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Work instruction quality in industrial management

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ABSTRACT

Employees who must rely upon poor quality work instructions are less efficient and have lower job satisfaction. Thus, it is in most companies' interest to avoid this type of situation. However, a literature review revealed that literature on work instruction quality is sparse. To address this issue, this paper proposes a framework for understanding information quality of work instructions in industrial management contexts. The framework includes 15 dimensions of work instructional information quality problems, which are grouped into five categories: intrinsic problems, representational problems, unmatched information, questionable information, and inaccessible information. To illustrate the relevance of the framework in an industrial management context, studies of two engineer-to-order companies were carried out. The studies revealed that the companies experienced problems related to all 15 dimensions. The framework may be used as a guide for industrial managers who wish to avoid instances of employees performing work based on poor quality instructions.

1. Introduction

If employees have to base their work upon poor quality work instructions, they are less efficient, make more errors and have lower job satisfaction (Conner and Douglas, 2005; Lind, 2008; Oakland, 2011). Thus, it is in the interest of companies to avoid this quality inadequacy. But in order to avoid poor quality information in instructions, it is necessary to understand what this kind of quality refers to. However, literature has not dealt much with this topic, for which reason it is not clear exactly what instructional information quality is. To answer this question, this paper proposes a framework, which defines relevant types of information quality in relation to work instructions. The framework is structured within an industrial management perspective, which implies a focus on instructions related to design procedures, operating machinery, producing components, assembling of components, handling deliveries, service inspections, after sales, use of technology, etc. However, the usefulness of the framework may not be limited to this context.

It has been argued that poor data/information quality in companies can have significant negative economic and social impacts on an organization (Wang and Strong, 1996; Ballou et al., 2004). More specifically, poor quality data/information is claimed to have negative effects such as less customer satisfaction, increased running costs, inefficient decision making processes, lower performance, and lowered job satisfaction (Redman, 1998; Pipino et al., 2002; Kahn et al., 2002). It has also been argued that poor quality data/information is a common phenomenon, and that even small data inaccuracies can have large effects (Redman, 1998; Häkkinen and Hilmola, 2008; Marsh, 2005). However, such literature focuses almost only on types of ‘factual information’, which can be contrasted to ‘instructional information’ (Floridi, 2010, p. 34).

In relation to work instruction quality, studies show that this is a significant problem in many industrial contexts. This includes studies of work instructions in relation to aircraft maintenance (Patel et al., 1994; Drury, 1998), process-control plant maintenance (Garrigou, 1998), chemical plant operations (Bullemer and Hajdukiewicz, 2004), process reengineering at a teleoperator and a truck manufacturer (O'Mahoney, 2007), railway operation and maintenance (Holmgren, 2005), shipping safety (Oltedal, 2011), automotive assembly line operations (Huang and Inman, 2010), and hearing aid design processes (Sickel et al., 2011). In the worst case, poor quality work instructions can lead to fatal accidents. This is demonstrated by the study by Lind (2008), which investigates accidents in industrial maintenance in the Finnish industry and links 63% of the fatal accidents and 38% of the non-fatal accidents to defective work instructions.

As opposed to the topic of work instructions, related topics such as ‘learning theories’ and ‘information/knowledge management’ have received more attention in recent years. However, in the context of engineering companies, addressing instruction quality

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problems with theories of learning or information sharing can be an inefficient approach. The learning perspective is problematic because, in many cases, the main focus of instruction processes is not to help someone acquire (learn) new skills or knowledge. Rather, the purpose of giving instructions is often to provide someone with a description of what to do or how to do it, while the intention is not that the provided information should be recalled after use. Obviously, it is more efficient for production personnel to assemble a unique product based on stepwise instructions rather than internalizing (learning) this information before beginning the assembly work. The knowledge sharing perspective is also problematic because the aim of an instruction process is not to share the knowledge of the instruction sender but, rather, to ensure that the instruction recipient acquires the information needed to carry out the task in a satisfactory manner. By perceiving the process of providing instructions as a knowledge sharing process, the focus may shift towards making the recipient understanding the "world" in the same manner as the instruction sender. Thus, this perspective will inevitably imply that information not strictly required to carry out the particular task is shared, for which reason the process becomes longer. For example, although a designer or an engineer understands why certain components are chosen and why they should be assembled in a particular manner, such information is not needed for those conducting final assembly; they only need to know which components to pick from stock and how they should be assembled.

The focus of this paper is on work instructions in a broad sense, which includes instructions delivered in both verbal form (words communicated orally or in writing) and non-verbal form (pictures, images, models, gestures, etc.). However, regardless of the communication form, poor quality instructions need more processing than high quality instructions before the task in focus can be carried out. High quality instructions refer to more than the correctness of the instructions, but also to unambiguousness, completeness, meaningfulness, etc. For example, if an instruction appears ambiguous, is incomplete or includes terms not clearly understood, the employee needs to reason, guess, or gather additional information to figure out what to do. To avoid these outcomes, there is a need to understand what information quality means in relation to work instructions. Thus, this paper answers the question:

Which types of information quality are relevant in relation to work instructions in industrial management contexts?

The remainder of the paper is structured as follows. Section 2 conducts a literature review on information quality and work instructions. With a basis in the literature review, Section 3 derives relevant information quality dimensions in relation to work instructions. Section 4 describes empirical investigations of the framework. The paper ends with a conclusion in Section 5.

2. Literature review

The literature review of this paper consists of three parts. The first two parts focus on clarifying the concepts of 'information' and 'information quality', and a structured review on 'work instructions' follows.

2.1. Information

The terms data and information (and sometimes even knowledge) are often used interchangeably. However, a distinction can be made. According to Floridi (2011, p. 83), the commonly used definition of 'information' in research fields related to information science and information systems is "data with meaning" (or context). According to Floridi (2011, p. 84), this General Definition of Information (GDI) can be formulated as a tripartite definition (subsequently explained):

1) Semantic information consists of n data, for $n \geq 1$
2) The data are well-formed (syntax)
3) The well-formed data are meaningful (semantics)

In the first clause, the term 'semantic information' is used. The reason why this term is used by Floridi (2010, p. 32), instead of merely 'information', is to distinguish this kind of information from 'environmental information'. Environmental information refers to the possibility of meaning being given to data independent of an intelligent producer/informer. An example is the rings in the wood of a tree (i.e. a non-intelligent informer), which may be used to estimate the age of the tree. In the second clause, the term 'well-formed' refers to the data being organized according to the rules of the system, code, or language in focus. Thus, this concerns syntax, which refers to the combinatorics of the units of a language without considering their meaning. In this context, syntax should be understood more broadly than linguistics, as "what determines the form, construction, composition, or structuring of something". For example, engineers, film directors, painters, chess players, and gardeners use the term 'syntax' in this broad sense (Floridi, 2011, p.84). In the third clause, the term 'meaningful' refers to data which comply with the meanings of the chosen system, code or language, i.e. semantics.

In spite of the widespread use of the GDI defined above, some theorists argue that this definition is too loose and that a 'truth' element is required. One example is Dretske (2008, p. 29), who gives the example of being told about train arrival plans. If nothing you are told is true, this in fact implies that you have not been given any information about the train arrival plans, but merely misinformation. As Dretske (2008, p. 29) states "… misinformation is not a kind of information anymore than decoy ducks are a kind of duck". However, Dretske (2008, p. 30) acknowledges that there may be special purposes, for which the distinction between information and misinformation should be ignored, but in order to build a theory of information, the distinction is necessary. In this vein, Floridi (2011, p. 93) states that although the expression 'false information', linguistically speaking, is both common and perfectly acceptable, it is problematic. Floridi (2011, p. 93) provides a long, logical arguments for a 'truth' element being needed in the GDI and, thus, concludes that instead of 'false information', it is better to talk about 'misinformation' or 'pseudo information', which is not information. In this context, the common understandings of 'knowledge' may also be considered, i.e. in the explicit form as 'justified, truth(ful) beliefs' (Fuller, 2002; Newell et al., 2002) or, in the tacit form, as "the individual ability to draw distinctions within a collective domain of action, based on an appreciation of context or theory, or both" (Tsoukas and Vladimirou, 2001). More specifically, if information is understood as a basis for the creation of such kinds of knowledge, obviously, only truthful information is relevant.

In relation to work instructions, Floridi (2010, p.34) makes an important distinction between instructional and factual information. To illustrate the difference, Floridi gives the example of a flashing red light, which is a phenomenon that can be interpreted in both an instructional and a factual manner. More specifically, the flashing red light can be seen as a piece of 'instructional information' in the sense that the light flash conveys the need for a specific action, for example, recharging of a battery. The flashing red light can also be seen as a piece of 'factual information' in the sense that the light flash represents the fact that the battery is flat (Floridi, 2010, p. 34). Instructional information can be imperative (e.g. a

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recipe) or conditional (e.g. if-then constructs).

2.2. Information quality

The term 'information quality' has been attributed several definitions in literature. An overall definition, which is often used in information quality research, is 'fitness for use'. However, using an overall definition of information quality can cause problems, since a definition which works in one context may be misleading in others. For example, although 'fitness for use' may be fine when discussing the usefulness of some information for a particular user, it may be misleading if referring to aspects such as the correctness or reputation of some information, since information, which is partly incorrect or has a poor reputation, may still be useful in some contexts. Since the context defines which aspects of information quality are relevant, to provide a proper understanding of what information quality is, the concept needs to be subdivided into different information quality dimensions. Such information quality (or data quality) frameworks have been elaborated upon by a number of researchers, either by defining dimensions or reorganizing existing dimensions. This includes O'Reilly (1982), Ballou and Pazer (1985), Wand and Wang (1996), Wang and Strong (1996), Shanks (1999), Naumann and Rolker (2000), Xu et al. (2002), Bovee et al. (2003), Kahn et al. (2002), Price and Shanks (2005), and Foley and Helfert (2010). A discussion of each separate framework goes beyond the purpose of this paper. In brief, a basis is taken in two frameworks, which seem to have been developed on the most solid grounds (logical argumentation and empirical basis respectively). More specifically, at the intrinsic level a basis is taken in the framework by Wand and Wang (1996) because of their ontological approach, and at the extrinsic level a basis is taken in the framework by Wang and Strong (1996) because of their solid empirical basis as compared to other identified frameworks.

Wand and Wang (1996) derive four intrinsic data qualities by taking a basis in possible mapping problems between objects in an information system and the objects in the real world that they are to represent. The four intrinsic qualities are: complete, unambiguous, meaningful, and correct. These dimensions were later extended by Price and Shanks (2005), who derive another quality dimension, namely 'non-redundant'.

Going beyond intrinsic dimensions, Wang and Strong (1996) collect 118 data quality attributes from data consumers and consolidate these into 15 dimensions in four categories, as shown in Table 1. As seen, most of the dimensions identified by Wang and Strong are more related to the context in which the information appears (e.g. the skills of a specific user) rather than the information itself.

2.3. Work instruction quality

Literature on information quality of work instructions was identified in several steps by searching in titles, abstracts, and keywords in ISI-indexed journal papers. The first search was made on: ("industrial management" OR "operations management" OR "supply chain management") AND "instruction(s)" AND ("information quality" OR "data quality"). This search did not return any papers. Thus, it was decided to leave out the quality aspect, i.e. to search on: ("industrial management" OR "operations management" OR "supply chain management") AND "instruction(s)". This search returned 16 papers. Of these papers, two are non-English, two are not accessible, six focus on university education, and two mention only 'instructions' without any further clarification. Thus, two new searches were carried out, the first by combining the terms "instruction(s)" AND "information quality" and the other by searching for "instruction(s) quality". These searches returned 7 papers and 15 papers, respectively. However, none of the papers discuss the nature of instructional information quality.

Based on the lack of results with the first searches, it was decided to conduct searches leaving out the term 'quality'. More specifically, these searches were with the terms "job instruction(s)", "work instruction(s)", and "work description(s)". These searches produced 8, 39 and 18 papers respectively. It was decided to use these as a basis for the literature review and use references from these papers to gather additional literature, i.e. a 'snowball strategy'. Relevant literature from this process is summarized in the following.

According to Watson et al. (2010), the popular cognitive view on how any information is processed is centered on the idea that we construct internal representations from information presented through external representations. This is done in different ways, depending on the form of the external representation. Two basic forms of representations are mentioned, 'descriptive' and 'depictive'. Descriptive representations are based on symbols (text) that have no similarity to their referent, while depictive representations are based on information that is similar to its referent (Kosslyn, 1994; Schnotz, 2005). In this vein, Ganier (2004) argues that the construction of mental models based on pictures implies lower cognitive load than for text. Ganier (2004) also suggests that accompanying text with pictures enhances elaboration of mental models. This is supported by the study of Watson et al. (2010) which shows that depictive instructional information implies significantly faster learning curves than descriptive. Their study, on the other hand, did not identify any significant differences between static and dynamic depictive representations.

Several of the identified papers describe case studies related to the information quality in work instructions. But although, they show the significance of the topic, they do not go into detail about what information quality is in relation to work instructions. Patel et al. (1994) studied a system delivering work instructions to aircraft inspectors. These instructions were in the form of work cards, which are documents issued to inspectors or mechanics, describing in detail the steps required for a specific inspection or repair procedure of an aircraft. The study by Patel et al. (1994) revealed that the typical work card did not conform well to the principles of good information design. On the other hand, the report from the implementation of improved work cards showed highly significant improvements. Wenner and Drury (2000) examined 136 paperwork errors in an engine overhaul facility at a major airline company. They found that many such errors appeared to be related to poor instruction document design. Drury (1998) investigated job instruction documents for civil aircraft maintenance. He found that a particular document produced a

Table 1
Data quality dimensions (Wang and Strong, 1996).

Data quality categories	Data quality dimensions
Intrinsic	Believability, accuracy, objectivity, reputation
Contextual	Value-added, relevancy, timeliness, completeness, appropriate amount of data
Representational	Interpretability, ease of understanding, representational consistency, concise representation
Accessibility	Accessibility, access security

number of paperwork errors when used operationally. Garrigou (1998) studied the role of know-how in maintenance in a high-risk process control plant. They concluded that because of the complexity of process-control plants, work formalization by means of stepwise instruction is an indispensable tool for operators. The paper by Chang et al. (2006) argues that in relation to product line engineering (product family engineering), in order to overcome difficulties because of manual and ad hoc approaches, it is desirable to develop a systematic process including a set of activities, detailed instructions and specifications. Lind (2008) studied accidents in industrial maintenance operations. Based on an analysis of reports on accidents in Finnish industrial maintenance operations from 1985 to 2004, Lind (2008) found that defective work instructions were an important factor in relation to dangerous working methods such as conscious or unconscious risk-taking in task execution. In fact, in 63% of the fatal accidents, defective work instructions were a latent condition. In the non-fatal accidents, 38% were related to defective work instructions. Huang and Inman (2010) compared the work instructions at two automotive assembly line stations, one of little complexity and one of high complexity. They concluded that the more complexity, the greater chance of workers picking a wrong component, putting the components in the wrong slot, and mislabeling components. Sickel et al. (2011) studied hearing aid design processes, which “often are dictated by a source template representing the anatomy of a patient and a set of work instructions representing the description of surface modifications”. A central problem identified in the cases was ambiguities in written work instructions. The paper argues that it is an outstanding problem in prostheses design that work instructions are often vaguely defined, and a suitable outcome largely depends on the knowledge, experience, and skill of the designer. The paper by Oakland (2011, p. 517) discusses total quality management (TQM) as “a comprehensive approach to improving competitiveness, effectiveness and flexibility through planning, organizing and understanding each activity, and involving each individual at each level”. The paper produces a list of questions for management to consider before deciding that there is not enough justification for implementing TQM. This includes the question: “Do job instructions contain the necessary quality elements, are they kept up-to-date, and are employees doing their work in accordance with them?” (Oakland, 2011, p. 519).

3. A framework of instructional information quality

This section derives relevant dimensions of work instruction quality in three steps:

1) Definition of intrinsic instructional information qualities
2) Definition of extrinsic instructional information qualities
3) Construction of a framework of instructional information quality

3.1. Intrinsic instructional information quality

Instructional information quality is closely related to the perception of the individual, although in some situations there is more consensus about the quality of some instructional information than in others. For example, if the operation of a machine includes a sequence of four steps which are all necessary to start the machine, but the instruction manual only mentions three of these steps, it is rather easy to agree that the instructions are incomplete. Also, if one of the four steps says to wait for a red light to flash, but, in fact, it is a green light that will flash, this is obviously incorrect information. On the other hand, in cases where instructions have less of a stepwise character, different qualifications of different employees may lead to different quality experiences. For example, an instruction text may be ambiguous to some but clear to others because they have more experience.

To derive intrinsic instructional information quality dimensions, the focus is turned to the relationship between ‘needed instructions’ and ‘given instructions’. This differs from the intrinsic qualities for factual information (Wand and Wang, 1996), which focus on the relationship between information and the real world aspect it is suppose to describe. Therefore, intrinsic quality has another meaning in the context of instructional information. By deducing all possible types of mappings between ‘needed instructions’ and ‘given instructions’, six types of situations emerge. These are shown in Fig. 1 and subsequently discussed.

The first type of quality problem is ‘deficient instructions’. The term ‘deficient’ is used instead of ‘incomplete’ (such as Wand and Wang, 1996) since ‘deficient’ more clearly refers to some missing but necessary instructional element rather than missing parts of an instructional element. In fact, both deficient and ambiguous instructions may be seen as types of incomplete instructions, but the first, as mentioned, refers to a necessary element that is missing, whereas the latter refers to additional explanation being needed. For example, if an instructional step is ‘press the red button’, but in fact there are two red buttons, this information is ambiguous. Since this ambiguity is caused by missing information about which of the two red buttons to press, it is a type of incomplete information. On the other hand, if there was no information about pressing a button, although the task requires this action, the instructions can be said to be deficient.

The next type of quality problem is ‘unneeded instructions’. The term ‘unneeded’ is chosen instead of ‘irrelevant’, since the situation outlined in Fig. 1 includes two types of situations, which the term ‘irrelevant’ fails to describe properly. The first type of situation occurs when some instructional information is not relevant in relation to completing the task in focus. For example, if the manual on how to operate a machine includes the history of the company, in most cases this would be irrelevant information. The second type of situation occurs when the instruction is relevant to completing the task in focus, but the instructional information is already possessed by the receiver, for which reason he/she does not need it. It may seem that ‘already possessed information’ refers to a problem of redundancy. However, as illustrated in Fig. 1, the two spheres which are the basis upon which that the dimensions are derived are ‘needed instructions’ and ‘given instructions’, and if some instructional information is already possessed, the instruction given is unneeded.

The next type of quality problem is ‘incorrect instructions’. This refers to the situation in which something stated simply is not correct. For example, if it is stated that pressing the blue button will make the machine stop, but in fact the red button has this function, such instructions are, obviously, incorrect. It should be noted that according to the discussion in Section 2.1 ‘incorrect information’ is not really a type of information. However, in the context of understanding quality of work instructions, it seems sensible to allow this expression because of communicative aspects.

The final type of quality problem is ‘too repetitive instructions’. The term ‘too repetitive’ is chosen instead of ‘redundant’ (which Price and Shanks (2005) apply) because redundancy or repetition is not by definition a problem. In fact, sometimes it is desirable to mention important aspects several times to ensure that the recipient notes this information. The dimension may seem closely related to ‘unneeded instructions’ in the sense that some of the repetitions are unneeded. However, if the instructional information in focus is, in fact, needed, the problem is not that the information is given but that it is repeated too often by the instruction sender.

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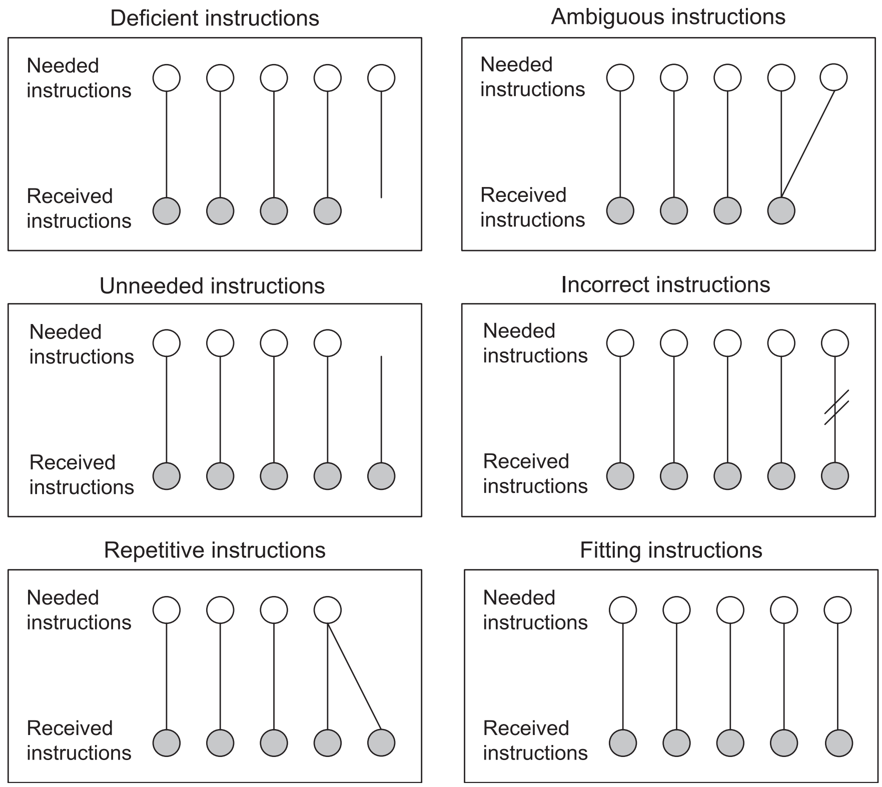

Fig. 1. Intrinsic instructional information quality.

The last picture, 'fitting instructions', refers to the case where all instructions needed to carry out a task are correctly described without redundant or irrelevant information. Thus, to summarize, five intrinsic instructional information quality problems/dimensions have been derived:

- Deficient (Complete)
- Ambiguous (Unambiguous)
- Unneeded (Needed)
- Incorrect (Correct)
- Too repetitive (Adequate repetitions)

3.2. *Extrinsic instructional information quality*

As opposed to the four intrinsic qualities defined by Wand and Wang (1996), many of the quality dimensions of Wang and Strong (1996) have a more extrinsic nature, i.e. being more dependent on the context and therefore harder to evaluate through a simple comparison to the real world. Taking a basis in the 15 dimensions proposed by Wang and Strong (1996), 10 extrinsic instructional information qualities are derived. This is summarized in Table 2, in which the column "Evaluation" describes whether or not each dimension included in the framework by Wang and Strong (1996) is relevant. These evaluations are subsequently explained.

With regard to 'believability' and 'reputation', these dimensions are relevant in relation to how an employee follows some instructions. More specifically, if some instructions are prepared in a way that makes them appear implausible, employees would be more inclined not to follow the instructions and instead figure out what to do themselves. The same can be the case for instructions with poor reputation, which can emerge if other employees speak negatively about the instructions or instructor.

With regard to 'timeliness', this dimension is relevant in cases where instructions are updated (because of changes related to processes, machines, organizational structures, etc.) and old instructions become obsolete. However, this does not mean that the old instructions do not accurately describe what they are supposed to (namely the old situation), but merely that they are outdated. For instructions to be timely, they need to be given at the time when they are needed and describe the current situation.

With regard to an 'appropriate amount of data', this dimension describes how well the amount of data fits with the cognitive capabilities of the person receiving the instructions. For example, some types of instruction manuals are too voluminous for persons with little patience or concentration.

With regard to 'ease of understanding' and 'interpretability', these dimensions can point in two directions, namely in relation to understanding the form of representation (syntax) and the meaning of the representation (semantics). For example, although some instructions are relatively simple, if the instructions are formulated in a manner, which the reader cannot understand (e.g. legal terms), this is a representational problem. On the other hand, if some instructions require some sort of pre-knowledge (e.g. engineering knowledge), no matter how gently this information is represented, the information may still be too complex for persons without this knowledge.

With regard to 'representational consistency', this refers to instructions using consistent terminology, symbols, logic, and so on. For example, if using different terms when referring to the same concept (e.g. 'item' and 'component'), this may confuse those receiving the instructions.

With regard to 'concise representation', this dimension is closely related to relevance. However, while 'relevancy' describes whether a piece of information is useful, 'conciseness' is more related to the form, such as avoiding long sentences and too many words.

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Table 2
Evaluation of extrinsic dimensions.

Dimensions	Evaluation
Believability	Relevant
Accuracy	Similar to 'correct' or 'complete' instructions
Objectivity	Not relevant, since the focus is on instructions as opposed to factual information
Reputation	Relevant
Value-added	Similar to 'needed instructions'
Relevancy	Similar to 'needed instructions'
Timeliness	Relevant
Completeness	Included in the intrinsic quality dimensions
Appropriate amount of data	Relevant
Interpretability	Relevant
Ease of understanding,	Relevant; related to both representation and the complexity of the information itself
Representational consistency	Relevant
Concise representation	Relevant
Accessibility	Relevant
Access security	Relevant

With regard to 'accessibility' and 'access security', the first refers to problems in relation to identifying relevant instructions and the latter to missing access rights.

3.3. A framework of work instruction quality

The discussions of the previous sections allow a total framework of instruction quality problems to be constructed. This is shown in Fig. 2. As seen, the derived quality dimensions/problems have been grouped into five categories: intrinsic problems, representational problems, unmatched information, questionable information, and inaccessible information. The category name "unmatched information" refers to the mismatches described by its three dimensions, i.e. the mismatches between: the complexity of data and the user's ability to handle complexity; the amount of data provided and the amount of data which the user can handle; and the point of time when the data was needed and the time data was provided.

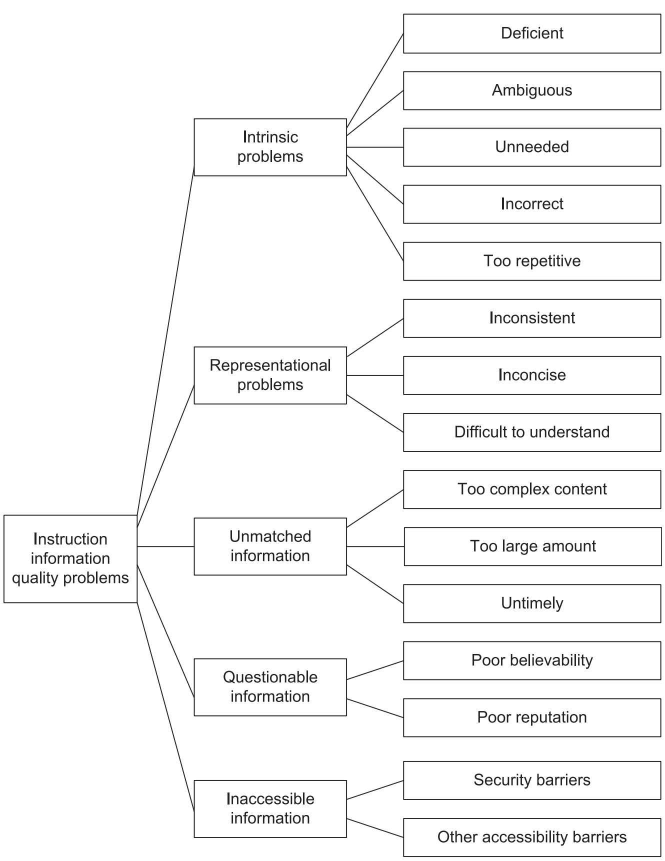

Fig. 2. A framework of instruction information quality problems.

As stated earlier, it is recognized that it is often not possible to achieve consensus about the quality of some instructional information. However, the primary purpose of the proposed framework is not to facilitate such quality judgments but, rather, to provide a means for guiding communication. While creating instructions, the framework may be applied to ensure that all relevant quality dimensions are considered. Obviously, this does not guarantee that the receiver experiences that the instructions are of adequate quality, but it is likely to increase the chance of this. In situations where a sender and a receiver disagree on the quality of some instructions, the framework may serve as a means for resolving such conflicts by offering a nuanced way of understanding instructional information quality rather than discussing it at an overall level.

As mentioned, the paper focuses on instructions delivered both orally and in writing. In this context, the framework may support decisions of which communication form is most appropriate in a particular context. For example, if the sender of instructional information is uncertain of the skills of the receiver, it may be better to deliver at least part of such information in oral form in order to avoid 'representational problems' or 'unmatched information'. On the other hand, choosing to deliver instructions in oral form may be inappropriate if the information is extensive or there is a need for drawings or calculations. Finally, cultural issues may also play a part in relation to the means of communication. Some organizations emphasize having almost everything documented in writing, while others emphasize that employees talk to each other. Nevertheless, the framework may promote a better understanding of the nature of instruction quality.

4. Empirical studies

To position the proposed framework in an industrial management context, two engineer-to-order companies were investigated. The main purpose of the studies was not to provide empirical validation but rather to illustrate the relevance of the defined instructional information quality dimensions in an industrial context. Thus, only two initial case studies were carried out.

4.1. Research method

The two case studies were carried out by interviewing an engineering process manager at an industrial equipment producer and a business development manager at a building renovation company. The two interviews were semi-structured and lasted 45–60 min. The interviews were given on condition of anonymity in order to allow the interviewees to talk freely about problematic issues. About one week after each interview, the interviewee was contacted again in order to check the answers initially given and for further clarification.

The interviews were carried out by asking the interviewee to provide examples of problems in the company related to each of the defined instructional information quality dimensions. Subsequently, the interviewee was asked to describe the business processes in which poor instructional information quality occurs and the consequences of such problems.

4.2. Case 1

The engineering process manager from the industrial equipment producer pointed to one area in particular in which he was aware of that poor instruction quality causes significant problems in the company, namely after-sales. The problem is that when selling spare parts for sold equipment, often information about which parts are compatible with this equipment is unavailable. This relates both to that documents lack such information (deficient) and problems in acquiring the relevant instruction documents (inaccessible information). The engineering process manager also pointed to problems in design and manufacturing processes. In the design phase, the problems concern product managers and engineers failing to properly instruct sales personnel in which types of solutions they should sell. Such instructions are communicated via extensive documents (text and diagrams) and meetings with sales personnel. However, because the company sells complex engineered products, it is almost impossible to completely foresee future customer requests, which means that sales personnel in some cases have deficient instructions. In addition to experiencing deficient instructions, sales personnel often find such instructions to have problems related to the categories ‘representational problems’ and ‘unmatched information’. In relation to manufacturing, the engineering process manager pointed to problems of incorrect and deficient information in the manufacturing/assembly instructions given to suppliers. In relation to manuals for operating machines and software systems, the engineering process manager stated that a central problem is that many such manuals are written for a diverse audience with different interests, for which reasons parts of the information are often perceived to be too repetitive, unneeded, inconcise, or difficult to understand.

4.3. Case 2

The business development manager from the building renovation company pointed to two main problem areas in relation to instruction quality, namely instructions from municipal architects and sales personnel. In relation to municipal architects, the company experiences many problems related to deficient information and representational problems in the guidelines (written and oral form) for which types of rebuilding projects that will be approved. This implies that it can be difficult for sales persons to know what they can sell to customers and that they have to sell projects with some reservations. In relation to sales personnel communication, often agreements with customers are made orally, and sometimes the sales persons forget such agreements and, therefore, fail to provide complete instructions to the project manager. In worst case, such deficient instructions result in the delivered project being different from the agreements made with the customers. The company has made great efforts to avoid this kind of problem by investing heavily in project management IT. In relation to the design process, the company has made extensive descriptions of construction and design guidelines to instruct the sales personnel in what they are allowed to sell. However, in some cases such instructions can be overruled because of strategic customers, implying that the instructions for the sales personnel become ambiguous. The business development manager also experiences errors in the design specifications (instructions) given to suppliers. This does not occur frequently, but it can be costly when it does. In relation to construction site production processes, the company earlier experienced many problems because different workers applied different solution principles. This was a problem both because of non-uniform solutions and because some of the solutions were of poor quality. To avoid this, the company has elaborated extensive instructions for construction site workers.

4.4. Empirical examples of dimensions

Some of the examples provided by the interviewees in relation to the defined instructional information quality dimensions are shown in Table 3. In the table, the column “Form” shows if the situation involves instructions in written (W) and/or oral (O) form.

5. Conclusions

This paper investigated the question as to which types of information quality are relevant in relation to work instructions. A literature review on quality of work instructions demonstrated that although several papers provide insights into the effects of poor quality work instructions, they do not provide details as to what information quality is in relation to work instructions. Thus, it must be concluded that the topic in focus of this paper has not been given much attention in academia so far.

To address the lack of research on work instruction quality, this paper took a basis in general information quality frameworks. First, five intrinsic instructional information qualities were derived by logically deducing possible mappings between elements of ‘needed instructions’ and ‘given instructions’. Next, 10 additional extrinsic quality dimensions emerged based on a discussion of the 15 dimensions in the information quality framework by Wang and Strong (1996).

To illustrate the relevance of the framework in an industrial management context, interviews with managers in two engineer-to-order companies were carried out. These interviews revealed that the companies experienced problems related to all of the defined 15 instructional information qualities. The manager from the process equipment manufacturer perceived instructions related to sales of spare parts as a main problem area but also recognized significant problems in relation to design and production processes. The manager from the building renovation company mainly experienced significant problems in the design process related to instructions given by municipal architects to the company and instructions given by sales personal to project managers.

Since all 15 instructional information quality dimensions were identified in practice and no others were identified, the studies demonstrated that the dimensions are relevant in industrial management contexts and indicate that the framework includes the most important quality aspects. Thus, the paper may serve as a guideline for persons giving work instructions in either written or oral form. More specifically, bearing the 15 dimensions in mind, while giving work instructions, is likely to result in higher quality. From the perspective of academia, the paper provides a solid basis for future research in work instructions and may promote further research.

Future research needs to investigate the significance of the individual instructional information quality dimension in different

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Table 3
Empirical examples of quality dimensions.

Category	Dimension	Examples from studies of engineer-to-order companies	Form
Intrinsic problems	Deficient	Sales personnel miss information about which types of product designs they may sell	W+O
	Ambiguous	Suppliers experience that references to components in design specifications are ambiguous	W
	Unneeded	Too general instruction manuals on the use of a design-related software system, instead of specific instructions for individual users	W
	Incorrect	Errors in production instructions to suppliers	W
	Too repetitive	Similar instructions on design principles given from different managers	O
Representational problems	Inconsistent	Different terms are used about the same components in production instructions	W
	Inconcise	Too elaborate descriptions in manual about quality assurance procedures	W
	Difficult to understand	Unclear assembly instructions from an international supplier	W
Unmatched information	Too complex content	Too complex information given about how to make simulations of process equipment	O
	Too large amount	Too much information about design principles given at once	O
	Untimely	Use of outdated versions of service instructions	W
Questionable information	Poor believability	Instructions about the handling of a product differed from the instructions for similar products	O
	Poor reputation	Supplier experienced a lack of trust in production instructions because of frequent errors	W
Inaccessible information	Security barriers	No access to after-sales service instructions	W
	Other accessibility barriers	Problems in locating instructions about spare parts related to specific orders	W+O

types of industrial contexts as well as the role played by instructional information in learning processes. Questionnaire surveys may be applied to produce a better understanding of the extent of the problem of poor quality instructions in different types of industries and what the consequences are. The role of instructional information in learning processes may be acquired by observing and interviewing employees in job situations involving instructions being given.

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