

# 13 Digital transformations and their design

## Renewal of the socio-technical approach

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Digitalisation of society is a trend that increasingly impacts various sectors of society like healthcare, education, finance, and government. This digitalisation does not only create new technological developments but also impacts society and its traditional structure, institutions, and organizations. As technology and society intertwine increasingly, it becomes a challenge to address future problems facing individuals, organisations, and society at large, as these problems inevitably become complex in an increasing pace. Wickedly, even specifying and recognising such so-called socio-technical problems become difficult due to the fading borders among cause-and-effect relationships. Specifying and addressing these socio-technical problems will be a great challenge ahead of us in 2030. Addressing this challenge will require innovative approaches that aim at creating an acceptable balance among (contending) values like functionality, economics, ethics, and democracy. In this contribution we motivate adopting a fine mix of designerly approaches and traditional approaches (like engineering) in order to address the uncertainty inherent in socio-technical problems while making maximum use of the existing certainties (i.e., deterministic relationships). Further, we suggest a couple of directions for Rotterdam University of Applied Sciences to appropriately embed cyber-social studies into its fabric and to adequately prepare its future graduates so that they can meet the challenges of designing and realizing cyber-social systems in the future.

### 1. The digital transformation as a cyber-social experience

Society is facing several big transformations in the early 21<sup>st</sup> century – those related to energy, digitalization, healthcare, and social equality, to name a few. The digital transformation, the focus of this paper, is affecting all domains – technology, business, healthcare, education. The digital transformation affects society on every scale, from the molecular and individual to groups and organisations, to

cities, regions, territories, and even to the global and interplanetary scale. The range from individuals to regions appears to cover the most interesting arenas of digital transformation for a university of applied sciences.

There are lines of thought<sup>1>></sup> that particularly focus on the disappearance of technologies into the fabric of everyday life. And while these cyber-physical systems and Internet of Things applications and their artificial intelligence components might hide away their technical intricacies and blend into more mundane objects such as mirrors and walls, cars and cargo ships, lifts and automatic sliding doors, they will inevitably remain technological artifacts that interact with their environment – with other technologies, with the dead and living nature, and with human beings.

As technological artifacts, those objects seemingly underwent a digital transformation and gained what some like to call autonomy. However, they will still be the results of human endeavour; there still will be professionals in computing, engineering and design who sketch, build, and programme those objects, who connect them to other objects and to subordinate or overarching systems, and who devise how humans are supposed to interact with these objects and interpret their actions. Eventually, it will be people who determine the utility of those digitally transformed objects by interacting with them (or not), despite all that technical charm.

Therefore, we understand the digital transformation as a fundamentally cyber-social experience. *Cyber* because we agree that digitally transformed objects will be technically connected to many other objects, and form systems of objects and systems of systems. Fundamentally *social* because inventing, creating, building, programming, implementing, and applying and misusing these objects and systems require intentional (and maybe sometimes unintentional) human intervention.

Such a fundamentally cyber-social experience can never happen unrelated to the larger material and social context in which it happens. As such, the cyber-social experience is not only strongly related to the affordances of this context but also needs to be constrained to the limits of this context. In other words, the digital transformation must respect the planetary boundaries and the principles of social justice as postulated as the outer and inner limits of all human activity (Raworth, 2018).

In the following, we will look at the driving forces of the digital transformation and analyse the digital transformation as a wicked problem – or at least as a weakly-structured problem. We will then present two approaches to problem solving from different domains, namely the engineering domain and the designerly domain. Revisiting the Tavistock tradition of joint optimisation of technical and social aspects of mainly industrial settings, we postulate the requirement of joint optimisation of the cyber-social experience of the digital transformation as a transdisciplinary endeavour which will draw from key enabling technologies, key enabling methodologies and key enabling philosophies. We close in sketching how we envisage teaching cyber-social studies within applied universities in 2030.

## **2. Driving forces of the digital transformation**

It has long been noted that communication and interaction in the era of digital technologies are different to the patterns of the analogue before. Rifkin (2011) describes them as “a profound shift in the very way society is structured, away from hierarchical power and toward lateral power” (pp. 36–67). This notion is an extension to themes that have been discussed in much earlier research, particularly the aspect of self-organisation in the context of the studies of socio-technical systems (Trist & Bamforth, 1951).

Particularly, it is the Internet that has brought the potential of lateral governance to attention. The first-generation Internet, so John Perry Barlow (1996) declared, was a different world, a place where “whatever the human mind may create can be reproduced and distributed infinitely at no cost”, not requiring the “obsolete information industries” anymore. The Internet he saw was like “an act of nature and it grows itself through our collective actions”.

By the year 2000 when the dot-com boom abruptly ended, also “most of those hopes that were based on the Internet being altogether a different place hit ground rather roughly” (Stalder, 2001). What emerged was a second-generation Internet that still was built around lateral communication patterns. However, these became embedded in closed platform ecosystems – like those of Google, Twitter, Facebook, Instagram – that in essence use what appears to be lateral communication as input for their obscure algorithms (obscure both in the sense of opaque and of vague), creating a monopoly for the platforms that collect and control the data and for the algorithms

that structure, combine and reveal it, hence verticalizing communication once again (and even more strongly siloed than before). According to Stalder (Stalder & Pakis, 2018) the Internet stands at a (political) crossroad between – or is rather subject to – two opposing trends of development, post-democracy and commons:

*The former is moving toward an essentially authoritarian society, while the latter is moving toward a radical renewal of democracy by broadening the scope of collective decision-making. Both cases involve more than just a few minor changes to the existing order. Rather, both are ultimately leading to a new political constellation beyond liberal representative democracy (p. 127).*

From a position of social justice, as postulated above, post-democracy and authoritarian developments must be seen as retrograde developments. It is rather the idea of the commons that confers design principles that align with the premise of social justice. Examples of such design principles are the congruence between appropriation and provision rules and local conditions – appropriation rules, i.e. rules restricting time, place, technology, and/or quantity of resource units should be related to the local conditions and to the provision rules that govern the supply of labour, materials, or money – and the establishment of collective-choice arrangements – that most individuals affected by the operational rules should participate in modifying these operational rules (Ostrom, 1990, pp. 92–93).

### **3. Challenges of digital transformation**

In the light of educating future practitioners who will be in charge of realizing meaningful and responsible digital transformations, we look at digital transformation from the viewpoint of a development process whereby an information system is devised, built, deployed and maintained in its social context. Such systems traditionally have been described as a socio-technical systems (Emery & Trist, 1960).

The process of establishing such a socio-technical system can be regarded as a *System Development Life Cycle (SDLC) process*. This process is challenging because the socio-technical systems are complex, their complexity

stemming both from the technical and the social context. In the technical context, the complexity stems from the fact that such systems are not stand-alone anymore but co-dependent on other systems, interacting with lower order systems and rigged into higher order system. In the social context, the complexity stems from the fact that there are many interacting perspectives to consider (like personal, legal, ethical, societal, technological and political perspectives) when devising, building, implementing and maintaining such systems. The system development life cycle, as a result, becomes a multi-disciplinary problem.

The socio-technical complexity leads to uncertainty in problem definition, uncertainty in identifying the stakeholders, ambiguity of stakeholder demands, difficulty of eliciting relevant system requirements, and the necessity of making trade-offs among many contending requirements. For example (as also mentioned in Bargh, 2019; Bargh & Choenni, 2019), designers should address the preferences of users, limitations of technologies, constraints of ethics, laws and regulations, ill intention of adversaries, societal and political values, and (unforeseen) side-effects of information systems in operation. Moreover, some of the constraints, like the privacy preferences of data subjects, are subjective and dependent of the context (e.g., location and time, cultural backgrounds).

In order to characterize the problem of developing socio-technical systems we use a problem classification model introduced by Georgiadou and Recklen (2018). The model has two criteria:

- Problem definition: The stakeholders having or not having dissensus over the goals and values concerning the problems;
- Solution definition: The stakeholders being or not being certain about the factual and cause-effect knowledge needed to solve them.

Based on these two criteria, Table 1 presents a classification of problems to structured (or tamed) problems, unstructured (or wicked) problems, and weakly-structured problems.

Table 1: A classification of policy problems in governance  
(from Georgiadou and Recklen, 2018).

Problem class		Problem goals and values	
		No consensus (dissensus) among stakeholders	
Special knowledge needed to address the problem	Certainty about facts and cause-effect	<b>(1) Tamed</b> or structured problems ( <i>debating on the technicalities</i> )	<b>(3) Weakly-structured</b> problems ( <i>debating goals and values</i> )
	Uncertainty about facts and cause-effect	<b>(2) Weakly-structured</b> problems ( <i>debating cause-effects and optimizing fact collection</i> )	<b>(4) Wicked</b> or unstructured problems ( <i>endless debate</i> )

In the category of wicked problems – or malignant (in contrast to benign), vicious, tricky or aggressive – stakeholders do not agree about the goals (and the values behind the goals) and do not know how to approach (or address) the problem. More specifically, wicked problems are characterized in ten properties (Rittel & Webber, 1973, pp. 160–168).<sup>2>></sup>

1. *There is no definitive formulation of a wicked problem.*
2. *Wicked problems have no stopping rule.*
3. *Solutions to wicked problems cannot be true-or-false, only good-or-bad.*
4. *There is no immediate and no ultimate test of a solution to a wicked problem.*
5. *Every solution to a wicked problem is a “one-shot operation”; because there is no opportunity to learn by trial-and-error, every attempt counts significantly.*
6. *(Wicked problems do not have an enumerable (or an exhaustively describable) set of potential solutions, nor is there a well-described set of permissible operations that may be incorporated into the plan.*
7. *Every wicked problem is essentially unique.*
8. *Every wicked problem can be considered to be a symptom of another problem.*

9. *The existence of a discrepancy representing a wicked problem can be explained in numerous ways [depending on the Weltanschauung of the designer]. The choice of explanation determines the nature of the problem's resolution.*
10. *The [wicked problem solver has no right to be wrong [- he is fully responsible for his actions].*

Designing digital transformations as cyber-social experiences is certainly not a tamed problem as argued above. In other words, it tends to be wicked – or at its best weakly structured (i.e., it resides in quadrants 2, 3 and 4 in Table 1). That means that traditional problem-solving methodologies, which are tuned for tamed problems, are not suitable for designing digital transformations. Therefore, designing digital transformations asks for enhancing traditional problem-solving methodologies (like those adopted in the engineering approach, see section 4) with co-creative problem-solving approaches (like those adopted in the designerly approach, see section 5). Subsequently, we are going to elaborate upon our vision for integrating these currently loosely coupled approaches in order to address cyber-social problems (see sections 6 and 7) and for embedding these integrated approaches in the curricula of universities of applied sciences by 2030 (see section 8).

## 4. Engineering approaches to problem solving

In this section, we briefly describe a couple of traditional engineering approaches for problem solving (adopted with adaptation from Bargh, 2019; Bargh & Choenni, 2019). Engineering is a “branch of science and technology concerned with the design<sup>3</sup>, building, and use of engines, machines, and structures” (Oxford, 2020). For developing information systems, *software engineering* aims at creating ICT-based systems that address a real problem in the practice. Like in any other discipline, the SDLC process in software engineering encompasses a number of phases (like problem investigation, analysis, logical design, physical design, implementation, and maintenance) corresponding to the lifecycle of an information system. In the following, we are going to discuss the characteristics of two main types of SDLC methodologies in software engineering, namely: plan based and agile, using two example methods of the waterfall model and the Scrum model, respectively.

The *waterfall model* is a plan-based SDLC methodology, where the system developer goes through each phase of the SDLC process – like specification



(requirement engineering), development, implementation, evaluation (verification, validation and testing) and evolution – sequentially. In every phase, the input of one phase is the output of the previous one. For implementing an information system, it may be necessary to iterate the cycle over time. Being document driven is a key characteristic of such a process, requiring the documentation of the outcomes of each phase of the SDLC process. The documentation capability of plan-based methodologies makes them suitable in cases where compliance (with standards, policies, regulations and laws) and certification are very important. Ensuing compliance and certification (thus documentation of the development process) are necessary in developing critical systems where, for example, containing safety hazards is perceived as vital. Further, documentation of the development process becomes important where an SDLC of a complex information system takes place at different sites. As its main limitation, the waterfall model does not easily allow changes to the design. Therefore, it is not applicable to volatile environments where the stakeholders' needs, and the guiding design principles/rules may change frequently during the SDLC process. Often, socio-technical systems are subject to such volatility, and therefore cannot be well developed using a waterfall model entirely.

Contrary to the waterfall model, agile SDLC methodologies aim at achieving rapid system development via, among others, minimizing documentation and formal communication within the development process. A well-known agile methodology is *Scrum*, which is a team-based SDLC method with closely collaborating team members. The duration of the SDLC process is usually split in intervals of a few weeks called sprints. Every sprint in Scrum is dedicated to creating a few deliverables, which are components/parts of the information system in mind. The Scrum deliverables are determined in the beginning of a sprint in collaboration with the customer. The work progress and outcomes are reviewed by the project team members and customers through daily builds and end-of-sprint demos. As such, Scrum heavily involves customers in the SDLC process, especially during the reviews, and thereby it is user focused. Scrum is often used for developing apps in fast iterations as the needs of the customers are not well-known beforehand. As to its limitations, agile-based SDLC may suffer from lack of interest of customers to get involved in the development process. Furthermore, in agile-based SDLC the system structure tends to degrade as the process goes through many iterations. The impact of this degradation becomes more pronounced in larger-scale information systems, or in those information systems that require a high level of integration.

Currently information systems should comply with regulations without being certified (i.e., there is a need to show compliance whenever asked for, without having compliance checking before deployment). Therefore, socio-technical systems cannot be well developed using an agile model entirely due to the lack of rigid documentation within such models.

Most SDLC practices are a mix of these two agile and plan-based types. From an engineering perspective, the development process needed for socio-technical systems falls more within this mixed category as, for example, they need compliance with a wide range of subjective and non-subjective requirements (like user preferences and regulations) without affording certification. Nevertheless, a mix of agile and plan-based software engineering methodologies is not enough for developing ICT-based socio-technical systems. To elaborate on this viewpoint, let's focus on the challenges of the requirement engineering component in these SDLC methods.

Requirement engineering aims at linking the real world with the information system, whereby the needs, perceptions, expectations, and concerns of the stakeholders should be understood and specified as far as the information system in mind is concerned. This understanding requires integrating multiple perspectives like personal, legal, ethical, societal, technological, and political perspectives. In the area of requirement engineering, several methods have emerged for integrating multiple perspectives during requirements elicitation. Nevertheless, there are several challenges in requirement engineering, some of which are:

- Being difficult to involve stakeholders in requirement engineering;
- Having no objective way to compare alternative requirements;
- Having many subjective (i.e., not rational) requirements (e.g., politics and personal preferences).

It is not surprising that the engineering approach does not focus on elucidating the high-level legal, ethical, social, cultural, and personal problems and goals because this approach is devised for resolving tamed problems.

## 5. Designerly approaches to problem solving

While we consider engineering a branch of science and technology, we follow Cross (1982) in understanding (“designerly”) design as its own discipline with its own subject of study, its own methods, values and goals – distinct from science and the humanities. Design, he posits, studies the man-made world, whereas science studies the natural world, and the humanities study the human experience. While science seeks truth and humanities justice, design seeks appropriateness. Correspondingly, the values in science are objectivity, rationality, and neutrality. In the humanities, the values are subjectivity, imagination, and commitment. Design values are practicality, ingenuity, and empathy. The methods used follow this pattern: controlled experiment, classification, and analysis in science; metaphor, criticism, and evaluation in the humanities; and modelling, pattern-formation, and synthesis in design.

Designerly approaches to problem solving, therefore, try to embrace the wickedness of the problem by imagining “that-which-does-not-yet-exist” (Nelson & Stolterman, 2012, p. 12), overcoming the impossible that “may actually only be a limitation of imagination”, and thinking “toward new integrations of signs, things, actions, and environments that address the concrete needs and values of human beings in diverse circumstances” (Buchanan, 1992, p. 21).

While teaching how to imagine the unimaginable might appear somewhat paradoxical, various authors have attempted it, and the term *design thinking* has become a common denominator for *what designers do*, both narrowly in product design and more broadly in the design of all sorts of socio-technical systems (Brown, 2008; Cross, 2011; Kimbell, 2011, 2012; Liedtka & Ogilvie, 2011). *Design thinking* in essence consists of three elements: (1) in a much more exploratory approach to the problem and solution space – which is often symbolized with the double diamond diagram shown in Figure 1; (2) a sequence of five (sometimes six, sometimes four) stages: empathize (or discover, sometimes split into understand and observe), define (or synthesize), ideate, prototype, test (also combined as develop; cf. Figure 1 and Figure 2); and (3) a principle of oscillating between stages, and between problem and solution space (Figure 3).

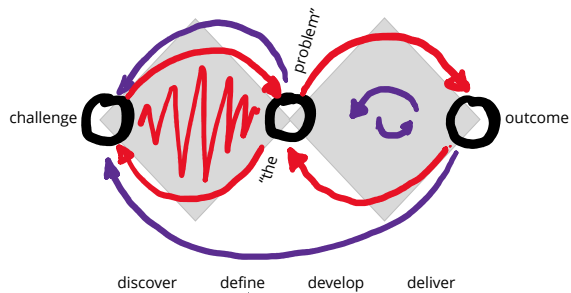


Figure 1: The double diamond diagram showing problem space and solution space (adapted from Design Council, 2019)

The *double diamond methodology* (Design Council, 2015) states that design starts with exploring the problem space by discovering and defining what the challenge is before developing (including testing and refining) multiple solutions and narrowing down the solution space to one solution to deliver. The red lines in the diagram show that designing means repeatedly opening the space before narrowing it down again. And while the “challenge”, the cross-over between problem space (discover and define) and solution space (develop and deliver), and the “outcome” are depicted on one linear line, it is well understood in designerly approaches that the refined challenge at the end of the discover and define activities might differ substantially from the initial challenge offered. Equally the outcome need not be a linear consequence of the refined challenge. Note also that various dotted blue arrows indicate that the sequence discover–define–develop–deliver is not seen as linear, either. Rather, designers might (and probably will) revert and pursue other routes of discover, define, develop, and deliver, to explore the problem and solution space more widely.

The five stages of *design thinking*, as illustrated in Figure 2, represent a similar process that starts with understanding the problem before creating and testing various solutions:

- empathize (to understand the real concerns of stakeholders);
- define (to find out the deeper roots of the needs);
- ideate (to explore and generate solutions);
- prototype (to make tangible objects for some ideated solutions);
- test (to evaluate the prototypes with the end-users and learn from them).

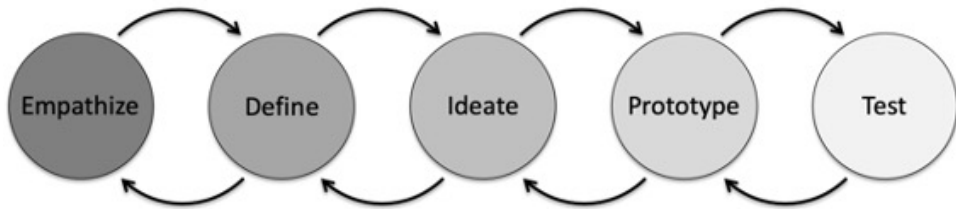


Figure 2. Typical stages of design thinking processes (adopted from Bargh, 2019; Bargh & Choenni, 2019).

Note again that the design thinking stages may occur concurrently and are rapidly iterated, where the prototyped artifacts (e.g., products, services, tools or processes) are tested per iteration. The practical experiences gained with the prototyped artifacts in every design round inform the following round about how to improve the artifacts. Improving the most viable concepts in more detail results in attaining a viable product eventually. This oscillation between stages and between problem and solution space are typical for a designery approach, as shown in Figure 3. This, it appears, is a major distinction between the engineering and the designery approaches. Particularly in doing “discover” in the problem space, the oscillation within the space and between problem and solution is known as “the fuzzy front end of design” (Sanders & Stappers, 2008, p. 6f.)

The starting point in design thinking is a good understanding of the practice field. Further, the design process is informed by the practice and is highly collaborative, where end-users are involved in all phases of developing the artifacts. Involving end-users, especially early in the design process, prevents disappointments in that the artifacts do not cater users’ real needs. This early involvement of end-users (or stakeholders) enables discarding suboptimal solutions as soon as possible. This so-called fail fast approach gears the design process towards producing viable products with high chance of user adoption (Poot & McKim, 2020). Giving users the opportunity to give their inputs, ideas and viewpoints during the design process, is important in developing social services where citizens’ participation and acceptance are of outmost importance.

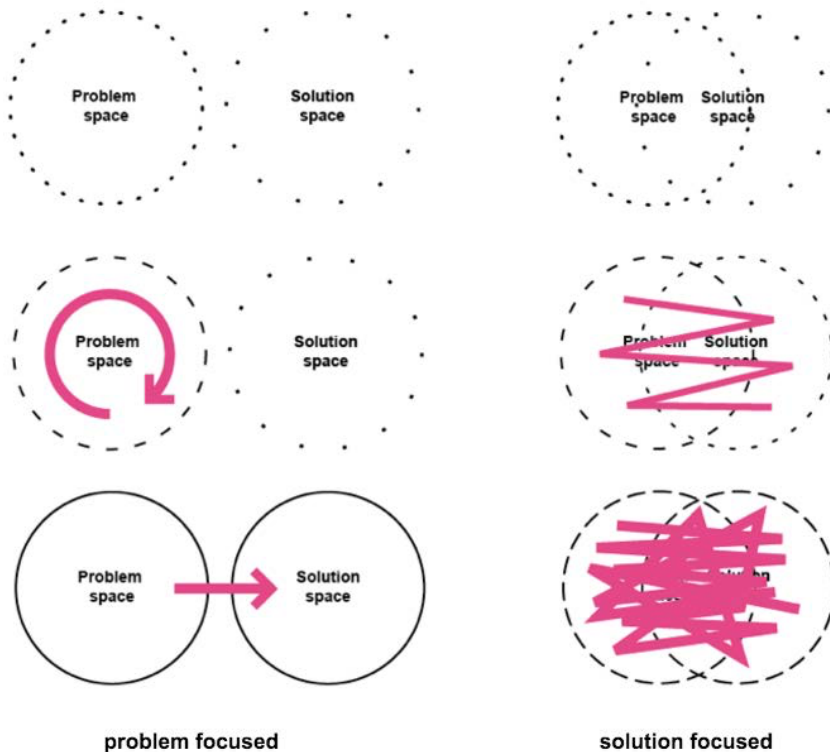


Figure 3. Problem-focused vs. solution-focused approaches in engineering (the former) and design (the latter). Drawing Bas Leurs based on Quaggiotto et al. (2016).

Design thinking aims at creating human-centric solutions that are: innovative, based on real end-user needs, holistic in considering the contextual circumstances, with social impacts, and mindset changing. Design thinking achieves these objectives, among others, by engaging multi-disciplinary stakeholders and end-users in the design process, by trying to empathize with and understand users' emotions, desires, aspirations, experiences, and by allowing many failures in fast design iterations (Bargh, 2019; Bargh & Choenni, 2019).

Design thinking is well suited for unstructured problems, or so-called wicked problems. Using design thinking, one can approach wicked problems by creating consensus over the goals/values concerning the problems or by increasing certainty about the factual and cause-effect-knowledge needed to solve them. In doing so, wicked problems become more manageable and come closer to weakly-structured problems. In the area of developing information systems, design-thinking has been proposed for, for example,

creating innovative mobile apps, designing complex embedded or IoT systems, and devising the social information systems that bring positive social changes.

Although design thinking supports the process of discovering the hidden needs of stakeholders and eliciting the soft requirements which information systems should meet, it faces several challenges (Hehn et al., 2018) such as:

- coverage (focusing more on user requirements while neglecting system requirements);
- traceability (linking with the needs weakly);
- contextualization (formalizing the context weakly);
- motivation (not a systematic specification of requirements);
- lack of time and lack of structure (the knowledge being implicit).

## **6. Transdisciplinarity – reconciling engineering and design**

In the following, we will first suggest some example scenarios for using a mix of engineering approaches and designerly approaches to move wicked problems towards more manageable weakly-structured problems (i.e., to move upwards or leftwards from quadrant 4 in Table 1), and weakly-structured problems towards tamed problems (i.e., to quadrant 1 in Table 1).

The two of the suggested scenarios for mixing engineering and designerly approaches are tuned towards tackling weakly-structured problems (see quadrants 2 and 3 of Table 1) because these problems, in our opinion, resonate often when designing cyber-social systems currently. These scenarios are concerned with creating multiple design options and choosing the one best suited (see section 6.1), or with approximating a best-fit solution in smaller steps (see section 6.2). Subsequently in section 6.3, we briefly elaborate on the potential of reconciling the engineering and designerly approaches to address also wicked problems.

Based on these suggestions, we are going to argue that it is necessary to prepare and educate future systems designers and practitioners with a skill set that accommodates an appropriate mix of design methodologies from engineering and designerly approaches.

## 6.1 Creating multiple design options

In reference to the problem typology mentioned above in Table 1, this heuristic is supposed to deal with those weakly-structured problems on the lower left side (quadrant 2). Via this heuristic, one seeks out clarity about cause-effects and optimizing the solution direction. When a solution direction is chosen, engineering can be used for debating on the technicalities.

There are many design trade-offs in the design space, as explained above. Therefore, it becomes difficult for information system designers to make a design in a deterministic way (i.e., by engineers and based on some scientific rules). Using design-thinking (see Bargh, 2019; Bargh & Choenni, 2019), one can integrate the true knowledge (i.e., the models and theories from science) with the how knowledge (e.g., the technological opportunities demonstrated by engineers) through an active process of ideating, iterating, and critiquing to come up with potential design options and to pick up the right thing/design (as suggested in Zimmerman et al., 2007). Figure 4 illustrates the idea of creating 'a series of artifacts', i.e., design options  $D_1, \dots, D_6$ , in a design space of two contending values (e.g., for designing a privacy preserving system with two values of data disclosure risk versus data utility).

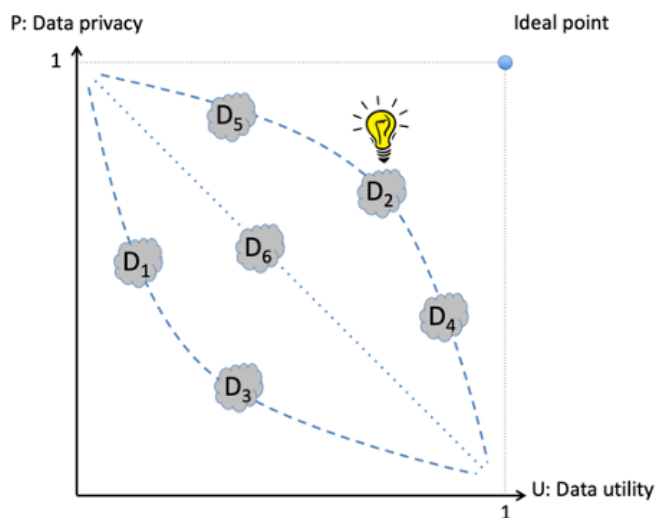


Figure 4: Illustrating multiple design options (adopted from Bargh, 2019; Bargh & Choenni, 2019).



The design space in Figure 2 typically arises when applying statistical disclosure control methods (Bargh et al., 2018), as part of the privacy-by-architecture approach. Not only can design-thinking help to devise these six viable design options of  $\{D1, \dots, D6\}$  by making trade-offs among various criteria, it can also help stakeholders to achieve consensus on a viable design, for example, design D2 shown in Figure 4.

## 6.2 Incremental solution approximation

In reference to the problem typology mentioned in Table 1, this heuristic corresponds to those weakly-structured problems on the upper right side (quadrant 3). Via this heuristic, one seeks out clarity about goals and values as well as optimizing the solution direction. When a solution direction is chosen, engineering can be used for debating and deciding on the technicalities.

Instead of deriving several design options and choosing one of them, this heuristic can be useful for fine-tuning or configuring those technological and/or non-technological solutions that are going to be operationalized in a complex and possibly unpredictable social context. For example, Bargh et al. (2016) aim at creating transparency in a judicial setting through information dissemination while preserving privacy. After publishing a supposedly anonymized dataset to the public, there might be side effects due to linking the published dataset with background information and revealing personal information. Therefore, realizing a gradual change process by taking small steps in the right direction is necessary to appropriately deal with these unforeseen side effects of information dissemination. Figure 5 illustrates such a transition management strategy that aims at achieving a systemic change (Ison & Collins, 2008) through taking small steps in strategically chosen directions in the problem-understanding and solution-fine-tuning plane. Each small step shown in Figure 5 can be regarded as a design option  $D_k$  (or a prototype) that is going to be fine-tuned in the following iteration of the process, i.e., in design option  $D_{k+1}$ , by putting it into practice for testing and learning.

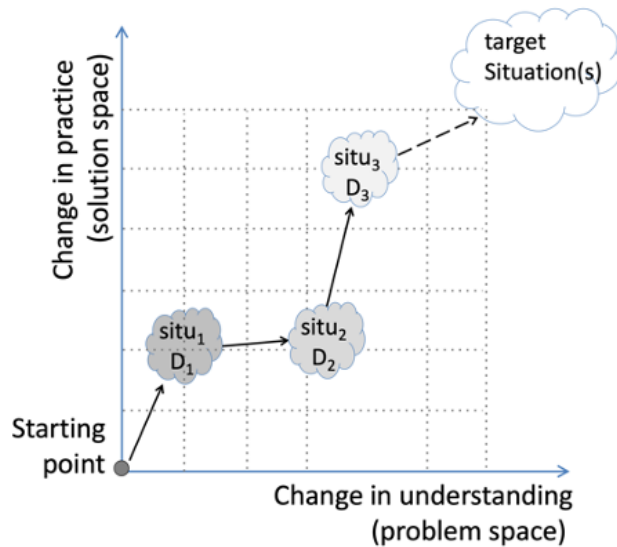


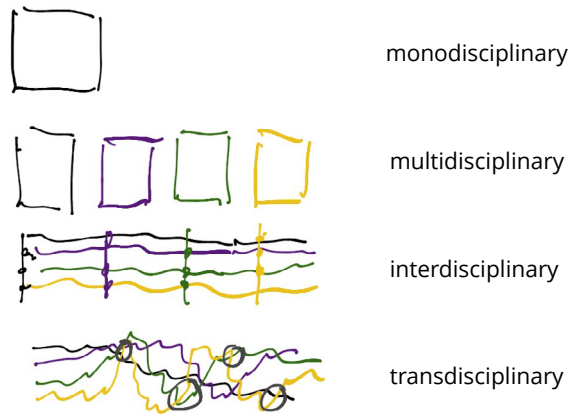
Figure 5: Illustrating transition changes (adopted from Bargh et al., 2017; Ison & Collins, 2008).

### 6.3 The dance of the disciplines

Both approaches of creating multiple design options and incrementally developing solutions are combinations of engineering and design approaches that are already effective at tackling weakly-structured problems. And they might actually be sufficient in these cases. However, their common strategy is to deal with the one aspect that causes debate and the weak structure. Hereby, the strategy aims at taming the weakly-structured problems.

However, when dealing with wicked problems, see quadrant 4 in Table 1, with Churchman we argue that such an approach only “tames the growl of the wicked problem: the wicked problem no longer shows its teeth before it bites” (Churchman, 1967, p. B142). Churchman goes on to warn that the verbal caveat that such methods might be an approximation, not a taming, of the wicked problem, comprises a moral dilemma: “The model, or the large computer program, plus expensive months of data collection and analysis, must give the impression that most of the wicked problem has been tamed. Dishonesty, as any con-man knows, can be created in the environment of complete, outspoken frankness and honesty.” And he calls upon operations research and management science not to be indifferent to the morality of the profession, but to begin to discuss it.

So how can we reconcile engineering and design in a way that goes beyond adding disciplinary craft or borrowing methodologically from each other for a bit of taming of the growl? We believe that both disciplines, with their own epistemological and methodological approach and their professional values can contribute to addressing wicked problems. Such reconciliation is thus more than a multidisciplinary addition or an interdisciplinary mix. We are looking for true transdisciplinary work that would allow both faculties to transgress their boundaries into the unimaginable – professionally (and morally) dealing with wicked problems. The concepts of monodisciplinary, multidisciplinary, interdisciplinary, and transdisciplinary are illustrated in Figure 6.



*Figure 6: An illustration of the concepts of monodisciplinary, multidisciplinary, interdisciplinary, and transdisciplinary.*

Transdisciplinary work has been characterised in terms of “boundary crossing” (Bakker & Akkerman, 2014), a term borrowed from industrial anthropology and the study of computer supported work (Suchman, 1994). When people work on a problem, they are bound to encounter the boundaries between various practices – professional domains, goals, and knowledge. While these boundaries may hinder collaboration, they can also prompt understanding different perspectives, learning from commonalities and differences, and creating connections between different approaches. Boundary crossing in transdisciplinary work instils broader perspectives on a problem and creates the foundation for new solutions beyond the possibilities and “imagination” of a single discipline.

Boundary crossing is the dance of the disciplines that turns the commonalities and the differences in transdisciplinary work into generative forces for problem solving. As illustrated in Figure 7, it is a dance to the rhythm of (a) *identifying* the commonalities and differences by making them explicit, (b) *coordinating* the collaboration to primarily appreciate and to efficiently address the problem at hand, from what forms a common understanding, (c) *reflecting* the differences and reframing the viewpoints based on the multiplicity of perspectives, and (d) *transforming* and bridging those different perspectives so that they lead to the new solutions that would not have been possible without the transdisciplinary collaboration. Boundary crossing is creating power and direction from the commonalities and forming new ideas from the generative combination of the differences.

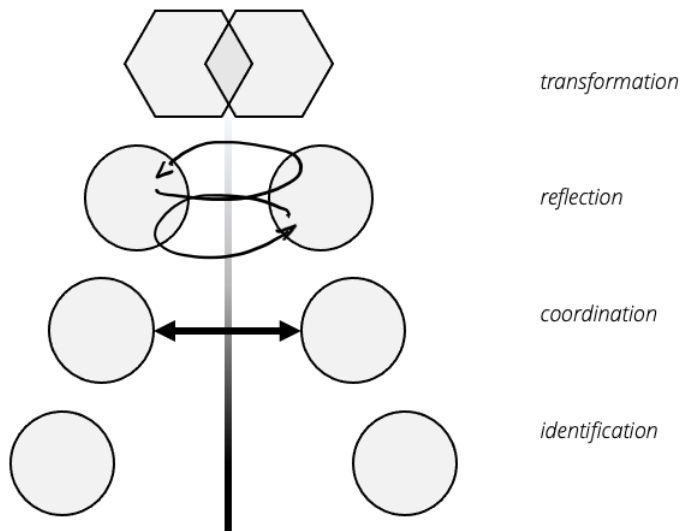


Figure 7: An illustration of boundary crossing (adapted from Bakker & Akkerman, 2014, p. 12)

## 7. Illustrative example – development of the CoronaMelder app

The Dutch CoronaMelder app and the surrounding ecosystem, in our opinion, is an example of a contemporary socio-technical system. In this section we look at the development process of the CoronaMelder app from the viewpoint of socio-technical systems development. To this end, we mention a few steps of the CoronaMelder SDLC process, where designerly approaches can be used as a complement to the engineering approaches. Our intention here is to illustrate some transdisciplinarity aspects of CoronaMelder SDLC, where designerly and engineering approaches are reconciled. Note that we here by no means aim to evaluate the app or its current SDLC.

We start with shortly introducing the CoronaMelder app in section 7.1, and positioning the app and its ecosystem as a socio-technical system in section 7.2. Subsequently, in section 7.3, we describe a few stages within the CoronaMelder app SDLC process where designerly approaches can be exploited to tackle the weakly-structured (and wicked) aspects of the CoronaMelder app SLDC based on the scenarios sketched in section 6.

### 7.1 Objectives of the CoronaMelder app

In collaboration with a number of organizations, the Dutch Ministry of Health, Welfare and Sport (abbreviated as VWS, see table 2) has been engaged in developing and deploying a mobile app, called CoronaMelder, to alert citizens who are potentially subject to an infection with the Covid-19 virus. The objectives of the CoronaMelder app are to automate (part of) the source and contact research, which is currently being conducted by the Dutch Municipal Health Services (GGD). More specifically, the objectives (Raamwerk Programma van Eisen, 2020) include

- to alert people who were in contact with an infected person about a possible contamination,
- to allow a quick testing for potentially infected persons, regardless of having Covid-19 symptoms,
- to notify those who have been in contact with a positively tested person faster, and
- to make more targeted use of available test capacity.

The main organisations involved in the development of the app are the National Institute for Public Health and the Environment (RIVM), Health Services and Regional Medical Assistance Organizations (GGD GHOR), the Netherlands Institute for Human Rights, and the Dutch Data Protection Authority (AP), among others (VWS werkt samen, 2020). These organisations have contributed to eliciting the requirements and the evaluation of CoronaMelder app according to these requirements.

*Table 2: Organisations involved in the development of the Dutch CoronaMelder app.*

Abbreviation	Dutch name	English name
VWS	(Ministerie van) Volksgezondheid, Welzijn en Sport	Dutch Ministry of Health, Welfare and Sport
RIVM	Rijksinstituut voor Volksgezondheid en Milieu	National Institute for Public Health and the Environment
AP	Autoriteit Persoonsgegevens	Dutch Data Protection Authority
GGD	Gemeentelijke Gezondheidsdiensten	Dutch Municipal Health Services
GGD GHOR	Gemeentelijke Gezondheidsdiensten en Geneeskundige Hulpverleningsorganisaties in de Regio	Health Services and Regional Medical Assistance Organizations
—	College voor de rechten van de mens	The Netherlands Institute for Human Rights

## **7.2 CoronaMelder app as a socio-technical system**

Using the CoronaMelder app for the source and contact research requires collecting highly sensitive personal information about citizens' health status (someone being infected by the disease or being in the vicinity of an infected person). The intention is to share these data with third parties (like governmental organizations) in charge of managing the pandemic. In addition to citizens' Corona related health status, the collected information may, if the app is not designed well, also capture other privacy sensitive information, like the locations, social contacts, and behaviours of citizens/

individuals. The idea behind the app seems legitimate and useful, but it can create adverse threats to the privacy of individuals (i.e., have social impacts) if it is wrongly implemented. Therefore, we characterize the CoronaMelder app as a typical socio-technical system as described in section 2.

### **7.3 Addressing weakly-structured aspects**

There is a wide range of stakeholders involved in the CoronaMelder. At first glance, the governmental organisation in charge of managing the pandemic (like the RIVM) and the citizens are the primary parties being affected by the app. In addition, the app is surrounded by many parties that can influence the SDLC process of the app. Examples of stakeholders are citizens acting as data subjects, the central government organisations (such as VWS, RIVM, and GGD GHOR), civil rights public organizations (such as the Netherlands Institute for Human Rights and the AP), national security organizations, civil rights activists (such as individuals associated with Bits of Freedom), independent legal experts (such as privacy lawyers) and system developers (such as software engineers, system architects and cyber security experts). Involving all these stakeholders in the design process has been at the core of the VWS's attention. To this end, the VWS has established an advisory board to supervise the development of the app. There are 15 board members who have knowledge of, for example, epidemiology, virology, technology, privacy, and security, to supervise adherence to the app requirements (Begeleidingscommissie, 2020).

Identifying all stakeholders and involving them in the design process at a right level and as early as possible are typical challenges within the design process for which a designerly approach can be used. The setup of the stakeholders can influence the design options considered and the solution direction adopted. Two parties that can be added to the list mentioned above are citizens and local government organizations. Let us investigate the role of the local GGDs which may be interested in implementing local measures (e.g., regional lockdowns). Fulfilling such needs of local GGDs might have required collecting citizens' location information in order to devise regional policies accordingly. Collecting location information is not pursued in the current implementation of the CoronaMelder app due to its extensive (currently unacceptable) violation of privacy. This design option (i.e., not collecting location information) should be a deliberate choice when making trade-offs among contending values and should not be an outcome of negligence (i.e., not involving local authorities as stakeholders).

With a close investigation of the SDLC process of the CoronaMelder app, one can recognize a phase where multiple solution prototypes were being developed. There were, for example, a couple of events on 18 and 19 April 2020 – called “appathon” and organized by the VWS – to examine several prototypes of the app. The events were accessible for all interested parties (such as organizations and independent experts) to watch and recommend. This process was like the illustration shown in figure 4, where several contending designs were created, and one was chosen based on making a trade-off among contending values. This process could be accomplished by using a designerly approach because it was difficult to deterministically merge the design values/principles and choose the most promising design rigorously.

When involving all stakeholders in the early stages of the design process, it is possible to misunderstand the viewpoints of some parties. For example, during early discussions, some technological solutions were based on the honest-but-curious party model. According to the honest-but-curious party model, there is a third party (like the GGD in the case of the CoronaMelder app) which facilitates communication among all parties without having access to privacy sensitive raw data (i.e., only via processing and exchanging encrypted data among all parties). This model could have been misunderstood as the fully trusted party model by other stakeholders. In a fully trusted third-party model, there is a third party (like the GGD in the case of the CoronaMelder app) which receives privacy sensitive raw data from all parties, processes the raw data, and shares the result with all those parties. Such misunderstandings are counterproductive and should be avoided in order to decrease the risk of lost opportunities. A designing thinking approach can help prevent such misunderstanding as it provides enough room for stakeholders to understand each other (see section 5).

As we witnessed, the current SDLC process of the CoronaMelder app went through a number of pilot implementations to test its capabilities and identify its limitations in action. One can imagine that this process led to identifying hidden issues (i.e., clarifying the problem space) and possibly new solutions (i.e., tailoring the solution space). This process was similar to the illustration shown in Figure 5, where several prototypes were sequentially created and put into practice. The course of producing these prototypes showed a strategy based on taking small steps in the right direction, for identifying unforeseen issues and refining the solution. This process could be accomplished using a designerly approach because it was difficult to navigate a one-step path to the ideal solution in an a-priory rigorous way.



So far, we have considered the SDLC process of the CoronaMelder app as a weakly-structured problem which resides in quadrants 2 and 3 of table 1. This is because almost all parties agree on the bigger problem (managing the pandemic via source and contact research) and the use of technology to address the problem. These parties, however, have concerns about which technology and complementary non-technical solutions to adopt, as well as about the unforeseeable side effects of these technical and non-technical solutions. It is foreseeable to imagine that at some point and within a specific situation the stakeholders disagree about the effectiveness of source and contact research, and therefore look for other measures to manage the pandemic. In such a situation, it might be inevitable to go back to the drawing board and approach the problem as a wicked problem.

## **8. Rediscovering the theory of socio-technical systems**

The theory of socio-technical systems was developed at the London Tavistock Institute in the 1960s-1980s, initially based on studies in the British mining industry in response to the introduction of new working methods. The Tavistock researchers described organisations as “open systems, in which social interactions are closely intertwined with technical components” (Lauche, 2011, p. 7). The Tavistock researchers were also at the forefront of the development of “Industrial Democracy” (Emery et al., 1969), the idea to include the workers in the design and development of the socio-technical work systems they were part of, which reflects the position of “social justice” and the ideas of designing a commons mentioned earlier. Socio-technical systems theory hence postulates that the technical and the social systems need to be jointly optimized.

### **8.1 The Tavistock tradition**

Researchers at the London Tavistock Institute predicted in the 1980s that information technology – the microprocessor and related electronic technologies such as telecommunication – would have applications in all industries and would eventually become “universal” and “pervasive”, including the built environment, travel, leisure and “proactive consumer linkage with selling organisations” (Trist, 1981, pp. 50–51).

By the mid-eighties it was clear that the “control revolution” (Beniger, 1986) would lead to an “age of the smart machine” (Zuboff, 1988). Beniger’s vision remained relatively sombre, of a control revolution that perpetuates formal

bureaucracy and rationalisation deep into the 20<sup>th</sup> century. Zuboff was hopeful of an antidote to that managerial “information panopticon” that would consist in a wholistic organization that would form a post-hierarchical learning environment, “more flexible, collaborative, and social integrative than anything (...) known” (p. 403).

Eric Trist – one of the pioneers of the conceptual framework of socio-technical systems – noted already in 1981 that the designers of new technologies occupied a crucial place when it came to modelling new plants, converting existing work establishments and transformations at the macrosocial level.

*The designers of new technologies dependent on computers and telecommunications belong to engineering disciplines far removed from socio-technical considerations. Unless educated to the contrary, they will follow the technological imperative and mortgage a good deal of the future. (Trist, 1981, p. 51)*

He suggested to engage with technology designers from a socio-technical perspective, by having system builders look at the quality of their own working life as a first step towards inducing them to look at that of users. This eventually led to advances in human-centred design and a whole field studying human-computer interaction and computer-supported cooperative work. These studies vastly improved the design and development of software systems, the user interface design, i.e., the design of input devices and workstations.

The wider socio-technical issues of work system design, however, were largely left unconsidered, as the table of contents of the Handbook of Human-Computer Interaction (Helander, 1997) sadly demonstrates. And while Eason (1997) in his contribution concedes that “[m]any methods now exist which can make a contribution to the achievement of broad based socio-technical systems design in organisations” (p. 1493), he still recognizes, a few years later: “The wider issues of organizational design remain outside the normal systems development agenda. This has serious implications for the next wave of technology applications. These are forecast to lead to even more revolutionary changes in organizations as they enter the virtual world of work” (Eason, 2001, p. 328).

Thus, the concept of socio-technical systems and the need for designing

these systems are not new. The rise of digital transformation in its social context brings up the subject matter to the forefront of our attention in this early stage of the 21st century.

## **8.2 Performativity and responsibility**

Specifying or addressing the wicked problems of quadrant 4 in Table 1 is a grand challenge. The approaches presented in sections 6.1 and 6.2 are, in essence, workarounds, reductionist attempts to either eliminate the uncertainty about facts and cause-effect relations through choosing between multiple design options, or to overcome the dissensus among stakeholders by approaching a target situation by incremental solutions. Both approaches aim to reduce the complexity of problems by adding structure, so weakly-structured problems are turned into tame problems again.

For wicked problems, instead, a more complex approach is required to interconnect the diffuse problem and solution spaces that would create an opportunity of responding to complexity with complexity. At the same time, such an approach needs to be flexible – but also efficient and compatible across disciplines. The design profession has successfully managed to position itself as multi-disciplinary and integrative. Other disciplines are quickly learning that lesson, too.

Kwa (2011), who studied the “styles of knowing” of scientific reasoning processes across history and cultures, identified a performative turn in science: “the rewards for sciences that can offer immediately applicable results will be far greater than those for less pragmatic disciplines” (p. 274). He lists interdisciplinarity, including borrowing from other disciplines, and working on a combination of science and technology in small teams as characteristics of performative science.

We propose that solving wicked problems, therefore, must first address the interdisciplinarity and performativity of the relevant disciplines and stakeholders.

Just aiming at delivering results, however, is not sufficient when developing socio-technical approaches to wicked problems. In Kwa’s view of a contemporary style of knowing, “scientist have a responsibility not only to offer facts and techniques, but also to shed light on their implications (and to train

students to do the same)” (Kwa 2011, 276). He refers to Zygmunt Baumann (1987) who stipulates that intellectuals as researchers – and we would strongly argue as practitioners, too – increasingly find themselves no longer in the role of the *legislator*, but in the role of *interpreter*, mediating between the many different communities affected by developments of responses to wicked problems in society, science and technology. This aligns nicely with the “wicked problem solver’s responsibility for their actions” (Buchanan, 1992, p. 16) and Nelson and Stolterman’s call for designers to “accept responsibility” (Nelson & Stolterman, 2012, p. 211).

To be an interpreter of science appears like a role which researchers, teachers and students of universities of applied sciences would readily and happily adopt. In fact, they could even become a role model of the interpreter and teach their approach to other ranks of professionals. Becoming a role model and teaching others, however, also requires reflecting on their own role, or on the relevant frames of reference, and therefore not jumping to conclusions too quickly. This challenge is not insurmountable. A professional practice of reflection (Schön, 1983) is needed to prevent being precipitate.

## 9. Studying the digital transformation as a cyber-social experience: three scenarios

What does studying the digital transformation as a cyber-physical experience entail? It aims, we believe, at bringing the power of the digital transformation to fruition,

- by making use of the specific – technical (in the case of the engineers), non-technical<sup>4>></sup> (in the case of domain-specific professionals, policymakers, and social work planners) and inventive (in the case of the designers) – competencies of a variety of disciplines,
- by bringing these disciplines to performance in a transdisciplinary setting, based on an understanding and practice of boundary crossing by all disciplines involved, and
- by dismissing the role of legislator and adopting the one of interpreter, and by accepting responsibility for all its actions.

So, there are three key ingredients to the study of the cyber-social: technologies, methodologies, and philosophies. The first two are well established in contemporary policy as “Key Enabling Technologies” (KETs)

– including micro-electronics, AI, data and digitalisation, and connectivity – and competencies, and “Key Enabling Methodologies” (KEMs) – including visioning, participation and empowerment, experimentation, change and monitoring. We might name the last ingredient “Key Ethics” (KEs) and propose it to include the discussion and application of deontology, consequentialism, and pragmatic ethics. To render the three elements in Sinek’s “Golden Circle” (2009), the KEs would answer the “why”, the KEMs the “how”, and the KETs the “what”.

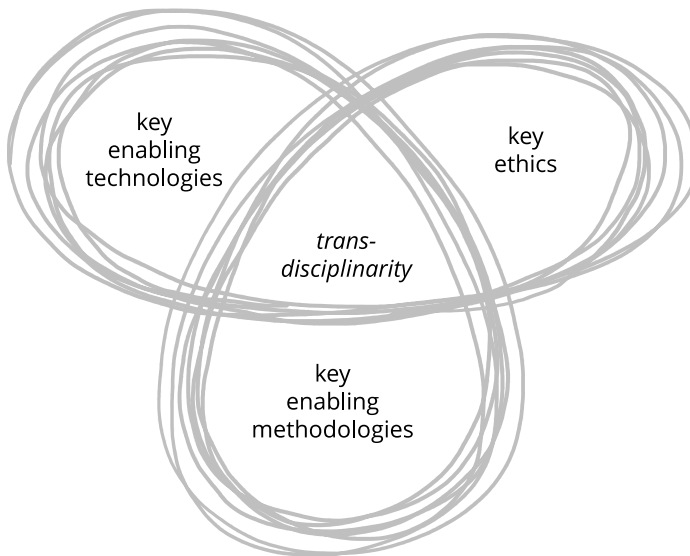


Figure 8: An illustration of KEs, KEMs and KETs

Fast forward to 2030, how can Rotterdam University of Applied Sciences implement the study of the cyber-social into its fabric? An attractive model to educate future generation students in applied universities is, as we call it, the federative model. This model builds on the existing educational disciplines and develops them further. Yet, there are more expansive scenarios possible. For instance, the university could approach the digital transformation as a technically driven development, which is methodologically supported and ethically aligned, or it could adopt the cyber-social as a new, integrative field of study that is interconnected with other domains. In the following sections we sketch these three scenarios in more detail, without divulging and discussing the merits and limitations of these scenarios.

## **9.1 Scenario 1 – The federative model**

As of 2030, the digital transformation has moved into full swing in the city and the harbour of Rotterdam. As expected, everything and everyone is connected and digitally available all-day round. Some of the self-employed and the wealthier private households were quick to adopt the digital. The big corporations and brands, the universities, hospitals, and the city council had all developed and implemented their digital strategies. Every small and medium business had found its own way into the digital realm – often with the help of graduates of Hogeschool Rotterdam. Eventually, in 2026, the city council proposed a digital inclusion programme to bridge the widening digital divide in society.

Hogeschool Rotterdam adopted a pragmatic approach to the digital transformation. Despite all the humdrum of “the digital” and how it would make existing professions disappear and new professions emerge, electrical, software, mechanical, civil, and maritime engineers remained in high demand, as did communication specialists, user interface designers, and indeed accountants, business administrators and marketeers. However, the curricula of these studies underwent some change – which was called “the digital turn in education”. This digital turn in education included not only teaching the use of new digital tools but also developing a practice of reflecting on their impact on the users and society at large. The digital turn happened almost simultaneously in secondary and in higher education. So, after a short transition period, first-year students at the university no longer had to be taught elementary coding – that had become an integral part of secondary education. And wider digital literacy, too, such as computational thinking, awareness of the use of algorithms, critically questioning digital systems and their purpose, were required subjects to successfully complete secondary education.

So the university could focus on the disciplinary use of digital technologies, and on the interplay of disciplines. Working transdisciplinary was not only encouraged, it had become a mandatory part of every degree – students had to spend at least one semester with a transdisciplinary project in a transdisciplinary group. The most fundamental change was recently introduced, after a lot of discussions and political fighting: since 2028 it was possible to carry out a bachelor’s thesis in a transdisciplinary setting, even between different universities of applied sciences. In these thesis

projects, the students collectively designed and realized crucial elements of socio-technological systems. A mandatory part of such a socio-technical systems design was to discuss and evaluate its wider societal and ethical implications.

Only recently, an experiment had started that allowed mixed teams with students from the traditional, more academically oriented universities and from the Hogeschool. The first results were more than promising. This was attributed to three reasons: First, the students were acting on a much more level playing field with respect to their overall digital literacy. Second, the specific transdisciplinarity training of the Hogeschool students also allowed them to interact professionally and efficiently with their more academically trained counterparts. Third, the Hogeschool students had become highly proficient in applying methods. That made them the perfect counterparts to their academic colleagues, and the first trial project produced nicely rounded projects that were also highly appreciated by the companies they were produced for.

While Rotterdam had positioned itself internationally with a number of flagship projects as the European leader in energy transition, this development would not have been possible without the strong digital foundation of the city's graduates who outperformed others technically, methodologically, and ethically ...

## **9.2 Scenario 2 – Rotterdam Key Tech Digital Transformation Academy**

As of 2030, the digital transformation has moved into full swing in the city and the harbour of Rotterdam. As expected, everything and everyone is connected and digitally available all-day round. The big corporations and brands, the universities, hospitals, and the city council had taken the lead. The self-employed and private households followed, and ultimately, every small and medium business has made the transition. Predominantly the latter required an enormous amount of digital innovation – innovation they were not able to create themselves. So particularly in the second half of the decade, they turned to Hogeschool Rotterdam which had just rebranded what the elderly still knew as “HTS” as the “Rotterdam Key Tech Digital Transformation Academy”.

The Rotterdam Key Tech Digital Transformation Academy (KeyTdTAc) comprised a few schools, educating professionals for the key technical sectors in the region like marine and offshore engineering, industrial biochemistry, metropolitan logistics, and urban sustainability. The academy was set up as a flagship project to demonstrate how Hogeschool Rotterdam embraced the idea of key enabling technologies for the digital transformation. The engineering and computer science departments had joined forces and focused several of their associate degree and bachelor programmes in a school for key enabling technologies, the “key tech school” – micro-electronics and IoT, data engineering, applied AI and the new field of “connetionics” (the study of digital connection design and engineering). Several modules were run as evening or block courses, so people already in employment could attend them as part of their lifelong learning activities. These modules included computational thinking, digital literacy, elementary machine learning, data acquisition, data clean-up etc. For such a module, external attendees would be awarded an “edubadge” that they could add to their lifelong learning backpack, a scheme that had been enthusiastically adopted in the region, as industry woke up to the fact that their workforce was utterly lagging behind in knowledge and skills regarding all digital developments.

The KeyTdTAc had invested in a “key tech graduate school” with corresponding master programmes in data science, digital twin engineering, predictive machine learning, physical internet, and cyber security and privacy. These master programmes all included a common graduate course in design thinking, which was hugely popular since people from outside the graduate school could also attend as a certificate course to earn a number of edubadges – for example empathy, ideation, prototyping – for their lifelong learning backpack. The master programmes also offered a number of elective modules, so students could specialize for instance in higher-order digital modelling, white hat hacking, out-of-the-box thinking, data and ethics, or nudging and communication.

The KeyTdTAc also participated in the “digital compliance engineering” programme that had been set up by the 4 Technical Universities to facilitate professional doctorate studies in the high-tech sector. This programme was established as industry leaders recognized that they were unable to handle the increasing demands on compliance regarding privacy, security, and legal issues that came in force as a consequence of increased connectivity and data intensity of all commercial activities. The Technical Universities



found that the problems that emerged in this field were not sufficiently academic to warrant proper PhD programmes, however their complexity and transdisciplinarity went way beyond what could be taught at a master's level.

KeyTdTAc was part of an international group of Higher Education establishments in Europe, that early on recognized the shifts required in education for a digitally transformed economy and society. This group, which called itself the "Digital Key to Europe" consisted of public and private universities in Bergen, Marseille, Rostock, Trieste, and Valencia. Together, they had established several international exchange programmes on all levels, from the bachelor to the PD ...

### **9.3 Scenario 3 – Rotterdam Institute for Cyber-Social Studies**

As of 2030, the digital transformation has moved into full swing in the city and the harbour of Rotterdam. As expected, everything and everyone is connected and digitally available all-day round. The big corporations and brands, the universities, and the hospitals had taken the lead, especially in a number of high-profile technology projects that were developed together with the 4 Technical Universities. However, the small and medium business were structurally neglecting the transition. Moreover, private households and many self-employed became more and more critical of the massive programmes that were driven by corporate interest of the big European players SAP-Siemens and Alstom-Orange-Telefonica. Promoted as an alternative to the US-American and Chinese "surveillance" platforms, they were nonetheless intrusive on privacy, and left little room for smaller companies and local initiatives. At least they were forced to publish their APIs and data exchange protocols.

In the light of the fast-growing resistance to Europe's big tech, three of the Dutch G5 cities decided to choose another route. In coordination with the universities of applied science in Rotterdam, The Hague and Utrecht they established the Rotterdam Institute for Cyber-Social Studies (RICSS) as a lighthouse project that was committed to a substantially more human-centric and holistic approach to digital transformation. The universities combined their competences in micro-electronics, robotics, data science and data engineering, computer science and computer engineering, artificial intelligence and machine learning, as well as in urban planning, media and games design, and communication. And they developed together a new

profile for a bachelor's degree in "responsible technology design". Students at the RICSS who would become the digital innovators and transformers should not only be competent in applying the latest technologies, they argued, they should also be competent in inventing new worlds that would be liveable and likeable. To that end, subjects addressing designerly empathy and human factors were included in the curriculum. This profile was a successful promise to prospective students who were longing for more purpose in their studies.

Soon, these developments caught the interest of some of the "old" universities, and they were looking for ways to support the RICSS. Existing contacts between researchers and institutions helped to quickly establish a few joint programmes – starting with a joint master's degree that was supposed to take the notion of "responsible technology design" to the next level – including the technology and design part provided by the RICSS, and the "responsible" part by the universities – mainly involving disciplines like management, psychology, sociology, philosophy, and ethics. When developing the joint degree, the institutions recognized that a much more transdisciplinary approach was needed in which a number of translations played a central role. It was not so much the more academic approach to responsibility that required translation to become practically relevant. The applied approach to technology and design needed translation into the academic field since "applied" was not, as assumed by some academics, just "the application of", but turned out to be much more like "creating new living (and working) environments" by using technology and design. So, the joint degree programme eventually was named "creating humane digital environments".

A welcome side effect of the development of the joint degree programme was that the partners recognized that there was a wealth of knowledge that yet had to be developed in the young field of cyber-social studies. So they decided to establish and fund a joint PhD programme of initially ten PhD places to extend and develop what cyber-social studies from an academic point of view would entail, while remaining fully aware of the "applied" economic and social context of the cyber-social.

It was this first cohort of PhD students that eventually attracted attention from outside the Netherlands. Particularly some of the smaller European countries like Denmark, Scotland, Portugal, and Greece were looking for alternatives to the Franco-German tech narrative ...

## 10. Conclusion

The digital transformation has been going on for decades. We regarded this digital transformation as a fundamentally cyber-social experience, occurring within a socio-technical ecosystem. In this ecosystem, digital objects interact with each other, with the environment and with humans, making them fundamentally social. Such social interactions, we believe, are basically invented, created, built, programmed, implemented, applied, used, and misused via intentional (and maybe sometimes unintentional) human intervention.

We recognized that the theory of socio-technical systems is not new, as it was already developed in the 1960s–1980s, initially based on studies in the British mining industry in response to the introduction of new working methods. This recognition entails considering digital transformation as a class of wicked or, at least, weakly-structured problems.

In the light of educating future practitioners who will be in charge of realizing meaningful and responsible digital transformations, in this chapter we looked at digital transformation from the viewpoint of a development process whereby an information system is devised, built, deployed, and maintained in its social context. Such a development process, we argued, should be transdisciplinary using a balanced mix of traditional system development approaches (like engineering) and creative designerly approaches (like design thinking).

This recognition led to a few requirements and challenges for our education system in the future. These requirements and challenges concern developing professional skills in the related technical and non-technological disciplines (key enabling technologies), as well as developing professional skills across these disciplines. The later entails acquiring competency for transdisciplinary understanding (i.e., comprehension), which can be facilitated via mastering methodological skills (i.e., key enabling methodologies). As a result, the future disciplines should take their own responsibilities in developing responsible social technical systems (key ethics). To frame the future approach of our education system within applied universities, we described three scenarios coined as federated, technology-driven, and cyber-social, without divulging and discussing the merits and limitations of these scenarios.

## Eindnoten

- 1 See e.g. Lier, B. van (2020). De digitale ecologie van 2030. Leven, werken en leren in een digitale samenleving in this volume
- 2 The wording of some of these points follows Buchanan's version – marked with square brackets – that incorporates earlier communications by Rittel (Buchanan, 1992, p. 16).
- 3 The term “design” is unfortunately somewhat ambiguous as it is used both in engineering contexts and in designerly contexts. As a convention, we try to use the verb “to design” in this text exclusively with the connotation of “designerly design”; however, we cannot avoid using the noun “design” – somewhat ambiguously – in both contexts, for the activity of or the result of engineering and for the result of designing as well as for the discipline of “design” (as opposed to engineering or the humanities).
- 4 Due to space limitation, we have not elaborated upon non-technical disciplines who are responsible for creating those components of a socio-technical solution that are not technical (like social/organisational policies, protocols, and procedures). Hereby we do acknowledge the need for and necessity of these disciplines and their solution components to shape the solution space of socio-technical systems.

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Mortaza S. Bargh obtained his PhD and MSc in Information Theory from Eindhoven University of Technology (in 1995 and 1999, respectively). Between 1999 and 2011 he carried out applied research in the areas of secure pervasive computing and ambient intelligence at former Novay or Telematica Instituut in Enschede, The Netherlands. Between 2012 and 2015 he was a part-time visiting research professor (Lector) on Cybersecurity and Privacy at RUAS and since 2013 he has been a scientific researcher at the Research and Documentation Centre (WODC in Dutch) of the Dutch Ministry of Justice and Security. Since December 2017, he has been appointed as research professor (Lector) on Privacy and Cybersecurity at RUAS. His current research interests include privacy/security by design engineering, privacy preserving data mining and data publishing, responsible machine learning algorithms, access and usage control, collaborative security, usable security, and risk management. He has published several articles on these topics and serves as a program committee member for various conferences.

## Selected recent publications

### 2019–2020

Amighi, A., Bargh, M.S., Choenni, S., Latenko, A., and Meijer, R. (2020). On protecting microdata in open data settings from a data utility perspective. *In Proceedings of the Fourteenth International Conference on Digital Society (ICDS), special track Protecting Privacy in Open (& big) Data Settings (PPODS)*, Valencia, Spain, November 21-25, (Top Paper award).

Bargh, M.S., Meijer, R., Vink, M., Schirm, W., van den Braak, S., and Choenni, S. (2019). Opening privacy sensitive microdata sets in light of GDPR: The case of opening criminal justice domain microdata. *In Proceedings of the 20th Annual International Conference on Digital Government Research (dg.o)*, June 18-20, Dubai, UAE.

Bargh, M.S., and Choenni, S. (2019). Towards applying design-thinking for designing privacy-protecting information systems. *In Proceedings of the 1st IEEE International*

*Conference on Trust, Privacy and Security in Intelligent Systems, and Applications (IEEE TPS)*, Los Angeles, California, USA (Co-located with IEEE CIC 2019 & IEEE CogMI 2019), December 12 - 14.

Bargh, M.S., Choenni, S., Meijer, R., and Choenni, A. (2019). A method for assessing the openness of semi-open data initiatives: Applied to the justice domain. *In Proceedings of the 8th International Conference on e-Democracy (e-Democracy)*, 12-13 December, Athens, Greece.

Choenni, S., Netten, N., Bargh, M.S., and van den Braak, S. (to appear). Exploiting big data for smart government: Facing the challenges. A chapter in the *Handbook on Smart Cities*, ed. J. Carlos Augusto, Springer.

Vink, M., Netten, N., Choenni, S., Bargh, M.S., and van den Braak, S. (2020). Mapping crime descriptions to law articles using deep learning. *In Proceedings of the 13th International Conference on Theory and Practice of Electronic Governance (ICEGOV)*, 22-25 September, Online, (Best Paper award).

### **Peter Troxler, PhD, MSc**

Lector Revolutie van de Maakindustrie,  
Kenniscentrum Creating 010



Peter Troxler doet onderzoek naar de impact van nieuwe, directe digitale productietechnologieën en methoden (zoals 3D printen en FabLabs) op ontwerpen en produceren in een nieuw type van maakindustrie. Met name van interesse zijn nieuwe vormen van organisatie, aansturing en eigenaarschap – zelforganisatie, participatieve en coöperatieve structuren, open source en gemeengoed zijn centrale concepten. Deze functie combineert hij sinds 2020 met die van waarnemend inhoudelijk directeur Kenniscentrum Creating 010.

### **Recente publicaties**

Kohtala, C., Boeva, Y., & Troxler, P. (Eds.). (2020, forthcoming). *Alternative Histories in DIY Cultures and Maker Utopias*. *Digital Culture & Society*, 6(2).

Hennekes, M., Troxler, P., & Voldborg Andersen, H. (2020, October 10). *FabLearn Dialogues*. A pilot for a trans-national maker education exchange. *FabLearn Conference 2020*, New York, NY.

Troxler, P., & Mostert-van der Sar, M. (2019). *Seven Years of Plenty? Learning in, with,*

through, from and for the Stadslab Rotterdam / Zeven jaar rijkdom? Leren in, met, door, van en voor Stadslab Rotterdam (2nd ed.). Kenniscentrum Creating 010, Hogeschool Rotterdam. [https://www.researchgate.net/publication/335422159\\_Seven\\_Years\\_of\\_Plenty\\_Zeven\\_jaar\\_rijkdom](https://www.researchgate.net/publication/335422159_Seven_Years_of_Plenty_Zeven_jaar_rijkdom)

Troxler, P. (2019). Building Open Design as a Commons. In L. Bogers & L. Chiappini, *The Critical Makers Reader: (Un)Learning Technology* (pp. 218–226). Institute of Network Cultures. <https://networkcultures.org/blog/publication/the-critical-makers-reader-unlearning-technology/>

Troxler, P., & Woensel, van, C. (2016). How will society adopt 3D printing? In B. Berg, van den, S. Hof, van den, & E. Kosta (Eds.), *3D Printing* (pp. 205–237). TMC Asser Press.

## Video

[Lector](#) Revolutie van de Maakindustrie Peter Troxler

Dit artikel is onderdeel van de bundel:

Gijsbertse, D. P., Van Klink, H. A., Machielse, C., & Timmermans, J. H. (Red.). (2020). *Hoger beroepsonderwijs in 2030: Toekomstverkenningen en scenario's vanuit Hogeschool Rotterdam*. Hogeschool Rotterdam Uitgeverij.

De volledige bundel is te vinden op: <https://hr.nl/hbo2030>