Designing for Change and Transformation: Exploring the Role of IS Artefact Generativity

Andreas Drechsler
School of Information Management
Victoria University of Wellington
Wellington, New Zealand
Email: andreas.drechsler@vuw.ac.nz

Abstract

This paper explores artefact generativity as a novel conceptual frame to inform information system (IS) artefact design beyond designing for artefact utility at the time of an artefact's introduction or implementation. The paper draws on three recently developed generativity conceptualizations and applies the findings to IS artefact design. Artefact generativity captures the notions that 1) sustained artefact utility may require potentially continuous artefact changes over its lifetime, 2) (re-)designers need to enact these changes within a design system, and 3) continuous artefact use may lead to further generative transformations in the artefact's social and technical environment. IS design science researchers can draw on this paper's findings to inform future artefact design decisions that address these three notions by drawing on the established and growing foundations of IS and social science theories that underlie the established generativity perspectives.

Keywords design science, artefacts, artifacts, generativity, design system, sustained utility, change, transformation

1 Introduction

Recent contributions to the information systems (IS) design science research (DSR) discourse have suggested increasing the attention paid to artefact effects beyond an artefact's immediate utility at the time of its initial adoption and use (Drechsler and Hevner 2016; Gill and Hevner 2013). These authors reason that, in the light of changing artefact environments, requirements, or even goals, IS artefact design should also aim for sustained artefact utility. In turn, sustained artefact utility is an important factor in achieving sustained organizational or societal impact or transformation through DSR.

Gill and Hevner (2013) conceptualize an IS artefact's requirements for sustained utility as 'artefact fitness'. They distinguish two general IS artefact fitness types: the artefact needs to be sufficiently adaptable to 1) achieve a sufficient goodness of fit with its environment for its initial adoption and 2) at least retain its initial utility given the changing artefact environment. However, this fitness notion has several limitations, as discussed in greater detail in Section 3, which in turn limit its usefulness to derive design requirements or principles addressing the need for sustained IS artefact utility or fostering theoretical contributions. Against this backdrop, this paper explores the artefact generativity concept with respect to its suitability to be a complementary or an alternative lens for conceptualizing the need to address sustained utility.

In a nutshell, in the IS context, generativity refers to "the capacity of a self-contained (digital) system to generate new outputs, structures or behaviours endogenously through the participation of uncoordinated third-party actors without deliberate planning from the originator of the system" (Lyytinen et al. 2016, p. 53). The generativity concept has been used in several discourses within and beyond IS (Avital and Te'Eni 2009; Eck et al. 2015), but has, to the author's knowledge, not been applied to IS artefact design in the DSR discourse. While there have been design-oriented applications of generativity to inform the design of information infrastructures, such as the Internet or industry-wide EDI networks (Hanseth and Lyytinen 2010), the applications are limited to these specific artefacts and do not reflect on their general implications for sustained IS artefact utility. This paper therefore contributes an initial – and positive –assessment of the generativity concept with respect to its suitability to guide theory-informed artefact design for sustained utility. The assessment takes the shape of a conceptual appraisal and discussion.

This discussion is structured as follows: The second section briefly introduces the DSR foundations later used to critically examine the artefact fitness concept and to conceptually bridge generativity and IS artefact design. The third section highlights the shortcomings of the artefact fitness concept as prevalent in the IS DSR literature. These shortcomings form the rationale for the examination of potential alternative concepts such as generativity. The fourth section summarizes the most relevant generativity perspectives. These perspectives are then contrasted with common IS artefact characteristics (including artefact fitness) in the fifth section in order to appraise their suitability. The sixth section highlights the generativity concept's identified potential to inform the design of sustainably useful IS artefacts against the backdrop of organizational or societal change and transformation. The seventh and last section discusses the paper's contributions and limitations, and concludes with an outlook on further research.

2 Theoretical foundations: IS DSR

2.1 IS artefact types in DSR

In line with the prevalent understanding of artefacts in DSR, this paper defines an artefact as an artificially constructed entity that is distinguishable from its environment (Simon 1996) and an IS artefact as an artefact that comprises social, technical, and informational elements (Iivari 2016). Unless noted otherwise, the terms 'artefacts' and 'IS artefacts' are used synonymously throughout this paper. Artefacts can be purely technical (e.g., a machine learning algorithm), purely social (e.g., a process framework for distributed agile software development), or incorporate both technical and social components (e.g., a novel healthcare system that comprises front-end mobile apps, back-end systems, and new interaction processes between doctors, nurses, and patients). Whatever the case, artefacts also have an informational component beside their social and technical ones that allows actors (humans or machines) to store, process, or transform information. Artefact utility is the main dependent variable used to evaluate an artefact (Gill and Hevner 2013). In addition to utility / usefulness, the 'ease of use' characteristic from the Technology Acceptance Model (TAM) (Davis 1989) is also relevant.

The distinction between artefacts and meta-artefacts (Iivari 2003) is also important for the appraisals of artefact fitness and generativity. Meta-artefacts are artefacts that lead to the development of others. Meta-artefacts comprise abstract or mid-range artefacts (e.g., an ERP system or a software development

(SD) process model) that need to be instantiated and introduced to specific local application contexts (Gregor and Hevner 2013). Such an instantiation and introduction process may also include adapting the artefact to fit a specific application context. Meta-artefacts also include artefacts that generate, or change, totally different artefacts – for example, using a process model to introduce a formal SD process into an organization that has not employed any formal SD process, or using a process model to adapt an existing SD process to cope with the challenges of globally distributed software development.

2.2 Artefact fitness

In order to highlight that utility should not be the only criterion for evaluating DSR research outcomes, Gill and Hevner (2013) have proposed a fitness-utility model for DSR. In particular, they distinguish between type 1 fitness, which is an organism's ability to survive over time, and type 2 fitness, which is an organism's ability to reproduce and evolve over generations. They operationalize the fitness concept further by proposing seven fitness characteristics for IS artefacts and one characteristic of unfitness:

1. *Decomposable*: Artefacts that are decomposable into smaller units allow the redesign of selected units (instead of the artefact as a whole) to cope with external changes.
2. *Malleable*: Malleable artefacts can be adapted to cope with changing environments and can be used for unintended purposes.
3. *Open*: Openness for inspection and change also fosters an artefact's adaption. Gill and Hevner (2013) regard the three characteristics malleability, decomposability, and openness as complementary and as enhancing one another.
4. *Embedded in Design Systems*: When artefacts are part of systems in which design and changes are common, one expects these artefacts to evolve more rapidly than those embedded in stability-oriented systems.
5. *Novel*: Novel (and viable) artefacts can trigger a wave of innovation or change encompassing an entire artefact landscape.
6. *Interesting*: Interesting artefacts may intrigue designers, researchers, decision-makers, or users and thus also trigger a wave of innovation or change – especially when artefacts are both novel and interesting.
7. *Elegant*: Artefacts perceived as elegant – in addition to being functional (= useful) – may trigger positive reactions in users and therefore be adopted or used more often or for a longer time.
8. *Too useful*: Artefacts may turn out to be too useful when they are highly useful at a certain point in time, but lack the fitness to evolve further to improve their utility or to adapt to changing circumstances in their environment.

2.3 Change and transformation: The fourth design cycle

The idea of considering aspects beyond artefact utility and within an artefact's immediate application context is further conceptualized by extending the established three-cycle view of DSR (Hevner 2007) with a fourth cycle (Drechsler and Hevner 2016) (see Figure 1).

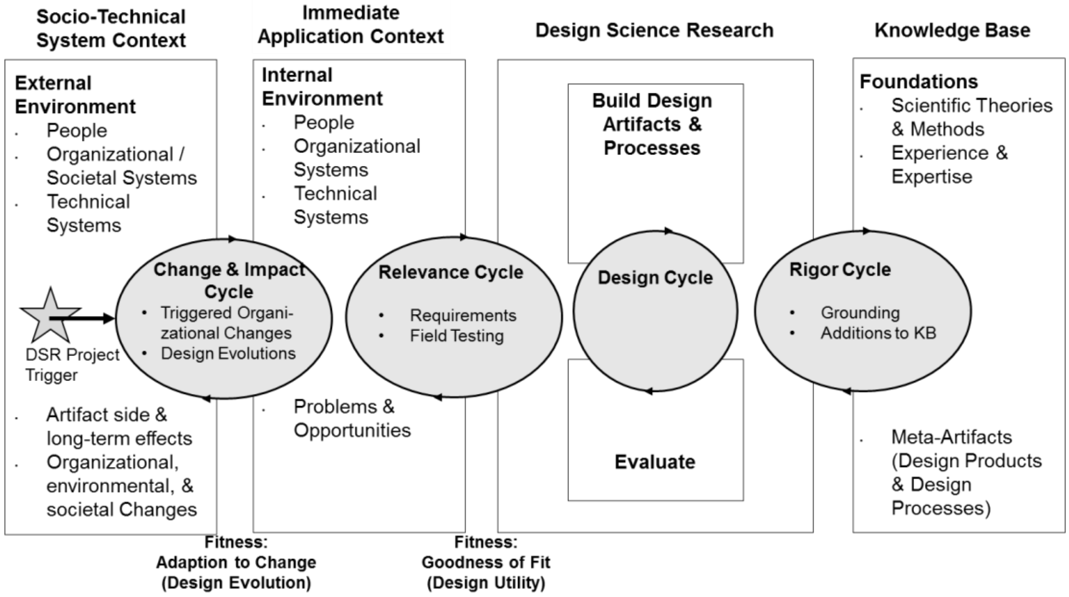

Figure 1. A Four-Cycle View of Design Science Research

This fourth cycle – the change & impact cycle – addresses 1) organizational or societal changes and transformations within an artefact's wider organizational and societal application context that are the impacts of the artefact's introduction and continued use and 2) artefact design changes or evolutions that (need to) occur due to these or other changes in the application context. The model draws on the two fitness types introduced in the previous section: Type 1 fitness fosters an artefact's impacts on its context and its ability to change in order to provide sustained utility. Type 2 fitness helps the artefact's initial adaption to its context and therefore its utility at the time of its introduction.

3 Limitations of the artefact fitness concept

While the extended perspective on artefact evaluation criteria beyond artefact utility is certainly a valid and important one, the artefact fitness concept – as an analogy rooted in evolutionary biology (Gill and Hevner 2013) – introduced in Section 2.2 has a number of shortcomings and inconsistencies that limit its usefulness for design science researchers seeking to inform their artefact designs with concepts built on a solid foundation.

First, when attempting to define the original evolutionary biology fitness concept precisely, several philosophical problems arise (Rosenberg and Bouchard 2015). Any analogy that draws explicitly on this concept is therefore potentially fraught with similar problems. Moreover, it is not easy to link the fitness analogy to other theoretical lenses that are closer to IS research than evolutionary biology. The artefact fitness's limited connectedness to the kernel theory landscape of IS artefact design makes it therefore difficult for design science researchers to draw on it to infer concrete implications for their artefact design. Furthermore, having to base one's work on an analogy also complicates subsequent theoretical contributions.

Second, unlike biological organisms, most IS artefacts usually do not (yet) automatically adapt themselves, but require external interventions by (re-)designers to change. These re-designers may not be the initial designers (researchers), but other designers / developers or even users. Moreover, these re-designers' interventions may comprise deliberate and formal acts of artefact redesign as well as informal changes to practices that affect artefact use – and all of the interventions may be outside the initial designers' control or even their awareness (Germonprez et al. 2011). However, Gill and Hevner (2013) do not discuss such '(re)design agency' or 'secondary design' issues in their paper, with the exception of a brief section (5.1). Instead, they take a very artefact-centric focus and only in passing consider the implications of an artefact's social and technical context for its adaption / re-design process.

Third, the seven artefact fitness criteria and the single artefact unfitness criterion introduced in Section 2.2 apply somewhat inconsistently to meta-artefacts and artefact instantiations. The first three characteristics (novel, malleable, and open) are inherent artefact characteristics that can be (at least somewhat) objectively measured. They apply to meta-artefacts as well as to instantiated artefacts. Over time, these characteristics can change, for instance, when a carefully designed service-oriented software or process architecture slowly becomes less malleable and decomposable when evolving into a 'spaghetti-oriented architecture'.

In contrast, novelty, interestingness, and elegance are not inherent artefact characteristics. They are relative to other artefacts (especially novelty), difficult to measure objectively and, most importantly, subject to individuals' perceptions. These perceptions may differ across individuals and may change over time. Note that these three criteria can also be seen as characteristics that foster *artefact resonance* with an artefact's various audiences (decision-makers, users, re-designers, etc.) (Drechsler et al. 2016). These audiences' main interests in meta-artefacts will probably be concerned with the initial artefact adoption, whereas their concerns regarding instantiations will probably include the artefact use as well. Resonance is an established Informing Science concept that builds upon various social science theories (Gill 2010).

Contrary to the six other artefact fitness characteristics, being 'embedded in a design system' does not relate to an artefact as such, but to its environment. While this characteristic applies to meta-artefacts as well as artefacts, the environment's meaning differs between the two. The meta-design system environment of a meta-artefact M would consist of other complementary meta-artefacts that provide tools, methods, or processes that can be used to change M. The design system environment of an instantiated artefact refers to its actual immediate and wider technical and social environment concerned with artefact change (for instance, auto-update mechanisms or improvement processes).

Lastly, the unfitness criterion of being 'too useful' is not clearly perceivable or measurable at the time of design, or when an artefact is highly useful. On the meta-artefact level, a too useful artefact is one that has become difficult to adapt to new instantiation contexts (due to changes to these contexts), thus reducing its chances of being adopted in the future (type 2 fitness). In contrast, on the instantiation level, a too useful artefact has become difficult to adapt to its actual environment (type 1 fitness).

Consequently, the four-cycle view of DSR introduced in Section 2.3 inherits the artefact fitness concept's shortcomings outlined above. The shortcomings become particularly apparent when attempting to derive design features for the design of a meta-artefact (or an instantiated artefact) with a high 'fitness' level in order to achieve a high and sustained impact potential (or actual impact). Against this backdrop, the following sections explore different understandings of the generativity concept and whether they are better suited to inform artefact design for sustained utility.

4 Theoretical foundations: generativity and related paradoxes

In this section, three theoretical generativity conceptualizations, selected to match the technical, social, and informational aspects of IS artefacts, are introduced. Note that due to this paper's exploratory scope and limited space, no systematic and comprehensive literature review was conducted. Despite this, the possibility of matching the three generativity conceptualizations introduced below directly to the three IS artefact components (social, technical, informational) underlines the overall approach's viability.

4.1 Technical generativity

Against the backdrop of the Internet's unique generative nature, Zittrain (2008) discusses five general characteristics of technical systems that foster generativity, i.e. produce unanticipated change by means of various audiences' (including developers and users) inputs. While his perspective acknowledges the need for human actors within the system to use and exploit the system and make any changes to the system, the characteristics themselves are largely centred on the technical system the actors use (the Internet, in his case). These five characteristics are:

1. *Leverage*: captures how well the system allows an actor using the system to perform better than one who does not.
2. *Adaptability*: addresses the system's ability to adapt to different contexts.
3. *Ease of mastery*: how easy it is for actors to exploit the system's full potential.
4. *Accessibility*: characterizes the height of the system's entry barriers to initial use.
5. *Transferability*: refers to the extent to which changes can be transferred from one part of the system to another part or to another system instantiation and the effort required to do so. For instance, modifications to a user interface in a piece of software can be rolled out to the software's users rather easily (a new installer for each user or a central software roll-out). Modifications to a web page, however, are immediately 'transferred' to all viewers. The information about a business process's modifications can be distributed to all its users quite easily; however, for a purely social artefact, the users have to enact the change to make it happen.

The overall assumption is that a system largely exhibiting all five characteristics has a highly generative nature in terms of producing unanticipated change.

4.2 Social generativity

In contrast to Zittrain's (2008) more technical perspective on generativity, Lane (2011) approaches it from a social angle and discusses five characteristics of generative relationships, i.e. relations between two or more human agents that can lead to innovation and change:

1. *Aligned directedness*: refers to the extent the agents' goals and actions follow a similar direction.
2. *Heterogeneity*: highlights the need for substantial differences between the agents, to allow innovations to emerge from these.
3. *Mutual directedness*: characterizes the consequent need for these agents to undertake joint actions in order to find a common ground and mutual understanding, which will allow them to exploit their differences to generate innovation.
4. *Appropriate permissions*: address the need for the agents to perceive their social setting in such a way that they have (or can obtain, or appropriate) permissions to engage with each other and exploit their mutual differences (and not merely accept, or side-step their differences). For instance, formal hierarchies and a top-down command-and-control culture within an organization may prevent users in one department from communicating with those in another or with the system designers in the IT department, which would allow them to harness the innovative potential of the information system that both departments use. Conversely, close

user involvement in system development, as well as a regular and participatively run continual improvement process after the initial system deployment, sends clear signals that critical user input is valued and encouraged.

5. *Action opportunities*: emphasize that social interactions in terms of engaging with and exploiting the agents' mutual differences are not sufficient to generate innovations, but that the agents also need to conduct joint actions to do so (e.g., participate in continual improvement processes that actually lead to changes to a system).

Again, the underlying assumption is that relationships largely exhibiting these characteristics are of a highly generative nature, i.e. foster the emergence and proliferation of innovations from the actions occurring against the relationships' backdrop. From this paper's perspective, such actions can include changes to social and technical artefacts or their components.

4.3 Informational generativity

Avital and Te'eni (2009) propose a third set of generativity-related characteristics. They investigate technology's generative fit regarding enhancing its users' generative capacity, i.e. allowing these users to produce 'something new'. The related characteristics thus emphasize an information system's informational rather than its technical aspects. Informational generativity's major characteristics are:

1. *Evocative*: enabling and fostering new thinking by creating an environment that stimulates the system users' creativity (e.g., through visualization, abstraction, communication, the integration of different perspectives, or the simulation of scenarios).
2. *Adaptive*: allowing a system to be adapted by customizing it in order to minimize distractions from the creative task, to reduce the cognitive load that the users require to operate the system (e.g., through automation), and, thus, to provide additional cognitive or creative capacity.
3. *Open-ended*: With respect to their social nature, open-ended systems foster peer production and communication between their user group members. With respect to their technical nature, open-ended systems allow rejuvenation by rewriting the existing system modules or by extending them with new functional modules.

At the other end of the spectrum (i.e. where a technology users' generative capacity is not enhanced) are systems that emphasize operational efficiency regarding executing a given task. Unlike in the other two generativity types, possessing more of a characteristic is not always 'better'. Instead, depending on the task an information system is supposed to support, the extent to which a system should be evocative, adaptive, and open-ended must fit this task's informational needs.

4.4 Generativity-related paradoxes

Moving beyond system-related characteristics, Tilson et al. (2010) highlight two paradoxes that occur during the 'life' of generative systems. It is important to note that their perspective covers entire digital infrastructures and their abstraction level may thus be far higher than a traditional IS artefact perspective. Nevertheless, their work provides more general insights for artefact design.

The first paradox is that generative systems (or artefacts) need to be simultaneously stable and flexible. While all the perspectives discussed above (artefact fitness and the three generativity types) emphasize change or adaption in one way or another, a certain amount of stability is necessary within and around the artefact to allow its users to actually fully exploit its utility. Also note that having an artefact as an entity that is distinguishable from its environment (cf. Section 2.1) implies a somewhat stable nature, which, in the first place, makes recognizing and distinguishing it possible.

The second paradox is the latent tension between control and autonomy. Conducting DSR implies that the researchers and at least some actors in the affected social systems exert control over their future development by designing and introducing artefacts or triggering purposeful changes. In contrast, all four previously discussed perspectives, as well as the definition provided in the Introduction, encompass notions of open(ended)ness, emerging novelty, or innovation. All these notions require a generative system to have at least some degree of autonomy or some within it.

5 Contrasting IS artefact characteristics with the three generativity perspectives

In this section, the artefact characteristics introduced in Sections 2.1 and 2.2 are contrasted with the characteristics of the three different generativity perspectives introduced in Section 4. Table 1 provides an overview of the relations between the IS artefact characteristics and the generativity perspectives.

IS Artefact characteristics	**Technical generativity**	**Social generativity**	**Informational generativity**
Utility / Usefulness	Leverage	/	Evocative Open-ended (socially)
Ease of use	Accessibility Ease of mastery	/	(Adaptive)
Decomposable	Adaptability Transferability	/	Adaptive Open-ended (technically)
Malleable			
Open			
Novel	/	/	/
Interesting	/	/	(Evocative)
Elegant	(Adaptability) (Ease of mastery) (Accessibility)	/	(Evocative) (Adaptive)
Embedded in Design System	Adaptability Transferability	Aligned directedness Heterogeneity Mutual directedness Appropriate permissions Action opportunities	Adaptive Open-ended
Too useful	/	/	/

Table 1. Contrasting IS artefact characteristics with the three generativity perspectives

Viewed through a generativity lens, an artefact's usefulness is reflected in the 'leverage' characteristic of its technical generativity (which enables users to perform better than non-users) and the 'evocative' and '(socially) open-ended' characteristic of its informational generativity (how well it enables users to be generative (= creative) in their tasks and how well it enables generative interactions with peers).

'Ease of use' corresponds closely to technical generativity's 'accessibility' and 'ease of mastery' characteristics as well as to adaptiveness's major purpose as viewed through an informational generativity lens. Since the latter is a more indirect correspondence, it is noted in brackets in Table 1.

The three fitness characteristics 'decomposable', 'malleable', and 'open' closely match the notion of adaptability / adaptiveness in respectively technical and informational generativity. Technical generativity's transferability bears a similarly close relation (i.e., transferring changes within a system requires at least openness and malleability), as does the technical aspect of open-endedness.

The fitness characteristics 'novel' and 'interesting' do not have a direct counterpart in any of the three generativity perspectives. One could argue that an interesting system contributes to stimulating its users' creativity, but this is a rather weak argument. Owing to the inherent vagueness of 'elegance', it is equally difficult to make a case for relations between this fitness criterion and the generativity perspectives (hence the brackets in Table 1). Systems can be perceived as elegant in terms of their use, mastering them, or adapting them, but this elegance is subjective, may vary between users, and its perception may change over time. As noted in Section 3, the artefact resonance concept also addresses these three aspects in the context of the initial artefact adoption.

In contrast, the notion of an artefact being 'embedded in a design system' is well represented in all three the generativity perspectives. On the technical side, adaptability, transferability, and being open-ended to change can all be seen as the technical components of a design system surrounding an artefact, or as being prerequisites for such a design system to function effectively. Social generativity highlights several qualities that the social component of such a design system should have: In order to change an artefact's social and technical components in order to sustain or enhance its utility, heterogeneous agents (users, (re)designers, decision-makers …) need to undertake permitted joint deliberations and actions aimed at aligned goals. The artefact's social open-endedness can also play a role here by enabling communication between an artefact's users, which can be a key part of such generative deliberations and actions.

Lastly, the notion of being too useful is not reflected in any of the three generativity perspectives.

6 Implications for artefact design in IS DSR

This section discusses the first implications for IS artefact design of the three generativity perspectives' additional insights and angles beside artefact utility and fitness.

6.1 Considering a complementary and deployable design system

As illustrated by Table 1, the three generativity perspectives largely highlight the role of a design system surrounding an artefact. Such a design system can control and enact artefact change in order to sustain or enhance an artefact's utility or ease of use over its lifetime. A design system may have technical components (tools to change an artefact) and will almost always have a social component, because even today's machine learning algorithms (an example of purely technical artefacts) are (still) mostly unable to evolve meaningfully on their own without any (re)designer intervention. In other words, to change artefacts, (re)designers need to take explicit actions to make changes to their technical or social components. These redesign actions need to be aligned with the goals of the artefact's users (to foster a positive impact on individual performance or well-being) and/or decision-makers goals (regarding the organizational performance) to at least ensure good intentions regarding enhancing the artefact utility.

Hence, taking generativity into consideration highlights the benefits of already considering a complementary socio-technical 'design system' during the artefact design. In respect of meta-artefacts, such a design system would take the shape of a meta-design system that includes general considerations regarding how to adapt and tailor the future artefact and surrounding design system instantiations. More specifically, the different generativity characteristics related to the design system in Table 1 can drive its specific design requirements' or principles' development or that of the artefact. It is conceivable that a design system could itself be treated as a different type of meta-artefact and the research attention could be focussed on its theory-informed design as a socio-technical artefact.

A design system can also be the element that balances the need to control the artefact's evolutionary directions (i.e. keeping the changes in line with all the organizational goals) with the need for autonomy to undertake generative actions (cf. Section 4.4). The design system's control aspect can also be extended to control an artefact's stability (with a corresponding emphasis on efficiency and performance) and to balance stability with flexibility (emphasizing the need to change and evolve).

6.2 Anticipating generative transformations of the artefact's environments

The different generativity perspectives also indicate that the continual and collective use of instantiated artefacts may lead to generative transformations of their immediate and wider environment, as well as, ultimately, to organizational / societal transformation. Such a transformation can be intended (if it is part of the initial design goals) or unintended (if it is the result of an artefact's generative nature), and incremental (or path-dependent) or disruptive (or path-creating) (Pandza and Thorpe 2010). Generativity can thus provide an alternative first step towards artefact fitness in terms of operationalizing the change & impact cycle in the four-cycle model showed in Figure 1. The likelihood of unintended changes also highlights that artefact change and the generative transformations of an artefact's environment may well lie outside the researcher's / initial designer's control and intention. Designers may therefore have to address the paradox of designing for autonomy in their design. In turn, the artefact fitness of deliberately non-generative systems – in the informational sense, i.e. systems with a focus on operational efficiency – warns designers against designing these systems to be 'too useful' and to instead consider appropriate generativity-related measures for sustained utility.

Similar to using a design system to control artefact change, the autonomy vs. control paradox needs to be kept in check to prevent the transformation of an artefact's environment from becoming non-beneficial. This need to balance autonomy and control may have to be even stronger in respect of meta-artefacts that 'merely' serve to generate new or transform existing artefacts. In other words, the main purpose of such meta-artefacts is to be highly generative by nature in order to affect their target environment. These meta-artefacts thus act as their own design systems aimed at affecting their application environment. Again, the different generativity perspectives can serve as starting points to derive specific theory-informed requirements or principles for designing such meta-artefacts.

6.3 Refining the two artefact fitness notions in the four-cycle view of IS DSR

The three generativity perspectives' offer more refined views of the artefact evolution and change, which also allow a reconsideration of the two artefact fitness notions in the four-cycle view of IS DSR as shown in Figure 1. The type 2 fitness notion between the design and the relevance cycle can be replaced with (meta-)artefact resonance (mainly addressing novelty, interestingness, and elegance) and instantiation-process-related (meta-)artefact generativity (mainly addressing decomposability, malleability, and openness). In addition, a surrounding (meta-)design system can address both aspects.

The type 1 fitness notion between the relevance and 'change & impact' cycle can be replaced with evolution-related artefact generativity (again addressing, decomposability, malleability, and openness) with the overarching goal of preventing an instantiated artefact from becoming 'too useful'. Once again, by taking a corresponding (re)design system into consideration on the instance level can complement the evolution-related artefact design considerations and foster the full exploitation of an artefact's generative potential over its lifetime.

6.4 Scoping IS DSR endeavours for sustained artefact utility

The question now arises how to formulate a specific IS DSR endeavour's scope beyond an artefact-centric design. In one way or another, the different generativity perspectives highlight the importance of the two ways of taking a wider systems perspective: 1) considering all three of an artefact's components (technical, informational, social) and a corresponding design system and 2) explicitly considering the artefact's boundaries and those of the entire design effort (i.e., where does the wider environment begin that the design effort and generative changes must not / will not affect?).

Consequently, if the initial design focusses strongly or even solely on technical aspects, a design system's additional considerations (regarding fostering sustained utility) and the artefact's generative effects on its wider technical and social environment may extend the DSR endeavour's scope quite quickly beyond mere technical considerations. The generativity perspectives can also inform artefact designers to already consider the environment's dynamic nature (whether a consequence or independent of the design effort) during the design time and, thus, to incorporate appropriate design (system) measures to foster the 'secondary design' efforts as Germonprez et al. (2011) call them.

Simultaneously, despite all the different angles that the generativity considerations introduce into a DSR endeavour, it is important that designers keep in mind that artefact utility is a central evaluation criterion. Consequently, DSR may become an exercise in balancing utility (in the sense of the exploitation of an artefact's usefulness potential) and flexibility (in the sense of a continuous exploration of an artefact's generative potential). In other words, DSR may become an ambidextrous endeavour.

7 Discussion and Conclusion

This paper introduced three different generativity notions and two related paradoxes from the literature, contrasted these with the established IS artefact utility and fitness characteristics, and discussed the first implications for artefact design in IS DSR. These implications comprise the benefits of considering a socio-technical design system focussed on an artefact as fostering sustained artefact utility, the roles of artefact generativity in changing and transforming an artefact's environment, and the implications of the previous two implications for the scoping of a DSR endeavour. The paper has also argued that, together, the two concepts artefact generativity and artefact resonance are good candidates to effectively replace the main artefact fitness characteristics.

By drawing on these generativity and resonance concepts, design researchers can avoid the potentially problematic analogy of evolutionary biology fitness, can benefit from a clearer picture of human agency during artefact (re)design, and are given more immediate links to social science theories. Artefact generativity thus has the potential to allow theories that are prevalent in an IS context to more strongly inform design researchers' artefact design. Likewise, drawing on the generativity perspectives also allows design researchers to make potentially stronger theoretical contributions than drawing on artefact fitness. Ultimately, designing artefacts for generativity promises a higher sustained utility for the artefacts' users in practice and may even foster the capability for change of their surrounding organizations or parts of society.

Moreover, the artefact generativity perspectives contribute several insights that go deeper than the artefact fitness characteristics. In particular, the social generativity perspective highlights the prerequisites (e.g., permissions) and roles of different actors within a design system focussed on the artefact of interest to effectively enact generativity, even if it is purely technical by nature. Informational generativity also sheds light on the role of technical artefacts that allow social exchanges in order to foster generative potential. Simultaneously, informational generativity points out that an artefact's purpose may not be to foster innovation, but to emphasize a given task's operational efficiency. However, the additional generativity perspectives and the four-cycle view of IS DSR highlight that a given task may not remain static over an artefact's lifetime. Generativity therefore informs designers to consider explicit ways of sustaining an artefact's high operational efficiency regarding tasks that may change over time, and to do so through deliberate artefact and design system design. Considering generativity in the DSR context ultimately points towards the possibility of understanding DSR as an ambidextrous endeavour due to the need to juggle efficiency (or exploitation) and flexibility (or exploration).

A limitation, however, in this context is replacing a seemingly elegant concept (fitness) with two more complicated – but also richer and better grounded – concepts (generativity and resonance). Artefact fitness also has the stronger metaphorical (and thus rhetorical) appeal than the quite technical concepts of generativity and resonance. Moreover, the artefact fitness notion of being 'too useful' remains an important reminder to not only consider artefact utility, but also its inherent capability for change.

Future research can extend and deepen this paper's initial and purely conceptual take on generativity with a more comprehensive approach to shed light on, understand, and structure the generativity concept's implications for IS DSR. Promising next steps for such an endeavour are 1) conducting a systematic literature review of papers that draw on the various generativity lenses as well as other papers that explore similar ideas, 2) building a comprehensive conceptual model of the different roles that the different generativity and other identified perspectives can play in the IS DSR context, and 3) deriving concrete and theory-informed design requirements and corresponding design principles for a) generative artefact design and b) for designing a surrounding and complementary design system. Future research can also further explore the ambidextrous nature of DSR projects aimed at change and impact.

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