

**Sustainability, circular economy, and creative computing**

Open educational materials

Slide deck supporting material

Created by Action GRADE CA21141 and supported by COST (EU Cooperation in Science and Technology). Distributed under the Creative Commons License

2024

**Introduction**

**Why did we create this material?**

Currently, there is an increasing concern about sustainability and robustness of complex infrastructures upon which many of our day-to-day activities depend. In the European Union, the term circular economy is a well-established element of the European Green Deal, describing a transformation towards greater sustainability and waste reduction. Many of us work in fields related to creative computing, and have spent time researching the right to repair and other sustainable practices related to creative computing. These materials were created to provide an opportunity to educators and learners to explore these ideas based on practical examples and accessible activities.

**How to use this material?**

This material is available for non-commercial re-use under the Creative Commons License. It comprises of a slide deck and supporting materials, both available for free on the website [https://costgrade.eu](https://costgrade.eu/). The slide deck may be used during lessons in secondary school in both formal and informal settings. Educators may also edit and re-use the material in their own teaching tools. The supporting materials file includes descriptions of each slide, and suggestions for further reading.

**Who created this material?**

This material was created by *Grassroots of digital Europe (GRADE)*, a network of scientists, researchers, activists, and artists from the EU and beyond, created within the COST framework for European Cooperation in Science and Technology. GRADE Working Group 2, *Institutionalising digital grassroots,* is responsible for the creation and distribution of these materials. Contributors include: Carlos Cunha, Ana Orelj, Antti Knutas, Eglė Stankevičiūtė, Erkan Saka, Lidija Pulevska Ivanovska, Leanete Thomas Dotta, Luís Miguel Teixeira, Maria Garda, Marsida Ibro, Sasho Josimovski, Thiago Freires, Ugnė Rakauskaitė. Slide design by Laurynas Marčiulaitis.

Find out more about our work at:

[https://costgrade.eu](https://costgrade.eu/)

*COST (European Cooperation in Science and Technology) is a funding agency for research and innovation networks. Our Actions help connect research initiatives across Europe and enable scientists to grow their ideas by sharing them with their peers. This boosts their research, career and innovation.*

Find out more about COST:

[https://cost.eu](https://cost.eu/)

|  |  |  |
| --- | --- | --- |
| Slide number(s) and title(s) | Notes and further info | Further reading |
| **Sustainability, Circular economy, and creative computing**  (slide n 1) | **Sustainability, Circular economy, and creative computing**  Greetings,  Working Group 2 Institutionalizing Digital Grassroots of COST Action CA21141 - Grassroots of Digital Europe: from Historic to Contemporary Cultures of Creative Computing (GRADE) is providing these Open Educational Materials to facilitate the teaching of Sustainability, Circular economy, and creative computing We welcome your editing our resource to accommodate your teaching style and needs. Thanks for helping others to learn about these key aspects of the current environment. |  |
| **The Big Picture**  (Slide n 3) | **The Big Picture**  Sustainability as a broad concept is discussed below. Sustainability encompasses several categories as shown by the circles in the Big Picture (all of which are also discussed in more detail below). The Circular Economy is a smaller part of Sustainability, and the Right to Repair (R2R) is a component of the broader Circular Economy. In addition, Creative Computing as well as Open Source Software and Hardware have overlapping circles that at times lie outside of the Sustainability circle. |  |
| **Sustainability**  (Slide n 5) | **Sustainability**  In 1987, the United Nations Brundtland Commission described sustainability as "fulfilling present needs without jeopardizing the ability of future generations to meet their own." Today, nearly 140 developing countries are striving to achieve their development goals, but with the growing threat of climate change, it is crucial that concrete actions are taken to ensure that progress made today does not harm the prospects of future generations.  See more information here: [https://www.un.org/en/academic-impact/sustainability#:~:text=In%201987%2C%20the%20United%20Nations,development%20needs%2C%20but%20with%20the](https://www.un.org/en/academic-impact/sustainability" \l ":~:text=In 1987%2C the United Nations,development needs%2C but with the)  <https://www.un.org/development/desa/dpad/wp-content/uploads/sites/45/publication/2015wess_ch5_en.pdf> | Sustainability:  Goodland, R. (2002). Sustainability: human, social, economic and environmental. *Encyclopedia of global environmental change, 5*, 481-491.  [https://www.un.org/en/academic-impact/sustainability#:~:text=In%201987%2C%20the%20United%20Nations,development%20needs%2C%20but%20with%20the](https://www.un.org/en/academic-impact/sustainability" \l ":~:text=In 1987%2C the United Nations,development needs%2C but with the)  <https://www.un.org/development/desa/dpad/wp-content/uploads/sites/45/publication/2015wess_ch5_en.pdf> |
| **Sustainability**  (Slide n 6) | **Environmental sustainabilit**y represents efforts aimed at protecting the environment by addressing issues like ozone depletion, carbon emissions, forest loss, and water and sanitation. The goal is to ensure the sustainable use of natural resources and prevent environmental degradation, all while promoting international cooperation between developed and developing countries. The text highlights progress made in reducing ozone-depleting substances, protecting forests and marine areas, and improving access to clean water and sanitation infrastructure.  In simpler terms, environmental sustainability is about taking care of the planet's natural resources so that we can use them today without harming the environment for future generations. Thisincludes actions like reducing pollution, protecting forests and oceans, and making sure people have access to clean water and sanitation. It also involves cooperation between countries to make sure that economic growth does not harm the environment.https://www.un.org/development/desa/dpad/wp-content/uploads/sites/45/publication/2015wess\_ch5\_en.pdf  **Social sustainability** focuses on understanding and managing business's impacts—both positive and negative—on people. A company's ability to foster strong relationships and engage meaningfully with its stakeholders is crucial. Whether directly or indirectly, businesses influence the well-being of employees, workers throughout the value chain, customers, and local communities, making it essential to address these impacts proactively.  A company’s **social license to operate** is closely tied to its commitment to social sustainability. Moreover, factors like poverty, inequality, and weak governance can undermine social development, posing significant challenges to business operations and long-term growth. Therefore, addressing these social issues is not just an ethical responsibility but a strategic imperative for sustainable success. (un.org )  **Human sustainability** is about maintaining people’s well-being, often referred to as **human capital**. This includes an individual's health, education, skills, knowledge, and access to services. Investing in aspects like education, health, and nutrition is considered essential for economic development.  Since human life is relatively short, **human sustainability** requires ongoing investment throughout a person’s lifetime. This starts with promoting maternal health, safe childbirth, and proper care for infants and young children. It can take 20–30 years of education and training for a person to fully develop their potential. Adult education, skills development, and healthcare are also crucial and can be as expensive as formal education (Goodland, 2002).  **Economic sustainability** means preserving capital, ensuring that economic resources remain intact over time. This aligns with **Hicks's definition of income**, which is the amount one can consume while still being as well off at the end of the period. In essence, economic sustainability involves consuming the added value (interest) without depleting the core capital.  **Economic and manufactured capital** can be substituted, but overcapitalization can lead to inefficiencies. For example, having too many fishing boats or sawmills depletes declining fish stocks and forests (Goodland, 2002). | Environmental sustainability:  https://www.un.org/development/desa/dpad/wp-content/uploads/sites/45/publication/2015wess\_ch5\_en.pdf |
| **Sustainability**  (Slide n 7) | **Embrace Sustainable Choices**  Suggestions from one organization:  Zero Waste Alliance Ireland  <https://www.zwai.ie/>  Greenwashing  <https://www.un.org/en/climatechange/science/climate-issues/greenwashing> | Zero Waste Alliance Ireland  <https://www.zwai.ie/>  Greenwashing  <https://www.un.org/en/climatechange/science/climate-issues/greenwashing> |
| **Sustainability**  **Development Goals**  (Slide n 8) | The Sustainable Development Goals (SDGs) provide a blueprint for enhancing the quality of life globally while addressing the harmful impacts of climate change.  <https://sdgs.un.org/goals>  The SDGs, also known as the Global Goals, were established by the United Nations in 2015 as a worldwide call to action aimed at eradicating poverty, safeguarding the planet, and ensuring that all people experience peace and prosperity by 2030.  The 17 SDGs are interconnected, acknowledging that progress in one area influences outcomes in others, and that development must strike a balance between social, economic, human, and environmental sustainability.  Nations have committed to focusing efforts on those who are most marginalized. The SDGs are designed to eliminate poverty, hunger, AIDS, and to combat discrimination against women and girls.  Signs of progress can be seen in some areas, but much remains to be achieved to reach the targets. | <https://sdgs.un.org/goals> |
| **Sustainability**  **Development Goals**  (Slide n 9) | Do you know all 17 SDGs? <https://www.youtube.com/watch?v=0XTBYMfZyrM> |  |
| **Circular economy**  (slide no 11) | A circular economy refers to an economic model based on the efficient use of resources, intending to develop systems that privilege closed-loop usage of materials, i.e., economic growth is decoupled from resource use by lowering materials input whilst maximising usability and minimising waste generation. It aims to accomplish sustainable development by focusing on reusing, recycling, and recovering materials in production/distribution and consumption processes. A circular economy refers to an economic model which is based on the efficient use of resources, with the intent to develop systems that privilege closed-loop usage of materials (Lakatos et al., 2021; Morseletto, 2020). Therefore, in a circular economy, economic growth is decoupled from resource use by lowering materials input whilst maximising usability and minimising waste generation (Lakatos et al., 2021). By focusing on reusing, recycling, and recovering materials in production/distribution and consumption processes, it operates at the micro (products, companies, consumers), meso (eco-industrial parks), and macro levels (city, region, nation), with the aim to accomplish sustainable development (Kirchherr et al., 2017). Such a process leads to achieving sustainable development while fostering economic growth apart from the negative consequences of resource depletion and environmental degradation (Morseletto, 2020).  A circular economy is the opposite of a linear economy, where people buy a product, use it, and then throw it away. Target is sustainability and ability to repair (see the later slide on “6R” principle).  Producers have to make material that is actually repairable. Even before the production starts, it should be the way of thinking (ethos / philosophy). | www.europarl.europa.eu/  Kirchherr, J., Reike, D., & Hekkert, M. (2017) Conceptualizing the circular economy: An analysis of 114 definitions. Resources, Conservation and Recycling, 127, 221-232. <https://doi.org/10.1016/j.resconrec.2017.09.005>    Lakatos, E. S., Yong, G., Szilagyi, A., Clinci, D. S., Georgescu, L., Iticescu, C., & Cioca, L. I. (2021). Conceptualizing Core Aspects on Circular Economy in Cities. Sustainability, 13, 7549. <https://doi.org/10.3390/su13147549>    Morseletto, P. (2020). Targets for a circular economy. Resources, Conservation and Recycling, 153. <https://doi.org/10.1016/j.resconrec.2019.104553> |
| **Circular Economy** (slide no 12) | **Circular Economy Activism**  Zero Waste Alliance Ireland   * "6 R" principle:   + Rethink,   + Refuse,   + Reduce,   + Reuse,   + Recycle,   + Repair. | Zero Waste Alliance Ireland  <https://www.zwai.ie/> |
| **Sustainability in computing** (slide no 14) | **History: early cases and pioneers of sustainable computing**  Sustainability is a later year term. Linking to early days through:   * Better usage, less e-waste * More resource sharing * Improving efficiency | <https://ieeexplore.ieee.org/document/10214579> A Comprehensive Review of Green Computing: Past, Present, and Future Research |
| **Sustainability in computing**  (slide no 15) | Sustainability in computing involves integrating effective and reliable processes for delivering IT services, which are capable of minimising power consumption and hazards by managing environmental waste with a green approach (which includes expanding the life span of digital devices).  Sustainable computing services are pouring sustainability beyond simply energy use and product considerations, dealing with the loss of control by individuals, businesses, and governments while pursuing secure computing services to users.  There is debate on whether the term sustainability should even be used given that current resources are stretched to the limit. Torsten Schäfer, for example, addresses this discussion at https://www.alumniportal-deutschland.org/en/magazine/the-global-goals-powered-by-alumni/agenda-2030/sustainability-confusing-term-for-a-clever-concept/ |  |
| **Digital Transformation**  (slide no 17) | **Digital Transformation**  Definitions  Because the term digital transformation (DT) comes from different industries and contexts, it was used, abused, and stretched to name diverse phenomena. Here are some definitions especially from the business sector:  The use of technology to radically improve the performance or reach of an enterprise (W. Westerman, Arslan, Dorsman, & Karan, 2011).  The implementation of innovation and new digital technologies to affect business improvements in an organization (G. Westerman, Bonnet, & McAfee, 2014).  The use of digital technologies to radically improve the company's performance (Bekkhus, 2016).  The application of digital technologies to fundamentally impact all aspects of business and society (Gruman, 2016).  The use of new digital technologies (social media, mobile, analytics, or embedded devices) to enable major business improvements (such as enhancing customer experience, streamlining operations, or creating new business models) (Fitzgerald, Kruschwitz, Bonnet, & Welch, 2014).  DT encompasses everything from the cultural and organizational changes required to the related use of new digital technologies in order to enable major improvements – such as enhancing user services, streamlining operations, or creating entirely new services (Brown et al., 2014).  DT involves leveraging digital technologies to enable major business improvements, such as enhancing customer experience or creating new business models (Piccinini, Hanelt, Gregory, & Kolbe, 2015).  The use of new digital technologies, such as social media, mobile, analytics, or embedded devices, in order to enable major business improvements like enhancing customer experience, streamlining operations, or creating new business models (Horlacher & Hess, 2016).  DT goes beyond merely digitizing resources and results in value and revenues being created from digital assets (McDonald & Rowsell-Jones, 2012).  The digitization of previously analog machine and service operations, organizational tasks, and managerial processes. It changes a business model in two ways: how the organization creates value for its customers (the customer value proposition) and how it captures that value (how it makes money) (Iansiti & Lakhani, 2014).  The process through which companies converge multiple new digital technologies, enhanced with ubiquitous connectivity, with the intention of reaching superior performance and sustained competitive advantage, by transforming multiple business dimensions, including the business model, the customer experience (comprising digitally enabled products and services) and operations (comprising processes and decision-making), and simultaneously impacting people (including skills talent and culture) and networks (including the entire value system) (Ismail, Khater, & Zaki, 2017).  Use of new digital technologies, such as mobile, artificial intelligence, cloud, blockchain, and the Internet of Things (IoT) technologies, to enable *major business improvements* to augment customer experience, streamline operations, or create new business models (Warner & Wäger, 2019).  Yet, to research DT, it is first important to define what it is and what it is not. Gong and Ribiere (2021) made an attempt to merge several definitions (some of them listed below) and clarify the term DT:  **A fundamental change process enabled by digital technologies that aims to bring radical improvement and innovation to an entity [e.g., an organization, a business network, an industry, or society] to create value for its stakeholders by strategically leveraging its key resources and capabilities** (Gong & Ribiere, 2021).  Most definitions of DT focus on organizational level, but more recent definitions try to have a more wholistic overview in a way that they take into consideration socio and technological factors, because DT can lead to socio-technical, and more broadly, socio economical change (Dąbrowska et al., 2022).  In that sense they define DT as:  A socioeconomic change across individuals, organizations, ecosystems, and societies that are shaped by the adoption and utilization of digital technologies (Dąbrowska et al., 2022). | Bekkhus, R. (2016). Do KPIs used by CIOs decelerate digital business transformation? The case of ITIL.  Brown, A., Fishenden, J., Thompson, M., Brown, A., Fishenden, J., & Thompson, M. (2014). Organizational structures and digital transformation. *Digitizing Government: Understanding and Implementing New Digital Business Models*, 165-183.  Fitzgerald, M., Kruschwitz, N., Bonnet, D., & Welch, M. (2014). Embracing digital technology: A new strategic imperative. *MIT sloan management review, 55*(2), 1.  Gruman, G. (2016). What digital transformation really means. *InfoWorld, 18*(1), 1-3.  Horlacher, A., & Hess, T. (2016). *What does a chief digital officer do? Managerial tasks and roles of a new C-level position in the context of digital transformation.* Paper presented at the 2016 49th Hawaii International Conference on System Sciences (HICSS).  Iansiti, M., & Lakhani, K. R. (2014). Digital ubiquity:: How connections, sensors, and data are revolutionizing business. *Harvard business review, 92*(11), 19.  Ismail, M. H., Khater, M., & Zaki, M. (2017). Digital business transformation and strategy: What do we know so far. *Cambridge Service Alliance, 10*(1), 1-35.  McDonald, M. P., & Rowsell-Jones, A. (2012). *The digital edge*: Gartner, Incorporated.  Piccinini, E., Hanelt, A., Gregory, R., & Kolbe, L. (2015). Transforming industrial business: The impact of digital transformation on automotive organizations.  Warner, K. S. R., & Wäger, M. (2019). Building dynamic capabilities for digital transformation: An ongoing process of strategic renewal. *Long Range Planning, 52*(3), 326-349. doi:<https://doi.org/10.1016/j.lrp.2018.12.001>  Westerman, G., Bonnet, D., & McAfee, A. (2014). *Leading digital: Turning technology into business transformation*: Harvard Business Press.  Westerman, W., Arslan, Ö., Dorsman, A., & Karan, M. B. (2011). Introduction: Financial Aspects in Energy. In A. Dorsman, W. Westerman, M. B. Karan, & Ö. Arslan (Eds.), *Financial Aspects in Energy: A European Perspective* (pp. 1-7). Berlin, Heidelberg: Springer Berlin Heidelberg.  Dąbrowska, J., Almpanopoulou, A., Brem, A., Chesbrough, H., Cucino, V., Di Minin, A., . . . Ritala, P. (2022). Digital transformation, for better or worse: a critical multi-level research agenda. *R&D Management, 52*(5), 930-954. doi:<https://doi.org/10.1111/radm.12531>  Gong, C., & Ribiere, V. (2021). Developing a unified definition of digital transformation. *Technovation, 102*, 102217. doi:<https://doi.org/10.1016/j.technovation.2020.102217> |
| **Digital Transformation** (slide no 18) | Positve and Negative sides of Digital Transformation  Digital transformation permeates every facet of our personal, social, and professional lives, becoming an integral part of our daily experiences. Existing literature dominantly describes a positive impact of digital transformation on both firm performance and capital market performance (Cheng, Li, & Zhao, 2024). Some industries with big systems and multi-million user bases spotted their opportunity and need and embraced DT quite early. Banking (Hou & Yang, 2024), auditing (Leng & Zhang, 2024), big manufacturing systems (Wang & Yang, 2024), healthcare (Kraus, Schiavone, Pluzhnikova, & Invernizzi, 2021) and many others have completely changed the way they operate because of DT. Digital transformation is not just about upgrading technology within one single company (Autio, Nambisan, Thomas, & Wright, 2018; Dąbrowska et al., 2022; Vial, 2019). Its impact stretches far and wide, affecting individuals both inside and outside organizations, reshaping business models, platforms, and entire industries. However, DT has not bypassed the remote rural areas and forced the inhabitants to change (Li, Wang, & Soh, 2024).  Warner and Wäger (2019) emphasized the continuous nature of DT which constantly revitalizes the business model, collaborative approach, and ultimately organizational culture. From a purely business perspective, it has been shown that the digital transformation of a single company has a synergistic effect, implying that the digital transformation efforts of one enterprise positively influence others within the same supply chain (Tian & Shi, 2024). Positive effects of DT are shown regardless of the maturity of the company, but they are different in different stages (Cheng et al., 2024),  Digital transformation initiatives are often connected to the green economy as digital transformation is presented as a new option to reach the goal of reducing carbon emissions (Zhang, Fang, Ge, & Sun, 2024). The results of the study done by Alabdali et al. (2024) imply the existence of a strong correlation between processes of Green Digital Transformational Leadership, Green Digital Mindset, and Green Digital Transformation. This further indicates that efficient and effective leadership with a strong focus on environmental sustainability can positively influence not only the mindset of employees but also transform organizations towards eco-friendly practices.  “Importantly, regardless of the level, DT does not always lead to positive outcomes. It may also trigger conflicting interpretations, contradictions, and tensions, for which there is no single best solution,” (Dąbrowska et al., 2022, p. 932).  Those are not the only negative consequences: DT can cause a significant increase in herd behavior in corporate innovation (Wang & Yang, 2024). In addition, while one of the roles of DT is to reduce overall costs of operations, it seems that at the same time, it increases business complexity and thus costs, but also amplifies excess perk consumption (Wu, Liang, & Liu, 2024). | Alabdali, M. A. H. A., Yaqub, M. Z., Agarwal, R., Alofaysan, H., & Mohapatra, A. K. (2024). Unveiling green digital transformational leadership: Nexus between green digital culture, green digital mindset, and green digital transformation. *Journal of Cleaner Production*, 141670. doi:<https://doi.org/10.1016/j.jclepro.2024.141670>  Autio, E., Nambisan, S., Thomas, L. D., & Wright, M. (2018). Digital affordances, spatial affordances, and the genesis of entrepreneurial ecosystems. *Strategic Entrepreneurship Journal, 12*(1), 72-95.  Cheng, W., Li, C., & Zhao, T. (2024). The stages of enterprise digital transformation and its impact on internal control: Evidence from China. *International Review of Financial Analysis, 92*, 103079. doi:<https://doi.org/10.1016/j.irfa.2024.103079>  Dąbrowska, J., Almpanopoulou, A., Brem, A., Chesbrough, H., Cucino, V., Di Minin, A., . . . Ritala, P. (2022). Digital transformation, for better or worse: a critical multi-level research agenda. *R&D Management, 52*(5), 930-954. doi:<https://doi.org/10.1111/radm.12531>  Hou, X., & Yang, R. (2024). Bank digital transformation and liquidity mismatch: Evidence from China. *International Review of Economics & Finance, 92*, 581-597. doi:<https://doi.org/10.1016/j.iref.2024.02.050>  Kraus, S., Schiavone, F., Pluzhnikova, A., & Invernizzi, A. C. (2021). Digital transformation in healthcare: Analyzing the current state-of-research. *Journal of Business Research, 123*, 557-567.  Leng, A., & Zhang, Y. (2024). The effect of enterprise digital transformation on audit efficiency—Evidence from China. *Technological Forecasting and Social Change, 201*, 123215. doi:<https://doi.org/10.1016/j.techfore.2024.123215>  Li, J., Wang, H., & Soh, W. (2024). Digital transformation, financial literacy and rural household entrepreneurship. *Finance Research Letters*, 105171. doi:<https://doi.org/10.1016/j.frl.2024.105171>  Tian, H., & Shi, T. (2024). Corporate Digital Transformation and Supply Chain Synergy Effects. *Finance Research Letters*, 105247. doi:<https://doi.org/10.1016/j.frl.2024.105247>  Vial, G. (2019). JOURNAL OF STRATEGIC INFORMATION SYSTEMS REVIEW Manuscript title: Understanding digital transformation: A review and a research agenda.  Wang, Z., & Yang, F. (2024). Digital Transformation and Corporate Innovation with Herd Effects. *Finance Research Letters*, 105240. doi:<https://doi.org/10.1016/j.frl.2024.105240>  Warner, K. S. R., & Wäger, M. (2019). Building dynamic capabilities for digital transformation: An ongoing process of strategic renewal. *Long Range Planning, 52*(3), 326-349. doi:<https://doi.org/10.1016/j.lrp.2018.12.001>  Zhang, C., Fang, J., Ge, S., & Sun, G. (2024). Research on the impact of enterprise digital transformation on carbon emissions in the manufacturing industry. *International Review of Economics & Finance, 92*, 211-227. doi:<https://doi.org/10.1016/j.iref.2024.02.009>  Dąbrowska, J., Almpanopoulou, A., Brem, A., Chesbrough, H., Cucino, V., Di Minin, A., . . . Ritala, P. (2022). Digital transformation, for better or worse: a critical multi-level research agenda. *R&D Management, 52*(5), 930-954. doi:<https://doi.org/10.1111/radm.12531>  Wang, Z., & Yang, F. (2024). Digital Transformation and Corporate Innovation with Herd Effects. *Finance Research Letters*, 105240. doi:<https://doi.org/10.1016/j.frl.2024.105240>  Wu, J., Liang, Y., & Liu, W. (2024). The dark side of corporate digital transformation: Evidence from excess perk consumption of executives. *Finance Research Letters, 61*, 105033. doi:<https://doi.org/10.1016/j.frl.2024.105033> |
| **Digital Transformation**  (slide no 19) | The Digital Transformation Canvas is a comprehensive framework designed to guide organizations through the process of planning and executing digital transformation initiatives. Let us delve into each component in more detail:    1. \*\*Digital Transformation Strategy\*\*: This component sets the stage by defining the purpose and strategic direction of the initiative. It ensures that the digital transformation efforts are aligned with the broader organizational goals and digital strategy. The strategy encompasses identifying the problem or opportunity that the initiative aims to address, understanding customer needs and expectations, and considering internal and external factors driving the transformation.    2. \*\*Digital Transformation Operational Pillars\*\*: These pillars serve as the foundation for implementing the strategy and achieving the desired outcomes. They include:  - \*\*Process\*\*: Encompasses the various activities and organizational areas impacted by the initiative. It involves streamlining workflows, optimizing processes, and identifying areas for automation to enhance efficiency and effectiveness.  - \*\*People\*\*: Focuses on the individuals involved in the initiative, both internally and externally. This pillar emphasizes the importance of engaging stakeholders, fostering a culture of innovation, and equipping employees with the necessary digital skills to drive successful transformation.  - \*\*Platform\*\*: Encompasses the digital technologies and infrastructure required to support the transformation process. This includes identifying and implementing relevant digital tools, systems, and data management solutions to enable seamless collaboration and integration across the organization.  - \*\*Partners\*\*: Involves collaborating with external providers, experts, and stakeholders to leverage their expertise, resources, and capabilities. Partnerships play a crucial role in accelerating the pace of transformation, accessing specialized knowledge, and leveraging complementary strengths to achieve shared goals.    3. \*\*Digital Transformation Value\*\*: This component articulates the expected value and benefits that the initiative aims to deliver. It encompasses various dimensions, including:  - \*\*Product Innovation\*\*: Creating new digital products or services or enhancing existing ones to meet evolving customer needs and preferences.  - \*\*Performance Improvement\*\*: Driving economic growth, enhancing operational efficiency, fostering innovation, and strengthening collaboration networks to achieve sustainable business outcomes.  - \*\*Societal Impact (Planet)\*\*: Addressing social, institutional, and environmental concerns through sustainable practices, such as reducing resource consumption, promoting remote work, and mitigating environmental footprint.    4. \*\*Digital Transformation Pitfalls\*\*: While pursuing digital transformation, organizations must be mindful of potential pitfalls, particularly concerning data privacy and protection. This component emphasizes the importance of implementing robust strategies and tools to safeguard sensitive information, prevent cyber threats, and comply with regulatory requirements such as the EU's General Data Protection Regulation (GDPR).    By leveraging the Digital Transformation Canvas, organizations can systematically plan, execute, and monitor their digital initiatives, ensuring alignment with strategic objectives, maximizing value creation, and mitigating risks along the journey. | Elia, G., Solazzo, G., Lerro, A., Pigni, F., & Tucci, C. L. (2024). The digital transformation canvas: A conceptual framework for leading the digital transformation process. *Business Horizons*. doi:<https://doi.org/10.1016/j.bushor.2024.03.007> |
| **European framework for digital transformation**  (slide no 20) | **European framework for digital transformation**  European Commission recognized that the competitive potential of the European economy heavily depends on advanced digital network infrastructures and services; and thus on February 21st, 2024, the Commission introduced a set of alternatives to facilitate the innovation, security, and resilience of digital infrastructures. The idea behind this is to ensure fast, secure, and widespread connectivity as it was recognized as crucial for the implementation of emerging and advanced technologies.  This digital connectivity package should serve as a basis and platform for cooperation with stakeholders, Member States, and like-minded partners and should provide the direction of future EU policy actions. The main goal of the package is to ensure better synergy and coordination between existing initiatives and funding programs in the EU, as well as to support potential future initiatives like supporting European innovators, in their efforts to develop **integrated connectivity and collaborative computing infrastructures.** | Source: <https://ec.europa.eu/commission/presscorner/detail/en/ip_24_941> |
| **Digital transformation and circular economy**  (slide no 21) | **Digital transformation and circular economy**  Digital transformation plays a crucial role in enabling and advancing circular economy initiatives, focusing on sustainable resource utilization and waste reduction.  A blend of Industry 4.0 technologies (including the Internet of Things, big data analytics, cloud computing, and artificial intelligence) is central to this transformation, facilitating a shift from traditional linear models to circular models that emphasize resource efficiency, product lifecycle extension, and the closing of the loop for materials and products.    Recent research underscores how digital transformation can significantly impact the circular economy by operationalizing circular strategies across the entire product lifecycle. This encompasses product design, product use, and product recovery or recycling stages, aligning with CE principles like reduce, reuse, repair, recycle, and restore. By leveraging digital technologies, businesses can innovate circular business models, making full use of idle resources and offering high-quality, personalized services. | <https://www.mdpi.com/2071-1050/15/3/2067> |
| **Creative computing**  (slide no 23) | **Creative computing**  Creative computing encompasses a broad and dynamic field that merges computing with creative practices, opening avenues in art, design, entertainment, and more. It leverages computer science and technology as tools for creativity, encouraging innovative thinking and the creation of digital art, interactive media, and various computational artifacts.  It introduces computer science and computing-related fields to young people in a way that is connected to their interests and values—instead of emphasizing technical detail over creative potential.  It also encourages young people with access to computers to participate as designers or creators, rather than consumers.  Questions for discussion:  --Does commercial intent make something out of it? (we can make a product for selling and it is still creative computing) / do we count windows as creative computing (people contribution – wise);  --Commercial VS non-commercial (we need to draw a line and clarify some concepts):  • Creativity  • Grassroots  • Computing  --It does not necessarily need to involve art.  --It is more about expression than functionality in creative computing.  (Expression as an act of resistance / anti-corporations and anti-large companies) | A possible source: Brennan, K., & Resnick, M. (2012). "New frameworks for studying and assessing the development of computational thinking." In Proceedings of the 2012 annual meeting of the American Educational Research Association. |
| **Open-Source Resources and Communities**  (slide n 24) | Open-Source Resources and Communities   * What are Open-Source Resources?   + Collaborative ecosystems where developers, designers, and enthusiasts come together to build and improve open-source software. * Benefits of Open-Source Resources   + Collaboration (shared knowledge and expertise)   + Diversity (contributors from different backgrounds)   + Innovation (rapid development and problem-solving)   **Definition of OS:** Open source means that the source code of a software or project is freely available for anyone to view, use, modify, and share. It is like having a recipe that is not secret—you can see all the ingredients and steps, change aspects if you want to, and even share your own version with others. Open source projects encourage collaboration and are often developed by communities of programmers who work together to improve the software, fix bugs, and add new features. Examples of open source software include the Linux operating system, the Firefox browser, and the programming language Python. The main idea is about openness, sharing, and allowing everyone to contribute.   1. **Individual and Group Sponsorship:** This involves volunteers, independent developers, enthusiasts, or small groups who contribute their time, skills, and sometimes financial support. They often join open source projects out of personal interest, a desire to improve a tool they use, or a commitment to the open source philosophy. 2. **Corporate Sponsorship:** Many companies support open source projects by providing funding, resources, or developers who work on the projects as part of their job. Companies may do this to benefit from the software themselves, enhance their public image, or contribute to the wider tech community. Examples include Google supporting TensorFlow and Microsoft contributing to the Linux kernel.  * Managing Open-Source Communities   + Roles and Responsibilities     - Functions such as maintainers, contributors, and leaders * Best Practices for Community Participation   + Active Engagement     - Participate in discussions and contribute.   + Respect and Kindness     - Treat others with respect.   + Documentation     - Document your work and share it.   There is the diversity of support that open source (OS) communities can receive. Open-source projects often thrive due to contributions and sponsorship from both individuals and companies, each playing a unique role:  **Critiques and problems:**   1. Open source (OS) software is widely praised for its transparency, collaboration, and flexibility, but it also faces several critiques and challenges: 2. Sustainability and Funding Issues: Many open source projects struggle with the lsck of consistent funding and resources. While large projects backed by companies may thrive, smaller ones often rely on volunteer contributions, which can lead to burnout among developers and slow progress. 3. Lack of Professional Support: Unlike proprietary software, which often comes with dedicated customer support, open source projects may lack professional support services. Users may have to rely on community forums and documentation, which can be incomplete or difficult to navigate, especially for non-technical users. 4. Security Vulnerabilities: While open source allows anyone to identify and fix security issues, it also means that vulnerabilities are publicly visible. Not all bugs are fixed promptly, especially in less popular projects, making some open source software susceptible to attacks. 5. Fragmentation and Compatibility Issues: Open source projects can suffer from fragmentation, where different versions or forks of the software are developed independently. This can lead to compatibility issues, a lack of standardization, and confusion among users over which version to use. 6. Quality and Usability Concerns: Open source software is sometimes critiqued for lacking the polish and user-friendly interfaces found in commercial software. Since many projects are driven by developers rather than professional designers, usability and aesthetics can be secondary priorities. 7. Governance and Decision-Making Challenges: Open source projects can face conflicts over direction, leadership, and decision-making, especially in larger communities. Without clear governance, projects can become stagnant or diverge due to disagreements among contributors. 8. Dependence on Key Contributors: Many open source projects depend heavily on a few key maintainers or developers. If these individuals leave or lose interest, it can jeopardize the project’s future, creating a single point of failure. 9. Intellectual Property and Licensing Conflicts: The open nature of source code can lead to legal challenges around licensing, copyright, and intellectual property. Misunderstanding or ignoring licensing terms can result in legal disputes, especially when open source code is incorporated into proprietary software. | FURTHER READINGS  **“The Cathedral and the Bazaar” by Eric S. Raymond:** This essay explains the principles of open source development in an engaging way. It is a foundational text in understanding how open source communities work.  Raymond, E. (1999). The cathedral and the bazaar. *Knowledge, Technology & Policy*, *12*(3), 23-49.  **“What is Open Source?” - OpenSource.com:** A beginner-friendly guide that provides insights into the open source movement, its benefits, and challenges. Available online for free.  **YouTube Channels like “The Linux Foundation”**: They offer videos that explain open source software in a simple and engaging way, suitable for younger audiences. |
| **Open-Source Resources and Communities**  (slide no 25) | **Open-Source Resources and Communities**  Some exemplary communities and resources:  **Wikimedia Foundation (**[**https://wikimediafoundation.org/**](https://wikimediafoundation.org/)**):** The organization behind Wikipedia and other open-knowledge projects.  **OpenStreetMap (OSM) (**[**https://www.openstreetmap.org/**](https://www.openstreetmap.org/)**):** A collaborative mapping project to create free, editable maps of the world. It is the open-source alternative to services like Google Maps.  **GitHub (**[**https://github.com/open-source**](https://github.com/open-source)**):** The largest and most popular repository for open-source code. If you can think of an open source project, it is likely hosted on GitHub.  **Apache Software Foundation (ASF) (**[**https://www.apache.org/**](https://www.apache.org/)**):** Home to incredibly important projects like the Apache HTTP server, Hadoop, OpenOffice, and a massive number of libraries.  **Stack Overflow (**[**https://stackoverflow.com/**](https://stackoverflow.com/)**):** An essential question-and-answer forum for developers. Chances are, if you have had a programming issue, someone has already asked (and gotten an answer) on Stack Overflow.  **Opensource.com (**[**https://opensource.com/resources**](https://opensource.com/resources)**):** A hub of news, tutorials, and articles all about open source.  **SourceForge ([**[**https://sourceforge.net/**](https://sourceforge.net/)**]):** One of the original open-source project repositories, still hosting a large number of projects.  **Mozilla (**[**https://www.mozilla.org/**](https://www.mozilla.org/)**):** Developers of the open-source Firefox web browser, along with other internet and privacy-focused technologies.  **Open Source Initiative (OSI) (**[**https://opensource.org/**](https://opensource.org/)**):** The guardians of the Open Source Definition and a key organization promoting and protecting open-source principles.  **Reddit (Open-Source Subreddits):** Reddit has a vibrant collection of subreddits dedicated to open-source. Some popular ones include:   * r/opensource (<https://www.reddit.com/r/opensource/>) * r/linux (<https://www.reddit.com/r/linux/>) * r/programming (<https://www.reddit.com/r/programming/>) |  |
| **Tools and Technologies Enabling Creative Computing in Circular Economy Initiatives**  (slide no 26) | **Tools and Technologies Enabling Creative Computing in Circular Economy Initiatives**   * Technologies   + Blockchain: * could provide promising results to address the supply chain's sustainability in terms of trust, traceability, and transparency. * Augmented Reality (AR) and Virtual Reality (VR)   + AR and VR technologies enhance user experiences and visualization.   + Example: Using AR to showcase circular economy practices in retail environments * Internet of Things (IoT)   + IoT devices collect real-time data for monitoring and optimizing circular processes.   + Example: Smart waste bins that notify collection services when full.   The name blockchain stems from its technical structure - a chain of blocks. Each block is linked to the previous block with a cryptographic hash. A block is a data structure that allows storage of a list of transactions. Transactions are created and exchanged by peers of the blockchain network that modify the state of the blockchain (K. Wüst and A. Gervais, "Do you Need a Blockchain?," 2018 Crypto Valley Conference on Blockchain Technology (CVCBT), Zug, Switzerland, 2018, pp. 45-54, doi: 10.1109/CVCBT.2018.00011. )(Nofer, M., Gomber, P., Hinz, O. et al. Blockchain. Bus Inf Syst Eng 59, 183–187 (2017). <https://doi.org/10.1007/s12599-017-0467-3>).  Trust, traceability, and transparency emerge as critical factors in designing circular [blockchain](https://www.sciencedirect.com/topics/computer-science/blockchain) platforms in supply chains (Centobelli et al., 2022). To bridge the three circular supply chain reverse processes (i.e., recycle, redistribute, remanufacture) and the three factors affecting blockchain technologies (i.e., trust, traceability, transparency), a circular blockchain platform can be designed in a supply chain, including manufacturer, reverse logistics service provider, selection centre, recycling centre, and landfill. The results highlight blockchain's role as a technological capability for improving control in the movement of wastes and product return management activities.  Here are some more examples:  https://www.blender.org/ - **Blender** is the free and open source 3D creation suite. It supports the entirety of the 3D pipeline—modeling, rigging, animation, simulation, rendering, compositing and motion tracking, even video editing and game creation.  [https://www.tinkercad.com](https://www.tinkercad.com/) –  **Tinkercad** is a free-of-charge, online 3D modeling program that runs in a web browser. Since it became available in 2011 it has become a popular platform for creating models for 3D printing as well as an entry-level introduction to constructive solid geometry in schools.  <https://www.sketchup.com/> -  **SketchUp** is 3D modeling software that allows users to create and manipulate 3D models of buildings, landscapes, furniture, and other objects. It is commonly used in architecture and interior design.  <https://github.com/> - **GitHub** is a developer platform that allows developers to create, store, manage and share their code. It uses Git software, providing the distributed version control of Git plus access control, bug tracking, software feature requests, task management, continuous integration, and wikis for every project.  <https://gitlab.com/> - **GITLAB GitLab Inc.** is an open-core company that operates GitLab, a DevOps software package that can develop, secure, and operate software.  Scratch - a programming language developed to foster creativity and computational thinking. Scratch allows users to create interactive stories, games, animations, and more, emphasizing the playful aspect of learning to code and engaging with digital media. |  |
| **Tools and Technologies Enabling Creative Computing in Circular Economy Initiatives**  (slide n 27) | **Tools and Technologies Enabling Creative Computing in Circular Economy Initiatives**  These technologies enable efficient, automated processes that support the transition from linear to circular production systems, enhancing sustainability and competitiveness .  These include:   * Artificial Intelligence and machine learning for optimizing resource use and waste reduction, * High-performance computing for processing large data sets, * Internet of Things for tracking material usage, * Big data analytics for insights on sustainability initiatives, * Blockchain for transparency, and * 3D printing for minimizing material waste. * For businesses aiming to embrace a circular economy, leveraging a mix of advanced digital technologies is key. | <https://www.unep.org/resources/emerging-issues/blockchain-technology-and-environmental-sustainability>  (K. Wüst and A. Gervais, "Do you Need a Blockchain?," 2018 Crypto Valley Conference on Blockchain Technology (CVCBT), Zug, Switzerland, 2018, pp. 45-54, doi: 10.1109/CVCBT.2018.00011. )  (Nofer, M., Gomber, P., Hinz, O. et al. Blockchain. Bus Inf Syst Eng 59, 183–187 (2017). https://doi.org/10.1007/s12599-017-0467-3).  (Centobelli, P., Cerchione, R., Vecchio, P. D., Oropallo, E., & Secundo, G. (2022, November). Blockchain technology for bridging trust, traceability and transparency in circular supply chain. Information & Management, 59(7), 103508. <https://doi.org/10.1016/j.im.2021.103508>) |
| **Right to repair (R2R)** (slide no 28) | **Right to repair (R2R)**  **We Need Right To Repair**  The Digital Right to Repair Coalition is an independent nonprofit organization advocating for freedom of choice and fair competition for repairing anything with a computer chip. | <https://www.repair.org/> |
| **Right to repair (R2R)** (slide no 29) | **Right to repair (R2R)**  Repair can be understood as a constitutive part of humans’ life on Earth, and there are many ways to conceive and manage how repair is performed (Hernandez et al., 2020). In opposition to maintenance, repair is defined by the event of malfunction, meaning it holds a reactive nature (Hernandez et al., 2020). In this scope, the right to repair encompasses a response to negative legacies of contemporary consumer culture, and it is an important way of increasing the lifespan of goods and addressing global e-waste (Manwaring et al., 2022). Therefore, the right to repair claims to address the problems associated with the contemporary ‘throwaway’ culture (Graziano & Trogal, 2017), while realizing several barriers of economic level such as commercial strategies that limit the availability of spare parts, proprietary tools, and fittings alongside often-confusing consumer warranty conditions and the increasing sophistication of everyday consumer products (Manwaring et al., 2022). According to Graziano & Trogal (2017), antecedents that influenced the formation of a repair movement can be traced in autonomous initiatives such as the Hackerspaces and Medialabs of the early 1990s, as well as the independent bicycle-repair workshops opened by many squatters’ movements across Europe since the late 1970s. While policy and legislative debates around the right to repair have largely arisen in the Global North, questions of repair also are increasingly being recognized as pertinent in the Global South, where historically the Global North have discarded their unrepaired goods (Manwaring et al., 2022). Repair has the capacity to connect across diverse fields and interests, and studies of diverse fields concerning repair practices and cultures are fostering important discussions that are political in nature, going beyond the confines of specific subjects (Graziano & Trogal, 2017). Graziano & Trogal (2017) remark that the right to repair movement is currently fed by campaigns to change legislation, repair cafés, community tool libraries, and online fora. | Hernandez, R. J., Miranda, C., & Goñi, J. (2020). Empowering Sustainable Consumption by Giving Back to Consumers the ‘Right to Repair’. *Sustainability*, 12, 850. <https://doi.org/10.3390/su12030850>  Manwaring, K., Kearnes, M., Morgan, B., Munro, P., Pala, R., & Samarakoon, S. (2022). What does a right to repair tell us about our relationship with technology? *Alternative Law Journal*, *47*(3), 179-186. <https://doi.org/10.1177/1037969X221108557>  Graziano, V., & Trogal, K. (2017). The politics of collective repair: examining object-relations in a postwork society. *Cultural Studies*, *31*(5), 634-658. https://doi.org/[10.1080/09502386.2017.1298638](https://doi.org/10.1080/09502386.2017.1298638) |
| **Right to repair (R2R)** (slide no 30) | **Right to repair (R2R)**  EU regulation and the Right to Repair   * Common rules to promote the repair of goods for consumers proposed * Both within and beyond the legal guarantee * Makes it easier and more cost-effective to repair products instead of replacing them with new ones   EU regulation and the Right to Repair   * March 2023 European Commission adopted new consumer rights * February 2024 European Council and Parliament accepted concept * Once formally adopted, Directive goes into force | <https://www.europarl.europa.eu/news/en/press-room/20240419IPR20590/right-to-repair-making-repair-easier-and-more-appealing-to-consumers>  <https://ec.europa.eu/commission/presscorner/detail/en/ip_23_1794> |
| **Right to repair (R2R)** (slide no 31) | **Right to repair (R2R)**   * The Repair Café has the following goals: * Repair: to bring repairing back into local society in a modern way; * Spread: to maintain repair expertise and to spread this knowledge; * Promote: to promote our badly needed circular economy. | For example,  <https://www.repaircafe.org/en/>  <https://repairtogether.be/carte-repaircafe/> |
| **Right to repair (R2R)** (slide no 32) | **Right to repair (R2R)**  What can be fixed?   * Furniture upholstery * Tool and knife sharpening * Old cameras and slide equipment * Photographic and digital images * Textiles – sewing, knitting, darning * Garden equipment * Wooden items |  |
| **Right to repair (R2R)** (slide no 33) | **Right to repair (R2R)**  **Stewards of Mother Earth** **Zero Waste Alliance Ireland**  Small changes in our daily habits can make a big impact on reducing waste and conserving resources. |  |