Personal Learning Environments as socio-technical systems: does decentralised data finally give us the right balance?

Entornos personales de aprendizaje como sistemas sociotécnicos: ¿los datos descentralizados nos dan por fin el equilibrio adecuado?

Kamakshi Rajagopal
IMEC, KU Leuven. Kortrijk, Belgium
kamakshi.rajagopal@kuleuven.be

Abstract
In this conceptual article, I pose three claims on the data ecosystem of Personal Learning Environments (PLE). I argue that (i) the current centralised data ecosystem is inherently incompatible with the concept of a PLE; (ii) that mainstreaming this concept will involve a transition to a technical decentralised data architecture, with Personal Data Storage for learners; and (iii) that new governance structures are needed to ensure learners' data creates value for learning and learners themselves. I support these claims by analysing the technological data ecosystem of a PLE under the lens of sociotechnical systems theory. I consider the centralised data and decentralised data (based on Solid - Social Linked Data) conditions to unravel in which ways social relations, power and agency are shaped by technological and organisational choices.
Key words: decentralised web; personal learning environment; sociotechnical systems theory; entanglement; educational ecology; design

Resumen
En este artículo conceptual, planteo tres afirmaciones sobre el ecosistema de datos de los Entornos Personales de Aprendizaje (PLE). Sostengo que (i) el actual ecosistema de datos centralizado es intrínsecamente incompatible con el concepto de un PLE; (ii) que la integración de este concepto implicará una transición hacia una arquitectura de datos técnica descentralizada, con un almacenamiento de datos personales para los alumnos; y (iii) que se necesitan nuevas estructuras de gobernanza para garantizar que los datos de los alumnos crean valor para el aprendizaje y para los propios alumnos. Apoyo estas afirmaciones analizando el ecosistema tecnológico de datos de un PLE bajo el prisma de la teoría de los sistemas sociotécnicos. Considero los datos centralizados y descentralizados y sus condiciones de uso (basados en Solid - Social Linked Data) para desentrañar de qué manera las relaciones sociales, el poder y la agencia son moldeados por las elecciones tecnológicas y organizativas.
Palabras clave: web descentralizada; entorno personal de aprendizaje; teoría de los sistemas sociotécnicos; enredo; ecología educativa; diseño

1. Introduction

A Personal Learning Environment (PLE), as a learning environment designed and controlled by an individual learner to facilitate their lifelong learning, should be the workhorse of any knowledge-based society. However, although this concept has been around for over a decade (Van Harmelen, 2006), it has so far failed to take up this position. In this conceptual paper, I make three claims:

1) the concept of PLEs is inherently incompatible with the current organisation of data storage, management and ownership on the Internet.
2) For learners to fully exploit PLEs to support their knowledge work activities, a transition needs to be made to decentralised data management through initiatives such as the Solid (Social Linked Data) Project (Solid Project, 2022).
3) New governance structures are needed that enable learners to share data appropriately for the benefit of learners themselves.

This article is structured as a theory synthesis (Jaakkola, 2020): First, I will elaborate on the phenomenon of PLEs as a conceptual perspective on a technological ecosystem that support individuals' knowledge work. I will discuss the problems arising in the current implementations of PLEs, aligning it with other issues of data ownership. I will also focus on upcoming solutions on data decentralization and data collectives. Then, I will introduce the theoretical perspective of sociotechnical systems (STS) theory as a lens to view data in PLEs. I will contrast an STS-based model of the current situation against an STS-based model of a potential future based on decentralised data management (using the Solid Project). Finally, I will formulate arguments for the three theoretical claims I pose above, that can inform future research.

2. PLEs and data

2.1. PLEs for Knowledge Work

In today's society, knowledge work has become the nature of many professions. People building a career in current society are expected to constantly develop their knowledge and skills relevant to their career, following the needs of their profession in the digital age. Reinhardt et al. (2011) present a model of a knowledge worker's interaction with the external world and their individual context.

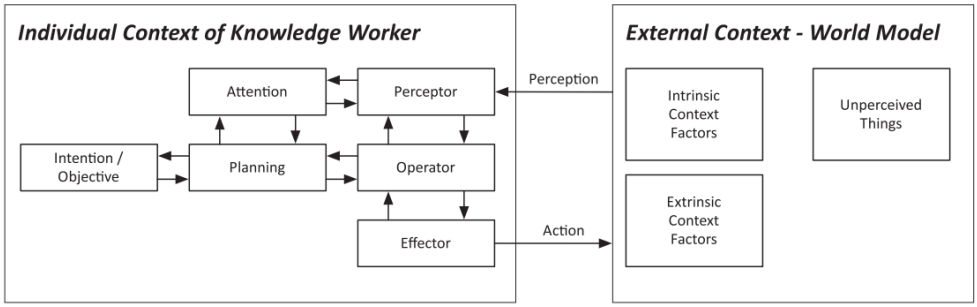


Figure 1 Human-world interaction model

Figure 1 Context of a Knowledge Worker (taken from Reinhardt et al., 2011)

Knowledge workers conduct various knowledge creation and knowledge management activities to support their learning and working objectives. This individual context interacts iteratively with the external context of the world, with perception of factors and action in the world. Working in such an environment, knowledge workers need continuous professional development strategies that are appropriate and sustainable.

One such appropriate and sustainable infrastructure, of much interest in the research community, is the Personal Learning Environment. The concept of the Personal Learning Environment has been proposed as the technosocial infrastructure that can support lifelong learning and working, cutting across formal, non-formal and informal learning contexts (Dabbagh & Castaneda, 2020). As such, it can be the environment that supports learners throughout their learning career as knowledge worker and lifelong learner. PLEs are (often) supported by cloud-based technologies, allowing in principle for learner agency and control, made possible by the ease of use of Web2.0 technologies. Nan Cenka et al. (2022)'s Model identifies 4 dimensions of the PLE that shape the environment: (i) personal, (ii) technology, (iii) teaching and learning, and (iv) organization and social (Nan Chenka et al., 2022). The PLE has the potential to be an environment that is a self-driven context of the learner, created to adapt to and grow with the learner, through a lifelong learning context. In other words, the PLE is a technological infrastructure highly suited for today's needs in society, as it offers a flexible, extendable, adaptable solution, that can capture the complexity of a knowledge worker's learning environment.

Through PLEs, learners can effectively design their technological and social infrastructural context, that create the learning environment in which knowledge workers learn and work. This learning environment is complex and multi-dimensional. I distinguish four dimensions to a learning environment:

1. Technological dimension: the technologies used to support the learning of the learner. In a PLE, these are the technologies part of the environment around the learner.
2. Social dimension: the social constellations chosen to support the learning of the learner. In a PLE, these can take on various forms, including individual activities, group activities, communities or networks.
3. Pedagogical dimension: the pedagogical approaches used to help the learner progress towards their learning goals. In a PLE, these can be led by the self-directed learner, or a teacher/educator who guides the learner.
4. Organisational dimension: the choices made related to structure and organisation of learning. In a PLE, this is led by the self-directed learner.

The complexity of a learning environment has become of increasing interest over the past years, with multiple authors seeking ways to define this complexity. Taking an ecological perspective, Ellis & Goodyear (2019, pp. 4-5) distinguish three different entities:

(i) a (learning) environment, which is the immediate and close surrounding around a learner. This environment is shaped by a learner and the learner is shaped by the environment. This takes a egocentric view of the environment around the learner.
(ii) an (learning) ecosystem, consisting of multiple learners who engage with each other and non-living things around them. The prototypical case is a classroom.
(iii) an (educational) ecology, in two meanings – as a synonym for an ecosystem and as a field of study, researching ecologies. The prototypical case is a school or university.

All three entities identify different types of pedagogical, social, technological, and organizational intertwinements in which it may not always be possible to distinguish the

original components (Ellis & Goodyear, 2019). Fawns (2022) calls out the appeal of determinism in using a primarily pedagogical or primarily technological focus, foregoing a recognition of the complexity of the environment. He proposes a model of Entangled Pedagogy, where the aspiration is to use purpose, context and values as guiding principles for pedagogical and technological choices, leading to knowledge building. Selwyn (2012) argues that we need to consider more profoundly the social nature of digital technologies, recognizing the intricate interweaving of social relations in digital technology. Moreover, he states that "a careful use of social theory is an essential component of developing rich understandings of the structures, actions, processes and relations that constitute uses of digital technologies in educational settings and contexts" (Selwyn, 2012, p. 82).

So as more attention is being called for the complex social, technological and pedagogical intricacies of a learning environment, one aspect that is currently highlighted less in these discussions is the complexity created by the organizational aspect. The organisation of a learning environment relates to the choices made on structural approaches to the learning, with thought on processes and practices undertaken. In a sense, the organisational dimension is the precursor to all other dimensions, as decisions taken on this aspect will largely determine what the other dimensions will look like. Moreover, organisational decisions will be guiding the learner in making their PLE more suitable to achieve their learning goals.

An example may make this aspect clearer: Marianne, a business analyst, wants to explore entrepreneurship as a career. As she is in the early stage of exploration (*organisational*), she starts talking to entrepreneurs in her acquaintance network to gain insight into the career path (*social*). As she is convinced in these early talks that this is the path for her (*organisational*), she does some research on the practical aspects online (*technological*) and reaches out to some career coaches online (*technological-social*). After the discussions with the coaches, she wants to take the first steps in setting up her own business (*organisational*), but she feels she lacks skills in business administration aspects. She enrols in some courses on how to run a business and how to draft a financial plan at her local college (*pedagogical*). She also discovers that some regulars at her gym class are experienced entrepreneurs and willing to advise her informally in this starting phase (*social*).

In this example, organisational choices determine which learning goals the student will pursue, and how she will approach them. These choices are often subtle and may even grow organically (rather than explicitly), but they do determine practice (technologies chosen, social roles taken up, pedagogical approaches taken).

As early as 1969, Herbert Simon included the field of education in the same category as other design sciences such as architecture and engineering because educators through their interventions shape environments for their learners. The resulting learning environment becomes a mix of a partially designed, partially natural environment and context, in which the learner lives (Simon, 1969). Especially in durable learning environments, organisational, structural choices become highly important, as they determine what environments will look like over time. Once embedded into processes

and working methods, organizational choices are more likely to become part of systems shaping future generations of users.

From a learner's perspective, PLEs can be conceptualized as follows:

- a PLE is the partially designed, partially natural complex learning environment in which they learn and work
- a PLE involves social, technological, organisational and pedagogical dimensions that are highly intertwined.
- a PLE enables learners to work and learn more effectively, focusing their vision on relevant external factors, and filtering out irrelevant factors. The learner determines the boundary between relevant and irrelevant.
- The ultimate goal of a PLE is to promote learning, and the design choices a learner makes are geared towards that goal.

2.2. PLEs remain on the side lines of mainstream education

With this conceptualization of a PLE, it can be expected that a PLE takes up a central role in learning solutions in our current knowledge-based society. Despite the opportunities afforded by the concept of the PLE for lifelong learning, it has not yet found its way into mainstream education. Attwell (2021) identifies some issues that may be the cause of this (Attwell, 2021, p 522-523). Building on Attwell (2021), I select and paraphrase the 5 reasons identified, and link them to the dimensions of complexity of the learning environment involved.

Table 1

Reasons for failure of PLE concept and related dimensions of complexity

	Reasons (based on Attwell, 2021)	Dimension of Complexity involved
1	The pedagogy of a PLE was under-researched, whereas more interest appeared to be in the technological support of a PLE	Pedagogy-Technology
2	Students need advanced levels of technological, self-regulation and self-directedness skills to benefit from PLEs	Technology – Social – Pedagogy
3	Students have been increasingly characterized as customers seeking (and paying for) a service and not as learners seeking an education.	Organisation – Social
4	The initial decentralized web with a burgeoning of web 2.0 apps has disappeared. On the contrary, services are increasingly grouped in big centralized/commercial service providers.	Organisation – Technology

5	The commerce of EdTech has increasingly associated with control and managerialism, moving away from empowerment of students in managing complex, self-created learning environments.	Organisation – Social – Pedagogy – Technology

Two things can be observed. Firstly, all reasons involve multiple dimensions of complexity in the PLE. In other words, to solve them will involve better understanding of the problem. Secondly, underlying many of these stated causes lies a concern of student personal data, its creation, control, management and sharing rights.
In this article I primarily focus on those issues that involve the technological dimension, and in particular the issues concerning data.

2.3. The digital data ecosystem

The digital environment in which PLEs operate have become spaces where whoever controls data has huge power over what they can achieve (Verhulst, 2022). Data is seen as an asset, and data rentiership, i.e. appropriation of "value through ownership and control of data as an asset" is seen as a way for innovation (Birch et al, 2020, p 470).
In recent years, this aspect of digital technology commerce has been under the spotlight with many cases of fraudulent and unethical data management, data breaches (Olesen, 2019) and the use of algorithmic power to manipulate public opinion through media access (Dowling, 2022). Societal pressure from governments and regulators is growing to break monopolies of big technology companies and their control over personal data. The Digital Services Act and Digital Markets Act in the European Union are just one example of how governments are regulating this space to (re-)empower the individual user of the Internet (Turillazzi et al, 2022; Carugati, 2022).

The appreciation of data has created various economic and social inequalities. Verhulst (2022) groups these in three asymmetries:

- Data asymmetry: caused by a "divide or disparity in control of and access to data" (Verhulst, 2022). This is typically between companies and their users, but can equally exist between companies, resulting in (semi-)monopolies. Asymmetry can also exist between companies and government, or even governments and society at large. Addressing data asymmetry needs to go hand in hand with regulation on privacy and ethical sharing of data.
- Information asymmetry: data on its own is not valuable if it cannot be analysed and understood as information. However, in the current technological landscape, fewer and fewer actors have access to the "technical, financial and human resources" needed to "translate data into actionable information."
- Intelligence asymmetry: the methodologies themselves used to analyse data (i.e. algorithms) also create asymmetry, as not all actors are able to use them effectively and interpret results critically. As algorithms are used to automate services based on data, this creates asymmetry between the ones who understand and the ones who do not.

To counteract this centralization of data and power in a few large corporations, technologists have also been formulating technological solutions, by re-exploring the decentralized web (Mechant et al., 2021), where data is stored in Personal Data Spaces or Personal Data Stores and shared actively by individuals in data networks. One such technical implementation is the Solid project, fronted by Tim Berners Lee (Sambra et al., 2016). Combining several existing web standards, Solid promotes a platform that specifies how data of users is managed independently of the applications that use them. Users can manage their own data through their personal *pod* and provide access to service providers to use their data for as long (and only as long) as the user desires. This creates more agency for users, because the data is owned by user, and actively shared with user-selected service providers. Recent months has seen political interest in the Solid project. For example, Flanders in Belgium will become the first region to widely implement Solid, in a bid to provide their citizens with an alternative to current technological silos (Vlaanderen, 2022).

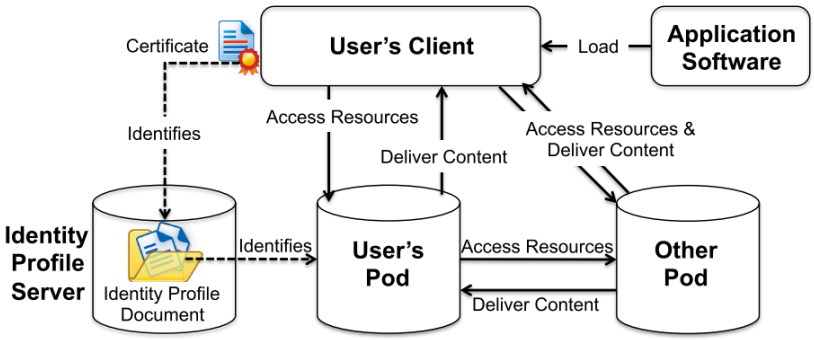


Fig. 1. Solid Architecture. The user controls his/her identity using an RDF profile document, often stored on a pod server. The user loads a Solid application from an application provider. The application obtains the user's pod from the identity profile. It then follows links from the profile to discover data on the user's pod, as well as on other pods, performing authentication when needed.

Figure 2 Solid Architecture (from Sambra et al., 2016) – User pod is the controller for user data

If data is organized in Personal Data Stores, there is still a need to share this data with others to acquire services or to work together. A solution promoted by several authors in the field is the use of data networks, collectives, or cooperatives (Hardjono & Pentland, 2018; Verhulst, 2021). In these structures, agreements are made beforehand on who owns the data, how data will be used to create value and how data sharing will be dealt with in an ethical fashion. Although these structures have many positives, researchers are critical about their effectiveness, as it requires more interest and agency on the part of individual consumers. Initial experiences of e.g. the application of GDPR in Europe show great levels of indifference in most consumers with respect to their data privacy (Merchant et al, 2021). Additionally, the emergence and durability of social networks is also uncertain.

3. The PLE as a sociotechnical system

To understand the tension points of PLEs in the current data ecosystem, it is useful to analyse the concept using a lens of sociotechnical systems (STS) theory. In this section, I will first introduce STS theory, to then present two models of the PLE in a current centralized data ecosystem and a potential decentralized data ecosystem.

3.1. Sociotechnical Systems Theory

A theoretical perspective from organizational sciences that is particularly useful here is sociotechnical systems (STS) theory (Trist & Bamforth, 1951; Perrow, 1973; Guest, Knox & Warhurst, 2022). Originating in the 1950s and developed throughout the 1970s-1980s, STS considers the relationship between the social system and technical system within an organization and how they contribute towards the productivity of an organization. STS emphasizes that "for a given technology, there was a choice of social organization, and that for effective operation, it was necessary to optimize both the social and technical system, or (…) 'to have a social and a technological whole'" (Guest, Knox & Warhurst, 2022, p. 2).
To achieve this "whole", STS theory predicates joint optimization of the social and technical systems, to reach balance for effective productivity. Joint optimization is achieved by organizational choices, and here STS theory is guided by three principles: (i) responsible autonomy, where groups in an organization are given autonomy for self-governance and self-organisation with responsibility and accountability attached to it; (ii) adaptability, where organizational choices are dynamic, reacting to internal and external influences; and (iii) meaningfulness of tasks, where organizational work is centered around meaningful tasks grouped in a number of core jobs (Walker et al., 2008). Moreover, STS theory views organisations as open systems, characterized by the following features (Walker et al., 2008):

- They interact with an external world and other systems. This means they can be influenced and can change due to factors outside of themselves.
- They go through fluctuations of "steady states" (or forms of stability for specific periods of time) and periods of change.
- They have features of equifinality, i.e. they can achieve the same outcomes by using different internal processes.

Although STS theory is prevalent in organisational and to some extent technological research, it is largely unknown in educational research. An exception is its application in the organisation of higher education such as in Legemaate et al. (2021).

The data ecosystem in a PLE is highly complex, with social, technological, pedagogical and organizational aspects intertwined in its implementation, where taking a sociotechnical system perspective on the phenomenon can be very fruitful. To understand the issues of data management in the complex context of Personal Learning Environments described above, I analysed the PLE using the lens of sociotechnical systems theory (Trist & Bamforth, 1951; Perrow, 1973; Guest et al. 2022). To ensure that a comprehensive view of the PLE is taken, I use the ontology-based conceptual model of a Personal Learning Environment (Nan Cenka et al., 2022) to identify the elements and relations of the social system (*who is in the social system?*) and the elements and relations of the technical system (*what is in the technical system?*) in centralized and decentralized

technological infrastructure set-ups, including data control and data flows in these systems.

3.2. Sociotechnical system of the PLE in a centralised data ecosystem

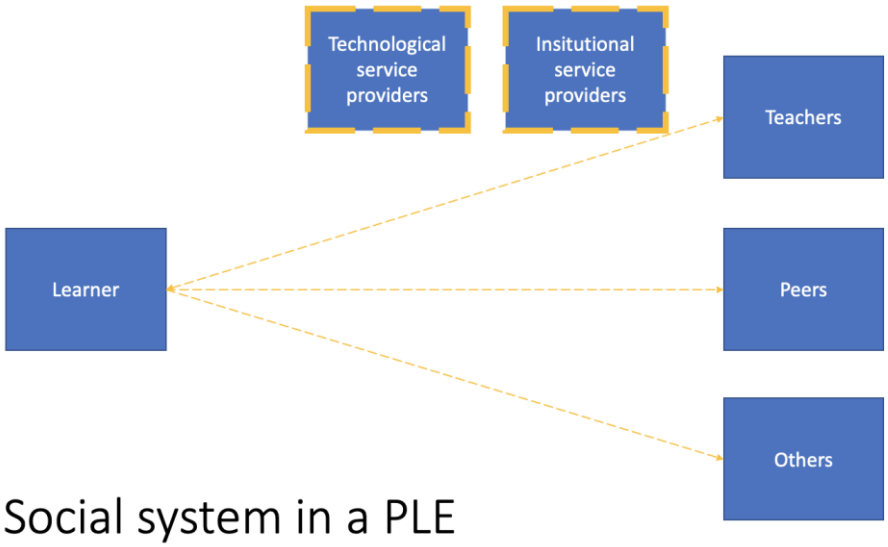
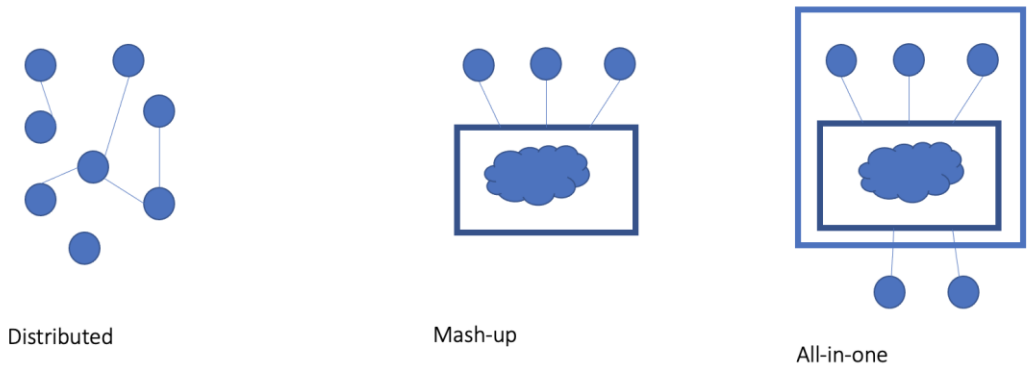


Figure 3 Social System in a PLE (dashed orange = hidden)

Figure 3 identifies the elements and relations of the social system in a PLE, in a data centralized technological infrastructure. The first element in this social system is the learner, who takes charge of the learning. The teaching and learning dimension shows that a second social element (i.e. the teacher or peers) can be involved, to interact with the individual learner. There may also be others who are involved in the PLE of a learner, depending on their roles in the learning process of the individual learner. Apart from these obvious learning-related social actors, the technology dimension reveals that there are hidden social roles for the technological service providers and institutional service providers. These latter social roles exert a great amount of control over the relations between learner and teacher, learner and peer and learner and others in the learning process. This control takes the shape of technological access provision and channel management.

Figure 4 discusses the technical system of the PLE in a centralized data ecosystem. The technical system fulfils several functions for the learner at the centre of the PLE but is primarily shaped by its architecture. Following Nan Cenka et al. (2022), I distinguish three modes: distributed, mashup and all-in-one. In distributed architectures, the web-applications are individual entities with limited connections between different applications. Data is managed by different applications, in different technical environments. In a mash-up context, data from individual applications are brought into a mash-up view of the data, creating more user-friendly access for the learner. Although the learner may have more ease of working, the data remains distributed across different applications. In an all-in-one architecture, data on the learner can be available inside and

outside institutional boundaries. This data can still be aggregated together into a mash-up view providing more user-friendly access. Here too, the data ultimately remains with individual applications, although the institutional boundaries create options to provide more insight with institutional-level data.



Techical system in a PLE

Figure 4 Technical system in a PLE (blue dots = applications; cloud = mash-up view)

Concluding this part, the sociotechnical system in the PLE (Figure 5) shows that in all three technological architecture formats, the hidden social role of the technological service provider and the institutional service provider have a lot of control over the data flows within a PLE. A learner is subject to the data management whims of individual service providers in a distributed architecture. Although the mashup context gives the learner more control over which data is imported into a particular view, this control is subject to the technical interaction between the mash-up view provider and the individual application providers. In the all-in-one context, the mash-up situation is further complicated by the inclusion of an institutional service provider, who has further access and control over learner data.

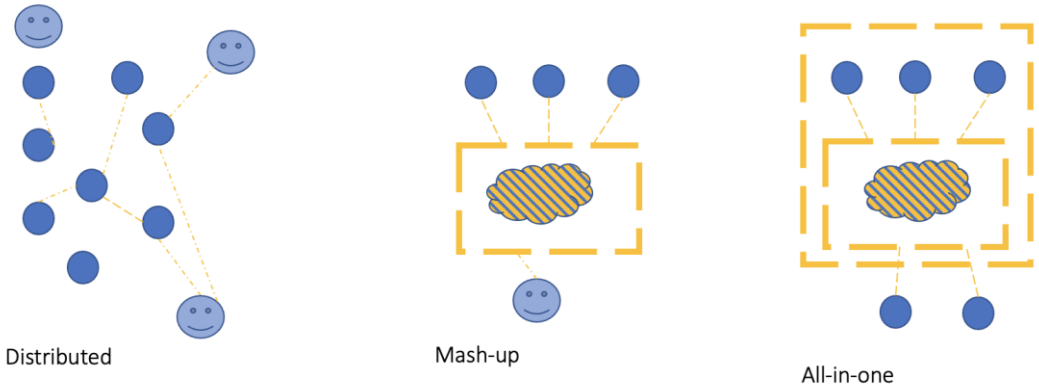


Figure 5 Model of Sociotechnical system of a PLE (blue dots = applications; smiley = person; dashed orange = hidden)

3.3. Sociotechnical system of the PLE in a decentralised data ecosystem

Coming to a potential future situation with a decentralised web infrastructure based on Solid, Figures 6 and 7 show the Solid-based social and technical systems of a PLE. The primary difference is all actors (learner, teacher, peers and other individuals) are unified with their personal data in their pod. This personal data is in their full control, and they actively need to give access to others. In other words, although the social roles of technological service providers and institutional service providers still exists, these roles no longer control personal data access in the PLE system.

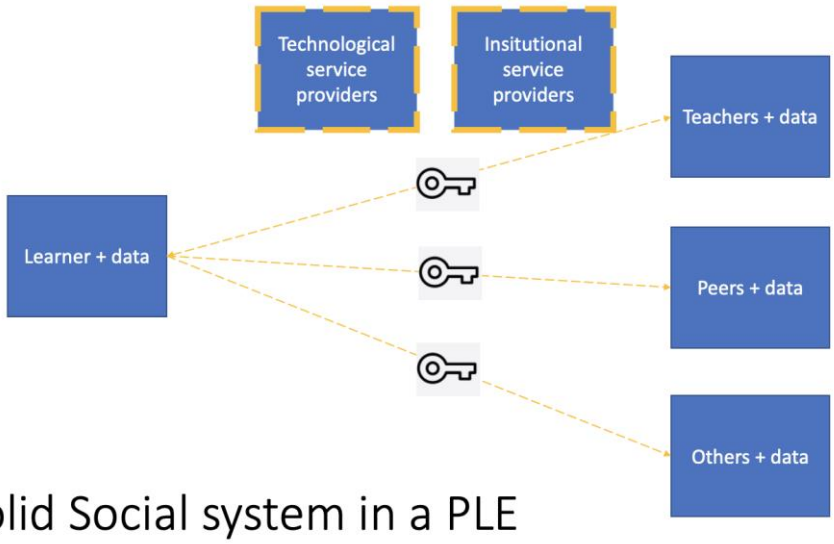


Figure 6 Solid Social System in a PLE

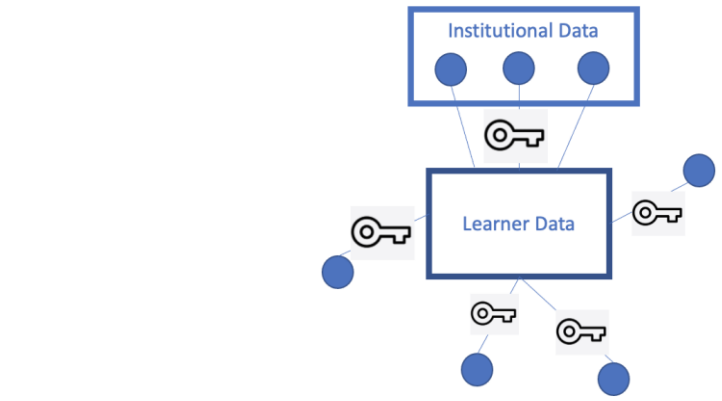


Figure 7 Solid technical system in a PLE

The Solid-based technical system shows that the learner data is stored in one space (the learner-controlled pod) and needs to be actively shared with application providers or directly with other learners. Compared to the different architecture options with distributed personal data in the current situation, this key concept of centralised data under learner control remains in every architecture options. Mashup view providers and institutional application providers still need to be actively granted permission to access personal data and this data access can be revoked by the learner, leaving no trace of data to the application provider.

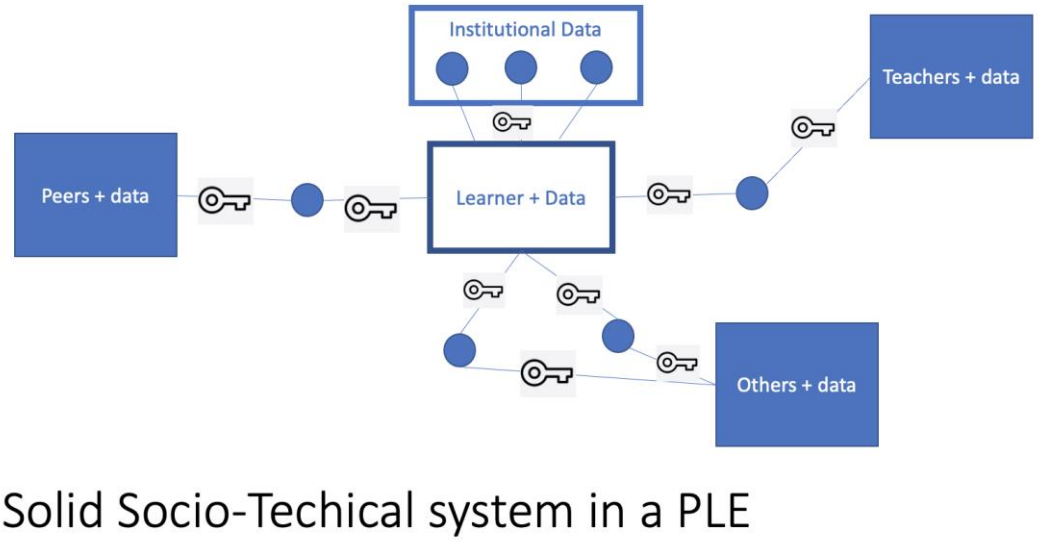


Figure 8 Model of decentralised sociotechnical system in a PLE

The Solid-based sociotechnical system gives much agency back to the learner in very tangible terms, by giving them full control over their personal data and who accesses it. Moreover, it gives this same level of control to all individuals in the social system.

4. Theoretical claims

Based on the analysis above, I propose three theoretical claims on the implementation of PLEs.

Claim 1: The concept of PLEs is inherently incompatible with the current situation of centralised data storage, management, and ownership on the Internet.
The concept of a PLE promotes a learner' individual control and power over their learning. In principle, they design their learning environment using various technological infrastructure according to their needs and learning goals. However, my analysis based on sociotechnical systems theory shows that there are several hidden, powerful social actors that govern individual learners' interactions with this technological infrastructure. The channels through which learners engage with their teachers, other learners, institutions, and the content they engage with or even themselves create, are under the control of external social actors whose priorities may not necessarily be a learner's learning gain. The analysis also shows that personal data of learners are often stored at distributed locations with different service providers. Additionally, the educational institutions individual learners engage with also have a say in which technologies are accessible to learners.

Technological and institutional service providers have a large influence in creating the channels that connect learners with their PLE. They enable interaction with the external world, they allow for better planning, analysis, etc. However, they also hold much control over these channels, to the detriment of individual learners, resulting in unpredictable situations for learners (such as the shutting down of services or functionalities, incorporation into larger services or other issues). Service providers also have great power in monitoring the access of individual learners to the platforms, and as such also to personal data on that platform. Moreover, personal data on the platform can be used to improve services but is also (and increasingly) monetized by selling to external parties. The learner in this context is highly dependent on the service providers of applications in their PLE but have little power in the system. The learner's autonomy is therefore highly restricted: they can refuse to use a service or minimise their use of it, but if they wish to leave, their personal data is removed and inaccessible as well. There have been small changes (e.g. Google's options to see which personal data they hold, or Twittter's option to archive your tweets), but these are minimal with respect to the larger issues of data control, ownership and management.

The STS analysis clearly shows that the current power relations on the World Wide Web are systemically skewed towards service providing organisations and institutions, through the personal learner data they have access to. Moreover, other asymmetries on information and intelligence leave individual learners in highly powerless positions.

In other words, in the current situation, the technical and social system of knowledge workers are not in balance, creating a detrimental situation for the individual's autonomy and productivity in terms of learning (and consequently working). The promise of a PLE, where learners are in full control of their learning, is undermined as the organisational choices made by learners cannot always be implemented in social, technological or pedagogical practice. Learners are in a weak position when it comes to the implementation of their Personal Learning Environment, adhering to decisions made by both the service providers of the technologies they use, as well as the educational institutions they study at. Principally then, the concept of the PLE does not rhyme with this centralised technological infrastructure.

Claim 2: For learners to fully exploit PLEs to support their knowledge work activities, a transition needs to be made to decentralised data networks through initiatives such as the Solid Project.

A move towards a more decentralized model of data management with Personal Data Spaces (the *pods* in Solid) and some forms of networked interaction spaces will align the technical infrastructure to the conceptualisation of a PLE.

The Solid platform seems to create an organizational structure that centralizes personal data around the individual, giving more control to this individual to give external parties access to their data. This means the learner can choose which other individuals (teachers, peers, others) she gives access to her data. She can also choose which service providers in her PLE can access her data to provide that service competently. This re-organisation diminishes the control of external service providers on personal data, in particular concerning data access and data monitoring they currently hold. Moreover, the direct interaction made possible between a learner's pod and other individuals' pods effectively removes the channel mediated by service providers. Regarding data flows, it means the service providers are effectively that: they provide a service that learners can use to create, collaborate, manage, plan, etc. But once the service is used, and data is created, this is stored and managed in the individual learner's pod (and that of other individuals). Solid turns around the current power relations by making data something that service providers use and return at a moment of the individual's choice, rebalancing data asymmetry towards the user.

Decentralised technological infrastructure seems to increase human agency in PLE, by pulling data control and data management to the individual learner. Within the context of a decentralized web, applications can remain with service providers, but individual learners need to actively share their personal data to these actors. This technical implementation is much closer to the conceptual role of the learner in a PLE, and it can be hypothesized that this would increase the individual learner's awareness of data control and data management building on learner autonomy.

The sociotechnical system of a PLE under a future Solid-based infrastructure shows that the power balance can be readdressed, with decision-making coming back to the individual learner. This increases the autonomy of the learner in tangible terms.

Claim 3: There is a need for new governance structures that enable learners to share data appropriately for the benefit of learners themselves.

Whereas the previous claims discuss the technological infrastructure for a PLE, this final claim focusses on the organisational aspects. The sociotechnical analysis shows that asymmetry primarily arises from the fact that ownership and management of personal data of learners lies in external organisations. Although a decentralised data management will address this partially and technically, it does not address the fact that individual learners on their own have limited possibilities to create relevant information or knowledge from this data with an objective to improve learning. For this, some form of collaboration is necessary that empowers learners. However, there are currently few governance structures that implement collective ownership and management of personal data. Networks, communities, and collectives can offer a way for this: whereas the focus in learning networks and communities of practice are on exchange of ideas and experiences, it is still an open question how these can be transformed into governance structures that also manage learning data creation and sharing. Some options can be data cooperatives (Hardjono & Pentland, 2019) or data collectives (Verhulst, 2021). These types of collaborations need to be supported by other technologies such as distributed ledgers (Verborgh, 2018). However, this is by no means a given recipe for success, as Mechant et al (2021) point out, that collective governance has often failed.

The sharing and aggregation of learner data will open the possibility for many innovations that support learning behaviour and learning productivity. Self-evident applications can be in line with Quantified Self applications such as self-tracking, where learners garner insight from data on their own activities (Lupton, 2016). Similar applications are already well-established in the medical and fitness sectors (Gimpel et al, 2013). However, particularly in the learning industry, aggregation of data will enable learners to insight into understanding individual and group learning behaviour better, and how this understanding can benefit learners individually and in group. The field of Learning Analytics (LA) aims to do the same (Greller & Drachsler, 2012), with the primary difference that with the implementation of LA into mainstream education, we see many applications giving insight to teachers and institutions, rather than benefits for the individual learner (Viberg et al, 2018).

This discussion on data rentiership therefore kickstarts a larger discussion on how data can enable knowledge creation and insights, and who has a stake and ownership in those activities. Two aspects merit attention here. The first deals with privacy concerns of users in a learning environment. Research shows students and teachers are sceptical of institutions using personal data and are open to using privacy-preserving measures (Amo et al, 2020). However, the reflection I bring up here is that users also need to see the tangible benefits of sharing their data. I argue here that in the current context, students and teachers do need more guidance and education in this, but that this needs to go hand in hand with immediate added value for them. A second deals with the role of educational institutions in this debate. A decentralised technological infrastructure based on Solid will necessarily affect the current institutional technological ecosystem, although it is not clear at this point in which way. There seem to be multiple options in which educational institutions can use Solid to engage with learners' personal data. Treating individual institutional applications as separate entities may allow learners to choose which applications they engage with within an institutional ecosystem. Alternatively, institutions can also choose to create standardized sets of applications for all students. This would mean the student effectively shares personal data with the

institution as a whole at one point in time. This form of implementation might enable institutions to effectively gain insight into learner activities across their applications and platforms. In any case, students will be able to keep hold of their personal data after leaving the educational institution. Organisationally however, these two solutions offer different ranges of value for the educational institution: in the first scenario, the institution needs to invest many more resources in the analysis of the data to gain the same level of value as the second scenario, although the second may be less desirable for individual students as it gives them less choice. The question then necessarily drifts into a debate on the value that can be created from student data and the potential impact it could have on educational services provided.

5. Avenues for Future Research

In this final section, I list five research questions that could boost the PLE concept into the mainstream in education.

1. **RQ1**: Does learner autonomy become more tangible in a decentralised Solid-based architecture?

A learner needs to actively share their personal data with other individuals, and other service providers. This means they will need to think about who has access to their data, which aspects of their data they have access to, and what the nature of their collaboration is with this other party (individual or company). This means they need to consider the relation between content, person and process (technology), and what they want to occur from this relation in terms of learning activities and learning outcomes. Using a Solid infrastructure, a learner necessarily needs to be aware of the purpose of interaction which ultimately increases their autonomy, i.e. their ability to take charge of their own learning (Holec,1979). However, it remains unclear to what extent learners experience this level of autonomy.

2. **RQ2**: Participation is explicitly chosen in Solid architecture. Does this increase a learner's sense of agency in their learning?

Through the actions she takes, a learner needs to explicitly choose participation in shared environments. This means a learner needs to consider which learning activities are so useful for a particular purpose, that they merit active participation. These metacognitive activities can develop the student's sense of agency. It is useful to investigate which considerations students take when choosing to participate and the level of effort they are prepared to take for this.

3. **RQ3**: To what extent are current functions of a PLE maintained and extended through a decentralised Solid-based infrastructure?

Nan Chenka et al. (2022) identify several functions that are supported by a PLE: planning & managing, collaboration, recording and reflection, content repository, tools for creating content and profile & portfolio. These align with the knowledge worker roles of Reinhardt et al. (2011). A PLE in a Solid architecture will amplify these functions by giving more opportunities to individual learners to collect and manage their own data, as well as opportunities to gain more insight into this personal data. This future infrastructure gives individual learners possibilities to develop their personal learning environments in data-driven ways, by understanding their learning behaviour through their personal data.

4. **RQ4**: In a decentralised Solid-based infrastructure, the mediating role of service providers largely disappears. How can information-creating and intelligence functions that are currently taken up (but not widely shared) by these service providers be provided through other governing structures?

In the current infrastructure, service providers play a mediating role, creating the space in which individual learners interact. This creates the situation that even if an individual may not prefer a service provider platform, they would still be a member on it, because the people they want to connect with are on that platform. The mediating provider therefore has access to much data that can be understood for commercial (and other) advantage. In a Solid future, individuals may be able to connect directly with other individuals through their pods, eliminating the role of a mediating provider. The provider merely becomes a lens through which data from different *pods* can be made visible. How could data be used in such a scenario to create value for the learners themselves?

5. **RQ5**: To what extent do learners expect an immediate "return on investment (ROI)" for sharing data in a decentralised Solid-based infrastructure? What would such ROI include for a learner? To what extent is ROI dependent on alternative governing structures?

In a Solid architecture, learners have the option to share their personal data with service providers. This means they have the power to give applications access to their data. It is likely that learners might expect to see what their data is used for, and how it is used. In other words, the "return on investment" for learners needs to be sufficient in order to persuade them to share personal data. An interesting research avenue to pursue is to understand the considerations of learners in what immediate value they expect to see from the sharing of their data. It is also useful to understand the boundaries they set for data sharing.

6. Conclusions

A decentralised technical infrastructure such as Solid seems to be the 'missing link' in enabling the concept of the Personal Learning Environment to gain ground in mainstream education. As the concept has grown out of the need to consider a sustainable professional development environment for knowledge work, it fulfils current needs in the educational contexts. The changed power dynamics will instigate a different data-sharing culture and different data analytical innovation, with a more human focus, aimed at individuals and groups – stepping away from the learning analytics currently pursued by larger structured (public or private) organisations.

This article has also shown that sociotechnical systems theory is a useful theoretical framework to consider relations between the social and technical systems in our designed learning environments. Looking at the balance between the social and technical systems in our learning environments can highlight which power relations are present, and how they affect productivity in these environments. Moreover, thinking in terms of joint optimization of these systems can also improve the design of learning environments. Sociotechnical Systems Theory therefore brings together research in the Learning Sciences and Learning Engineering by giving a theoretical framework that can be used to

reflect upon the complexity of pedagogical, technological, social and organisational in a coherent and comprehensive way.

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Rajagopal, K. (2023). Personal Learning Environments as socio-technical systems: does decentralised data finally give us the right balance? *RED. Revista Educación a Distancia*, *23(71)*. http://dx.doi.org/10.6018/red.526851

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References

Amo, D., Alier, M., García-Peñalvo, F. J., Fonseca, D., & Casañ, M. J. (2020). Protected Users: A Moodle Plugin To Improve Confidentiality and Privacy Support through User Aliases. *Sustainability*, *12*(6), Article 2548. https://doi.org/10.3390/su12062548

Attwell, G. (2021). Personal Learning Environments: Looking back and looking forward. *ACM International Conference Proceeding Series*, pp. 522–526. https://doi.org/10.1145/3486011.3486504

Birch, K., Chiappetta, M., & Artyushina, A. (2020). The problem of innovation in technoscientific capitalism: data rentiership and the policy implications of turning personal digital data into a private asset. Policy Studies, 41(5), 468–487. https://doi.org/10.1080/01442872.2020.1748264

Carugati, Christophe, The Implementation of the Digital Markets Act with National Antitrust Laws (April 22, 2022). Available at SSRN: https://ssrn.com/abstract=4072359 or http://dx.doi.org/10.2139/ssrn.4072359

Dabbagh, N., & Castaneda, L. (2020). The PLE as a framework for developing agency in lifelong learning. *Educational Technology Research and Development*, Vol. 68, pp. 3041–3055. https://doi.org/10.1007/s11423-020-09831-z

Dowling, M. E. (2022). Cyber information operations: Cambridge Analytica's challenge to democratic legitimacy. Journal of Cyber Policy, 1-19.

Ellis, R. A., & Goodyear, P. (2019). *The education ecology of universities: Integrating learning, strategy and the academy*. Routledge.

Fawns, T. (2022). An Entangled Pedagogy: Looking Beyond the Pedagogy—Technology Dichotomy. Postdigital Science and Education. https://doi.org/10.1007/s42438-022-00302-7

Gimpel, H., Nißen, M., & Görlitz, R. (2013). Quantifying the quantified self: A study on the motivations of patients to track their own health.

Greller, W., & Drachsler, H. (2012). Translating Learning into Numbers: A Generic Framework for Learning Analytics. Educational Technology & Society, 15(3), 42– 57

Guest, D., Knox, A., & Warhurst, C. (2022). Humanizing work in the digital age: Lessons from socio-technical systems and quality of working life initiatives. *Human relations*, 00187267221092674.

Hardjono, T., & Pentland, A. (2019). Data Cooperatives: Towards a Foundation for Decentralized Personal Data Management. 1–12. Retrieved from http://arxiv.org/abs/1905.08819

Holec H., Autonomie et apprentissage des langues étrangères, 1979 Strasbourg Council of Europe (English translation published in 1981 as Autonomy in Foreign Language Learning. Oxford: Pergamon.)

Jaakkola, E. (2020). Designing conceptual articles: four approaches. AMS Review, 10(1–2), 18–26. https://doi.org/10.1007/s13162-020-00161-0

Legemaate, M., Grol, R., Huisman, J., Oolbekkink– Marchand, H., & Nieuwenhuis, L. (2021). Enhancing a quality culture in higher education from a socio-technical systems design perspective. *Quality in Higher Education*, *00*(00), 1–14. https://doi.org/10.1080/13538322.2021.1945524

Lupton, D. (2016). *The quantified self*. John Wiley & Sons.

Mechant, P., De Wolf, R., Van Compernolle, M., Joris, G., Evens, T., & De Marez, L. (2021). Saving the web by decentralizing data networks? A socio-technical reflection on the promise of decentralization and personal data stores. 14th CMI International Conference - Critical ICT Infrastructures and Platforms, CMI 2021 - Proceedings. https://doi.org/10.1109/CMI53512.2021.9663788

Nan Cenka, B. A., Santoso, H. B., & Junus, K. (2022). Personal learning environment toward lifelong learning: an ontology-driven conceptual model. *Interactive Learning Environments*. https://doi.org/10.1080/10494820.2022.2039947

Olesen, T. (2019). The politics of whistleblowing in digitalized societies. Politics & Society, 47(2), 277-297.

Perrow, C. (1973). The short and glorious history of organizational theory. Organizational Dynamics, 2(1), 3–15. https://doi.org/10.1016/0090-2616(73)90007-7

Reinhardt, W., Schmidt, B., Sloep, P., & Drachsler, H. (2011). Knowledge worker roles and actions-results of two empirical studies. *Knowledge and Process Management*, *18*(3), 150–174. https://doi.org/10.1002/kpm.378

Sambra, A. V., Mansour, E., Hawke, S., Zereba, M., Greco, N., Ghanem, A., ... & Berners-Lee, T. (2016). Solid: a platform for decentralized social applications based on linked data. *MIT CSAIL & Qatar Computing Research Institute, Tech. Rep.*

Selwyn, N. (2016). Making sense of young people, education and digital technology: The role of sociological theory. Digital Technologies in the Lives of Young People, pp. 81–96.

Simon, Herbert A. 1969. The Sciences of the Artificial (3rd ed.). Cambridge, MA: MIT Press. ISBN 9780262193740.

Solid Project (2022). Solid Project. https://solidproject.org/

Trist, E. L., & Bamforth, K. W. (1951). Some Social and Psychological Consequences of the Longwall Method of Coal-Getting. Human Relations, Vol. 4, p. 3. Retrieved from https://noppa.aalto.fi/noppa/kurssi/tu-53.1410/luennot/TU-53_1410_luettava_artikkeli.pdf

Turillazzi, Aina and Casolari, Federico and Taddeo, Mariarosaria and Floridi, Luciano, The Digital Services Act: An Analysis of Its Ethical, Legal, and Social Implications (January 12, 2022). Available at SSRN: https://ssrn.com/abstract=4007389 or http://dx.doi.org/10.2139/ssrn.4007389

Van Harmelen, M. (2006, July). Personal learning environments. In *Sixth International Conference on Advanced Learning Technologies* (pp. 815-816). IEEE Computer Society.

Verborgh, R. (2018), "Decentralizing the Semantic Web through incentivized collaboration", in van Erp, M., Atre, M., Lopez, V., Srinivas, K. and Fortuna, C. (Eds.), Proceedings of the 17 International Semantic Web Conference: Blue Sky Track, Vol. 2189, ceur Workshop Proceedings.

Verhulst, S. G. (2021). The Value of Data and Data Collaboratives for Good: A Roadmap for Philanthropies to Facilitate Systems Change Through Data. In Data Science for Social Good (pp. 9-27). Springer, Cham.

Verhulst, S. G. (2022). The ethical imperative to identify and address data and intelligence asymmetries. AI and Society, (0123456789), 22–25. https://doi.org/10.1007/s00146-022-01410-5

Viberg, O., Hatakka, M., Bälter, O., & Mavroudi, A. (2018). The current landscape of learning analytics in higher education. *Computers in human behavior*, *89*, 98-110.

Het Vlaamse Datanutsbedrijf. (2022), *"Europa's eerste bedrijfsklare Solid platform."*Het Vlaamse Datanutsbedrijf https://www.vlaanderen.be/digitaal-vlaanderen/het-vlaams-datanutsbedrijf/europas-eerste-bedrijfsklare-solid-platform

Walker, G. H., Stanton, N. A., Salmon, P. M., & Jenkins, D. P. (2008). A review of sociotechnical systems theory: A classic concept for new command and control paradigms. Theoretical Issues in Ergonomics Science, 9(6), 479–499. https://doi.org/10.1080/14639220701635470