Repositioning Technology in Modern Sociotechnical Systems Design

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Abstract

The Modern Sociotechnical System Theory (MST) of the Lowlands focuses on the study and design of organizational structures. The emphasis is on the design of production processes which transform inputs into outputs. In order to do so, MST developed a design sequence for (re)designing organizations. The first step consists of the top down design of the production structure (i.e. task division). Second, a control structure (i.e. coordination) is added on top of the production structure. This happens bottom up. The position of technology in the MST design sequence is secondary and only comes into play after the two previous steps. This paper argues that this current position of (digital) technology in the design sequence is appropriate only for transformation-supporting technology. Transformation-changing technology though, should be considered sooner in the MST design sequence. We illustrate this position with the example of 3D printing in construction. Finally, we suggest some revisions of the MST design sequence and initiate a debate on the position and meaning of technology in organizational design.

Introduction

What is the place of technology in the sequence of (re)designing organizations? Does technology predetermines the design options, or should it only come into play in the phase of operationalizing and implementing the organizational design? In which design step should technology be taken into account? And has the position of technology in the organizational design sequence changed in recent years due to possible new transformation possibilities that were previously unimaginable?

This paper is embedded in the Modern Sociotechnical System Theory (MST) as developed in the Lowlands. While the classical socio-technical approach, as developed in the sixties and seventies of the twentieth century, mainly focused on the micro-level (of workplace and job design), MST complemented sociotechnical theory and practice at the micro-level with a growing attention for the study and design of the organizational structures. The work by De Sitter (de Sitter et al., 1997; de Sitter, 1984) was of major importance for the development of the theoretical foundation for socio-technical organization (re)design. The objective of MST was to find design principles that do not only lead to improvements in the quality of work, but also contribute to the quality of the organization (in terms of organizational effectiveness, flexibility and product quality).. The development of MST took place in a context of continuous iteration between theory and practice and resulted in a coherent set of design principles and rules which are part of a design sequence (Sitter, et. al., 1994). The purpose of this paper is to critically analyze the role of technology in the design sequence of MST.

New technology may alter how organizations (can) organize their production processes. Production processes transform inputs to outputs (Van Hootegem, 2000). Technology consists of the way to support and realize a transformation. Accordingly, new technology may open up transformation possibilities that were previously unimaginable. For example, 3D printing can be seen as a revolutionary technology for building houses. New and existing materials (i.e. inputs) are brought together in a whole new transformative machinery to construct buildings (i.e. outputs). As we will argue in this paper, the current MST design sequence may not fully acknowledge this transformation-changing capacity of specific technologies.

The paper is divided into four main sections. In the first section we describe the current design sequence of MST and clarify the position of technology in it. The second section offers an evaluation of the position of technology in the MST design sequence. We identify three possible problems with regard to this position. The third part is a discussion section in which we offer some arguments and thoughts which may foster the debate on the position of technology in the organization design sequence. We formulate suggestions on how to improve the current position of technology in the MST design sequence, and propose some specific modifications of the MST design sequence. We end the paper with some concluding remarks.

The position of technology in the Modern Sociotechnical Systems Design Sequence

Some MST scholars and practitioners argue that the name 'MST' is an unlucky pick. 'Sociotechnical' seems to imply that the theory concerns itself with separate social and technical systems. Indeed, the core of 'traditional' Sociotechnical Systems lies exactly in the simultaneous improvement of social and technical systems within an organization. The social system represents human relations, whereas the technical system represents material relations (Van Hootegem, 2000). Researchers from the Tavistock Institute realized that changes regarding the technical system lead to changes in the social system, and vice versa (Trist & Bamforth, 1951). Subsequently, the consequences of those changes should proactively be understood for both social as technical systems.

The modernization of Sociotechnical Systems by Ulbo de Sitter did away with the separation between social and technical systems (Sitter, 1989). In short, interactions between humans have technical components. Purely social or technical interactions do not exist. 'Social' interactions need a material medium; 'technical' interactions are socially programmed. Hence, the social and the technical cannot be separate systems, but are always part of one sociotechnical system, For example, even the language we use to communicate has a certain technical aspect, namely the syntaxis, which makes talking both a social and technical activity (Sitter, et. al., 1997). Moreover, de Sitter focused his approach to production processes as sociotechnical systems.

Figure 1 Production processes in MST design sequence, (Source: Kuipers, et. al., 2010).

As explained in figure 1, *production processes* are transformations of inputs (I) into outputs (O), which can be products or services. Hence, MST is preoccupied with how transformations are organized throughout production processes. Several *operations* (Op) are needed to complete the transformation of inputs into outputs. The way organizations arrange these operations is called the production structure. De Sitter states that there is a logical sequence to design organizations. First, an organization must ask itself how its end product or service should look like, which de Sitter calls the *product structure* (see number 1 in figure 2). This product structure already reveals something about the materials and technology that need to be used to create the product or service. However, this affects only in a limited way the next steps in the design sequence, according to De Sitter (1989).

The organization should arrange operations into an optimal production structure following the principles of parallelization and segmentation (see number 2 in figure 2). *Parallelization* means that 'production streams' should be devised that each serve a separate customer segment. The products and services delivered within one stream should have similar production processes (i.e. transformations). Consequently, the different production streams do not interfere with each other and can be seen as parallel, (semi)autonomous lines. *Segmentation* is necessary when a production stream is still too complex to operate autonomous . A segment is defined as a part of a production stream that consists of multiple transformations that are internally interdependent and externally (towards other segments) independent. In other words, the segments within a production stream are again kept as autonomous as possible with regard to other segments, despite them being interconnected as part of the same production stream (Sitter, 1989). Finally, operations are bundled within each segment. The bundling of operations happens following the same idea as above: bundles of operations should be internally dependent, but externally as independent as possible. This results in the creation of different task groups.

The next step in de MST design sequence concerns the control structure (see number 3 in figure 2). Designing the production structure applies as a necessary precondition. Only than the exact inputs and outputs you effectively want to operate and control become clear and you can start thinking about how to organize the control loops. Whereas the production structure is designed top down, from macro level (parallelization) to meso level (segmentation) and from meso level to micro level (task groups), the control structure is designed the other way around. The design of the control structure starts bottom up and follows one rule: only if there are clear arguments to bring a specific control function to a higher organizational level, control functions should be kept at the lowest level of the task groups, resulting in autonomous teams. Operational decisions should remain on an micro level, matters of structural improvement should be handled on meso level, while the macro level should decide on strategic renewal. Moreover, designing the control structure bottom up is considered as a prerequisite to manage the ever changing circumstances in which modern organizations operate (Sitter, et. al., 1997).

Only after the design of the production structure and the corresponding control structure technology comes into play (see number 4 in figure 2). After delineating segments and if necessary task groups, the inputs and outputs supposedly become clear and the question rises at last which technology could support the transformations each segment or task group performs. Looking at the concrete operations in the different task groups, the question is posed which operations can be supported or automated using technology. The deliberation then follows which specific machines are to be used at which capacity and with which level of flexibility[1]. Note that technology only comes into play after the complete production and control structure has been designed.

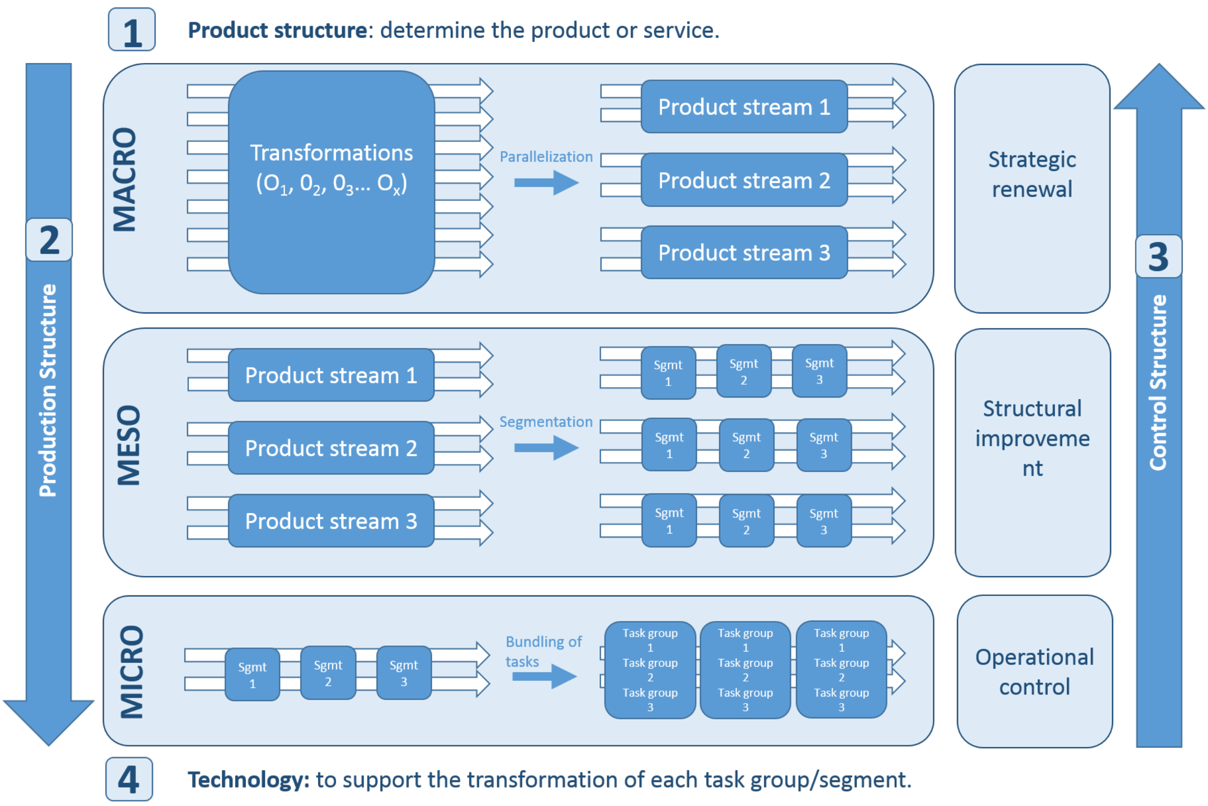

Figure 2 MST Design Sequence, (Source: Kuipers, et. al., 2010).

[1] De Sitter (1989) differentiates between technology and technique to make clear the difference between the rather open question ‘which technology to use?’ and the concrete question ‘which exact machines to use?’.

The previous paragraph shows that the position of technology is secondary in MST. De Sitter argues that he does not neglect the role of technology. As stated above and represented in figure 3, the product structure and the intended outputs (O) already reveal something about the materials that need to be used to create the product or service; the materials that need to be used can be transformed using a limited number of technologies; each technology implies particular operations. However, he does argue that the importance of technology for organizing production processes is overstated. For example, organizations using the same technology show different production structures. Moreover, de Sitter stipulates that technology should be developed to fit with the optimal production structure rather than the other way around. In summary, the product structure reveals something about the technological possibilities and implications but the MST design sequence remains ambiguous about the practical implementation of those implication.

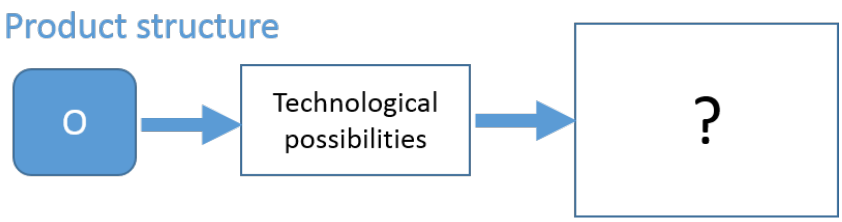

Figure 3 The product structure in the MST design sequence (Source: Kuipers, et. al., 2010).

A critical evaluation of the position of technology in the Modern Sociotechnical Systems Design Sequence

We advance here that the supportive role of technology in Modern Sociotechnical Systems may contradict with the key insight that the social and the technical cannot be separated in two different systems. De Sitter makes clear that each interaction has inseparable human and technical components. Consequently, an operation is nothing more and nothing less than people using some kind of technology to transform a certain input material to a desired output. The prioritization of the production structure design over technological choices is then questionable. What do the operations, forming the production structure, consist of if their technical component is not clear yet? For example, look at a construction firm. What are the different steps in building a house? The answer depends on the technology chosen: traditional step-by-step construction, standardized and prefabricated components, or completely 3D designed and build (see Box 1). Depending on the technology chosen, different steps will involve different operations.

Box 1. The example of 3D printing in construction

3D printing is a transformation-changing technology in, among others, construction. The 'traditional' way of building a house consisted of: architectural design; land prepping; foundation laying; rough carpentry; roofing; insulating; electric, plumbing and heating arrangements; interior carpentry; and flooring. This way of operating has changed little over the past 100 years. Large-scale standardization or prefabrication did never materialize due to the high degree of variability each project requires. Moreover, construction happens on site in everchanging circumstances, which further increases the need for flexibility.

3D printing allows to combine the required flexibility with the efficiency gains of a standardized production process. 3D printing enables to produce the entire structure: an aesthetically pleasing exterior, but also an intricately detailed 3D printed interior (Krassenstein, 2015).

Construction will become faster, cheaper and the quality will increase (Van Sante, 2016). In addition, there will be a decreased demand for materials and labor on site but the importance of design and modelling will increase. In the perspective of 3D printing, all other steps need to be reconsidered as well. The focus will shift from on-site production to design and planning. The complete phase of on-site production expires while the new step of 3D modelling is added to the production process. This has consequences for the operation structure as well. Manual labor will be mainly replaced by mechanical production but maintenance and management of the 'printer' will create new employment possibilities. 3D printing poses different requirements. Accordingly, different capacities are needed to address these requirements. An architect for example needs to acquire the necessary software skills to be able to design houses that are manufactured using a 3D printer (Van Sante, 2016).

In sum, the whole production process needs a new design. 3D printing has important implications for not only the different transformation steps but also for parallelization- and segmentation-related choices. Hence, it is important to take this technological innovation into account at the beginning of the design sequence.

We agree with de Sitter that technology does not predetermine the design of the production structure. Whatever technology is being used and whichever implications it has, considerable degrees of freedom remain to arrange operations in many different ways. The point we wish to make here is that designing the production structure without making a number of fundamental technological choices simply seems impossible because operations, i.e. the building blocks of the production structure, are concrete interactions with intertwined social and technical components. Based on this observation we now take a critical look at the actual MST design sequence . Three possible inconsistencies are identified, which may necessitate a revision of the MST design sequence.

The first problem lies in de Sitter acknowledging that the product structure already reveals which technological options remain on the one hand, and the lack of guidance on how to deal with those technological options during the MST design sequence on the other hand. No account is given of how to identify possible technologies to realize a particular product structure. In addition, obviously, information on possible technologies is also not used in the design of the production structure. The MST design sequence goes straight from product structure to production structure. The problematic consequences of this lack of guidance on how to deal with technological possibilities are further highlighted in the next paragraph.

Second, the parallelization principle runs into trouble. Product streams are supposedly parallelized on the basis of, among others, similarity between production processes. Products and services that are characterized by a similar production process and/or customer segment are put together in the same stream. However, it appears to us that the outlook of the production process is still uncertain as no technological choices have been made. The product structure makes clear what the end result of the production process should be, but building blocks of the production structure have not yet been defined. Information on technological possibilities, derived from the product structure, could exactly serve this purpose. In our revised design sequence we present at the end of this paper, we take this into account. Here, it should be clear that the 'similar production process' criterion for parallelizing product streams currently neglects the possible implications of technological innovation.

Third, de Sitter states that technological choices are to be made after segmenting product streams. He states that the inputs and outputs have then become clear. Subsequently, technological choices can then be made to perform the intended transformations. This sequence is inconsistent with our observation that the building blocks of the production structure have not yet been defined. Again, only the end result of the production process is clear as long as no technological choices have been made. Therefore, it remains unclear whether product streams may be too complex and segmentation could be necessary, without detailing main transformation steps and necessary operations. And detailing main transformation steps and necessary operations is only possible based on technological choices. Consequently, the order of steps in the MST design sequence may also best be revised with regard to the segmentation principle.

The position of technology in the MST design sequence suggests that technology only plays a secondary, supportive role in function of previously defined operations. Yet, as stated above, new technology supposedly might change the face of transformation activities themselves.

Towards new ways of addressing technology in Modern Sociotechnical Systems Design?

In this section, we discuss the position of technology in the context of the historical development of the MST Theory. By doing so, we aim for a better understanding of how and why technology has the role it currently possesses. Afterwards, a first draft of additional design rules is developed. The goal is to complement and enrich the MST design sequence.

The MST theory was developed in opposition to a technological determinism that was generally accepted in the 80's. In an era where it was taken for granted that technological advance would increasingly determine the design of organizations and the corresponding quality of labour, MST argued the contrary and stressed the rather limited role of technology in organizational design. In this sense, by rejecting any technological imperative, MST defended the idea that the 'quality of organization' was a matter of design(principles). Nowadays, technological determinisms can still be found, for example in discussions about robotization and its supposed effects on organization and labor. Nevertheless, one can hardly deny that technology is rapidly evolving, and that it plays an ever growing role in how the world is organized. We advocate a rational approach towards technology, one that gives technology an appropriate position in the MST design sequence without falling into the trap of technological determinism. Hence, a critical approach to the general role and meaning of technology in organizational design is needed.

Several of the problems and possible inconsistencies mentioned above, come back to the question whether or not technology influences or changes the actual operations and inputs in the production structure. The answer mainly depends on the perspective chosen (see figure 2). From a macro level technology does not fundamentally change the way the production is structured. But considered from a meso- or micro level, technology certainly does. Doing the dishes for example, has a clear input (i.e. dirty dishes) and a clear output (i.e. clean dishes). One can imagine different ways to organize this transformation into a production structure. The introduction of the dish washing machine automated certain operations in this transformation process. The question rises whether or not the technology of a dish washing machine changes the production structure in a fundamental way and thus should play a more important role in the design sequence. If this question is approached from a macro level, the question is clearly no: input, output and transformation stay the same. A dish washing machine is only a convenient tool that automates certain operations. As a result, it is not necessary to take this technology into account at the beginning of the design sequence. If approached from meso or micro level, a dish washing machine does change the way dish washing is organized, and different steps need to be reconsidered. The use of a dishwasher requires different types of jobs, for example someone who loads and unloads the dishes, and someone who performs the technical maintenance. Moreover, whether or not you have the ability to install multiple dishwashers can have consequences for the possible parallelization into different product streams. Approached from a macro level, the technology of a dishwasher only has to come into play at the end of the design sequence, from a meso or micro level the dishwasher technology should be taken into account in a more earlier stage of the design. The point we want to make here is that much depends on the perspective. We therefore suggest a new step in the MST design sequence between the macro and meso level of the production structure where possible technological implications can be explored.

Finally we conclude this paper with a first attempt to a revised MST design sequence (figure 4). We discussed the need for a repositioning of technology in the MST design sequence. A possible solution is making a distinction between different sorts of technology. Technology has previously been defined as ways of realizing a transformation. A distinction can possibly be made, however, between transformation-changing and transformation-supporting technologies. Transformation-changing technologies consist of new ways to transform an input into an output (for example 3D-printing). Transformation-supporting technologies improve existing ways of transforming inputs into outputs (for example the dishwasher). In other words, transformation-changing technologies involve new operations, whereas transformation-supporting technologies target existing operations. Consequently, the different types of technology require respectively new and improved production structures.

Technological choices have to be made to know the building blocks of the production structure. The implication of this observation is that transformation-changing technologies need to be accounted for at the start of the design sequence. Transformation-changing technology namely delivers the buildings blocks of the production structure. However, a methodology is missing to derive which new operations come about given a new transformation-changing technology. Below (figure 4) we introduce a new ‘exploration’ step after determining the product structure in the MST design sequence and list a number of questions such a step might involve. The implications of the previous observations regarding transformation-supporting technologies are limited. The current MST design sequence is namely fit for transformation-supporting technologies. Such technologies apply to existing operations. Consequently, they only play a secondary role in function of the production structure.

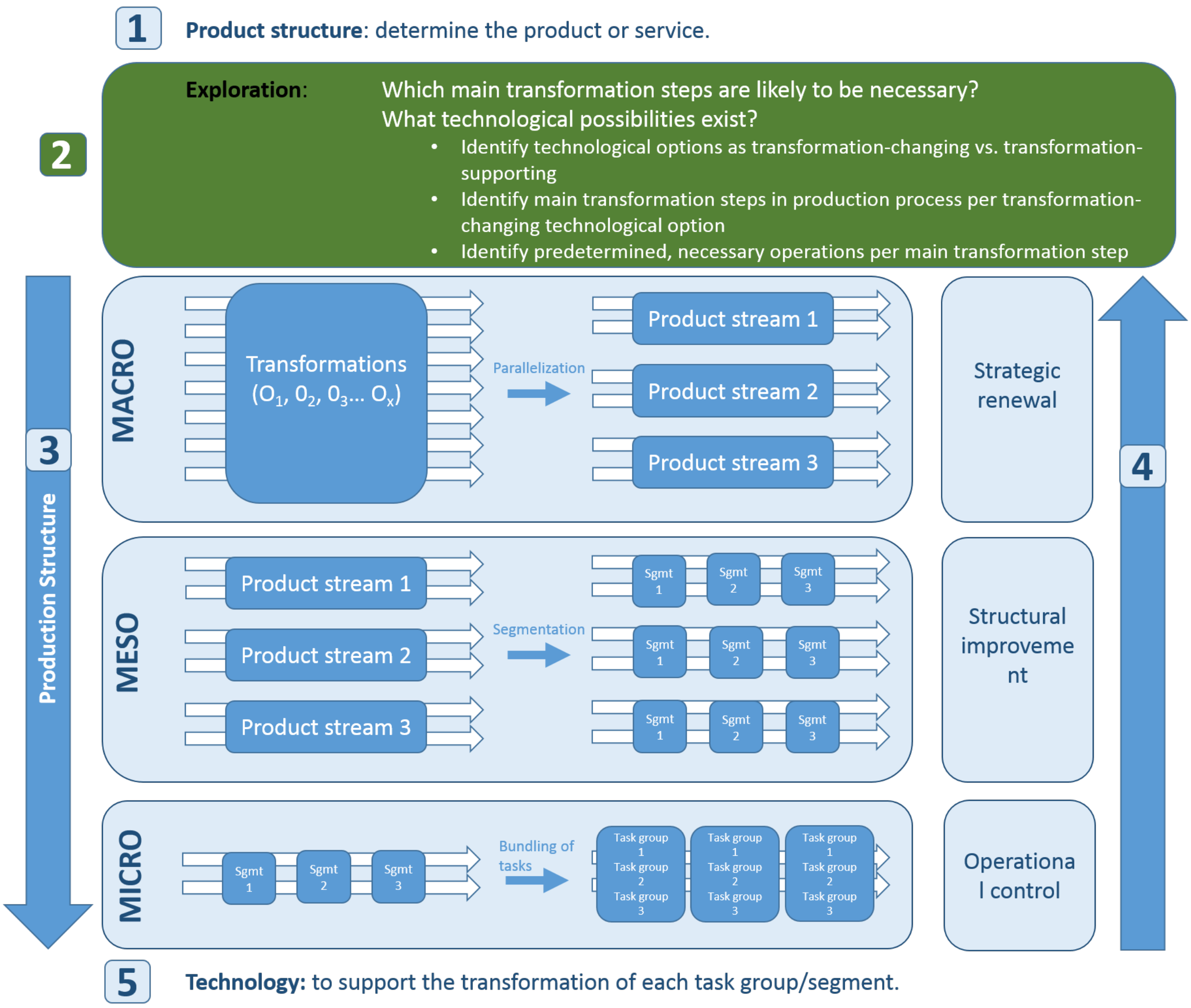

Figure 4: Proposal for a revised MST design sequence (Based on Kuipers, et. al., 2010)/

Conclusion

This paper critically examined the position of technology in the MST design sequence. By making a distinction between transformation-changing and transformation-supporting technologies and by proposing a new step in the MST design sequence in which (transformation-changing) technology and its implications can be explored, we tried to contribute to the discussion on the meaning and position of technology in the MST design sequence.

We want to conclude this paper with a reflexive note. The argumentation developed above relies heavily on the theoretical principles of the MST design sequence. However, it is presumably that in reality theory and practice do not fully coincide. When (re)designing organizations, it is likely that transformation-changing technologies are already, at least implicitly, accounted for. With this paper, we strive for a more explicit position of transformation-changing technologies in the MST design sequence.

Bibliography

Krassenstein, E. (2015). *Andrey Rudenko Plans to 3D Print a 2-Story 'Zero Energy' House in 5 Days with Advanced 3D Printer*, consulted on 26.08.2016 from https://3dprint.com/40154/3d-printed-house-rudenko/

Kuipers, H., Amelsvoort, P.V., Kramer, E.H. (2010). *Het nieuwe organiseren* [The new organisation] Acco: Leuven/Den Haag.

Sitter, L.U.D. (1984). *Synergetisch produceren* [Synergetic production]. Van Gorcum: Assen.

Sitter, L.U.D., Hertog, J.F.D. & Dankbaar, B. (1997). *From complex organizations with simple jobs to simple organizations with complex jobs*. Human Relations 50: 497.

Trist, E., Bamforth K. (1951). *Some social and psychological consequences of the longwall method of coal getting*. Human Relations, 4, pp.3-38.

Van Hootegem, G. (2000). *De draaglijke traagheid van het management* [Endurable slowness of management]. Acco: Leuven.

Van Sante, M. (2016). *Technologie in de bouw. Mass customization wordt mogelijk* [Technology in construction. Mass customization becomes possible], consulted on 30.03.2016 from https://www.ing.nl/.../ING-Technologie_in_de_bouw-Februari_2016_tc.