due to the many knowledge gaps between stakeholders. Conflicts of interest are particularly important and challenging, and may occur in many endeavours towards sustainability – which is often considered an overhead with unwelcome costs.

3.3 Sustainable and inclusive innovation

Michael Best (Georgia Institute of Technology – Atlanta, US)

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My overall research focuses on computing and global development. I use the UN SDGs to frame a lot of my work and so pain sustainability with a broad brush. One of my current projects is focused on inclusive innovation and sustainable entrepreneurship with a focus on the East Asia region. We are aiming to collaboratively develop up some new programs/facilities in Taiwan and perhaps Thailand. I would love to learn from this community inspired ways that we can act as valuable, ethical, and humble global collaborators as we partner on this endeavor.

3.4 Connecting people


Pablo Cesar (CWI – Amsterdam, NL)

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My research combines human-computer interaction and multimedia systems, focusing on modelling and controlling complex collections of media objects (including real-time media and sensor data) that are distributed in time and space. My aim is to better integrate core human-computer interaction methodologies and computer science research. In particular, I am interested on “connecting people”: how we can make remote togetherness possible. Since 2005, I have been involved in a number of research projects on Social TV, multi-party videoconferencing, and more recently social XR as a collaboration and communication medium. We are moving towards a connected intelligent world, in which always-on sensing and monitoring enable rich immersive media experiences (remote working, medical consultation, online cultural heritage experience, entertainment). These systems help towards a more resilient society, providing the means to communicate across distance in meaningful and natural manners, thus reducing the travel needs. Still, apart from the usage of resources, there are many sustainability goals, as identified by the UN: quality of education, good health, gender equality, decent work and economic growth, resilient infrastructure, sustainable cities and communities. My hope in this seminar is to discover the work of others and better understand how we as scientists can address the overall picture.

3.5 Towards more humane and sustainable experiences supported by digital technology

Katrien De Moor (NTNU – Trondheim, NO)

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Recent forecasts show an alarmingly high carbon footprint of ICT in the middle-term future, due to, among others, the increasing energy demand of data centres, as well as increasing use and consumption, including unsustainable use and viewing practices (e.g.,

binge-watching, media-multitasking), which have become more common over the last years and have partly been associated with negative health and wellbeing effects. Moreover, the wide range of experiences enabled by digital technology (e.g., XR, AI and IoT-supported smart environments) come with a growing number of ethical concerns (e.g., safeguarding meaningful human agency, designing for genuine empowerment, privacy under threat, inclusivity and equity), which should be even more prominently on the agenda. Through my research, I aim to subscribe the growing plea for a shift towards a more sustainable and humanity-centered paradigm, which considers to a much larger extent how digital consumption, increased user expectations and data demand may impact individuals, society at large and our environment and which wants to better “align technology with humanity’s best interests” (see e.g., humanetech.com). My interest and activities in this area are grounded in human-centered approaches and focus on:

1. Aspects related to the design, evaluation and use of audiovisual media (e.g., video conferencing, video streaming, immersive applications) and deal with aspects related to improving these more sustainable experiences, supporting inclusion and triggering more sustainable use practices.
2. The need to better understand users’ awareness (and lack of it) of their own “invisible” digital carbon footprint; and explore strategies and concrete mechanisms that may help to trigger more conscious and responsible consumption (both from the well-being- and environmental point of view).
3. Human- and humanity-centric design principles and the need for meaningful ways to evaluate whether desired outcomes such as empowerment, meaningful human agency, inclusivity, equity are reached.

3.6 Sustainable Software Engineering for Sustainable Development

Yvonne Dittrich (IT University of Copenhagen, DK)

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I would like to share 2 research points: 1) In a project on “Sustainable Irrigation Advice for Mid-Himalayan Farmers using Smart satellite Image Analysis” we address sustainability in 3 different ways:

1. Water management is part of climate change mitigation
2. We apply co-design to embed the irrigation advice in the farmers’ irrigation practices
3. The project aims at not only addressing the technical feasibility, but also the economically viable deployment and evolution by taking a software ecosystem approach.

The other project explores the development of domain specific standards of reporting of environmental and societal impacts and corporate governance. The European Commission is developing legislation for reporting and investors increasingly ask for this data. In future we will be accountable for the energy consumption of our services. In both cases, technical solutions need to take the needs of different actors and stakeholders into account. They need to support cooperation of heterogeneous stakeholders and support decentralised governance structures.

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3.7 Designing Sustainable Experiences

Markus Fiedler (*Blekinge Institute of Technology – Karlshamn, SE*)

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Sky-rocketing energy prices have increased our awareness of resource limitations. Having worked with quality-versus-energy tradeoffs since 2010, the emerging multi-reality digiphysical experiences make me curious of their potential to reduce environmental footprints without sacrificing the essentials of the experiences. Bringing together the “Research through Design” and “Quality of Experience (QoE) by Design” [1] principles, I see a great potential to create beyond-expectation immersive experiences with sustainability in mind, for instance Extended Reality (XR) telemeetings. Thereby, creative design of experimental artefacts based on fundamental relationships between QoE and provisioning, measurements and modelling efforts will pave the way towards optimised quality-versus-energy performance, expressed for instance through measures such as “QoE per Watt” (QoEW) or “QoE per Joule” (QoEJ) [2] – or as “QoE per kWh” (QoEkWh) that relates directly to the energy bill.

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3.8 Energy-Efficient Video Communications


Christian Herglotz (*Universität Erlangen-Nürnberg, DE*)

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Nowadays, research targeting the energy efficient use of video communication technology is an important research topic. In this respect, our team focuses on the energy consumption of two important aspects in a video communication pipeline: First, the generation, compression, and provisioning of videos, second, the consumption of videos on end-user devices. Methodologically, we usually start by measuring the energy consumption of a video system, then analyze the behavior with respect to parameters such as hardware, software, and video properties, and come up with numerical models that are further exploited to reduce the energy consumption. We noticed that next to the energy efficiency of distinct devices, the overall energy consumption of video services draws more and more attention in academia and industry. Hence, in this seminar, interesting challenges are to jointly optimize the energy consumption of distinct devices and a complete video service while keeping a high QoE for the end user.

3.9 Sustainable Remote Work: How to make virtual / hybrid conferences enjoyable?

Oliver Hohlfeld (Universität Kassel, DE)

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Many processes in work environments (including the prominent publication mode in Computer Science with in-person gatherings to present research output) have relied on in-person meetings, which often require travel. For many researchers, traveling to conferences may well be a significant, or even largest, contributor to their annual carbon footprint. To be sustainable, alternative processes – such as virtual and hybrid attendance modes – need to be established. To be successful, these must meet the goals of the gathering and provide a high experience (QoE). How to make virtual and hybrid meetings enjoyable and therefore sustainable is a question directly related to QoE research. To address this, I have studied the QoE of virtual conference attendance via a survey approach that identified areas in which this mode works and also exposes its limits. As a future trend, hybrid conferences are having their moment, primarily due to the prolonged and open-ended transition period from the COVID-19 pandemic. While hybrid conference also address rising concerns relating to the carbon footprint of air travel. Further, they promote inclusiveness of members of the community, e.g., those that are not able to attend due to family obligations, budget restrictions, difficulties obtaining a visa or disability. Yet, it remains unclear of how to design hybrid conferences well to achieve a high participant QoE, which will be an upcoming challenge to the QoE community. This imposes a direct question to this seminar on how to make work processes – such as hybrid attendance – enjoyable and thus sustainable by means of QoE research.

3.10 A Greener Experience: Trade-offs between QoE and CO₂ Emissions in Today's and 6G Networks

Tobias Hofffeld (Universität Würzburg, DE)

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Main reference Tobias Hossfeld, Martin Varela, Lea Skorin-Kapov, Poul E. Heegaard: “A Greener Experience: Trade-offs between QoE and CO₂ Emissions in Today's and 6G Networks”, IEEE Communications Magazine, pp. 1–7, 2023.

URL <https://doi.org/10.1109/MCOM.006.2200490>

Quality of Sustainable Experience raises several research questions which are addressing the different pillars of sustainability: human, social, economic, environmental. In particular, environmental sustainability calls for the following: What is the trade-off between QoE and CO₂ emission? How can an optimal operational point be derived in practice? Is the ratio of goodness, e.g. QoE, and badness, e.g. CO₂ emissions, e.g. energy consumption, a meaningful key value indicator (KVI) for today's and 6G networks? This ratio goodness to badness is Kleinrock's power metric from queueing theory. How much reduction in CO₂ emission can be achieved by a green user as compared to a high-quality user? How much reduction in CO₂ emission can be achieved by moving towards a green network? What is the relative impact on the reduction of CO₂ emissions of green user behavior as compared to green networking? Is it more relevant to focus (i) on green user behavior and empowering green user behavior or (ii) on green networking technology today and in the future in year 2030? What are the implications of solution approaches on the networking and communications technology?

3.11 Ecologically Valid Experiments

Lucjan Janowski (AGH – Univ. of Science and Technology – Krakow, PL)

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I work mainly with classical video quality. Right now, I am developing a Virtual Reality Laboratory. So I expect to work more with VR/AR in the context of 5G. My main focus right now is the development of ecologically valid experiments. Ecologically valid experiments are closer to the real-life scenario. We expect that such experiments can reveal situations where quality is less important than concluded from a classical lab study. It gives an option for further optimization of network resources, limiting energy consumption. Further, quality should not be the only goal and the trade between quality and the resources used should be better understood. An important component is not only the network, but also the habits of the users, like playing music from video, not even watching. A different essential aspect of the quality system is the development of algorithms for recompression from clear energy. We have to understand quality and user behavior outside the laboratory. Only then can specific solutions be proposed.

3.12 Sustainable India and World

Ashok Jhunjunwala (IITM Research Park – Madras, IN) and Reema Saha (IITM Research Park – Madras, IN)

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© Ashok Jhunjunwala and Reema Saha

It was good to see young academicians from so many countries, concerned about the society and the world. On the one hand, they worry that climate change could do an irreparable damage to our earth in coming years. On the other hand, most of them felt somewhat powerless, as big Governments and big industry seem to drive every aspect of life on planet. The youngsters work very hard to just have a decent life. They seem to be powerless in the current situation. Recognising this, the seminar attempted to do two things. The first was the little actions that they could carry out individually and in groups to start making some difference. The second was to dream of a future society – may be 100 years from now. What would be the norms and ways such that the people would really be empowered, free from the control of big governments and big industry. The participants knew that it was a mere beginning, but felt that even imagining a future society would be the first step to move towards such society in future.

3.13 Multisensory User Experience in eXtended Reality

Effie Lai-Chong Law (Durham University, GB)

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One of my current research foci is multisensory user experience (MUX) in extended reality (XR). Given the immersive and presence experience enabled by XR, the number of XR-based applications is ever-increasing, especially for social interaction such as in games, therapy, and

training. Avatars representing interactants are typically used. Non-verbal sensory signals (i.e. facial expression, gesture, gait) are essential for emotion portrayal. The MUX of social XR is determined by the extent to which intended emotions can be conveyed and recognized by the interactants. As XR technologies are highly energy-demanding, they can have a very negative impact on sustainability. The higher the avatar fidelity is, the higher the MUX quality can be, but the higher the energy consumed and costs. To address how to improve the greenability of XR, I am investigating how the avatar fidelity can be minimised but without compromising the perception and recognition of the intended emotions required for successful social interaction and quality MUX. Extensive user-based studies are designed to identify the minimum fidelity level for each type of sensory signal per emotion in a range of contexts. Advanced rendering techniques and machine learning models for adjusting avatar fidelity will be deployed. How MUX varies with different avatar fidelity levels will be evaluated. Overall, the main challenges are to scope the large problem space, considering the nature of emotion and the rapid growth of XR tech and techniques.

3.14 Imagination, Climate Futures, and the Qualities of Sustainable Experiences

Dan Lockton (TU Eindhoven, NL)

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My work explores designing tools for participatory (re-)imagining and futuring in an age of transitions (and crises) in climate, energy, health, and social inequalities. How we experience the world (interacting with technology, but also how we encounter societal and infrastructural systems) affects how we imagine, understand, live, and what we see as possible in our collective futures, with consequences for sustainability. Design has an important role to play in engaging with imagination and futures, and the urgency of climate crisis makes this acute: enabling people to share their experiences with others, giving voice to underrepresented experiences, and turning ideas into prototypes (including interfaces) which can be experienced, used, lived with, and reflected upon. Designers can bring plural possible futures to life, in the present. I see the qualities of how we experience the systems around us as important in building more sustainable ways of thinking and acting – better connections to impacts, consequences, and each other.

3.15 sustainability storytelling: mobilizing transformation

Colin Maclay (USC – Los Angeles, US)


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While I integrate research, teaching and engagement like any good faculty member, I am a hacker of universities and find that a lot of my attention goes to less traditional work like community creation, demonstrating different ways to do things and building new institutions. I lead fellowships, research groups and programs for troublemaking practitioners and scholars, host a podcast on popular culture and social change, create welcoming and non-hierarchical environments and try to engage respectfully and generatively with the community and the

world. After decades spent on the interaction of information and communications technology with organizational and institutional change, I have spent recent years more focused on sustainability, environmental justice and climate change, finding significant overlap and complementarities. A large part of my current attention is on reorienting the functions of my university around sustainability, where I focus primarily on research and engagement (and leadership, of course). I've learned that seeking a sustainability orientation echoes the challenges of the digital, diversity and other transformations before it, requiring not just modest changes to what we do or who we hire, but fundamental shifts for both individuals and organizations in how we see ourselves, our practices and our mission. It confronts identity, asks that we engage emotional complexities, requires us to engage our imagination, create different systems, communicate differently and address other seemingly distant considerations. I'm excited to hear what others are thinking about, experimenting with and learning as we navigate the unseen and deeper barriers that will begin to allow the sort of transformational developments that facilitate not just human survival, but thriving.

3.16 How to characterize QoSE [kō-zē] experiences?

Alexander Raake (TU Ilmenau, DE)

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We investigate perception and experience for traditional and immersive audiovisual media, including video (e.g., high-resolution, high dynamic range), spatial audio, and technology for Augmented, Virtual and Mixed Reality (AR/VR/MR). Two types of “resources” may be considered in terms of sustainability: (1) Human mental and physical resources, for example measuring fatigue for telemeetings versus face-to-face, or the positive impact on wellbeing with mediated social presence. (2) Energy and natural resources consumed along the end-to-end chain (e.g., by one media system implementation versus another), or resources saved (e.g., meeting via videoconferencing or MR rather than travelling). In this context the question arises, how “sustainable experiences” can best be characterized, and the result be applied towards a more sustainable way of life. A holistic and collaborative approach is needed to achieve this. Here, I see the QoSE seminar as a possible crystallization point for sharpening the participants' views and future collaborative work.

3.17 From QoE to Digital Humanism and Digital Ecology


Peter Reichl (Universität Wien, AT)

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Over the years, QoE turned out to be very successful in redirecting the attention of the communication networks community towards the user. However, the current multiple crises indicate that we have to extend our perspective on both sides, leading to two key questions: (1) Do we have the technology we need, and do we need the technology we have? (2) Which world are we currently building? Recently, several new movements formed to address these issues, especially in the context of the “Vienna Manifesto on Digital Humanism” or the “Rat für Digitale ökologie Berlin”. That leads to question number (3): What can QoE research learn from, and how can QoE research contribute to this broader perspective on the Digital Change?

3.18 Moodlebox: A Broadband Connectivity with Sustainable Quality of Experience for e-Learning in Rural and Remote Areas?


Fatuma Simba (University of Dar es Salaam, TZ)

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Rural areas are characterized by scattered settlements, lack or limited Information and Communication Technologies (ICT), hence they are disadvantaged in accessing e-learning resources. Different technologies have been proposed to address broadband connectivity for e-learning in rural and remote areas, such as the 3G UMTS operating in the 900MHz frequency band, and the Television White Spaces (TVWS), due to their wider coverage and capability to offer broadband connectivity. However, further research revealed that broadband networks configured in the best-effort approach cannot deliver video streaming with the required QoS for e-learning, which implies that users will end up unsatisfied, hence poor quality of experience. Trends in e-learning shows development of MoodleBox, which is a standalone mobile device that can provide both local broadband connectivity and e-learning resources. Potential research area here is to evaluate performance of MoodleBox in delivering multimedia e-learning contents in rural settings towards sustainable quality of experience in e-learning.

3.19 How to assess the value of services more holistically

Sascha Spors (Universität Rostock, DE)

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We work in the field of digital signal processing with a focus on the processing of audio and medical signals. Many applications and services use signal processing to extract information, for signal enhancement, or for transformation into other representations. While traditionally, model-based techniques played a much more prominent role, the employment of data-driven methods (machine learning, artificial intelligence) has increased significantly in recent years. This enabled significant breakthroughs, for instance, in speech recognition. However, in many cases, at the cost of increased resource consumption and corrupted privacy. While some of the current and upcoming technical possibilities are of great use to society, their employment is often discussed on an economic level only, and sustainability plays a minor role. I want to discuss how we can assess the benefit of new applications and services more holistically, including society, sustainability, and economics.

3.20 Innovation experience management

Fee Steinhoff (Hochschule Koblenz – Remagen, DE)

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Innovation experiences result from the (often unconscious) comparison of needs and offer and lead to emotion, cognitions and actions. For a convincing innovation experience, the following areas need to be actively “managed”:

- Utility: Is the innovation addressing “real” human problems and needs which are relevant to the target customers? (exemplary tool: jobs-to-be-done approach).
- User Experience: Is the innovation providing a convincing experience in the product and usage context? Is the user able to use the innovation easily and does the user like the way the innovation looks and feels? (exemplary tool: iterative UX prototyping & testing).
- Customer Experience: Is the innovation providing a convincing experience in the broader market context? For example, does the innovation create positive moments of truth and emotional binding along the whole customer journey? (exemplary tool: customer experience blueprinting).
- Transforming innovation experiences into more sustainable ones is obviously a very challenging task in our days. From a management perspective, exemplary questions are: How can innovators create convincing sustainable innovation experiences? How should innovators deal with the current “more, better, higher” consumption mantra? Which tools and methods are helpful to create sustainable innovation experiences (e.g. sustainable business model design patterns)? etc.

3.21 Digitalization supporting the integration of sustainability in product development tools

Denny Carolina Villamil Velasquez (Blekinge Institute of Technology – Karlskrona, SE)

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Researching in the field of sustainable product development and supporting manufacturing companies, we have identified that companies struggle to integrate sustainability in their processes. In Blekinge Institute of Technology, we have developed and tested tools and methods to guide companies to adopt a strategic sustainability perspective based on the Framework for Strategic Sustainable Development, by considering a holistic view, the environmental, economic and social dimensions of sustainability, the assessment of the complete product lifecycle, stakeholders’ collaboration and a long-term perspective. Finding that the sustainable society transformation requires the participation and support of many fields, where digitalization can be used to support this transformation. Moreover, digitalization might facilitate manufacturing processes and the usability of decision-support tools to develop solutions with a higher sustainability performance. Therefore, it is essential to discuss how digitalization can support the implementation of sustainability, considering trade-offs and additional requirements e.g., knowledge, infrastructure, management, social interaction and circularity.

3.22 QoSE for immersive communication

Irene Viola (CWI – Amsterdam, NL)

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Remote telepresence is essential to enable connection among users at a distance, facilitating communication and collaboration, while decreasing the amount of travelling and commuting required; as such, it has become a key point in research agendas both in the European

and national level to create sustainable travel habits and more liveable cities. Current telepresence solutions for telepresence have been shown to create exhaustion and fatigue, due to the unnatural way in which communication takes place, such as limited mobility and close-distance eye gaze. Extended Reality (XR) telecommunication systems promise to overcome the limitations of current real-time teleconferencing systems, enabling a better sense of immersion, enhancing the sense of presence and fostering more natural interpersonal interactions. To achieve their goals, they need to be designed keeping the user as the central perspective. How can we optimize the quality of such systems, such that they can maximise the Quality of Experience for the user, while ensuring the sustainability of their operating principles? How can we incorporate Quality of Sustainable Experience in the design, implementation and evaluation of such systems?

3.23 Beyond Human-Centeredness in Experience Design for Sustainability

Kaisa Väänänen (University of Tampere, FI)

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I work with experiences that drive ways in which people's activities in the world can be more sustainable, both socially and environmentally. Recently, together with my team we have worked a lot with AI-driven systems such as social robots and the ways in which they could motivate/persuade people act more sustainably. (At the same time realising that hardware robots may not be very sustainable in themselves.) Methodologically, we employ human-centered design thinking, and especially co-design and co-creation approaches, both in-situ and (when needed, e.g. due to pandemic) online. We also work with industry to help them adopt Human-Centered AI (HCAI) design approaches. It is timely and relevant for sustainable experience design to move beyond human-centeredness, towards what has been labeled as “post-human”, “more-than-human” or “planetary” design by various authors. While these concepts are attractive, they are currently still quite abstract and philosophical in terms of how to apply them in practical product and service design. Furthermore, qualities of AI – proactivity, dynamism and autonomy – introduce new possibilities to the system design process. Hence, we need to define practices for integrating the needs of humans, the ecosystem and AI to advance sustainability through experience design. These practices have to take into account the needs of the planet, not just of humans.

3.24 QoE for mobile immersive media

Hans-Jürgen Zepernick (Blekinge Institute of Technology – Karlskrona, SE)


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Sustainability has been a crucial demand for all generations of wireless communications systems in terms of optimal resource allocation subject to given key performance indicators. Due to the required high data rates, low latency, signal processing complexity and other constraints, maintaining QoE and sustainable QoE is a challenging task in ultra-reliable low latency communication applications such as mobile immersive media. 6G technology

shall support immersive mobile media experiences that extend over the entire continuum of digital computer-generated virtual worlds. A key emphasis in the growth of digital value platforms will be the convergence of multimodal engagement with media and the physicality of lived experience. In this context, architectures and technologies for green 6G networks shall be envisaged that offer sustainable QoE. In my current work, I conduct subjective experiments for mobile immersive media, subjective and objective quality assessment, mobile multimedia signal processing, analytical approaches on QoE-assured VR video streaming, energy harvesting in wireless networks. I am interested in discussing experimental designs for sustainable QoE, subjective and objective metrics for sustainable QoE assessment, technologies to enhance energy efficiency and low power consumption for 6G and beyond mobile telecommunication systems with application to mobile immersive media.

3.25 ICT and Sustainability – More than energy?

Thomas Zinner (NTNU – Trondheim, NO)

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I am working in the broad area of networked systems and applications. Technical systems have become more and more complex, and many problems are solved adding additional resources, bringing resources closer to the users, or using programmable hardware. My work aims at designing mechanisms and algorithms to improve the operation of technical systems by enabling customization considering user-centric metrics or utility functions. While this can for instance improve system utilization, improve revenue and reduce the carbon footprint per user, it also puts additional burden on the control planes, and increases costs and computational complexity.

Hence, my work strives sustainability of ICT, but my interest also covers how new ICT systems can be used to enable applications improving sustainability, e.g., immersive haptic / XR applications further reducing traveling. For that I am trying to understand relationships between social, environmental and economic factors.

4 Group work: introduction

4.1 Seminar structure and used methods

Katrien De Moor (NTNU – Trondheim, NO), Markus Fiedler (Blekinge Institute of Technology – Karlshamn, SE), Ashok Jhunjunwala (IITM Research Park – Madras, IN), and Alexander Raake (TU Ilmenau, DE)

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The seminar adopted a genuinely bottom-up approach and started with the phase of *inventory and exploration*. After the short introductory talks of the participants which took place on the morning and part of the afternoon of day 1, a first clustering session took place. Participants were asked to write down their core expertise and knowledge areas related to the topic. These inputs were clustered into the following overall categories during the *analysis and condensation phase*:

- ICT / measurement: e.g., sustainability of ICT and potential of ICT to contribute to more sustainable experiences in other sectors; methodologies, metrics, best practices e.g., to increase energy efficiency, to measure environmental impact
- Experience measurement: e.g., knowledge and methods to evaluate users' experiences, expectations, quality perceptions
- Changing perceptions and behavior: e.g., insights on design for behavioral change, triggering motivation and engagement.
- Policies and broader implications: e.g., regulatory landscape, policy perspectives, role of activism, implications for digital ecosystems and business models.

This first initial clustering allowed us to situate the participants in different areas based on the perspectives, knowledge, methods, etc. they brought to the seminar. As a next step, we conducted a brainstorming session on concrete topics that participants would like to address during the seminar and that they considered important and potentially impactful towards driving sustainable experiences. First, the participants were asked to write down ideas on post-its (individual phase), after which all ideas were placed on the blackboard, and everyone could build upon the listed ideas. After a saturation of ideas was reached, all ideas were briefly explained and further elaborated upon in a plenary session, so that all participants would have a good understanding of what was meant with the different ideas / topics. The last step of this session was a prioritization of topics to work on. All participants were given three vote stickers (1st, 2nd and 3rd choice) and could indicate which topics they would be interested to discuss during the subsequent group work. This prioritization resulted in the following topics that were discussed in smaller groups during the *analysis and condensation phase*:

- Group 1: Collaborative XR and remote attendance
- Group 2: Quantification / measures of QoSE
- Group 3: ICT as a means to drive sustainability
- Group 4: Needs versus greeds

By matching the topical prioritizations and expertise clusters, the discussion groups were selected such that each had a representative from all four expertise areas / perspectives listed above. The *synthesis phase* consisted of a number of activities. The first task of the group work was to discuss the group's topic more in-depth, to explore the views represented within the group and to discuss where there is a potential for impact. For this discussion, we used the COCD method [1], which distinguishes between NOW, WOW and HOW-ideas.

- NOW-ideas have a more short-term focus, are relatively easy to implement, are low-risk and generally not controversial.
- WOW-ideas can also be implemented, but in a slightly longer time-frame. Such ideas are exciting, innovative, potentially breakthrough ideas.
- HOW-ideas are more longer term, are, from the current perspective, considered more as longer-term dreams and challenges, ideas for the future, "cathedral" ideas.

All groups identified NOW-, WOW- and HOW-ideas and discussed what would be needed to realize these ideas. The groups documented their ideas via the online tool Taskcards [2]. Finally, for the last phase of the group work the groups switched topics and provided peer feedback on another group's ideas by means of De Bonos' six thinking hats [3]. Each hat represents another type of perspective:

- *White hat*: Information. Facts and information, neutrality, objective point of view. What is needed in terms of facts and data? What is missing? Where can more information be found?

- *Red hat*: Feeling and intuition. What does your gut feeling say? (no justification needed), spontaneous reactions? Does it feel right? Both positive and negative feelings are welcome and do not need to be justified.
- *Yellow hat*: Possibilities. Identify positive sides and possibilities, visionary thinking. Why is this worth trying out? How can it lead to improvement / value? Visions and dreams are allowed, speculative thinking as well.
- *Green hat*: Creativity. Thinking creative, opportunities for growth, how to extend? Which ideas have been presented? How can they be further explored and further developed? Alternatives and suggestions for solutions? New ideas, build on each other ideas. Criticism is not allowed with this hat on.
- *Black hat*: Critical perspective. This hat represents the devil's advocate. Focus is on identification of negative aspects, risky elements, weaknesses. Focus on vulnerabilities. Objective, rational evaluation.
- *Blue hat*: Process perspective. Where in the process is the group with their idea? What is the intended goal / outcome? What should be done now? Any decisions that need to be made? How to continue the work with the presented idea? Think in terms of process-orientation.

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5 Reports from the working groups

In the following section, we provide a brief overview of the main outcomes and ideas discussed in the different groups. The rapporteur for the group is always denoted with an (*) in the list of group members.

5.1 Group 1: Collaborative XR and remote attendance

Markus Fiedler (Blekinge Institute of Technology – Karlshamn, SE), Stepanie Arevalo Arboleda (TU Ilmenau, DE), Pablo Cesar (CWI – Amsterdam, NL), Effie Lai-Chong Law (Durham University, GB), Fatuma Simba (University of Dar es Salaam, TZ), and Hans-Jürgen Zepernick (Blekinge Institute of Technology – Karlskrona, SE)

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The group discussion on collaborative extended reality (XR) and remote attendance started with collecting items and ideas. In a second step, these were matched to the COCD questions. In the sequel, we present the emerging sets of items and ideas merged with feedback from the review group 3, amongst others wondering which organization/individuals would be most feasible to take care of the various challenges.

5.1.1 NOW-topics and cases

Collaborative XR and remote attendance approaches and solution should be aligned with the UN Sustainable Development Goals (SDGs) [1], in particular SDG4 (quality of education), SDG5 (gender equality), SDG10 (inclusion) and SDG11 (sustainable cities and communities). Ethical, Legal and Social Implications (ELSI) must be taken care of, ethics by design should be the preferred approach. Accessibility and inclusion are essential in XR, which necessitates inclusive and participative design. As current VR learning, training and medical experiences do not come close enough to reality, hybrid XR and digiphysical settings should be considered. Physicality (e.g. feedback) and visual representation (e.g. facial expressions) need to be decoupled and customized in order to include users (SDG10), convey the intended content and allow for tradeoffs of experiences. The latter are frequently targeted in sustainability-inspired comparative studies, which in turn require reliable data to be telling. For example, energy consumption should be estimated with reliable precision. Last but not least, limitations such as delays and cost incurred by trendy technology need to be overcome.

5.1.2 WOW-ideas

1. Inclusive and accessible XR experiences will be designed, and it is expected that they will be constantly evolving and impact ELSI in a positive manner. Also, people will be able to express themselves in XR in various versions, which will help to address and overcome prejudices and expectations.
2. Fidelity and altered physicality have to be chosen and controlled carefully depending on task and content in order to enable acceptable holoportation experiences.
3. XR experiences powered by alternative energy (through various harvesting approaches) will reduce the energy footprint and allow usage in remote areas.
4. Virtual coffee breaks and other happenstances, allowing for true digiphysical meeting experiences supported by multisensory interfaces (incl. smell and taste) and 3D audiovisuals.

5.1.3 HOW-ideas

1. How to address technology-related and -induced inequalities, e.g. w.r.t. SDG4 (education)?
2. How to handle delays and latencies in XR multiparty communication systems?
3. CoVid in mind triggered the controversial idea of an XR Dagstuhl Experience, moving 2D meetings to XR meetings with improved interactivity and well (re-)presented behavioral cues. While XR is failing on the very motto of Saarland people “Hauptsach’ gudd gess” (the main thing is to eat well), it might at least help to solve the enigma of Dagstuhl’s “White Lady”.

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5.2 Group 2: How to characterize QoSE [kō-zē] experiences? Towards a measurement framework for Quality of Sustainable Experiences

Yvonne Dittrich (IT University of Copenhagen, DK), Emma Beauxis-Aussalet (VU University Amsterdam, NL), Tobias Hossfeld (Universität Würzburg, DE), Lucjan Janowski (AGH – Univ. of Science and Technology – Krakow, PL), Alexander Raake (TU Ilmenau, DE), Daniel Schien (University of Bristol, GB), and Thomas Zinner (NTNU – Trondheim, NO)

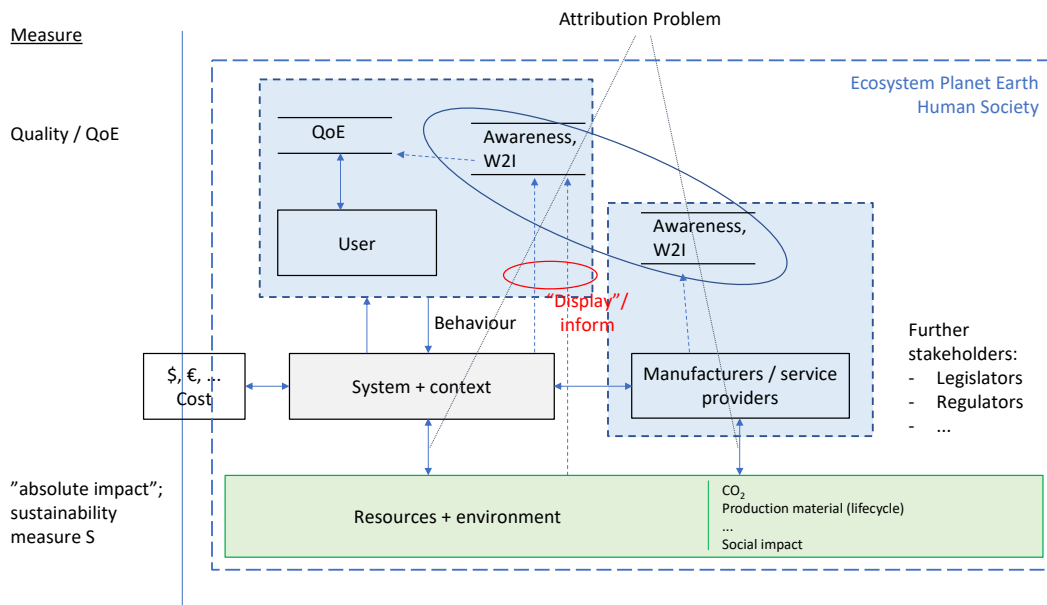
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© Yvonne Dittrich, Emma Beauxis-Aussalet, Tobias Hossfeld, Lucjan Janowski, Alexander Raake (*), Daniel Schien, and Thomas Zinner

The following text represents a summary of the work by Group 2 and the subsequent review by other groups, especially Group 4, and respective further discussions.

For both aspects individually, experiences on the one hand, and environmental impact on the other, different measures and measurement approaches have been developed in the past. In this group 2, we have discussed a framework for characterizing “Quality of Sustainable Experiences” (QoSE), with the aim to jointly characterize the user experience and the associated sustainability of the used system or service. The overarching perspective was referred to as the “cathedral view” within the group. In the group work, the framework was primarily instantiated for the case of media technology, for the example of videostreaming, for which some quantitative measures for both the “experience” and the associated consumption have been investigated in the past. A joint footprint and QoE measurement view had been addressed before by some of the group members, too, e.g. in [1] in terms of power consumption vs. video streaming QoE, and [2] with regard to CO₂ emission and streaming QoE. In the group’s discussions, a novel component was the possible impact of the users’ awareness of the degree of sustainability of their product-related behavior, which has been integrated into the experiencing process, updating an existing model view on QoE formation [3, 4, 5, 6].

To this aim, the group has sketched a first graphical representation of the framework, see Figure 1. Here, W2I refers to the willingness to invest, that is, to consume more moderately and at lower perceptual quality, if this reduces the environmental impact. Both during system operation (left) and system / service production and operation (right), environmental resources are being consumed. It is noted that the figure acknowledges the fact that the exact consumption of resources may be difficult to attribute to individual systems and/or manufacturers / service providers (“Attribution Problem”). It is general consensus in the QoE community now, that QoE happens in the users’ minds and results from the appraisal of the experience with regard to expectations. Here, awareness and W2I were thought by the group to influence expectations, hence increasing QoE in spite of possibly lower sensory / perceptual quality. In case of the manufacturer / service provider, awareness for the sustainability impact of the “experiences they sell” may lead to a more careful handling of resources and acceptance, that users may not strive for better and better perception. On the very left hand side, examples for aspects that need to be measured or characterized are indicated. Here, at the border between system / service and “measures”, the associated cost is given as a measure, which currently still strongly impacts user expectations and decisions in terms of acceptance. Also for the providers or manufacturers, cost is a key measure, determining many decisions. Here, too, awareness may be a driver for updated, more environmentally sustainable decisions. To raise awareness, sustainability- and/or experience-related measures can be used to display and inform (red in Figure 1) about the environmental impact and the role of experience therein, positively influencing production and consumption patterns.



■ **Figure 1** Conceptual model for QoSE measurement framework.

The ideas can be assigned to the categories of NOW, WOW and HOW as follows;

5.2.1 NOW-ideas

1. The framework concept and figure shall be incorporated into a conceptual paper
2. QoE and CO₂ or energy consumption may be considered together in research, also in conjunction with some aspect of “awareness”
3. The ongoing legislation on reports of companies of a certain size on environmental, societal and corporate governance need to be inspected for specific QoSE measures to be derived
4. The provision of usage reports for each user with regard to sustainability of each application / service could be a feasible goal

5.2.2 WOW-ideas

1. Making environmental and societal impact of the consumption subject of the quality of experience
2. Quantify “awareness”
3. Quantify QoE/sustainability with somewhat more evolved measure (beyond CO₂)
4. Changing the hidden optimisation criteria for technology design from economics only to also include sustainability
5. Conceive information approaches for sustainability, e.g., in terms of an intermediate, ICT-related, consumption-related “nutriscore”
6. Usage of service and substitution, e.g., in terms of “Drink less tea when watching TV (or other resource consuming activities like boiling water)?”

5.2.3 HOW-ideas

1. Enable the quantification and ultimately reduction of the “planetary resource usage” / sustainability and the associated and underlying “QoE”, including a running measurement framework

2. Understand the relation between QoE and wellness
3. Have “planetary consumption” established as a sort of currency
4. Enable counter-weighting societal impact vs. the fun and its sustainability imprint

5.2.4 Feedback and conclusions Group 2

In the group and based on the feedback provided from other groups, especially Group 4, it was agreed that in future joint research, the started work will be complemented by a literature review, and by collecting existing as well as specifying new measures for QoE and user experience on the one hand, and sustainability on the other. Here, the validity and relevance of the measures was considered an important aspect. Besides the academic literature and recommendations from standardization bodies, considerations by policy-making agencies were identified as key resources, and such agencies also ultimately as the target group for the measurement framework. It was further agreed that the continued work will need to result into a clearer roadmap with reachable goals. Further, the notion of “what is needed”, “what is enough” and how these are being perceived by individual users have been discussed, motivated by the respective considerations in this regard by other groups.

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5.3 Group 3: ICT as a means to drive sustainability

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© Ashok Jhunjhunwala, Dan Lockton, Colin Maclay, Peter Reichl, Reema Saha, Kaisa Väänänen, Irene Viola and Markus Fiedler (*)

We present the emerging sets of questions and ideas related to time horizons and based on the discussions within the group around the role of ICT and how it can be a means to drive sustainability.

5.3.1 5 years: NOW-ideas

There is a need to learn from recent CoViD experiences, and some of the new practices might be continued while observing longer-term implications. We observe relevant and promising trends such as moves to remote work and education, buying local, “right to repair” legislation as well as changes in consumption patterns and increased awareness of cooperatives, exploitation scenarios, outsourcing of externalities and more ethical supply chains, which is also visible in the younger “Generation Zero’s” attitudes, approaches and trends [1]. Indeed, there are many “ICT for Good” examples such as “Mastodon” [2] and “Fediverse” [3] (decentralized and community-owned social media), “Do Not Pay” [4] (providing AI-based legal support), and messaging apps used for organizing communities. The question arises what (affirmative) values in terms of plurality, diversity, individuality and care of each other will matter beyond the 5-year time horizon?

5.3.2 25 years: WOW-ideas

The big transitions’ effects on people will become obvious, implying tensions between survival, convenience, and bigger questions of existence. Fixation on (quality of) experience might become controversial, and the question how Quality of Life can be maintained or even improved with less consumption (and movements) will gain importance. ICT services should be incentivized to keep their users healthy, including the right to opt out. Hopefully, democratisation of access will provide more equal opportunities on a global scale. The question emerges which layers of the technology stack should be publicly owned, implementing a Fediverse [3] on which people can build their ICT solutions. How does governance of tech companies, the technology and the legislation need to evolve to serve public interest?

5.3.3 100 years: HOW-ideas

A vision for 100 years may include the Locavore idea “70% of what you consume is from 100-150 km of where you live” [5]. It becomes increasingly important where and how value is created (e.g. by sharing, repairing, re- and upcycling). Local governance, good relationships between communities, open access to networks and technologies will allow communities to create goods and services, yielding improved conditions for mankind. Accompanied by corresponding incentives for research, innovation and development (RID), ICT is a key tool to enable this utopia, keeping in mind the “authenticity of the human experience”.

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5.4 Group 4: Needs vs. Greeds

Michael Best (Georgia Institute of Technology – Atlanta, US), Katrien De Moor (NTNU – Trondheim, NO), Christian Herglotz (Universität Erlangen-Nürnberg, DE), Oliver Hohlfeld (Universität Kassel, DE), Sascha Spors (Universität Rostock, DE), Fee Steinhoff (Hochschule Koblenz – Remagen, DE), and Denny Carolina Villamil Velasquez (Blekinge Institute of Technology – Karlskrona, SE)

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The considerations tackled in this topic targeted the question whether a high QoE is really needed or not and aimed to challenge the paradigm of always more and always better. For most applications, it would be possible to define a certain minimum, basic requirement, which is sufficient to satisfy the needs of the user while avoiding that the striving for fulfillment of fundamental psychological needs becomes an act of greediness. Such “sufficiency” thresholds could be investigated for different use cases and implemented as the default configuration of applications. In this regard, the group discussed the need for a definition and better understanding of “sufficiency”: what does greedy or ungreedy behavior mean, what does it imply and what would be meaningful measures? Further, it was discussed that we should investigate which needs that drive human behavior are related to sustainability and how these could be used for pushing QoSE? A challenge here is however that the traditional test designs to evaluate quality are not suitable for this goal and would need to be redesigned. As a result, there is a need for new methodological approaches and metrics representing “sufficiency” as opposed to metrics targeting high quality. We briefly discuss the main NOW, WOW and HOW ideas, also incorporating the feedback from group 2 (De Bonos hats feedback round).

5.4.1 NOW-ideas

The main topic that was discussed is the need for a better understanding and definition of the common constructs and aspects (e.g., QoSE, sufficiency, striving for fulfillment of fundamental needs and balancing: when does need become greed?, theoretical models for consumption behavior). In particular, it was discussed that what greedy behavior entails is likely case-specific and that the line between greed and need-driven behavior is not clear-cut and represents a tension that should be investigated. Further, the group discussed the need to better understand what the outcomes and consequences of greedy behavior are (e.g., increased carbon footprint, impact on well-being or one’s mental health), and whether and how they can be measured and visualised. The proposal in this respect was to write a white paper based on a thorough literature review, incorporating also literature from relevant related fields, to better define the relevant concepts and quality needs, greeds, and their multiple facets before deriving any metrics. As a part of this exercise, concrete use cases should be defined, since the means to address need, greed, sufficiency may be more actionable if specific use cases are targeted.

A second NOW idea is to (re-) run studies with an additional set of measures, e.g., including questions and measures related to needs (actual vs. perceived), tasks and purpose of using a specific service, acceptability and behavioral measures. However, a starting point here should be a thorough check of existing databases to get an overview of what is already available.

5.4.2 WOW-ideas

Concrete suggestions and goals that were discussed include:

1. Studies on sufficiency to understand where the thresholds are situated. However, here it was pointed out that this may be culturally different and that other variables may play in here. In addition, there may not be clear-cut thresholds, but rather grey zones, which should be better understood as they can help to map users' willingness to "sacrifice" or to contribute (when formulated positively). The concept of fairness was also coined in the discussion of this idea as potentially relevant. Finally, in "sufficiency modeling" and need-related research, it should be considered that needs may change over time (reduce or become stronger).
2. Definition of meaningful metrics and useful subjective measures of sufficiency. Efforts aiming to define relevant metrics and measures in this respect should consider what has been done in relevant related fields.
3. Triggering user empowerment, better consumer awareness, more informed decisions. The group identified a potential to allow users / consumers to take more informed decisions, based on the assumption that users are today not well informed and therefore lack the necessary insights into how their choices and use of various services may impact sustainability. However, this requires good measures and reliable indicators (e.g., to visualise carbon footprint associated to a service usage session). Overall, the importance of striking a good balance between paternalizing / dictating what is "good", non-greedy behavior vs. empowering users and letting them decide for themselves, was underlined.
4. Gamification: challenge, compare, compete to trigger behavioral change. The idea to use nudging and gamification mechanisms to help users to adopt more pro-environmental behavior when it comes to use of digital technology was generally considered positive, but it was also pointed out that such an approach also has important limitations and may not reach all segments of the population. A broader understanding of different measures that can be used to incentivize users, e.g., depending on contextual factors, is therefore needed. A goal should also be that it's hip, attractive, "in" to be an environmental-friendly, low-energy consumer, so that people feel motivated and inclined to adopt a more sustainable lifestyle.

5.4.3 HOW-ideas

They include

1. finding meaningful "punishments" for non-sustainable habits. The group discussed what might be an equivalent to solutions to prevent waste in a food context. Some of the ideas discussed include paying or apps that are not used, or rather paying only if you really use an app (after a testing period). Further exploration of such ideas is needed, but it should be ensured that there is room for individuality and differentiation and that such mechanisms do not have the opposite effect (e.g., that usage gets enforced in order to avoid having to pay).
2. Product and cost should cover the whole cost of a service (externalities). While this would potentially also lead to more conscious consumption, there are various challenges to consider (e.g., how to globally enforce this). Yet, approaches that address both the user perspective, economic implications and environmental impact together would be useful and overall, such an approach could trigger more transparency.
3. Move towards a post-growth economy which is not prevailed by capitalism and economic incentives.

6 Pictures

This section contains a set of visual impressions from the seminar – joint work (Figures 2 to 7) and social activities (Figures 8 to 11) – as well as pictures of the participants (Figure ??) and co-organisers (Figure 12).



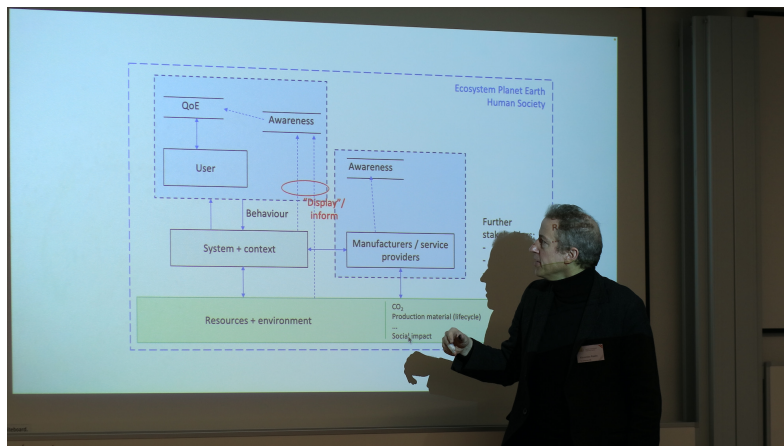
■ **Figure 2** Presentation by delegates (Daniel Schien).



■ **Figure 3** Discussion in plenum.



■ Figure 4 Group work (Group 1).



■ Figure 5 Presentation of group work (Group 2).



■ Figure 6 Presentation of group work (Group 3).



■ **Figure 7** Presentation of group work (Group 4).



■ **Figure 8** Sustainable social outing – walk in the surroundings.



■ **Figure 9** Refreshing Kneipp experience.



■ **Figure 10** Preparation of a music session.



■ **Figure 11** In the wine cellar.




■ **Figure 12** Co-organisers (from left to right: Ashok, Alex, Markus and Katrien).

7 Final reflections

7.1 Main outcomes

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This seminar approached the topic of sustainable experiences and the quality of sustainable experience from different angles and disciplinary perspectives, both in terms of current understanding and knowledge, tools and methods and challenges for future research. The main aim was to bring together a diverse set of participants in order to foster new alliances, inspire, trigger scientific renewal and to explore and map future opportunities and research challenges. The bottom-up methodology that was followed resulted in many ideas, as described in Section 5. We may summarize the main outcomes from the various group works as follows:

1. Openings for innovative sustainability-relevant services;
2. Conceptual model for QoSE measurement framework (cf. Figure 1);
3. An up-to 100-years sustainability perspective on ICT and related circumstances;
4. Concept and modeling of sufficiency.

Beyond “Quality of”, there is a need for a wider take and a longer time horizon on “Sustainable Experience”, reflected in alternative notions such as SDE (Sustainable Digital Experiences) or SUE (Sustainable User Experience).

7.2 Next steps

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To take these ideas further, a number of next steps have already been taken, including a special session on “Towards the design and evaluation of Sustainable Multimedia Experiences” at the International Conference on Quality of Multimedia Experience (QoMEX 2023). QoMEX 2023 has “Towards Sustainable and Inclusive Multimedia Experiences” as special focus and several of the Dagstuhl seminar organizers are also involved in the organization of the conference. In addition, one of the Dagstuhl participants, Dr. Daniel Schien, has been invited to hold a keynote speech at the conference. In addition, Dagstuhl co-organizer Prof. Markus Fiedler is also co-chair of the “Workshop on sustainability and QoE Management”, co-located with QoMEX 2023. Further, a video trailer has been compiled, based on recordings made during the Dagstuhl seminar. This video is available on YouTube [1] and will be used for disseminating around the focus of the seminar. In addition, joint journal and conference publications ideas were discussed and are under work. Further, there are plans for a COST Action, which even bridges to the Dagstuhl Perspectives Workshop 23092 and which could offer an excellent vehicle to continue the discussions, do community-building and to join forces on a global stage.

References

- 1 Dagstuhl Seminar 23041: Quality of Sustainable Experience (QoSE): short video trailer. https://youtu.be/D2vswi_807A. Accessed: 2023-05-29.

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