Designing Digital Platforms as Generative Systems Through the Lens of Complex Adaptive Systems Theory

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Abstract

As digital platforms continue to gain momentum, there is a pressing need for a better conceptualization of the ways these generative systems emerge through a deliberate, ongoing design. This design, we claim, is very different from more traditional approaches to Information Systems (IS) design with pre-defined requirements and the known end-goal. Instead, digital platforms are continuingly emerging, in response to changes in their organizational and wider contexts, through mutually shaping co-evolution. Focusing on a lesser-explored research area of internal digital platforms, in this paper we describe a case study of a novel digital platform designed through deliberate design and emergence. Based on our research findings, observed through the lens of the Complex Adaptive Systems theory, we propose a set of design principles for designing digital platforms as generative systems and discuss their practical implications

Keywords: internal digital platforms, complex adaptive systems, CAS, generativity, design

1. Introduction

The rising impact of digital platforms continues to attract the attention of multi-disciplinary research communities (Gawer, 2021; Szalkowski, 2023) and practitioners alike (Gauthier, 2023). Conceptualized as generative systems, and characterized by changing boundaries and growing complexity, digital platforms allow a perpetual state of evolution (Fürstenau et al., 2023; Hanseth & Rodon Modol, 2021). It is generativity, as a trait, that distinguishes digital platform from monolithic systems with clearly defined boundaries (Yoo, 2013) and up-front design goal. In a bid to realize their growth potential, modern-day organizations are motivated to draw on this generativity afforded by digital platforms (Fürstenau et al., 2023).

Although digital platforms have roots in many research disciplines, in this paper, we concentrate on an often-overlooked perspective of *internal* digital platforms (Rolland et al. 2018; Törmer, 2018). We conceptualize them as socio-technical constructs, embodying both technical and organizational components (Bartelheimer et al. 2022), which are mutually shaping through ongoing platform design. This view is different from a more common view of opening digital platforms to external collaborators (Parker et al. 2017). Internal digital platforms are thus semi-open and evolve within the organizational boundary, not outside it. They are only open across the organization and to its stakeholders.

There is growing evidence of internal digital platforms emerging even in traditional industries such as health (Hermes et.al 2020), banking (Sia et al. 2021), education (author reference), media (Karimi & Walter, 2015; Rolland et al., 2018), as well as the public services sector (Vestues & Rolland, 2021). Internal digital platforms often coexist in a tapestry of different technologies, intertwined with legacy systems and other platforms (Vestues & Rolland, 2021). As recent literature explains, architecture and dynamics of these internal platforms exhibit much more complex characteristics than those of platform ecosystems (e.g. Apple IOs) (Bygstad & Hanseth, 2018). Therefore, as our understanding of digital platforms shifts beyond platform ecosystems described in the early literature on the topic (Ghazawneh & Henfridsson, 2013; Tiwana, Konsynski, & Bush, 2010), it becomes pivotal to extend the scope of digital platform research by including internal ones (de Reuver et al. 2017).

With their strategic bearing coming to light, understanding how to design and develop digital platforms as generative systems (Yoo et al. 2012) becomes a key challenge for organizations. Greater insight is required on how digital platforms emerge, and how they can be intentionally designed (de Reuver et al. 2017). With the existing literature focusing much more on established digital platforms (Islind, 2018),

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how platforms are designed as generative systems remains unclear (Islind et al. 2019; Tura et al. 2017).

Past logic for designing and developing software becomes limited in the context of digital platforms. This is because digital platforms need to be designed to accommodate a growing number of complementary components (Spagnoletti et al. 2015) These components are acquired or designed without always knowing how they will fit into the whole (Yoo, 2013). Moreover, they are used by an always growing number of users (stakeholders), whose needs are not known in advance, rather than pre-defined group of users with their set requirements.

As Vial (Vial, 2023) explains, developing platforms goes well beyond the "implementation of a set of requirements that have fixed boundaries: it is generative, it is epistemic, and, importantly, it is often part of ecosystems in which pieces of software are shared and made available for reuse in repositories" (Vial, 2023 p. 1).

Against this research background, this research aims to address the following research question: *How are internal digital platforms designed as generative systems?* To answer this research question, we conducted a case study of a novel digital platform within an Australian university, in the early stages of design. We employ Complex Adaptive Systems (CAS) theory, as defined in the complexity theory, as a guiding theoretical lens for our conceptualization of the phenomenon and the analysis of the empirical findings. Our main research contribution to the limited Information Systems (IS) literature on internal digital platforms is in a set of design principles, which we articulate and theoretically explain using CAS lens. They include collaborative design, decomposition, modularity, re-use, generic IT capability building and choosing flexible and scalable infrastructure. The proposed design principles can also assist industry practitioners involved in the design of digital platforms, to either reuse/refine them in their own contexts or to reflect on their current practices.

2. Literature Review

Decades-long research on IS-design challenges has resulted in a plethora of different design processes, methods and approaches (Alter & Browne, 2005; Ba et al. 2001). The recent emergence and proliferations of digital platforms have introduced new challenges, as their design defies much of the past design logic of monolithic systems (Spagnoletti et al., 2015). As a socio-technical paradigm digital platforms are modular systems (Tiwana et al., 2010), whose value is enabled through their generative potential (Yoo, 2013). Following related literature, we define a digital platform as a technical artefact consisting of a core and a set of interrelated modules (Tiwana et al., 2010), whose value and functionality is extended through the interactions of different actors (Lusch & Nambisan, 2015). An internal ecosystem is thus understood to consist of "actors, business processes, technology and other resources within an organization" (Wang, 2021 p.401).

Instead of pre-defined users whose requirements need to be captured and translated into design requirements, digital platforms include diverse and growing user communities, not always known in advance (Hanseth & Lyytinen, 2010). It is for these reasons that platforms evolve and adapt in unforeseeable ways (Hanseth & Rodon Modol, 2021; Tiwana et al., 2010). Yet, understanding how this generativity can be achieved through deliberate design for platform growth and evolution remains elusive (Fürstenau et al., 2023). Given that early design choices can either impede or engender the evolution of the platform (Hanseth & Lyytinen, 2010), it becomes a worthwhile question to explore. Moreover, given that many digital platforms fail to achieve their initial pre-defined and desired goals (Wimelius et al. 2020), shedding light on effective design choices becomes even more pertinent.

For this, as de Reuver et al. (2017) explain, we need to turn our attention to the origins of digital platforms and not only the different dynamics during their evolution. To date, there is very little knowledge about the initial design phases of digital platforms, including the challenges, processes and outcomes of such design (Tura et al., 2017). Moreover, despite great interest in digital platforms and their evolutionary trajectories (Nambisan et al. 2020; Tiwana et al., 2010), there is a paucity of research on design of digital platforms.

Although prior research has focused on the design of digital infrastructures (DIs) (Grisot et al. 2014; Koutsikouri et al. 2018), digital platforms vary to some degree to these technologies in their organizing logic and control mechanisms (Hanseth & Lyytinen, 2010). On the other hand, the existing literature on the design of digital platforms is confined to certain types of digital platforms, such as those enabling online communities (Spagnoletti et al., 2015), mobility as-a-service (Tura et al., 2017), or patient care in hospitals (Grisot et al., 2014; Islind et al., 2019). However, as the use of internal platforms, often referred to as enterprise platforms continues to grow in organizations (Rolland & Hanseth, 2021; Schreieck et al. 2022), understanding how they can be designed to support an organization's operational and strategic goals remains largely unknown (Vestues & Rolland, 2021).

Designing digital platforms thus presents a new set of challenges for organizations. Past methods for designing software do not reflect the more complex reality of digital platforms — that is, more heterogeneous users and different design artefacts that can emerge during the process (Islind et al. 2019). Unlike tightly-bound systems, digital platforms rely on the reuse of loosely-connected components (i.e. modules) that can be configured in different ways to achieve different outcomes (Tiwana et al., 2010; Vial, 2023). To design for this kind of flexibility, the extant literature points to the building of repositories of generic modules that can be combined in different ways to produce unique solutions (Ross et al. 2019; Spagnoletti et al., 2015). Yet, evolvable systems should be designed to allow for disintegration, as well as integration of modules in a way that cannot be pre-defined. The two are not necessarily mutually-exclusive (Agarwal & Tiwana, 2015). Not knowing how each module will fit within the whole remains one of the biggest challenges of designing digital platforms (Yoo et al. 2012).

Architecture plays a vital role in the overall evolution and inherently the design of digital platforms (Haki & Legner, 2021; Spagnoletti et al., 2015). However, there are very few concrete guiding design principles we can draw on for designing internal platforms, apart from the Enterprise Architecture (EA) frameworks (Haki & Legner, 2021). Arguably, digital platforms are diminishing the relevance of EA principles in favor of a more dynamic approach (Masuda et al., 2021). Design tenets for digital platforms need to accommodate a complex, evolving and intertwining nature of socio-technical arrangements that is able to develop beyond the initial design (Hanseth & Rodon Modol, 2021).

In sum, we argue that greater insight is required on how to design digital platforms as generative systems. Particularly, scholarship would benefit from more clarity on how to design digital platforms for internal use, an underrepresented area of research. We now turn to the theoretical foundations, which form the foundation of this research.

3. Theoretical Foundations

Complexity theory, in particular the concept of Complex Adaptive Systems (CAS) have been used as suitable theoretical lens for different types of emergent information systems (IS) (Benbya et al. 2020; Vial, 2023). They include open government IS (Marjanovic & Cecez-Kecmanovic, 2017), crowdsourcing systems (Kautz et al. 2020) and other complex socio-technical systems (Kautz, 2012).

The related IS literature also shows two fundamentally different interpretations of complexity and its core concept of CAS. One interpretation originates from the engineering and IT interpretation of CAS. According to this interpretation, which is still widely-used, CAS consists of predefined components and is designed and implemented to achieve a predefined goal that is determined by the design requirements (Merali, 2006). For example, agent-based systems with known software agents interacting in a pre-defined way are seen as CAS.

The second interpretation of CAS, which we adopt in this research, draws its origins from a particular stream of complexity theory proposed by Cilliers (Benbya & McKelvey, 2006; Cilliers, 2004, 2013; Merali, 2006; Stacey, 2003; Stacey, Griffin, & Shaw, 2000). This interpretation is aligned with Merali's (Merali, 2006) definition of CAS as ''non-linear systems, composed of many (often heterogeneous) partly connected components that interact with each other through a diversity of feedback loops" (p. 219). Therefore, a CAS is interpreted as a socio-technical system, which emerges towards goals (more than one) that are not predefined and are ultimately unknown, even unknowable. Following Stacey et al. (2000), we interpret CAS' components as dynamic, autonomous and loosely connected agents (e.g. technical systems, humans, organizational entities). Rather than just reacting, agents are considered to have 'agency' and as such can act and adapt in a continuous manner [29].

Contrary to the engineering and IT interpretation, CAS' set of agents is never stable, pre-defined or even known in advance. Instead, they are constantly changing with new ones emerging. They interact with other agents through mutual adaptation and co-emergence, which always occur locally, based on information received from immediate neighbors (Cilliers, 2013). Consequently, CAS's behavior cannot be pre-defined due to non-linear interactions and mutual adaptations of its technical and social agents. Instead, the nonlinear local interactions, which are propagated throughout the system, are creating wide-ranging and ultimately unknowable effects. This in turn means that CAS has an emergent and constantly evolving behavior.

CAS is considered to be an open system, which is both shaped and is shaping its environment. Its boundaries are malleable (Cilliers, 2004) and constantly changing. Therefore, CAS is characterized by ''a more dynamic view of boundaries as relative and relational phenomena, linking system and environmental elements through different couplings" (Merali, 2006). Rather than having a pre-defined and agreed purpose, the same CAS could be perceived to

have very different purpose by different observers. Unlike engineering systems, CAS' overall behavior cannot be understood or inferred from localized behavior of its agents (Merali, 2006).

CAS is also a self-organizing system. Vidgen et al. (Vidgen & Wang, 2009) define the self-organization of CAS as ''the ability of interconnected autonomous agents of a complex adaptive system to evolve into an organized form without external force" (p. 358). As Stacey (2003) explain ''[i]t is the very essence of self-organization that none of the agents, as individuals, nor any small group of their own, can directly design, or even directly shape, the evolution of the system as a whole. The impact of any agent, no matter how powerful, on the system is indirect through their local interactions only" (p. 267).

In this paper, we use CAS as a suitable theoretical lens to observe and interpret emergent design of digital platforms as generative systems, which we perceive as complex adaptive socio-technical systems. Our choice of this theory is also supported by previous research by Kautz (2012), who confirms that CAS is indeed a relevant and suitable theoretical foundation for understanding and theorizing contemporary IS development practices. In this research, we recognize that our focus on internal digital platforms imposes a boundary to CAS, which affects our theorizing of the design principles. The boundary here is that the internal digital platform evolves within the organizational context and not outside it.

4. Research Methodology

Our research approach is interpretivist and exploratory in nature (Myers, 2013). As such it is devoid of a priori and up-front research hypotheses (Myers, 2013; Orlikowski & Baroudi, 1991). This approach is appropriate on the account of the emergent nature of the phenomenon of digital platforms. As a research method, we employ a case study of an internal digital platform within an Australian university, focusing on its design as a generative system.

Case studies are particularly suitable for emerging phenomena, such as the one under investigation, where not much prior literature is available (Myers, 2013). A single case study is a legitimate approach for interpretivist research, where generalizability is not achieved by statistical means, but the research insights are used for building a theory, which could be used in other contexts (Myers, 2013).

4.1 Case Description

AU-U (pseudonym) is an Australian public university with approximately 46 000 students and 4000 staff members (academics and administrative). As a long-term strategic commitment to world-class research, the university began the process of implementing an internal digital platform in 2019. Platform Link (pseudonym) was launched with the goal of connecting academics, research students and other staff across the university to enable better collaboration. At first, the intended user base was the internal staff and students, with a vision to branch out and connect with other partners and universities in the future. The digital platform's objective is to be the single point of access for research resources and activities within the university. Architecturally, the platform consists of a core (a cloud computing infrastructure), a content management system (CMS) and links into other internal auxiliary modules (a learning management system, a customer relationship system and in-house research related modules), as well as external, third-party modules for events management, and research. It also displays feeds from popular social media platforms.

4.2 Data Collection

The main data collection method included semi-structured interviews with a number of stakeholders, as an effective and flexible way to collect rich contextual primary data (Myers & Newman, 2007). Secondary data, collected from publicly available documents, web sites and internal project documentation made available to the researchers, were used to gain a better understanding of the organizational context, as well as for triangulation purposes (Pan & Tan, 2011). Twelve interviews were conducted in total, with eleven unique participants. After securing access to the whole project team, we interviewed self-selected participants in a number of different roles, which included a user, a senior project manager (interviewed at two points in time), business analyst, change manager, UX designer, enterprise architect, technical lead, HCD specialist, program manager and two product owners. The broad range of perspectives provided a rich data sample, which was complemented by project documentation and publicly available information posted on the university external web site. Each interview lasted for approximately 60 minutes and was audio recorded and transcribed.

4.2 Data Analysis

Data analysis was approached in an exploratory way by reading, re-reading and reflecting on the findings in order to demarcate the data into different stages and develop a narrative of Platform Link's emergence in context and over time. Starting with

open coding, we analyzed the data to come up with the preliminary set of codes. Axial coding, or recognizing the relationships between concepts was done in parallel (Corbin & Strauss, 2008), as we analyzed the data. Following the identification of first-order concepts through open coding and second-order themes through axial coding, we started abstracting these concepts further into what are known as aggregate dimensions (Gioia, Corley, & Hamilton, 2012), that led to the emergence of the design principles, which we observed and explained though the lens of CAS. As the literature on CAS was consulted the process changed from one of induction to abduction. The methodology followed is based on principles rooted in interpretive philosophy, where the findings are interpreted from descriptions to theory (Klein & Myers, 1999).

5. Findings: Deliberate Design of Platform Link

The Inception phase was from August to December 2019. The idea for Platform Link was born as a vision of the Executive team for a collaborative space that would connect academics, researchers and students. The aim was to uplift the research function across the university and enhance researchers' experience. Up to that point, opportunities and resources were not easily visible to the researcher community. Periodically, emails would be sent out, offering only a partial view of the available opportunities available across faculties and departments. Beyond the immediate operational goal to improve efficiency by creating an internal digital platform, AU-U had more strategic goals in sight to open up the platform to external collaborators in the future. Other universities with a similar digital platform experience were consulted during this phase.

Setting up the technical foundation for Platform Link required a deviation from AU-U's standard architectural practice. It involved decoupling a monolithic content management system (CMS) into a multi-tenanted architecture, capable of supporting Platform Link as a semi-autonomous digital platform. This had an effect on the overall architecture of the CMS, making it more flexible and capable of supporting multiple new platforms. In the words of a Project manager: *"we pioneered that"*. Along with the modular architectural backbone, a portal interface was designed. The new style guide used for the new platform helped to inform the university style guide which was considered outdated. The Project manager commented: *"So we've done things that are slightly different which are now informing [AU-U] style guide. So, we're actually feeding back in anything that we have."*

The Launch phase was from December 2019 to January 2020. Platform Link was launched in December 2019, initially offering resources, training and links to other research-related modules, some owned by third-parties and some developed in-house. It also provided the functionality to book and display upcoming events, through a third-party module. The aim was to achieve the minimum viable product and offer some initial value to users. In the words of a Product Owner: *"So what we're doing is putting up some easy wins".* Platform Link leveraged most of the functionality of existing modules. *"General guideline is that they want to reuse existing. If not re-use then look for of the shelf."— Technical Lead.* Different types of stakeholders played different roles in the design of the platform. Senior management was responsible for the vision and direction of the platform. UX and HCD specialists were responsible for the usability, while business analysts applied the learning from other implementations of digital platforms in the organization. Users (researchers and various stakeholders) across the organization provided feedback along the way which informed the design.

The Germination phase was from January to March 2020. During this phase, the initial design was elaborated to include a strategic roadmap and high-level design tenets. This included a collaboration between internal stakeholders from different areas of the university, as well as external partners and a consultant. The Human-Centered Design department held a workshop where the participants had the opportunity to communicate their vision using the Lego Serious Play method. The premise of this method is using hands to express ideas to impel greater creativity. In the words of a Project Manager: *"Lego works better than words, in many ways, it helps people to sort of articulate what they think they're trying to get out of the whole tool or the system"*. As the group worked towards formulating a vision for the digital platform, some ideas were discarded, and further details elaborated. Objectives were then articulated and prioritized. The Change Manager explained: "*A series of workshops happened which really drill down into, ok these are the features that we're going to add. Then we went and decided on the priorities that were signed off"*.

A project team was set up to lead the efforts and drive new functionality forward using an agile model of delivery. The senior management encouraged a culture of experimentation, approaching the design in an open-ended way. The Product owner commented: *"The trouble with what we're trying to do is, is not in any way shape, or form a standard [IT] type project.*

Because at the outset, although we have high level design principles, we actually don't know what we're going to build." The platform continued to expand with new features and modules. Feedback collected from users continued to inform future iterations of the platform. The Product owner continued: "*The user part of it is really critical to the design process".* Non-technical staff were also empowered to participate in the design and development through the use of a low-code module to develop new functionality (i.e. a booking form). The low code module on the digital platform provided an intuitive interface and visual tools to develop functionality without any knowledge of programming. In the words of a Technical Lead: *"It's a quick drag and drop. You don't have to be a programmer to do it, an end user can do it."* The architecture team engaged in designing generic modules that could be assembled in different contexts to produce different solutions. According to an Enterprise Architect: *"We're trying to avoid changes that are specific for a particular application and we're trying to build these 'build once use many times'"*. Developing modules with generic functionality (e.g. a plug-in for a videoconferencing module) would ensure anyone in the organization could easily reuse that component, when required.

The Adaptation phase was from March to July 2020. The onset of the COVID-19 forced AU-U into a fully online mode of operation due to social distancing measures. This stalled some of the planned design milestones for Platform Link, while others were reprioritized. The new, higher priorities placed a significant burden on the resourcing. The Technical Lead commented: *"COVID-19 is always considered to be a higher priority over everything else."* Platform Link now played an even more important role for researchers where connecting was now only possible in the virtual space. Similarly, the co-design between the different stakeholders now continued virtually. The increase in online content grew the functionality of the digital platform. Also, legal requirements of countries with the university's international student population drove the implementation of a new set of modules.

Ongoing evolution continued from August 2020 to present. The platform continues to evolve in an emergent way, with many unknowns the design process is trying to address. As the Senior Business Analyst explains: *"All of these questions are still evolving, although the [platform] is up and running"*. Personalization functionality is underway to allow researchers to customize their experience. However, with this novel functionality there is not much guidance form the central Architectural department. This new module on the platform will end up informing the wider AU-U identity management functionality. As the digital platform grows, it is attracting 2000 unique monthly users at the time of writing this paper.

The above evidence describes the process of deliberate designing of digital platforms as generative systems in an ongoing state of evolution and adaptation to different contexts. It also illustrates the importance of the platform shifting due to a change in the environment from a strategic initiate to a core operational enabler due to its generative potential. Next, we discuss the findings through the theoretical lens of CAS, drawing from the wider literature on digital platforms.

6. Discussion

Our research findings demonstrate that, although triggered by deliberate strategic intention, the design of Platform Link has emerged, and continues to emerge as a result of a dynamic and complex process, shaped by the ongoing interactions of a growing number of stakeholders (CAS participants) in the university (e.g. the project team, consultants, senior stakeholders, architecture design department and HCD department). These integrations occur in, and are shaped by contexts –organizational, industry (high education) and a wider societal context (as demonstrated by the adaptation phase). No single agent or group determined the design of the system as a whole (Stacey et al., 2000), but influenced it through mutual adaptations (Cilliers, 2013). For example, during the design workshop some ideas were adopted, and some discarded, as multiple diverse parties worked on articulating the vision for Platform Link. Similarly, due to a lack of direction from the central architectural department, the project team forged their own way with a personalization module, which will then influence the AU-U identity management functionality.

We observe here a divergence from CAS in that the design of an internal digital platform involves strategies of deliberate self-adaptation leading to emergent behavior. Consistent with the bootstrapping design method (Grisot et al., 2014; Hanseth & Lyytinen, 2010), we also find that initial design choices are motivated by offering immediate value to users to encourage adoption. For example, Platform Link launched with a suite of options most valuable to researchers, such as tools, training modules and events. Initially targeting internal staff and students, the vision for the platform is to expand and attract collaboration from other universities and partners in the future.

This study's findings also support recent claims that as the user base grows, the boundaries of the digital platform expand (Fürstenau et al., 2023). Our research contributes to these findings by introducing a new boundary condition (internal digital platform), positing that the interactions and the negotiations between stakeholders (including the users) drive the generativity of the digital platform through new ideas.

7. Design Principles for Digital Platform Design as a Generative System

In response to the research question: *How are internal digital platforms designed as generative systems?* we articulate a set of design principles, which we theoretically explain through the lens of CAS. An initial set of design principles, which were abductively derived from the data are presented in Table 1. The first principle illustrates how ongoing design, here termed '*collaborative designing*' can be achieved through a collaboration between heterogeneous stakeholders, both internal and external to the organization. For example, the Lego Serious Play method allowed these diverse stakeholders to find common ground and also to influence key organizational decision-makers. The literature points to the value of this method for improving communication by allowing participants to build models and justify them with a story (Grienitz et al. 2013).

The subsequent four principles relate to the architecture of the platform. Decomposition relates to breaking up a monolithic system to allow for a more flexible digital platform architecture. In the example of AU-U, a monolithic CMS was decomposed, by setting up Platform Link as its own semi-autonomous instance with its own evolutionary path. The multi-tenanted solution pioneered by Platform Link will enable AU-U to further decompose the system into modules that can be managed by different departments.

Decomposition supports evolution by decreasing interdependencies and fostering variety, but at the same time may cause a path-dependence by putting constraints on the design (Tiwana et al., 2010). As previously proposed, digital platform designs need to account for decomposition, as well as integration of modules (Agarwal & Tiwana, 2015).

The tenet of modularity, in relation to platform design, ensures that the functionality of the platform can easily be extended through semi-autonomous modules, both internally developed and third-party modules. For example, the third-party events modules were used across the university and were easily integrated via an API. Such modularity fosters re-use of modules, which makes up our next principle. Indeed, early platform literature points to the importance of this principle for designing digital platforms (Henfridsson & Bygstad, 2013; Tiwana et al., 2010), and more recently, software in general (Vial, 2023). The principle of building a generic suit of IT capabilities relates to the development of product-agnostic modules that can be integrated into new solutions and supports the principle of re-use. For example, at AU-U the building of a generic suit of modules enables multiple departments to develop platform solutions at greater velocity than previously possible. This principle is also supported by digital platform literature (Gregory et al. 2018; Spagnoletti et al. 2015).

The final principle relates to choosing flexible infrastructure that can be easily scaled up or down when needed. At AU-U, the use of cloud infrastructure, as well as third-party cloud modules allows the flexibility required for the platform to evolve. Our study confirmed previous findings that cloud computing alleviates the limitations and challenges of traditional IT management (Battleson et al. 2017). We posit that certain design principles are more important at different stages of the design process. At the initial stages decomposition and choosing flexible and scalable infrastructures may be the most important principles. Collaborative designing, modularity, re-use and generic capability building were observed as the more important principles during the growth stages of the digital platform.

The proposed design principles form the initial set, informed by our research findings. This set is expected to be refined and extended through future case studies of internal digital platforms in other contexts.

Table 1. Internal digital platform design principles

Design Principle	Description	Platform Link as CAS
Collaborative designing	Multiple parties from different areas of the organization, and the organizational hierarchy were involved in the design process, including external parties. This allowed everyone to equally contribute their ideas.	**CAS characteristics (Self-organization and Emergence)** Autonomous agents internal and external to the organization assembled into an organized form (e.g. the workshop), which allowed the platform design to emerge through their continuous interactions and adaptations. For example, the Lego Serious Play method encouraged multiple participants to articulate ideas through the use of Lego.
Decomposition	The ability to decompose a system into components that can develop as autonomous digital platforms with their own evolutionary path.	**CAS characteristics (Autonomy and Emergence)** Platform Link became a part of a decomposed whole and therefore emerged as its own autonomous platform, with its own configuration and control. This allowed Platform Link autonomy whilst still being a part of the internal ecosystem.
Modularity	Ensuring the modules in the digital platform have a certain degree of autonomy, so that any changes can be configured easily and without flow on effects to the other modules.	**CAS characteristics (Autonomy and Loose connectivity)** Adhering to a modular design meant that modules could be added easily, and due to being loosely coupled retained their autonomy. For example, AU-U includes a number of modules both internally developed, as well as third-party module that extend the platform but remain autonomous.
Re-use	The principle of re-use pertains to leveraging as much of the existing functionality as possible by the means of reconfiguration, not custom development.	**CAS characteristics (Emergence and Unpredictability)** Platform Link emerged through the re-use of existing components (not custom development). Reuse of modules allowed new solutions to emerge, unanticipated during the initial design. For example, the personalization came into being in an emergent way and also informed a higher-level AU-U initiative.
Generic IT capability building	Developing a catalogue of generic IT capabilities enables greater efficiency, by avoiding duplication of effort. When new functionality is required, it can then be configured easily and at greater speed.	**CAS characteristics (Emergence and Extendibility)** Building a generic suit of IT capabilities, that can be used by different departments can engender emergence at greater velocity, by allowing Platform Link (as well as other platforms in the internal ecosystem) to be extended.
Choosing flexible and scalable infrastructure	Choosing flexible and scalable infrastructure (e.g. cloud) to supports platform evolution and allows for greater efficiency and adaptability to change. In this way different modules can be switched with ease, if required.	**CAS characteristics (Adaptability and Non-linearity)** It also supports the notion of non-linearity, as small changes can lead to big impacts, due to its scalable nature. With Platform Link driving the multi-tenancy architectural set up, the same core cloud infrastructure can be shared between different platforms. Therefore, the perceivably small change of setting up multi-tenancy could have big implications for the evolution of Platform Link, as its own platform. The scalable nature of cloud infrastructure allows for scalability and thus supports a nonlinear evolution of the platform.

8. Conclusions, Limitations and Future Research

Digital platforms continue to be adopted by organizations at an accelerated rate. This study builds on previous work on the design of digital platforms (Islind et al., 2019; Spagnoletti et al., 2015) and infrastructures (Hanseth & Lyytinen, 2010). Its main theoretical contribution lies in the proposed set of principles for designing internal digital platforms, which to the best of our knowledge has not been covered in prior research. Moreover, we answer de Reuver's (2017) call for research on the origins and dynamics of digital platforms, proposing that digital platform design is that of a complex adaptive socio-technical system, leading to digital platforms as generative systems. This novel approach to studying digital platform design through the lens of the CAS theory and its outcomes, extend the IS body of knowledge pertaining to the design of digital platforms as socio-technical systems (Hanseth & Lyytinen, 2010) and the emerging body of research on designing generative systems (Fürstenau et al., 2023; Grisot et al., 2014).

This research also has implications for practice. As demonstrated by this study, even organizations in traditional industries, such as higher education, need to turn to digital platforms to innovate and sustain their activities in a highly dynamic and fast-paced environment, especially during major disruptions. Finally, it also provides insights for organizations looking to design and implement new internal digital platforms.

Our research is limited due to its focus on design principles in the early stages of implementation. Future research will include more principles for growing digital platforms. We envisage this research to be applicable to other contexts with internal digital platforms in the early stages of design and development.

9. References

Agarwal, R., & Tiwana, A. (2015). Editorial—Evolvable Systems: Through the Looking Glass of IS. *Information Systems Research, 26*(3), 473-479.

Alter, S., & Browne, G. J. (2005). A Broad View of Systems Analysis and Design: Implications for Research. *Communications of the Association for Information Systems, 16*, 981-999.

Ba, S., Stallaert, J., & Whinston, A. B. (2001). Research Commentary: Introducing a Third Dimension in Information Systems Design—The Case for Incentive Alignment. *Information Systems Research, 12*(3), 225-239.

Bartelheimer, C., zur Heiden, P., Lüttenberg, H., & Beverungen, D. (2022). Systematizing the lexicon of platforms in information systems: a data-driven study. *Electronic Markets, 32*(1), 375-396.

Battleson, D. A., West, B. C., Kim, J., Ramesh, B., & Robinson, P. S. (2017). Achieving dynamic capabilities with cloud computing: an empirical investigation. *EJIS, 25*(3), 209-230.

Benbya, H., & McKelvey, B. (2006). Towards a complexity theory of information systems development. *Information Technology & People, 19*(1), 12-34.

Benbya, H., Nan, N., Tanriverdi, H., & Yoo, Y. (2020). Complexity and information systems research in the emerging digital world. *Management Information Systems Quarterly, 44*(1), 1-17.

Bygstad, B., & Hanseth, O. (2018). *Transforming digital infrastructures through platformization.* Paper presented at the ECIS, Portsmouth,UK.

Cilliers, P. (2004). A framework for understanding complex systems. In P. Adriani & G. Passiante (Eds.), *Complexity Theory and the Management of Networks* (pp. 23-27). London: Imperial College Press.

Cilliers, P. (2013). Approaching complexity. In B. McKelvey & J. Bragin (Eds.), *Complexity – Critical Concepts*. New York, USA: Routledge.

Corbin, J., & Strauss, A. (2008). *Basics of qualitative research (3rd ed.) : Techniques and procedures for developing grounded theory* Thousand Oaks, CA: SAGE Publications, Inc.

de Reuver, M., Sørensen, C., & Basole, R. C. (2017). The Digital Platform: A Research Agenda. *Journal of Information Technology, 33*(2), 124-135.

Fürstenau, D., Baiyere, A., Schewina, K., Schulte-Althoff, M., & Rothe, H. (2023). Extended Generativity Theory on Digital Platforms. *ISR*.

Gauthier, A. (2023). Executive Essentials: Deploy Data and Analytics, Artificial Intelligence and Digital Platforms. Retrieved from https://www.gartner.com/document/4268099

Gawer, A. (2021). Digital platforms and ecosystems: remarks on the dominant organizational forms of the digital age. *Innovation*, 1-15.

Ghazawneh, A., & Henfridsson, O. (2013). Balancing platform control and external contribution in third-party development: the boundary resources model. *Information Systems Journal, 23*(2), 173-192.

Gioia, D. A., Corley, K. G., & Hamilton, A. L. (2012). Seeking Qualitative Rigor in Inductive Research. *Organizational Research Methods, 16*(1), 15-31.

Gregory, R. W., Kaganer, E., Henfridsson, O., & Ruch, T. J. (2018). IT Consumerization and the Transformation of IT Governance. *MIS Quarterly, 42* (4), 1225-1253.

Grienitz, V., Schmidt, A.-M., Kristiansen, P., & Schulte, H. (2013). *Vision Statement Development With LEGO® SERIOUS PLAY®*. Paper presented at the Proceedings of the 2013 Industrial and Systems Engineering Research Conference

Grisot, M., Hanseth, O., Asmyr Thorseng, A., & (2014). Innovation Of, In, On Infrastructures: Articulating the Role of Architecture in Information Infrastructure Evolution. *J. of the Association for Information Systems, 15*(4), 197-219.

Haki, K., & Legner, C. (2021). The Mechanics of Enterprise Architecture Principles. *Journal of the Association for Information Systems, 22*(5), 1334-1375.

Hanseth, O., & Lyytinen, K. (2010). Design Theory for Dynamic Complexity in Information Infrastructures: The Case of Building Internet. *Journal of Inf. Technology, 25*(1), 1-19.

Hanseth, O., & Rodon Modol, J. (2021). The Dynamics of Architecture-Governance Configurations: An Assemblage Theory Approach. *JAIS, 22*(1).

Henfridsson, O., & Bygstad, B. (2013). The generative mechanisms of digital infrastructure evolution. *MIS Quarterly, 37* (3), 907-938.

Hermes, S., Riasanow, T., Clemons, E. K., Böhm, M., & Krcmar, H. (2020). The digital transformation of the healthcare industry: exploring the rise of emerging platform ecosystems and their influence on the role of patients. *Business Research, 13*(3).

Islind, A. S., Lindroth, T., Lundin, J., & Steineck, G. (2019). Co-designing a digital platform with boundary objects: bringing together heterogeneous users in healthcare. *Health and Technology, 9*(4), 425-438.

Karimi, J., & Walter, Z. (2015). The Role of Dynamic Capabilities in Responding to Digital Disruption: A Factor-Based Study of the Newspaper Industry. *J. Mgt. Information Systems, 32*(1), 39-81.

Kautz, K. (2012). Beyond simple classifications: Contemporary information systems development projects as complex adaptive systems. *Faculty of Engineering and Information Science Papers, Research Online Series, University of Wollongong, Australia*, 1-20.

Kautz, K., Bjerknes, G., Fisher, J., & Jensen, T. (2020). Applying Complex Adaptive Systems Theory to Understand Distributed Participatory Design in Contemporary, Crowdsourced Information Systems Development. *Australasian Journal of Information Systems, 24*, 1-23.

Klein, H., & Myers, M. D. (1999). A Set of Principles for Conducting and Evaluating Interpretive Field Studies in Information Systems. *MIS Quarterly, 23*(1), 67-93.

Koutsikouri, D., Lindgren, R., Henfridsson, O., & Rudmark, D. (2018). Extending Digital Infrastructures: A

Typology of Growth Tactics. *Journal of the Association for Information Systems*, 1001-1019.

Lusch, R. F., & Nambisan, S. (2015). Service innovation: a service-dominant logic perspective. *MISQ, 39*(1).

Marjanovic, O., & Cecez-Kecmanovic, D. (2017). Exploring the tension between transparency and datification effects of open government IS through the lens of Complex Adaptive Systems. *The Journal of Strategic Information Systems, 26*(3), 210-232.

Masuda, Y., Zimmermann, A., Bass, M., Nakamura, O., Shirasaka, S., & Yamamoto, S. (2021). Adaptive Enterprise Architecture Process for Global Companies in a Digital IT Era. *Inter. J. of Enterprise Information Systems, 17*(2), 21-43.

Merali, Y. (2006). Complexity and Information Systems: The Emergent Domain. *Journal of Information Technology, 21*(4), 216-228.

Myers, M. D. (2013). *Qualitative research in business and management* (2 ed.). London: Sage.

Myers, M. D., & Newman, M. (2007). The qualitative interview in IS research: Examining the craft. *Information and Organization, 17*(1), 2-26.

Nambisan, S., Lyytinen, K., & Yoo, Y. (2020). *Handbook of Digital Innovation*. Cheltenham, UNITED KINGDOM: Edward Elgar Publishing Limited.

Orlikowski, W. J., & Baroudi, J. J. (1991). Studying Information Technology in Organizations: Research Approaches and Assumptions. *Information Systems Research,, 2*(1), 1-28.

Pan, S. L., & Tan, B. (2011). Demystifying case research: A structured–pragmatic–situational (SPS) approach to conducting case studies. *Information and Organization, 21*(3), 161-176.

Parker, G., Van Alstyne, M., & Jiang, X. (2017). Platform ecosystems: How developers invert the firm *MIS Quarterly Vol. 41* (1), 255-266.

Rolland, K.-H. H., Ole. (2021). Managing Path Dependency in Digital Transformation Processes: A Longitudinal Case study of an Enterprise Document Management Platform. *Procedia Computer Science, 181*, 765-774.

Rolland, K. H., Mathiassen, L., & Rai, A. (2018). Managing Digital Platforms in User Organizations: The Interactions Between Digital Options and Digital Debt. *ISR, 29*(2), 419-443.

Ross, J., Beath, C., & Mocker, M. (2019). *Designed for digital: How to architect your business for sustained success*. Cambridge, MA: The MIT Press.

Schreieck, M., Wiesche, M., & Krcmar, H. (2022). Governing innovation platforms in multi-business organisations. *European Journal of Information Systems, 32*(4), 695-716.

Sia, S. K., Weill, P., & Zhang, N. (2021). Designing a Future-Ready Enterprise: The Digital Transformation of DBS Bank. *California Management Review, 63*(3), 35-57.

Sigríður Islind, A. (2018). *Platformization, Co-Designing Digital Platforms in Practice.* University West,

Spagnoletti, P., Resca, A., & Lee, G. (2015). A Design Theory for Digital Platforms Supporting Online Communities: A Multiple Case Study. *Journal of Information Technology, 30*(4), 364-380.

Stacey, R. D. (2003). *Strategic Management and Organizational Dynamics: The Challenge of Complexity* (4th ed.). Harlow, UK: Prentice Hall.

Stacey, R. D., Griffin, D., & Shaw, P. (2000). *Complexity and Management – Fad or Radical Challenge to Systems Thinking?* New York, USA.: Routledge.

Szalkowski, G. A. M., Patrick. (2023). Understanding digital platform evolution using compartmental models. *Tech. Forecasting and Social Change, 193*.

Tiwana, A., Konsynski, B., & Bush, A. A. (2010). Research Commentary—Platform Evolution: Coevolution of Platform Architecture, Governance, and Environmental Dynamics. *Information Systems Research, 21*(4), 675-687.

Törmer, R. L. (2018). *Internal Digital Platforms and Generative Mechanisms of Digital Innovation*. Paper presented at the ICIS, San Francisco

Tura, N., Kutvonen, A., & Ritala, P. (2017). Platform design framework: conceptualisation and application. *Technology Analysis & Strategic Management, 30*(8), 881-894.

Vestues, K., & Rolland, K. (2021). Platformizing the Organization through Decoupling and Recoupling: A longitudinal case study of a government agency. *Scandinavian Journal of Information Systems, 33*(1), 123-154.

Vial, G. (2023). A Complex Adaptive Systems Perspective of Software Reuse in the Digital Age: An Agenda for IS Research. *Information Systems Research*.

Vidgen, R., & Wang, X. (2009). Coevolving Systems and the Organization of Agile Software Development. *Information Systems Research, 20*(3), 355-376.

Wang, P. (2021). Connecting the Parts with the Whole: Toward an Information Ecology Theory of Digital Innovation Ecosystems. *MISQ, 45*(1), 397-422.

Wimelius, H., Mathiassen, L., Holmström, J., & Keil, M. (2020). A paradoxical perspective on technology renewal in digital transformation. *Information Systems Journal, 31*(1), 198-225.

Yoo, Y. (2013). The Tables Have Turned: How Can the Information Systems Field Contribute to Technology and Innovation Management Research? *JAIS, 14*(5).

Yoo, Y., Boland, R. J., Lyytinen, K., & Majchrzak, A. (2012). Organizing for Innovation in the Digitized World. *Organization Science, 23*(5), 1398-1408.