Dimensions of Industrial Openness

Understanding Openness and Its Implications for Sustainable Transformation

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Openness in der Industrie – Offene Systeme und ihre Implikationen für eine nachhaltige Transformation

Das Thema Openness ist von wachsender Bedeutung für die Industrie, insbesondere in Europa. Der Begriff Openness wird jedoch sehr unterschiedlich verwendet. Openness beinhaltet mehrere Konzepte, darunter Open Source Hardware, Open Source Software, Open Data, Open Standards, Open Innovation, Open Science und Open Education. Die Konzepte richten sich an verschiedene Dimensionen von "open Businesses", die allesamt auf einer Art Partizipation basieren und das Ziel haben, mehr Transparenz und Zugänglichkeit zu schaffen. In diesem Artikel werden die Konzepte definiert und ein Grundverständnis von deren Bedeutung für die Industrie und für mehr Nachhaltigkeit geschaffen.

Schlüsselwörter:

Openness, Open Source Software, Open Source Hardware, Open Data, Open Standards, Open Innovation, Open Science, Open Education, Sustainability, Circular Economy

The topic of Openness is of growing importance for industry, especially in Europe. However, the term Openness is used very differently. Openness includes several concepts, including Open Source Hardware, Open Source Software, Open Data, Open Standards, Open Innovation, Open Science and Open Education. The concepts address different dimensions of Openness, all based on some kind of participation and with the goal to create more transparency and accessibility. This article defines the concepts and provides a basic understanding of their importance for industry and for greater sustainability.

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Openness within industry addresses various domains, including Open Source Software, Open Source Hardware, Open Data, Open Standards, Open Innovation, Open Science, and Open Education. In essence, all concepts are characterized by participation, emphasizing the active involvement and engagement of individuals and organizations by sharing, collaborating and contributing to the collective knowledge and resources. Some common principles referred to in the literature are:

1. **Community:** Openness both creates and depends on communities which collectively co-create solutions and solve problems. These communities provide support, feedback, and peer review, ensuring the quality and reliability of open resources [1, 2, 3].
2. **Collaboration:** Openness emphasizes collaboration and participation by individuals and organizations [1, 2, 3, 4]. The collaboration of the community creates a culture of sharing knowledge, expertise, and resources, leading to collective innovation [5].
3. **Accessibility:** Openness aims to remove barriers and to ensure equal access to knowledge, resources, and technologies [1, 5]. Accessibility is a crucial prerequisite for Openness and related concepts [2].
4. **Transparency:** Openness emphasizes transparency by promoting availability and accessibility of information and data [1, 2].
5. **Democratization:** By making resources and knowledge accessible to everyone Openness contributes to the democratization of society [1, 2, 5, 6].
6. **Freedom:** Openness creates freedom of choice for individuals and organizations by providing open resources and granting full access for any given purpose [1, 5]. By preventing so-called vendor lock-ins it strengthens resilience and independence of single resource providers [5].
7. **Reproducibility:** Openness emphasizes the reproducibility of data, research and technologies. By sharing methodologies, data sets, research findings and building plans it enables the validation and improvement of knowledge, resources and technologies in research, industry, and society [1, 6].

Although all principles are relevant for all concepts, they play different roles in each of them. And there are additional specific principles. In technical concepts, like Open Source Hardware, Open Source Software, Open Standards and Open Data, interoperability plays a vital role. Interoperability refers to ability for complex systems to exchange information and work together (inter-operate)

[7]. All these principles of Openness have significant relevance for the industry and their implementation can lead to sufficient innovation. Harnessing the benefits thereby leads to the development of high-quality products, services, and solutions [1, 2, 5].

All the concepts are interconnected and partially interdependent. The implementation in organizations' business models again requires a deeper understanding of the concepts and their implications. Splitter et al. [2] investigated some of these implications in a cross-domain principle, which they call open organizing, focusing on designing a collaboration friendly environment. They conclude that Openness in organizations requires continued adjustment to retain stability while reacting to changing circumstances and trade-offs between the different domains.

Defining concepts of Openness

The term "open" is used in many concepts. As explained above these share certain common principles. The core aspects on the other hand differ substantially and therefore the term "open" cannot be used interchangeably for all concepts. Key differences include the intellectual property (IP) licenses (e. g. covered by copyright or copyleft), commercial aspects (e. g. business models for value creation) and the relevant actors [4]. Subsequently, the basic terms and the main concepts referred to in this article are described briefly. Figure 1 shows some of the common labels used for Open Source declaration referred to in the definitions.

The wider domain of the addressed concepts are the knowledge commons. Knowledge or information commons are resources that are accumulated by the public. Sharing between different users improves the resource instead of reducing its quantity or quality [8].

The term "Open" in regard to the knowledge domain is best described by the Open Definition by the Open Knowledge Foundation (OKF):

"The **Open Definition** [promotes] a robust commons in which anyone may participate, and interoperability is maximized. Summary: Knowledge is open if anyone is free to access, use, modify, and share it — subject, at most, to measures that preserve provenance and openness." [9]

A very common term is **Open Source**. The term is deeply connected to the development of the Free and Open Source Software (FOSS) movement. The principle of the Four Freedoms, as already present in the Open Definition, simultaneously provides good orientation for understanding the concept of Open Source in general:

"Free Software can be used for any purpose and is free of restrictions such as license expiry or geographic limitations. Free Software can be shared and copied at virtually no cost. Free Software and its code can be studied by anyone, without non-disclosure agreements or similar restrictions. Free Software can be modified by anyone, and these improvements can be shared publicly." [10]

Open Source Software (OSS) is based on these principles. The Open Source Initiative (OSI) provides a widely accepted definition for OSS, encompassing the free redistribution and provision of the source code as well as the permission of derived works, the integrity of the author's source code, rules forbidding discrimination against individuals, groups or fields of endeavor and the distribution of product-unspecific, software-unrestrictive or technology-neutral licenses [11]. The SPDX archive [12] maintains a list of free and open licenses in accordance with the Open Definition and differentiates them respective to their compatibility with the OSI definition.

Open Source Hardware (OSH) similarly uses the Four Freedoms as basis. The most common definition of OSH is provided by the Open Source Hardware Association (OSHWA):

"[OSH] is hardware whose design is made publicly available so that anyone can study, modify, distribute, make, and sell the design or hardware based on that design. The hardware's source, the

Figure 1: Label for Open Source Hardware by OSHWA, Open Source Initiative (OSI) and Creative Commons (Public domain).

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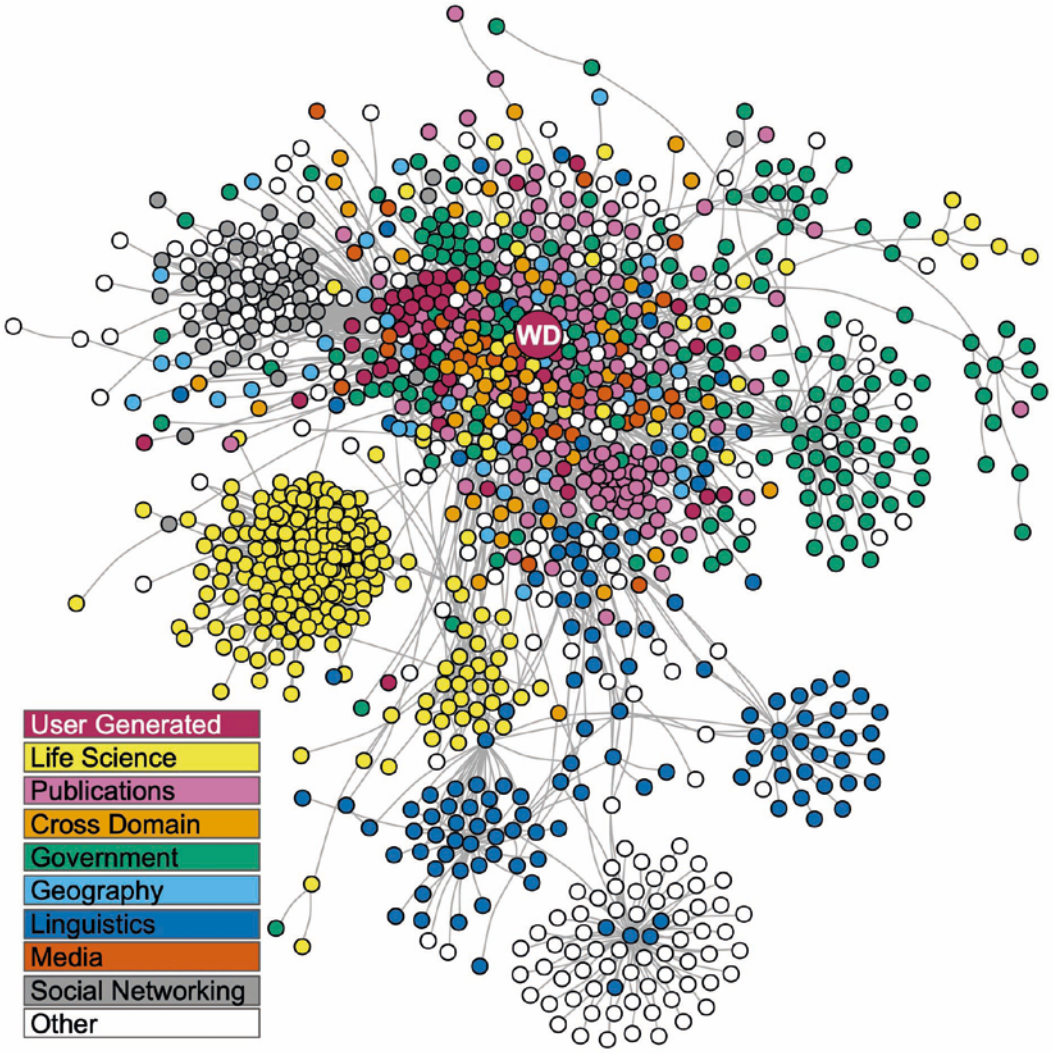

Figure 2: Linked Open Data Cloud by Thomas Shafee via Wikimedia Commons (CC BY 4.0).

design from which it is made, is available in the preferred format for making modifications to it. Ideally, open source hardware uses readily available components and materials, standard processes, open infrastructure, unrestricted content, and open-source design tools to maximize the ability of individuals to make and use hardware. [OSH] gives people the freedom to control their technology while sharing knowledge and encouraging commerce through the open exchange of designs." [13]

Open Data is data that is published under an open license. According to the Open Definition Open Data needs to available and accessible at reasonable costs, redistributable, reusable and allow universal participation [9]. The OKF therefore defines Open data as:

"[...] data that can be freely used, re-used and redistributed by anyone - subject only, at most, to the requirement to attribute and sharealike." [9]

As an example, figure 2 shows the structure of the Linked Open Data Cloud by Wikidata, to illustrate the types and connections between different domains in a data ecosystem.

Open Standards are an essential part of Openness, since they are key to enabling interoperability. The International Telecommunication Union (ITU) defines Open Standards as: "[...] standards made available to the general public and [...] developed (or approved) and maintained via a collaborative and consensus driven process. 'Open Standards' facilitate interoperability and data exchange among different products or services and are intended for widespread adoption." [14]

The Open Geospatial Consortium (OGC) further defines six additional criteria. In order to be open, standards need to be freely and publicly available, non-discriminatory, free of license fees, be vendor neutral (independent), be data neutral (technology independent), defined, documented, and approved in a consensus-based decision-making process [15].

Open Innovation is a collaborative approach for solving problems and creating new ideas. Bogers et al. [16] reviewed several definitions and describe it as cross-organizational information flows creating knowledge and technologies. It involves external knowledge that is integrated in organizations (outside-in) and the sharing of internal knowledge by the outside world (inside-out).

Open Science integrates different concepts for transparency, like open access and open data,

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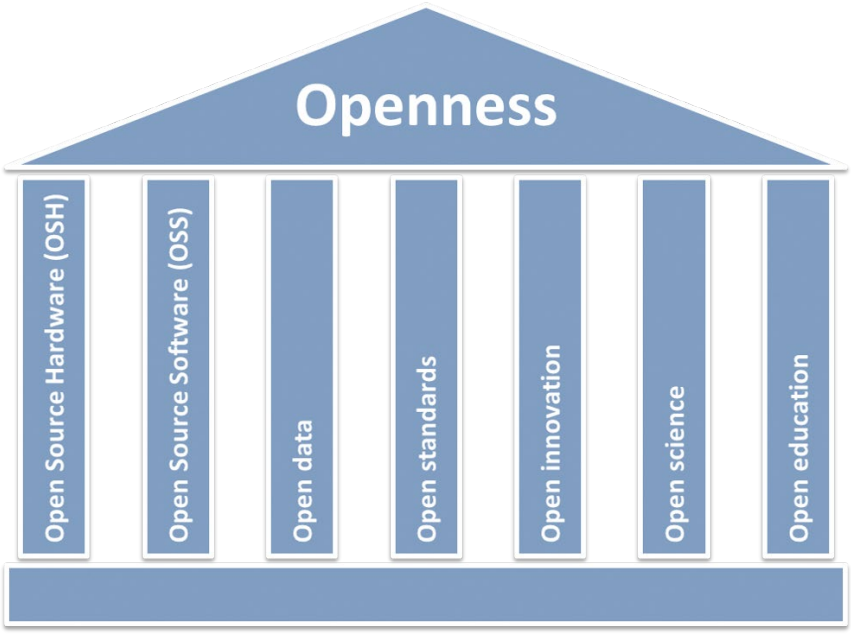

Figure 3: Seven concepts of Openness.

to make knowledge accessible. Vicente-Saez et al. derived a corresponding definition from the literature: "Open Science is transparent and accessible knowledge that is shared and developed through collaborative networks." [17]

Open education is a movement that promotes the use of Open Educational Resources (OER) along with open resources and practices without any barriers to improve the overall accessibility of education and knowledge [18].

Potentials of Openness for Industry

As presented in the previous section, different concepts are used to define the dimensions of Openness. Figure 1 summarizes the seven concepts that represent the pillars of open ecosystems in organizations. The given definitions provide an overview and references to common guidelines for reaching full Openness in the respective dimensions.

Companies need to implement new strategies to prepare for collaborative value creation. Opening business platforms allows different systems to exchange information and thereby enables cross-organizational collaboration. This involves new opportunities like cost savings, higher efficiency, smarter development and wider service offerings, but also risks, like market differentiation [19]. New business models are emerging constantly, opening up business and research opportunities alike (compare [3, 19, 20, 22]). However, the transition of businesses requires detailed understanding of the landscapes and adjustment of the value creation models in companies' core strategies. Broekhuizen et al. [20] define 5 dimensions for 'platform openness', actor-based (suppliers, customers, complementary services providers) and non-actor based (categories and channels), which provide a good guidance for value creation involving different stakeholders. What remains to be solved is to find suitable measurement for Openness that define and determine the level of actors participating in the system. To define and verify measures for Openness is the topic of future research.

Besides economic growth and autonomy of both individuals and organizations, Openness can have substantial effects on the environmental dimensions of sustainability by inspiring more responsible innovations [21]. By promoting transparency, accessibility and collaboration in communities Openness enables the exchange of knowledge and resources leading to co-innovations. For businesses this opens up new ways of value creation and intellectual capital management. Open Innovation processes are thereby likely to create innovations that are more socially responsible, environmentally positive, and economically stable [22]. Bonvoisin [3] further investigated how open design leads to eco-efficient technologies that can be easier repaired and upgraded, reducing waste and extending product lifetimes which are important design elements within the Circular Economy. Up to now there is not much scientific research existing on the relation of Openness, sustainability and the Circular Economy. Thus, it is also up to future research to investigate these relations.

Keywords:
Openness, Open Source Software, Open Source Hardware, Open Data, Open Standards, Open Innovation, Open Science, Open Education, Sustainability, Circular Economy

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