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Deskilling and Up-Skilling in an Information Systems Context

Effects and causes of IS automation

Bachelor's Thesis
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Abstract

Current computer hardware and software make it possible to automate knowledge work the same way industrial revolution allowed the automation of manual labour. Information systems automation has been observed to cause changes in the skills of the employee ranging from loss of skills (deskilling) to learning new skills (up-skilling). This thesis aims to provide a comprehensive literature review of the prior research in the fields of deskilling and up-skilling effects caused by automation.

While automation comes with benefits of increased speed, accuracy etc., the malfunction of automated systems poses great operational risks if workers are unable to perform tasks due to deskilling. Automation tools can also work as powerful platforms for furthering innovations and accumulation of knowledge, as automation performs the mundane and repetitive tasks leaving the creative work for humans.

Factors behind to the deskilling and up-skilling effects are identified and examined with frameworks and theories from prior research. The design of the automation system plays a crucial role in the way skills are affected, and thus research on the design of automation tools is also included in this review. Implementation of automation is the second key element and likewise included in the literature review.

Automation puts the designer in the place of the person who performed the task prior to automation and therefore plays an important role in the way automation affects skills. Relevant design factors range from the amount and type of feedback the automation tool provides to the extent which the tool automates tasks.

Decision to and how to implement automation is usually a decision made by management. How the post-implementation is managed can tip the balance between desired and undesired effects of automation. Training and support in automation tool usage strengthen the desired effects and solutions like job rotation mitigate loss of expertise caused by task automation.

As knowledge is identified as the most valuable source of competitive advantage in many organizations, a thorough understanding of the deskilling and up-skilling effect is crucial to prevent the erosion of knowledge and skills of the employees.

Keywords IS automation, deskilling, reskilling, up-skilling

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1 Introduction

Automation, a technology that executes functions that were previously performed by humans (Parasuraman and Riley, 1997), first took over manufacturing during the 20th century and became the predominant norm in the field of manufacturing industry. Automation was noticed having a deskilling effect on workers, which was studied extensively especially by Harry Braverman (McNally, 2010). The deskilling effect can be observed when skilled labour in an economy is eliminated by introducing automation techniques, which can be operated by less skilled labour. But while most workers are deskilled, some must simultaneously be reskilled or up-skilled (Braverman, 1998).

Automation is hailed as a solution eliminating manual effort, bringing speed and increasing value. Automation of physical functions freed humans from time-consuming and labour-intensive tasks (Parasuraman and Riley, 1997) and now advances in computer software and hardware allow automating information systems. Computerized decision aids, knowledge management systems, enterprise content management systems and other forms of automation are increasingly being adapted by organizations (Mascha and Smedley, 2007; McNally, 2010). Yet information systems automation (hereafter IS automation) does come with its drawbacks, similarly to the automation processes in manual labour. This thesis concentrates on the deskilling, reskilling and up-skilling effects of IS automation, and how the design and implementation of automation affects this change in skills.

Deskilling can be defined as a process where the users' decision-making skills decrease due to reliance on automation, which takes over, and as a result humans stop using and forget the skills needed to perform these prior tasks (Parasuraman et al., 2000; Arnold and Sutton, 1998). There are multiple factors explaining deskilling, the most predominant being reliance on technology. According to Braverman's (1998) deskilling thesis, deskilling occurs when technology is combined with management tools to subdivide the work processes into small components, which can then be performed by individuals with less skill. The engineering and brainwork involved in design and construction of automation systems facilitate task simplification, enabling workers with minimum training to perform the same jobs earlier assigned to highly skilled workers (Bhardwaj, 2013).

Technology alone does not deskill (Braverman, 1998) and a number of studies concerning the effects of introducing new technologies into the workplace indicate that technology can be implemented without deskilling taking place (Agnew et al., 1997). IS automation can be designed in a way that expands the employee's skillsets instead of diminishing them (Orlikowski, 1991), hence enabling the workers to build up on their human competencies.

This up-skilling happens, when the knowledge of the information system increases (Bravo, 2015). Agnew et al. (1997) noticed this effect often up-skilled managers while deskilling operators. But up-skilling can also occur in the same subject, where deskilling is present.

The third identified outcome of IS automation is the reskilling effect, where prior knowledge is substituted with another type of knowledge. Reskilling can be observed when deskilling and up-skilling happen simultaneously. While deskilling is an involuntary phenomenon, up-skilling must be confronted with proper training and support (Bravo, 2015).

Many organizations identify the knowledge developed and possessed by the individual employees as the main source of competitive advantage and thus the most important asset of an organization (Rinta-Kahila et al., 2017; McCall et al., 2008). Automation threatens to transform the way individuals develop and maintain knowledge, for better or worse. On the one hand IS automation promises many benefits; improved decision quality, reduction of decision bias and capturing experience in a permanent form just to name a few (Hampton, 2005), but on the other hand IS automation can lead to deskilling and the organization losing the ability to develop their own knowledge (McCall et al., 2008).

Therefore, it is imperative to understand how IS automation affects the employee's skills and how the design and implementation affects the outcome, so desired effects of automation can be achieved while mitigating the undesired effects.

1.1 Research objectives and research questions

The thesis concentrates on the effects of IS automation on knowledge workers and how IS automation should be designed and implemented. The objective is to describe the effects of deskilling, reskilling and up-skilling. Furthermore, this thesis aims to analyse how automation affects skillsets in an information systems context. IS automations' effects on employee skillsets can consequently be explained and managed by design and implementation factors and will be included in the scope of this thesis. The research questions this thesis aims to answer are the following:

A. How the introduction of automation affects the skills of knowledge workers?

B. How the design and implementation of the automation system affect the change of skills?

C. How can the negative effects of IS automation be mitigated?

I will aim to answer the research questions with hypotheses introduced at the end of the chapters covering the relevant literature.

1.2 Methods and scope of research

The method used in this thesis is a literature review covering the major databases such as Google Scholar and Scopus. Several phrases and keywords were used such as “IS automation”, “deskilling”, “reskilling” and “up-skilling”. Further cited searches were performed based on the most relevant articles.

Although much of the theoretical and practical background in the debate between deskilling and up-skilling has been carried primarily on industrial labour (Bravo, 2015), the same frameworks can still be used within the context of IS automation (McNally, 2010). The question whether IT increases or decreases skills isn’t per se a new notion, deskilling due to IT was already discussed in the ‘70s and ‘80s (Braverman, 1998). Alongside the research in the field of industrial automation, the more recent studies in IS automation provide an ample selection for this literature review.

Besides reading, a concept matrix (Webster and Watson, 2002) illustrated in table 1, was compiled for easier management of material and transitioning from author- to concept-centric approach. Isolating concepts by unit of analysis was especially important due to the slight variances in terms and frameworks, and additionally made it easier to keep the scope of this paper coherent. The concept matrix was composed from the research articles initially picked from database searches. The literature review is not limited to this initial choice of articles.

	Articles								
		Categorising automation	Deskilling		Reskilling and Up-skilling			Design	Implementation
	Unit of analysis		Industrial	IS-systems	Reskilling	Up-skilling	Other		
KLAPPERICH, H. and HAS	Hotzenplotz: Reconciling Automation with Experience	x							
GHAZIZADEH, M., LEE, J.	Extending the Technology Acceptance Model to assess automation	x						x	x
AGNEW, A., FORRES	Deskilling and reskilling within the labour process: The case of computer integrated manufacturing		x						x
BRAVO, E., 2015.	Deskilling, up-skilling or reskilling? The effects of automation in information systems context		x	x	x	x			x
PARASURAMAN, R. and	Humans and automation: Use, misuse, disuse, abuse		x	x				x	x
MCNALLY, M.B., 2010.	Enterprise content management systems and the application of Taylorism and Fordism to intellectual labour		x	x	x	x		x	
BHARDWAJ, S., 2013	Technology, and the up-skilling or deskilling conundrum			x		x		x	x
SCHUPPAN, T., 2014.	E-Government at Work Level: Skilling or De-skilling?			x		x			
SCHUPPAN, T., 2014.	Beyond automation				x	x			
SCHUPPAN, T., 2014.	Distributed cognition: toward a new foundation for human-computer interaction research							x	
SCHUPPAN, T., 2014	Automating amateurs in the 3D printing community: connecting the dots between ‘deskilling’and ‘user-friendliness’			x		x		x	
SCHUPPAN, T., 2014	Continued use of intelligent decision aids and auditor knowledge			x				x	
Parasuraman, R. and Ma	Complacency and Bias in Human Use of Automation			x				x	
Alberdi, E., Strigini, L., P	Why are people’s decisions sometimes worse with computer support?			X					
Alberdi, E., Strigini, L., P	Use of Knowledge Management Systems and the Impact on the Acquisition of Explicit Knowledge			x	x			x	x
Dowling, C. and Leech, S	Audit support systems and decision aids: Current practice and opportunities for future research.			x					x
Audit support systems a	Can computerized decision aids do “damage”? A case for tailoring feedback and task complexity based on task experience			x		x		x	x
Brody, R.G., Kowalczyk,	The effect of a computerized decision aid on the development of knowledge.								
The effect of a compute	The use of adaptable automation: Effects of extended skill lay-off and changes in system reliability							x	
Endsley, M.R., 2017	From here to autonomy: lessons learned from human-automation research							x	
McMurtrey, M.E., Grove	Job satisfaction of information technology workers: The impact of career orientation and task automation in a CASE environment.			x		x		x	
Job satisfaction of infor	A Model for Types and Levels of Human Interaction with Automation							x	
Zuboff 1985	Automate/Informate: The two faces of intelligent technology					x		x	x

Table 1: Concept matrix

1.3 Structure of the research

The previous sections have motivated the topic and introduced the objective and research questions. The thesis will proceed along the following structure.

The following chapter 2 offers a comprehensive literature review. Chapter 2.1 introduces IS automation. The objective of this chapter is to define the concept of IS automation and the effects of deskilling, reskilling and up-skilling, alongside the factors related to design and implementation of IS automation software. Chapter 2.2 introduces a deeper examination of the deskilling effect of automation in IS context. Chapter 2.3 examines reskilling and up-skilling effects in the context of IS automation. Reskilling and up-skilling are grouped together due to their similar nature of introducing new skills to the workers. The last chapter of the literature review 2.4 will review the relationship between the design of IS automation systems and the change in the user's skills and how the implementation of IS automation affects the skills of the employees.

The literature review will be followed by discussion in chapter 3 of the findings from the literature review. Finally, chapter 4 concludes this thesis with conclusions, implications to practice and limitations to the study alongside future research.

2 Literature review

2.1 Introduction to IS automation

Knowledge workers are employees with high levels of competencies and skills (OECD, 2001). Automation is the execution of functions by a machine agent that were previously carried out by a human operator, and in the case of IS automation the machine agent is a computer program (Parasuraman and Riley, 1997). Automation allows the outsourcing of human knowledge work. Thus, IS automation allows organizations to capture one of their most valuable assets, the knowledge internally developed and possessed by individuals within the organization (McCall et al., 2008; Rinta-Kahila et al., 2017).

There are, however two sides to the coin of IS automation. The debate of automate vs. informate is decades old. The concept of informate expresses the ability of IS technology to generate information about the underlying processes enabling IS to work as sources of learning and expertise (Zuboff, 1985). This positive outcome can be called as the ‘black-boxing’ of technology (Söderberg, 2013). Ideally the whole organization would have access to this black-box where all the knowledge of the automated processes is stored, and the information can be used to further the skills of the employees. But converting all the expert knowledge into a black-box can lead to deskilling and loss of control (Orlikowski and Barley, 2001) if the automation tool and process are not designed in a way that supports the learning of new skills.

Due to the nature of IS automation systems, people often feel the sense of deskilling (Hasan and Crawford, 2003), but the unnoticed latent deskilling is harder to manage and can cause significant disruption amongst workers, should automation fail or there be a change in information systems used by the company. Furthermore, it isn’t uncommon to have upper management decide on changing or discontinuing the use of information management systems out of the blue. Top management often lacks first-hand knowledge of the work processes. This is especially true as automation is linked to employee loss of control (Braverman, 1998; McNally, 2010).

In the event of automation failure the degradation of cognitive skills plays a particularly important role. A simulation study of workers reverting to working without automation found that following a malfunction of the automated system, performance was superior when the level of automation was intermediate compared to higher levels of automation (Kaber et al. 1999; Parasuraman et al., 2000).

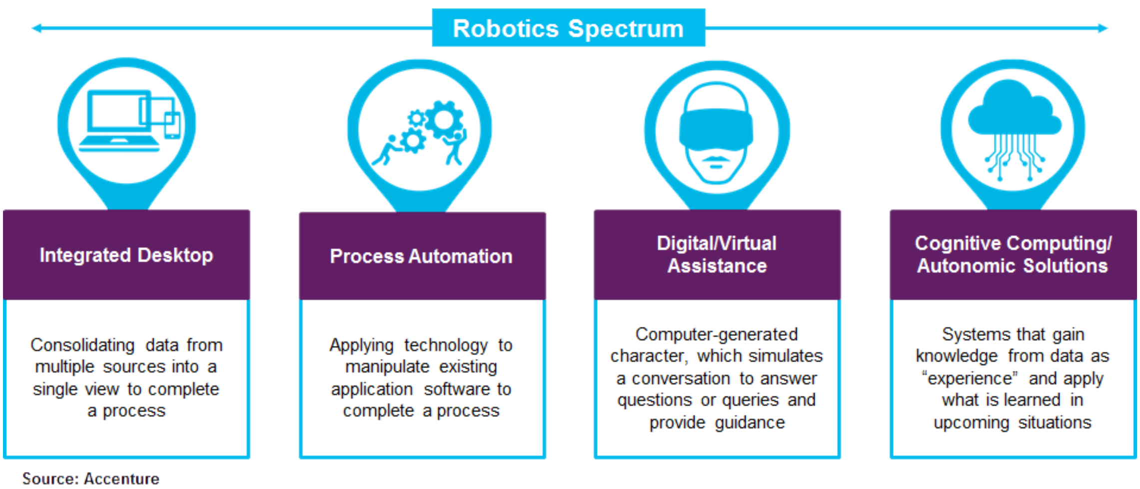

Figure 1: Robotic spectrum (Accenture)

Automation is not all or none (Parasuraman et al., 2000). Figure 1 illustrates a division of automation into four levels by Accenture. There is a wide variety of automation levels, from automation being a simple tool extending human capabilities, to the highest levels of full automation behaving as semi-autonomous partners (Parasuraman et al., 2000; Klapperich and Hassenzahl, 2016). At higher automation autonomy levels, the users have less room for decisions and opportunities to practise the skills involved in performing the automated task manually (Parasuraman and Riley, 1997).

Braverman's (1998) deskilling thesis states that while most employees are deskilled with the introduction of automation, some are simultaneously reskilled or up-skilled. Reskilling is the knowledge substitution effect of increase in automation. The decreased knowledge of the task can be compensated by an increased knowledge of the IS, in turn raising the technical competence required from the employees. (Bravo, 2015; Rinta-Kahila et al., 2017)

Automation can also be a driver for expanding the skillset of workers instead of diminishing them if designed accordingly (Orlikowski and Barley, 2001). Thus, up-skilling occurs when automation increases the knowledge of IS without decreasing the knowledge of the tasks (Bravo, 2015). The up-skilling thesis suggests that when automation takes over the repetitive work, workers should move towards furthering innovations (Arnold and Sutton, 1998).

2.2 Deskilling

Automation literature commonly identifies automation as a way for managers to gain more control over the labour process (Braverman, 1998; Agnew et al., 1997). The increased management control and highly specialised work degrades the worker to performing highly specified routines, impoverishing the work processes. The worker being denied opportunities to practise the skills involved in performing the automated task (Parasuraman and Riley, 1997) is the main impetus behind automation.

In his overview of enterprise content management (ECM) systems McNally (2010) echoes Braverman's thesis. McNally (2010) identifies the shift of control from workers to management as the first element of deskilling. Prior to the introduction of an ECM system workers were free to perform a wide range of tasks, maintaining the skill base of the worker. The narrower user focus can further lead the user losing the power to understand how the problems presented fit into the overall decision domain (Mălăescu and Sutton, 2015).

Deskilling is also a suggested result of multiple unrelated factors: a complex decision arena may cause professionals to utilize automation aids; the use of automation may result in reliance; reliance may severe the professional's involvement in the decision process; lack of involvement can dull the professional's decision-making skills and as a by-product result in an inability to make quality decisions unaided by automation (Mascha and Smedley, 2007). Overreliance on automation is identified as a key factor leading to deskilling and as higher levels of automation autonomy rarefy the opportunities for practising skills tend to lead to an even greater reliance on automation (Lee and Moray, 1994; Parasuraman and Riley, 1997).

Four variables are recognised as drivers for the level of reliance individuals place on decision aids; task experience, task complexity, decision aid familiarity and cognitive fit. Task experience depicts the level of experience a worker has in regards of completing a task and the degree of strategies formulated for completing or solving tasks. Task complexity is the degree to which the task at hand taxes the cognitive abilities of the decision maker. Decision aid familiarity is the amount of experience a user has with the decision aid thus leading to feeling comfortable using the decision aid. The last variable, cognitive fit, is the degree to which the cognitive processes used with the decision aid match the cognitive processes normally used by the decision maker. (Arnold and Sutton, 1998.)

Axelsen (2012) described the deskilling effect by dividing professional knowledge to declarative and procedural knowledge and examining the components affecting these two types of knowledge. Declarative knowledge is an individual's memory of facts and events; know-what knowledge (Sambamurthy and Subramani, 2005). Procedural knowledge is know-how knowledge and central in development of expertise as knowing 'how-to' is more complex and different than knowing 'what is' (Libby and Tan, 1994). For example, knowing that a bicycle has two wheels, a frame and a handlebar is part of declarative knowledge. On the other hand, knowing how to ride a bike is part of procedural knowledge.

The research model presented in figure 2 (Axelsen, 2012) considers six hypotheses of the negative relationship between the continued use of intelligent decision aid (IDA) and auditor skills. The greater extent of automation performing routine tasks, dependence and time spent with the automation had a negative impact on the auditor's declarative knowledge, consistent with (McCall et al., 2008). The results also supported a similar negative relationship with auditor's procedural knowledge.

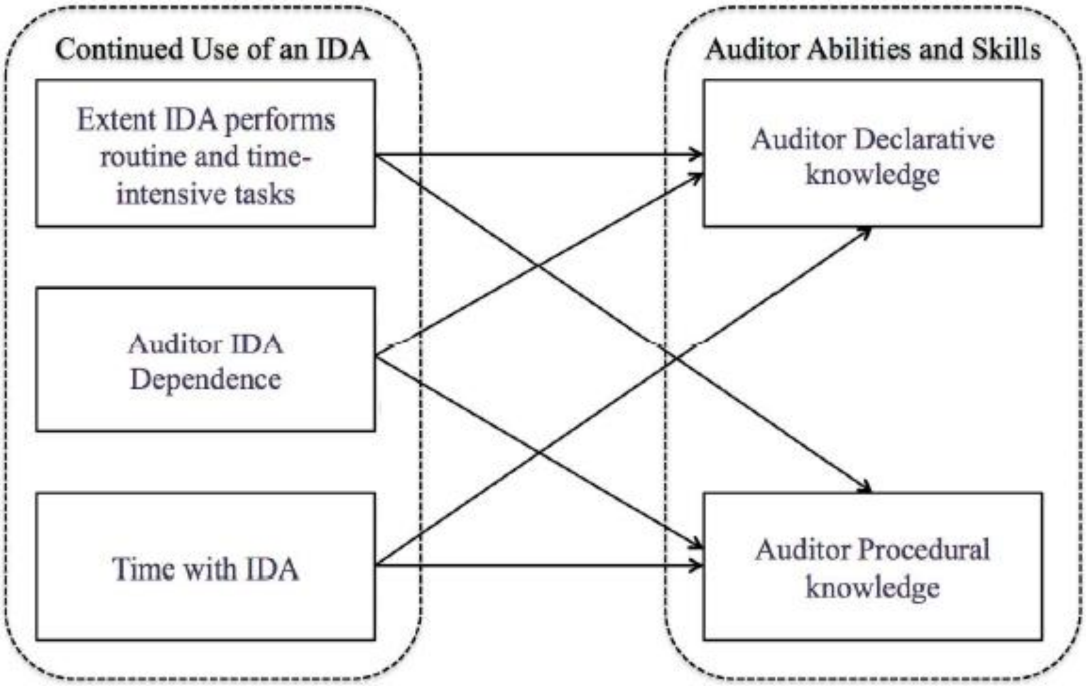

Figure 2: Extended research model of the deskilling proposition (Axelsen, 2012)

The Theory of Technology Dominance (TTD) implies that deskilling might be amplified when there is a mismatch between the decision environment for which the decision aid was designed and the user's experience level (Arnold and Sutton, 1998). When less experienced workers are facing a complex work environment they are more likely to resort to using automation, thus being dominated by automation. The higher the level of automation provided, the more likely it will lead to a vicious cycle where the workers skills stagnate, and no new experience is acquired. We can conclude that less experienced workers are more likely to rely on automation and thus in a greater risk of deskilling.

As reliance on automation plays a critical role in deskilling, we postulate the first hypothesis:

H1: Overreliance on automation is the major cause behind deskilling

2.3 Reskilling and Up-skilling

Automation has been noticed to have an up-skilling effect of creating a group of skilled administrations while deskilling machine operators (Braverman, 1998). Information technology departments benefit from the introduction of automation through upskilling as introduction of complex systems increase the skill requirements for IS administration.

The up-skilling thesis suggests that automation is implemented primarily in already-routinized contexts (Bhardwaj, 2013; Attewell and Rule, 1984). This in turn allows humans to be more concentrated on conceptual and decision-making skills. While processes and activities are transferred to automation, the users simultaneously increase their skills as they ultimately become programmers of the automation tools (Orlikowski and Barley, 2001; Bhardwaj, 2013).

Multiple studies suggest that deskilling and up-skilling do not happen in isolation, but rather simultaneously leading to reskilling (Agnew et al., 1997; Bravo, 2015, McNally, 2010; Schuppan, 2014). This notion can be traced back to the fundamental way automation affects work. Rather than simply supplanting human activity, automation changes the task structure, introducing new tasks and responsibilities (Parasuraman and Riley, 1997; Sarter et al., 1997). Due to the close relationship of deskilling and up-skilling, it is rare for deskilling and up-skilling to happen individually.

Figure 3 breaks performance into knowledge of IS and knowledge of the task. At lower automation levels knowledge of the task is the major contributor to performance. When automation levels increase, knowledge of the task is reduced (deskilling). For the level of performance to remain constant, knowledge of IS increases to become the main contributor to performance (up-skilling).

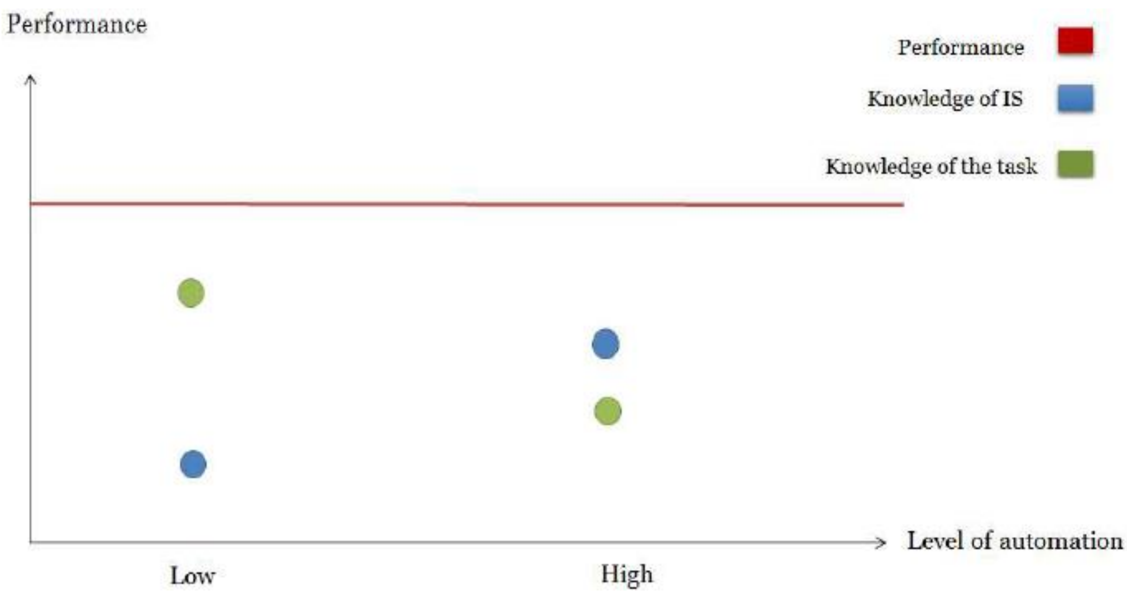

Figure 3: Automation level and types of knowledge contributing to performance (Bravo, 2015)

Bravo (2015) states that at lower levels of automation fewer tasks are assigned to technology, therefore the individual requires only a limited skill set of options and sequences of commands to execute these automated activities. In that case managing processes relies primarily on knowledge of the task. Increasing the level of automation leads to increased portion of the overall knowledge of tasks performed by an individual to be transferred to the IS, which turns this knowledge to become obsolete. This leads to reskilling, as obsolete knowledge is forgotten (Parasuraman et al., 2000) and formulae, rules and procedure required to operate the IS system increase. These results show that the presence of reskilling is evident in an individual when automation levels vary (Bravo, 2015).

Introducing IS automation teaches new skills, but not necessarily to the actual users of the automated tool. Inducing the new skills to the users of the automated tools users can compensate for the deskilling effect and potentially grant a wider skillset than prior to IS automation. Thus, we postulate the second hypothesis:

H2: High levels of reskilling can offset the knowledge lost due to deskilling

2.4 Design and Implementation

Dowling et al. (2008) list several factors leading to reliance on automation, such as incentives, feedback, the tools predinctive ability, the user's focus of control and the provision of explanations, which all can be affected by design and implementation decisions. In fact, new technology can be introduced into a workplace without the necessary deskilling taking place (Agnew et al., 1997). This chapter covers the steps that designers of automation tools and managers can take to mitigate the deskilling effect and facilitate up-skilling/reskilling.

As overreliance on automation was identified as the main impetus behind deskilling, system designer should recognise and counter the factors leading to reliance. Further, high workloads and low self-confidence are factors leading to overreliance which can be accounted for by training and work management. (Parasuraman and Riley, 1997). Hampton (2005) consolidates training as a potential solution to combat overreliance by stating that more experienced workers tend to rely less on automation.

With current computer hardware and software there is little that cannot be automated, which highlights the human performance issue in automation design (Parasuraman et al., 2000). However, the level of automation does not need to be fixed in the design stage and instead can vary according to the situational demand. This concept of adaptable automation allows a more flexible workload management (Parasuraman and Wickens, 2008) but still does not prevent deskilling from happening (Sauer and Chavaillaz, 2017). Bravo (2015) argues that varying automation levels in fact lead to reskilling. Thus, the design of IS automation should take into consideration that automation will result in impairing knowledge of the task but increasing knowledge of the IS. Consequently the design of IS automation systems has a great influence on the way automation transforms the skillset of the user.

Parasuraman et al. (2000) provide a model for automation desingers considering the level of automation to be implemented. In table 2 the level of automation is divided into a 10-point scale where higher levels represent greater autonomy of the automation tool over the human. For example at a low level of 2 all the automation tool provides is several options for the human operator. At an automation level of four the tool suggests one alternative but the user has the final decision. Increasing the level of automation further to level 6, gives the human operator a limited window to act before the tool carries out its decision. In addition, adaptable automation can be implemented, where for example the tool defaults to a lower level of 4 when the workload is light, but increases its automation to level 6 if the tool detects increased workload. If the automation permits the operator to make the final decision based on their own inspection of the information, higher levels of automation will benefit performance and reduce workload (Szalma and Taylor, 2011).

TABLE I

LEVELS OF AUTOMATION OF DECISION AND ACTION SELECTION

HIGH	10. The computer decides everything, acts autonomously, ignoring the human.
	9. informs the human only if it, the computer, decides to
	8. informs the human only if asked, or
	7. executes automatically, then necessarily informs the human, and
	6. allows the human a restricted time to veto before automatic execution, or
	5. executes that suggestion if the human approves, or
	4. suggests one alternative
	3. narrows the selection down to a few, or
	2. The computer offers a complete set of decision/action alternatives, or
LOW	1. The computer offers no assistance: human must take all decisions and actions.

Table 2: Automation design framework (Parasuraman et al., 2000)

According to the model there are four classes where automation can be implemented:

- Information acquisition
- Information analysis
- Decision and action selection
- Action implementation

Each function can be automated at different levels. An automated tool is not limited to a single function, but can rather involve automation across all the functions with different levels of automation. The more detailed definitions of the different functions are left outside the scope of this paper.

The flow chart in figure 4 illustrates the model's iterative process of designing automation with appropriate level of automation for each type of function. The primary evaluative criteria are human the performance concequenses. This design framework is also useful outside the deskilling context as alongside skill degradation, other factors such as mental workload and complacency are included in the primary evaluative criteria.

Parasuraman et al. (2000) state that any level of automation should be evaluated by examining the human performance concequences. The merits of automation can be determined by examining these consequences, but in order to apply the full model other factors, the secondary criteria, automation reliability and cost of decision and action outcomes are iteratively applied. The process is then repeated for the other types of automation.

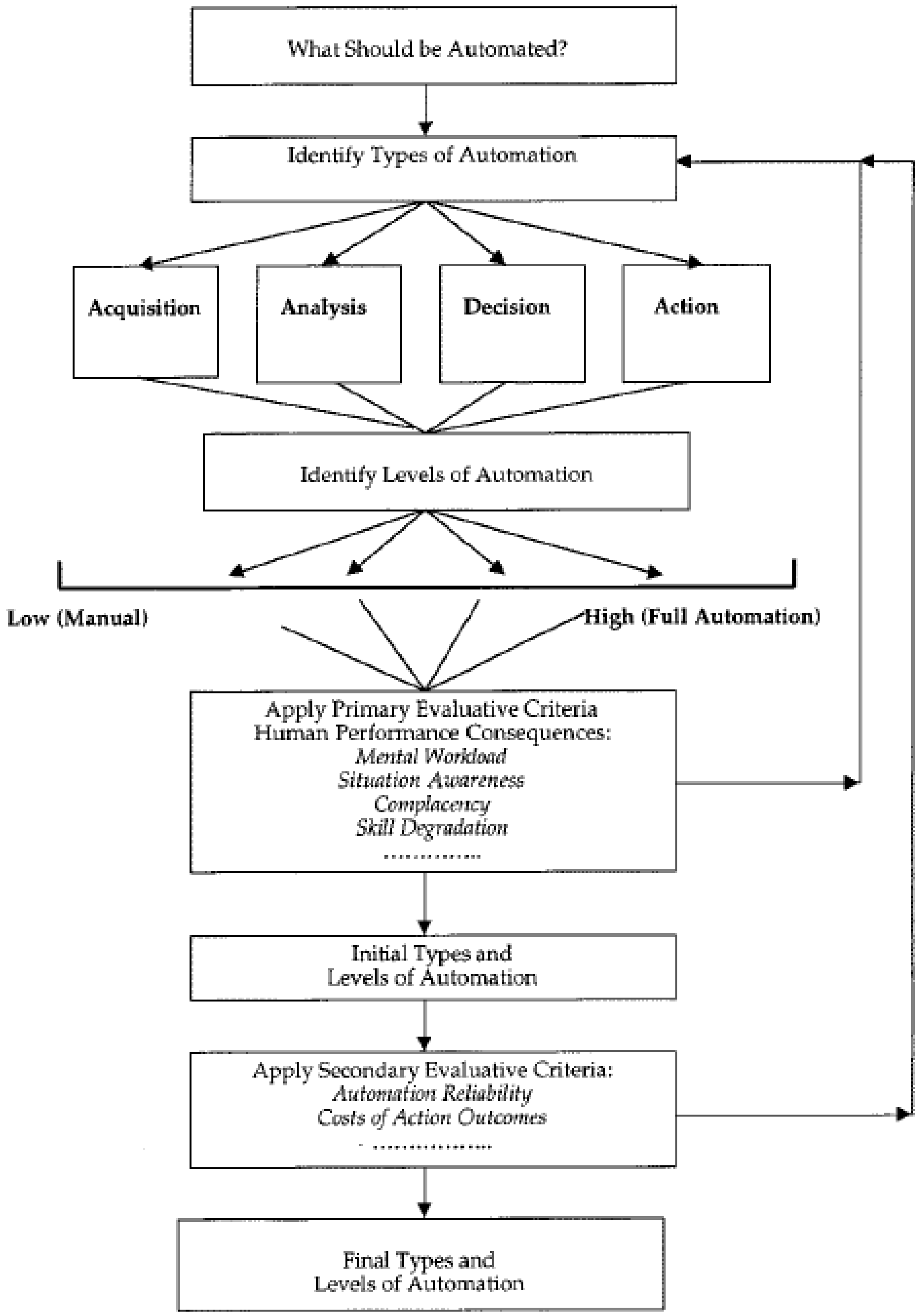

Figure 4: Automation design framework (Parasuraman et al. 2000)

Optimally the design of an automation tool should not be “one size fits all”, but anticipating all the unintended ways an operator might use the automation is difficult.

If the automated tool can be designed to be highly reliable then high levels of automation can be justified (Parasuraman et al., 2000). In such a case the negative effects of deskilling are mitigated as the automated tool can reliably perform the assigned tasks, in turn facilitating reskilling as human operators can reliably focus on their human capital as the main source of productivity and innovation. While higher levels of automation are identified as causes of deskilling, situations where the deskilled employees have to perform the forgotten tasks are rare if the automaton tool has a high level of reliability. However, high reliability of an automation tool with high level of automation is not a solution to deskilling, but a temporary fix.

While automation tools can be designed to be reliable in the known conditions, there are a multitude of unknown factors that are hard to be accounted for. Such factors are unplanned variations in the operating conditions, malfunctions, unexpected behaviour of other software or operators etc. The temporary fix from high automation reliability does not negate the operatonal risk when deskilling and operators unfamiliarity with the manual operation of the task prevent the operator from succesfully completing the task should automation fail (Parasuraman and Riley, 1997). Since perfectly reliable automation is an elusive target, employee training and work practices should reflect the fact that automation is not fully reliable (Rovira et al., 2002).

While Braverman (1998) acknowledged that machines can be designed in a variety of ways, he argued that the management’s ideology of control determined which designs were comissioned and deployed. Typically managers invest in new IS technology when they believe it will allow for quicker and less expensive accomplishment of operations, but the more complex ways IS can provide sources of competitive advantage are starting to be identified by managers (Zuboff, 1985).

The way automation is implemented can greatly affect whether deskilling or reskilling happens. If the operators’ confidence in their own abilities is greater than their trust in automation, the tool tends to be left unused (Parasuraman and Wickens, 2008), while low level of self-confidence can lead to overreliance of automation (Parasuraman and Riley, 1997). But whether employees used automation to deskill depended on their attitudes and backgrounds (Buchanan et al., 1983). These factors can be addressed with adequate training and evaluation.

As the decrease in professional interaction with the decision processes leads to deskilling, the feedback given by the automated tool can be used to motivate the professionals to involve themselves in the process (Mascha and Smedley, 2007). Mascha and Smedley propose embedding information within the explanatory facilities of a decision aid as a solution. However, just a passive monitoring mode encourages deskilling (Bhardwaj, 2013) and thus the automation tool should leave room for practice with feedback. Job rotation can be used to facilitate the need for practice, encouraging employees to develop a wider skillset and alleviate the side effects of performing the same tasks for a long time (Adler, 1986; Schuppan, 2014). Returning full control over the task to the employee for periods of time can be used to prevent deskilling and additionally encourage more attentional sampling of the automated task (Rovira et al., 2002).

Arnold et al. (2004) explain the different ways novices and experts benefit from different types of explanations according to their expertise:

- *Novices*, in their declarative phase benefit from explanations that provide declarative knowledge and problem-solving strategies
- The knowledge compilation phase of *experienced* users is enhanced by strategic explanations and feedback how the declarative knowledge was used in formulating the solution
- *Experts'* problem-solving methods are unconscious in the procedural phase, and they benefit from explanations for anomaly resolution when there is disagreement between the expert and the tools conclusion

The user's orientation toward goals can also affect the level of recall and performance, if the user is not oriented towards learning they are less likely to encode knowledge even if encountered during problem resolution (McCall et al., 2008). This can render the feedback provided by the tool as an obsolete measure for countering deskilling. Individuals goal orientation is a factor that can be addressed in hiring processes.

Feedback can be provided as rules the automation follows when arriving to a solution, or as text-based feedback explaining these rules. While TTD itself does not provide guidance for the question which kind of feedback a tool should provide, it can be extended to explain how feedback can affect automation reliance. Thus, TTD serves as a valuable tool designers of decision aids helping to evaluate how much and what kind of feedback the automation should provide. (Mascha and Smedley, 2007)

Managers and automation designers should aim to keep up employee competency through informating (Hollan et al., 2000) whether through system design or work practices. An IS automation tool that functions as a source informating the users about the underlying productive processes can work as the base for further innovations (Zuboff, 1985).

Based on the literature covered in this chapter we hypothesize that:

H3: Automation tools should be designed without excessively high levels of automation and with built in feedback mechanisms to keep the operators in the process loop

H4: Management can compensate for deskilling and facilitate reskilling through employee training and designing work processes anew with automation in mind

3 Discussion

When managers decide the level of automation to be implemented they should bear in mind that deskilling is an involuntary phenomena, but reskilling is a challenge that must be stimulated with training and support (Bravo, 2015). If the challenges and possibilities of automation are not tackled accordingly, the organization may end up with a technology that neither augments skills nor pushes the boundaries of possible, but rather replaces human skills with a technological solution (Klapperich and Hassenzahl, 2016).

As latent deskilling poses a great operational risk for companies, automation should be approached as a tool for informating the users. Instead of the IS automation becoming a black box which operates the tasks with occasional feedback, the system should enable the human workers to further develop their skills and work as a platform for futher innovation.

This can be accomplished with appropriate IS automation desing by factoring in the different aspects of IS automation design discussed in the previous chapter and by advisable implementation of automation. The automation tool should encourage task involvement. Training with feedback and varying levels of automation facilitate reskilling and skill retention. Automated tools should be designed as sources of knowledge informating users, rather than operators taking over the processes previously executed by humans.

The correct implementation encases the planning of work processes accordingly, training and support in the use of the automation. Management taking preventitive measures against alienating from workers is basic business doctrine, but holds true in context of deskilling as well. The epmloyees are the company's in house experts and should be involved when the the features of an automated system are defined. Work processes with automated tools should include training and processes encouraging practicing the automated processes. Job rotation and disabling automation for periods of time are potential means to retain skills.

4 Conclusions

This paper has reviewed a wide range of literature covering automations effects on the skillset of the user and how design and implementation of automation play a role in the change of skills. The objective was to describe the deskilling, up-skilling and reskilling effects in an information systems context. The aim was to identify the factors and causes behind these effects to further understand what actions can be taken to manage these changes in skillsets.

The research papers covered discussed deskilling and up-skilling in both industrial and information systems. Deskilling and up-skilling in an industrial context have similar traits to deskilling and up-skilling in IS context, so the inclusion of the research papers with industrial frameworks provided a deeper insight how automation affects skills. This holds true to the design and implementation of automation as well.

Deskilling is present when automation is introduced to processes previously performed by humans. Ultimately deskilling is caused by the lack of exercising the tasks outsourced to automation. Increasing automation levels deskills the users more than low levels of automation. Hight levels of automation further leads to automation reliance, which has been identified as the main impetus behind deskilling.

Yet while automation causes deskilling, it can introduce new skills as well. This effect called up-skilling caused by the need to learn new skills to actually operate the automation and new work processes with automated tools. Up-skilling can widen the skillset of the users of automation or the non-users. For example, users can learn troubleshooting skills and non-users like a company's IT department can learn new skills needed to upkeep the automated system.

Deskilling and up-skilling rarely happen independently, whereupon the reskilling effect is present. To compensate for the loss of skills reskilling should be stimulated with training and support.

As deskilling is an inherent feature of automation, automated tools should be designed and implemented with this fact in mind so preventative measures against deskilling can be taken. Managerial tools against deskilling are facilitating practice of the skills needed to perform tasks without automation, such as job rotation and disabling automation for periods of times. Furthermore, training and support should be used to induce reskilling.

Automation designers can design the tools to give the users feedback on the operations it executes so that the underlying processes stay visible and comprehensive. Excessively high levels of automation lead to reliance, therefore what to automate and to which degree plays a major role in automation design.

4.1 Implications to practice and limitations of the study

The introduction of IS automation can have unnoticed effects on the skill base of the workers, potentially leading to crippling of in house expertise, to enabling further innovations and expertise development. Managing this change IS automation can bring forth is not a simple concept to grasp.

This paper offers a summary of the effects automation has on skills and what factors play a role in the outcomes. Understanding these effects and factors are especially important when aiming to higher levels of automation or the automation of complex tasks to mitigate operational risks.

An IS automation tool should have built in preventative measures against overreliance on automation. The tool should provide users appropriate levels of feedback and opportunities to train to prevent dismissing the old skillset as obsolete.

Job rotation or disabling automation for periods of time are managerial means to combat overreliance. Planning the work processes to capitalize on IS automation to facilitate reskilling can be used to negate or even surpass the negative effects of deskilling. The automated tool should be used to free human workers to exercise their strengths creative thinking and other fields where humans excel over computers.

Generating a backup plan for automation failure beforehand can be a salvation in the event the automation of a critical function fails. This is even more important as latent deskilling is hard to detect thus posing great operational risk to an organization.

Some of the literature covered in this thesis discusses automation in the context of industrial or manual labour. While the same frameworks can be used in the context of IS, it should be noted that they might not represent the context of IS, as the deskilling of intellectual workers does not follow the same linear manner as the deskilling of manual labourers (McNally, 2010).

4.2 Future research

This paper offers a comprehensive literature review to the effects IS automation has on the skills of the users. This paper mostly conglomerate previous research on the field of deskilling and up-skilling, using frameworks from both contexts of manual and IS automation, and the design and implementation factors that have a relevant effect.

While automations deskilling, and up-skilling effects have been the subject of research from the middle ‘80s, there exists some difference in opinions as to the cause and terms related to deskilling. Still prior research in the field of manual labour automation offers valuable knowledge to the deskilling and reskilling effects, and should not be disregarded when shifting focus to IS automation.

The coping strategies for recovering from the disruption caused by deskilling were left outside of the scope of this thesis and should be considered for future research, as current research on coping methods have mainly been discussed in contexts other than IS (Rinta-Kahila et al., 2017).

Additionally, how automation should be designed and implemented for it to work as the source informating the users was left outside of the scope of this paper and offers an interesting area of research how IS automation can be further capitalized on.

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