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Obsolescence in IT Work: Causes, Consequences and Counter-Measures

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Abstract. The fast-moving nature of information technology is causing frequent obsolescence of technologies and competences. Changes in the environment cause a reduction in the need and demand of old competences. This results in a depreciation of these old competences and a reduction in performance in comparison to individuals with up-to-date competences. Obsolescence is especially relevant for IT professionals because the technologies they work with, and thus the demanded competences, change particularly frequently. However, what effect does that have on the education and development of IT professionals and IT work? To answer that question, we have conducted a systematic literature review. We have analyzed 115 relevant hits and identified key aspects and issues for future research. Causes for obsolescence, consequences of obsolescence, and counter-measures against obsolescence are presented as the three central dimensions of the topic.

Keywords: obsolescence, IT professionals, IT work, training, literature review.

1 Introduction

IT professionals are of high demand, given their unique skills in areas such as programming or software design [1]. Therefore, obsolescence is a current and important issue in information technology. When technical or economic skills are obsolete, they are less valuable and the individual is less capable than an individual with more recent skills. This can be problematic for employees and organizations. It is especially relevant for IT professionals because the technologies they work with, and thus the demanded competences, change particularly frequently [2-5].

In April 2020, the US state of New Jersey was looking for COBOL programmers because their unemployment insurance system was overburdened by the many requests resulting from the COVID-19 pandemic. The problem was that hardly any programmers can still use COBOL because the language has been outdated for about 30 years and is no longer taught [6]. This example shows that the obsolescence of systems and skills can have unexpected consequences for various aspects especially for the work of IT professionals. To prevent professional obsolescence, it is necessary to constantly renew one's skills [7-8]. This makes it interesting to investigate how

obsolescence affects the education and further training and learning of IT professionals. For example, continuous training and learning [7], [9-12], and updating [13-16] are necessary to deal with obsolescence. In addition, a change in the organizational context [17], career pathing and planning [9] or special job design [15], [18-19] may be required.

Up to now, the topic of obsolescence in research has not been uniformly understood across its various dimensions (e.g. [10], [13-17]). Moreover, there are different perspectives on the topic, especially with regard to the definition of the phenomenon [4], [18], [20-27]. In order to better understand the phenomenon of obsolescence in all its aspects and to find out what causes, consequences and counter-measures exist for obsolescence, we investigate how obsolescence has been conceptualized so far and conduct a structured literature review for this purpose. Therefore, the following research question will be answered: *What are the central characteristics and causes of obsolescence and what are the consequences and possible counter-measures for IT professionals, IT work and organizations?*

The structure of this paper is as follows. The next section reviews the central conceptualizations of obsolescence and highlights differences through an analysis of the definitions. The methodology is then described. The subsequent section presents the three main dimensions of the topic: causes for, consequences of, and counter-measures against obsolescence. Afterward the results are discussed and finally, limitations and issues for future research are described.

2 Theoretical Background

Obsolescence describes that something becomes outdated and therefore loses value [4]. Related to professional competences this means that the once valued competences are not in demand anymore because they do not fit the requirements of the job or the profession and therefore decrease in value and contribute less to performance [4], [18], [20-21]. Knowledge, skills and abilities are often equated with competencies [22]. There are many different categorizations of skills and abilities, with a division into technical or hard skills and soft skills being common. Soft skills include interpersonal, management and other non-technical skills [23]. In IS research, definitions of obsolescence are not consistent. There are still some differences between the concepts, for example in terms of depth, detail and focus.

In general, obsolescence is frequently not explicitly defined, only a small part of the papers that mention obsolescence in an IS context provide a definition, presumably because obsolescence is part of common language usage. Table 1 lists the most important definitions of obsolescence in an IS context.

The following definitions are based on definitions from other disciplines. While Ferdinand [24] describes obsolescence in engineers and scientists, Dubin [25], Fossum et al. [26] and Kaufman [27] cover obsolescence in professionals in general. Ferdinand [24] and Kaufman [27] both define obsolescence as the lack of up-to-date knowledge. Dubin [25] and Fossum et al. [26] on the other hand describe that obsolescence results from a discrepancy between requirements and competences.

Table 1. Definitions of Obsolescence

Paper	Definition
Blanton, Schambach & Trimmer [18]	"Professional obsolescence represents a deficiency that occurs to the extent a mismatch develops between vocational requirements and abilities possessed by the professional. [...] Professional competency is a broad concept, whereas job competency relates only to ones' ability to perform requirements of their current job or position."
Fu & Chen [20]	"Professional obsolescence refers to the decay or decrease in the value of professional competencies. It occurs when the job incumbent's expertise (which was sufficient to the requirements of the profession previously) is mismatched with current work demands and skill requirements owing to change in the knowledge domain."
Glass [31]	"There will come a time, I realize, when I am no longer able to keep abreast of the states of the art and practice. And I will know I have reached that point because I have just read or heard something about one or both of those states that I am unable to follow, no matter how hard I apply my own personal understanding based on having been there and done that, or studied about it."
Joseph & Ang [4]	"Professional obsolescence is typically defined as the erosion of professional competencies required for successful performance. It is essential that IT professionals possess up-to-date competencies because it affects their employability, career development, and compensation. Therefore, the erosion of competencies constitutes a potential threat to IT professionals, i.e., the threat of not being up-to-date with the rapidly changing technology environment."
Rong & Grover [21]	"Obsolescence examines the discrepancy between the changing rates of job requirements and the rates of acquiring knowledge and skills. In essence, it reflects the extent to which professionals lack in knowledge of up-to-date methods needed to maintain effective performance in their current or near-future job roles."

While most of the previous definitions are somewhat similar some notable definitions differ. Shearer and Steger [28] argue that a definition of obsolescence should not be tied to effectiveness because they see no satisfactory way to measure that. They also do not distinguish between obsolescence and incompetence, in contrast to almost all other definitions, which describe obsolescence as incompetence only in relation to up-to-date competences. However, Pazy [14], [29] emphasizes the importance of exploring individuals' perceptions of obsolescence, which tend to be varied and can therefore not be aggregated. She contrasts this with the prevalent view of obsolescence as simply a deficiency. De Grip, Van Smoorenburg and Borghans [30] describe different kinds of obsolescence, of which obsolescence according to other definitions is only one type, e.g. they also consider wear and tear as one type of obsolescence. But all of these are not specifically related to IS professionals.

Some differences between conceptions are already pointed out in previous research. Pazy [29] categorizes definitions based on whether they focus on the lack of knowledge as a reason for obsolescence or on the consequences, mainly in terms of impaired skills and work performance. Pazy [17] notes that obsolescence is usually defined in relation to the requirements of the workplace or the broader occupational field, but sometimes the reference is a consensually estimated body of knowledge.

Other differences are the inclusion of both obsolescence regarding the current job and obsolescence regarding the general profession (e.g. [24] vs. [20]), the focus on influencing factors or outcomes (e.g. [26] vs. [28]) and whether it is explicitly connected with less effectiveness or performance (e.g. [4] vs. [26]).

Taking all these differences into account, it is difficult to systematize the various definitions, as they are usually based on the same aspects with only minor differences. In all definitions the professional is obsolete because he is not familiar with the competences that are expected of him. In some cases, this is specifically due to new knowledge, sometimes the expectations are specified as job requirements and in some definitions the obsolescence has an explicit impact on performance.

3   Method

In this review, we searched for publications that focus on causes, consequences and countermeasures of obsolescence. We screened relevant outlets according to the guidelines of vom Brocke et al. [32] and then coded the studies with regard to their key findings on the central aspects of obsolescence. We determined the scope of the systematic literature review based on the proposed taxonomy following Cooper [33].

At first, we conducted a search (title, abstract, keywords) with the search term "obsolescence" AND (train* OR learn*) AND (it OR is OR "information technology" OR "information systems" OR cs OR "computer science" OR "programming") in the journals included in the Senior Scholars' Basket of Journals of the Association for Information Systems. However, we have not limited the search to these journals. Hits from other journals and conferences were also included. The following journals were most commonly used (number in brackets): MISQ (5), SIGMIS Database (5), CACM (4), JHRM (4), JISE (4). In addition, the following conferences were used most frequently (number in brackets): ACM SIGMIS CPR (9), AMCIS (6), ICIS (3), HICSS (2). We searched the local university library database, EBSCOhost in Business Source Premier, ERIC, Engineering Source, Education Source, and EconLit, at Scopus and in the ACM Digital Library. The time span was not limited in the literature search. First, we screened the title and then the abstract of all 836 articles and identified 41 relevant publications. Some articles were excluded by an exclusion procedure based on the following criteria. Articles in which the topic of obsolescence is not mentioned and researched were excluded. In addition, the article should refer to IS professionals and the topic of learning or training should be included in the elaboration. Sometimes articles were included in the analysis that met only one of the criteria, because an interesting aspect is covered.

Then we performed a forward and backward search based on the articles collected so far, looking mainly for theoretical foundations, further new applications and results. This resulted in 38 additional publications. Based on these hits, a second forward and backward search was carried out, which resulted in 50 extra articles. After the exclusion of some hits, the sample consists of 115 articles. Table 2 provides a summary of the literature search process.

Subsequently, we coded the selected publications along three main coding dimensions. The first dimension covers the different causes of obsolescence. Various causes occur in the environmental context (e.g. new technologies) or in the organizational context (e.g. job requirements or organizational development) [26]. The second dimension represents the possible consequences of obsolescence. Obsolescence has different effects on individuals (e.g. emotional consequences), organizations (e.g. worse performance), or the whole environment such as the labor market (e.g. unemployment) [9]. Lastly, the third dimension comprises counter-measures against obsolescence. Various actions can help to combat obsolescence (e.g. updating or job design) [18], [34]. By summarizing the key aspects and findings along the three coding dimensions, we can carve out the focus of existing research and identify issues for future research.

Table 2. Summary of the literature search process

Outlet	Search	Hits	Selected
Scopus	*obsolescence AND (train* OR learn*) AND*	193	20
ACM DL	*(it OR is OR "information technology" OR*	37	0
EBSCOhost	*"information systems" OR cs OR "computer*	66	6
local university library database	*science" OR "programming")*	540	15
	Forward search	-	23
	Backward search	-	15
	second Backward and Forward search	-	50
			129
	excluded		14
	Total	836	115

4   Results

In this section of the paper, we summarize the insights from our literature review on obsolescence in IS following the three main coding dimensions: causes, consequences, and counter-measures of obsolescence. Causes are various conditions or factors that lead to obsolescence. Consequences are conditions or factors that are caused by obsolescence, and counter-measures are actions that can be taken to prevent or mitigate obsolescence. Each dimension is summarized in a separate table. The number of studies

identifying the relevant aspects is listed. If more than one aspect is included in the study, it was sometimes counted twice.

4.1 Causes of Obsolescence

Obsolescence occurs when the abilities of the individual no longer match the abilities required by the role. The causes for obsolescence are therefore changes in the role that do not match the changes of the individual. Role changes can be influenced by the environmental context (e.g. new or changed technologies) or by the organizational context (e.g. job requirements or organizational development) [26]. Table 3 summarizes the main causes of obsolescence.

Most articles see the main cause of obsolescence in the technological context, as can be seen in Table 3. Relevant technologies, and thus skills and roles, change over long periods of time [9]. Technological change is often cited as the central driver for role changes and therefore obsolescence (e.g. [35-39]). Existing technologies change and develop over time. Two examples of recent technological changes are the shift from mainframe to client-server (or vice versa) or the move to enterprise resource planning systems [36]. Besides the development of existing technologies, new and innovative technologies also play a major role [21], [40-44]. In addition to technological change or innovation, other factors from the external environmental context can also cause obsolescence. Dubin [25], Blanton et al. [18] and Egan et al. [44] see an impact of globalized markets. In addition, Ang and Slaughter [9] see an influence from IT labor markets, through labor shortages and regional differences.

Table 3. Main causes of obsolescence

Causes for Obsolescence		Studies	Total	Example Articles
technology	existing technologies that are changing or developing	55	71	[35-37]
	new technology and technological innovation	16		[21], [40-42]
organization-individuum fit	job requirements (e.g. changes of knowledge and skill requirements)	22	40	[16], [20]
	change in roles	7		[3], [8]
	organizational development (e.g. differences between job changes and personal changes)	11		[22], [26], [45]

Another important reason for obsolescence lies in the organizational context. High work and job requirements, overload, a lack of opportunities and support can lead to a continuous failure to keep up to date [46]. Especially in the IT discipline new skills and knowledge are needed due to rapid technological change [7-8]. Role changes of IT professionals are potential causes of obsolescence [26]. New technology creates the

need for new jobs and a broader skills base [23]. More IT professionals work outside the traditional IT department and the tasks of professionals have changed [3]. There are also more IT professionals working as independent contractors [8]. Finally, organizational development can lead to obsolescence, e.g. in consequence of differences between job changes and personal changes [22], [26], [45]. Sørensen and Stuart [47] describe that obsolescence also occurs when the organization's innovations no longer match environmental demand due to technological change.

4.2 Consequences of Obsolescence

The consequences of obsolescence are described below and summarized in Table 4. Different levels are considered: the level of the organization, the individual level, and the macro-environment [9]. The organizational level includes human resources and business results, the individual level covers attitudes and behavior of employees and the macro level describes the aspect of labor markets and the national economy. The results at these levels also influence each other. For example, if individuals are not able to perform high-quality work, this results in the underperformance of companies and thus of the industry as a whole [19].

Table 4. Main consequences of obsolescence

Consequences of Obsolescence		Studies	Total	Example Articles
individual level	emotional consequences: stress, strain, work exhaustion, uncertainty	13	24	[29] , [35-36], [46]
	turnover	3		[4], [48]
	change of professions or career commitment, turnaway	8		[20], [49-51]
organizational level	worse performance or productivity	11	18	[36], [43], [52-54]
	need for investments or higher costs, legacy systems	7		[29], [55]
macro level	(un)employment	3	18	[54], [56]
	shortage of skilled workers	5		[7], [19]
	universities: obsolete curricula, obsolete teaching material, outdated courses	10		[39], [57]

On the individual level, the emotional consequences of experiencing obsolescence can include dissatisfaction, tension, boredom, pessimism and frustration [29]. Other

common negative emotions are helplessness as well as inability and fear for one's reputation. The reason for this can be the forced self-assessment that calls one's own professional identity into question [35], [46]. Obsolescence can also have an impact on stress and psychological strain. Chilton et al. [36], for example, showed mental stress among professionals in transition.

Obsolescence also influences the intention to change the organization or profession ("turnover intention" or "turnaway intention"). Arman et al. [50] as well as Colomo-Palacios et al. [51] identify a strong correlation between the threat of obsolescence and the intention to change the profession or to give up the software career. This is also consistent with the findings of Fu [49] and Fu and Chen [20], which found a correlation between the threat of obsolescence and career commitment among IT professionals. Joseph and Ang [4] note that IT professionals who feel threatened by obsolescence are more likely to want to change their organizations than their careers.

At the organizational level, obsolescence can lead to lower productivity and performance [43], [52-53]. The lower performance can result from a skills mismatch in the labor market [54]. Lower productivity may also be a reason for lower performance because a lot of learning is needed in transition periods [36]. Obsolescence can also result in information systems becoming "legacy systems", i.e. obsolete systems. This makes them more expensive to maintain [55].

At the macro level, technological change in the labor market can lead to a skills mismatch between supply and demand and thus to higher unemployment [54]. Another emerging problem at the macro level concerns universities. Obsolescence leads to outdated curricula, obsolete courses, and obsolete teaching materials [39], [57].

4.3 Counter-measures against Obsolescence

Previous research has not yet brought together what can be done to combat obsolescence. Therefore, this section groups and explains the most important counter-measures against obsolescence. Table 5 summarizes the results. We divided the measures into two categories: Measures relating to the person or the individual and those relating to the task or work of the person.

Measures that start in higher education are mostly about adapting to the needs of the industry. The major problem in curriculum design is the increasing range of skills required by employers [22], [58]. One way to provide this necessary breadth of skills is to offer different courses of study to prepare students for different IT professions [3], [41]. Great flexibility in the composition of courses can also be helpful to allow for different specializations [58]. Another measure against obsolescence is a change in the way teaching is organized, for example, to promote non-technical skills such as communication [38-39], [63].

Table 5. Main counter-measures against obsolescence

Counter-Measures against Obsolescence			Studies	Total	Example Articles
related to person	education	curriculum design or redesign	24	79	[22], [41], [58]
		changing the structure of teaching	8		[38-39], [57]
	skills set	training, continuous and lifelong learning	35		[9-12]
		support updating	12		[13-16]
related to task	changing the organisational context		6	17	[21], [59-60]
	staffing		4		[23], [26], [61-62]
	career pathing and planning		2		[9], [19]
	job design		6		[15], [18-19], [63]

Other measures that relate to the individual are aimed at changing the person's skill set. On the one hand, continuous learning and training play an important role. With rapid changes in IT, it is challenging to maintain a capable workforce [7]. Training is an important part of development measures that can prevent obsolete and stressed employees and staff turnover [7], [9-12]. Training helps employees to acquire the new skills they need to fill new roles [9]. In addition to technical skills, non-technical skills and characteristics such as self-efficacy should be trained [7], [20]. On the other hand, organizations must support updating. Updating can be a reaction to obsolescence [13], [16]. Furthermore, it is a way of coping with obsolescence [13-14], [17].

Additional measures relate to the work and tasks of individuals. Because the most important learning takes place at work, a supportive climate, work design, and support from supervisors are particularly important in preventing obsolescence [17]. According to Solomon [59], it is important to create an organizational environment where information is shared and to create a culture that sees continuous learning as a core value of the organization. Furthermore, the authors Gallivan et al. [58] and Lentini and Gimenez [52] describe lifelong learning as necessary for IT professionals. Aasheim et al. [41] underline the importance of the willingness of IT graduates to learn. Other research highlights the need to create a basis for lifelong learning [23], [64-65].

Staffing can also be a way to prevent obsolescence at the organizational level. For organizations, recruitment can be faster than training their own employees [26]. It may also be cheaper to train a graduate than to teach new technologies to a more experienced and thus possibly better-paid employee [23]. Recruitment is also a way for the company to learn. They help older organizations, in particular, to combat obsolescence by creating new areas of knowledge in the company [61].

Additionally, Ang and Slaughter [9] see career pathing and planning as an effective part of professional development. The development of career development plans for individual workers to help to combat obsolescence [19].

Furthermore, the design of the work (job design) determines what kind of work has to be done and how it has to be performed. Challenging tasks and rotation programs can prevent obsolescence [15], [18-19]. Work design can be used to provide growth opportunities and develop human capital. It also affects job satisfaction and employability [7]. Therefore, job design, for example through job rotation or job enlargement, should be part of development programs [63].

5   Discussion

In this section, we discuss central issues for future research on obsolescence in IS based on the analysis of the existing literature. We discuss three major issues: the importance of obsolescence for IT work research, the need for further research on the counter-measures against obsolescence, and the specialty of the topic for new forms of work like working the gig economy. We suggest that future research on these topics will deepen our understanding of obsolescence in IT and enable us to derive recommendations for dealing with it in practice.

We firstly suggest that obsolescence is especially important in the IT discipline and must be better understood in the future. A constant renewal of the skills and knowledge of IT professionals is necessary, as rapid technological change and other factors mean that old skills are no longer needed and demanded. For example, because of the pressure to adapt to rapidly changing customer requirements and manage increasingly complex IT architectures, many organizations have begun to establish joint cross-functional DevOps teams that integrate tasks, knowledge and skills related to the planning, building and operating of software product activities [66]. At the same time, skills may remain relevant beyond their actual obsolescence if systems based on obsolete technology are not fully replaced [23], [35-37]. This phenomenon should be further investigated in the future.

Especially IT professionals are affected by obsolescence because current technologies and market conditions, and therefore the skills required, change particularly frequently [67]. IT work is driven by rapid technological change, resulting in rapid obsolescence of knowledge and the continuing need for learning, updating and training [68-69]. The IT discipline has changed more rapidly than other professions. The demands on skills and knowledge of IT professionals have changed significantly and technological change is causing dynamic developments [68]. For this reason, obsolescence is one of the greatest career challenges and a threat to IT professionals [2-3]. The knowledge and skills of IT professionals are becoming obsolete faster than the skills of other professionals [4].

Despite this described relevance for IT work, the problem of obsolescence has received little attention in previous IS research. It should be investigated more in the future, especially since the topic of obsolescence will become even more important in

the future, as new technologies are always being developed, but the old technologies are never completely replaced.

Second, the literature research revealed that there are limitations of current research concerning counter-measures against obsolescence. Although IT professionals are constantly faced with the threat of professional obsolescence, little research has focused on how to deal with it and what counter-measures can be taken. Previous research has not yet brought together what can be done to combat obsolescence.

Several counter-measures were identified in this study, but these will have to be examined more closely in the future. It should be highlighted how the different ways to combat obsolescence affect individuals and organizations. Furthermore, it has not yet been fully investigated how employers and organizations can be motivated to take obsolescence seriously and implement measures to manage it.

The topic is also relevant to universities. In the analysis of this paper, it was emphasized that education has to deal with the consequences of obsolescence, such as obsolete curricula, obsolete teaching material or outdated courses. Due to the special importance of obsolescence in the IS discipline, IT degree programs in particular need to be adapted. Therefore, future research in this area is necessary.

Finally, an analysis of the existing literature revealed a lack of research on the consequences of obsolescence in non-standard employment situations. Papers dealing with updating and obsolescence only consider traditional employment relationships. Although they point out changing roles and labor markets, the focus is usually on employees. Novel work conditions such as those of the gig economy are very different from the working conditions of traditional employees.

Technological change has led to more people working outside strong organizational contexts in a so-called "gig economy", as independent workers loosely linked to organizations or selling directly to the market [70]. Typical characteristics of gig workers, as opposed to traditional employment relationships, are higher financial instability and job insecurity, higher autonomy, career path uncertainty, work transience and psychical and relational separation or loneliness [71]. Self-employed IT professionals such as gig workers must, therefore, take care of measures against obsolescence themselves as they do not receive any support from the organization, their supervisors or colleagues. They cannot shift the responsibility for updating to entire departments and must themselves take the measures that are actually the responsibility of the organization. Also, the motivation of the individual for dealing with obsolescence plays a major role. But the motivation of gig workers may be different from that of traditional employees [72]. Furthermore, the transience of this form of work requires gig workers to constantly apply their skills and expertise to new combinations of tasks when moving between jobs. Thus, many open questions become apparent which can be addressed in future research.

Our study makes several contributions to IS research and practice. First, we provide a broad overview of research on obsolescence in IS and the main aspects of the topic, and we bundle the results in different dimensions. Especially the three result tables help to sort the previous results by developing a structure for embedding obsolescence in the three dimensions. Second, we contribute to the IS literature by expanding the knowledge about the causes of obsolescence, the understanding of the consequences of

obsolescence at the individual, organizational and macro levels will be improved and countermeasures against obsolescence will be presented, which are person- or task-related. Third, we identify relevant gaps in research. Fourth, we emphasize the relevance of the topic, especially for IT work. However, it also becomes clear that the results are also relevant for other disciplines such as medicine or mechanical engineering. Finally, this study is relevant to practice by showing the relevance of dealing with obsolescence in organizations. There are several negative consequences if no or the wrong counter-measures are applied.

Despite valuable contributions, our study underlies several limitations. First, the literature search may not cover all relevant studies due to the choice of outlets and keywords. Second, the selection of sources is subjective, despite the systematic approach. Third, there may be other relevant topics for future research that were not identified in this study. These could be discovered by future work.

6   Conclusion

In this paper, we summarized and analyzed recent literature on obsolescence in IT and derived central issues for future research based on the presented results. We analyzed the different definitions and conceptualizations of obsolescence and described differences among these definitions. Furthermore, we identified and presented three main dimensions of the topic: causes for, consequences of, and counter-measures against obsolescence. In doing so, we highlighted three major issues for future research. First, we suggest that obsolescence is very important for IT work and must be better understood in the future. This will become even more important in the future as new technologies are always being developed but the old ones are never completely replaced. Second, the counter-measures against obsolescence need to be examined more closely. Different questions arise, for example how the measures affect different individuals or how employers can be motivated and supported to implement different measures. Third, it is very important, especially for new forms of work such as the gig economy, to investigate the different dimensions of obsolescence, as there is much more self-responsibility among gig workers for their careers and thus also for updating and training.

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