Towards more effective information distribution in data-driven organizations

Development of a lens for the assessment of user-centeredness in existing structuring in manufacturing organizations

Elianne F.G. de Regt

Faculty of Technology, Policy and Management, Delft University of Technology, Netherlands
Student number: 1355686

ARTICLE INFO
Date:
June 17th, 2015

Keywords:
- Information distribution
- Information seeking behaviour
- Manufacturing organizations
- Organizational design
- Information overload
- Structure

ABSTRACT
Manufacturing organizations commonly produce large amounts of information that, in order to be of value, needs to be processed by individuals in that organization. When the information distributed to these individuals exceeds their information processing capacity, information overload occurs. Literature suggests that structure in the distribution of information is needed to enable individuals to better utilize their processing capacity. This paper explores the concept of a user-centered perspective on the structuring of information distribution in manufacturing organizations. It describes the development of a theoretical lens by means of a progressive case-study through which the current structuring mechanisms in organizations can be assessed for indicators of this user-centeredness. The lens is further developed and specified using insights derived from a case study at a large manufacturing organization in the Netherlands. As a whole, the lens may be used by designers of information distribution structures. Next steps in this area are validating the insights derived from theoretical and empirical study by means of additional case studies, as well as further specification of the relation between the core concepts of the lens.

1 Introduction

For manufacturing organizations in today’s information driven-economy, one of the keys in improving their performance lies in their capacity to acquire sound, relevant and timely information as input for decision-making, and the extent in which they are able to act upon that information (UNIDO, 2013). Improvement efforts or changes in the area of information management generally involve either creating more information, or implementing additional or new information (management) systems (Hicks, 2007). With the increasing volume of information available, the risk of information overload increases (Hicks, 2007). Research shows that information overload can costs employees up to 25% of their workday, as they attempt to deal with the flood of information constantly coming their way (Spira, 2011). While being faced with problems of information overload, information scarcity is believed to be a problem as well (Königer & Janowitz, 1995). This means that some sort of information-paradox exists; employees feel overwhelmed with the amount of information that is available, while at the same time perceiving that not enough information is available to provide them with valuable insights on the performance of the system.

A matter of structure
According to e.g. Choo et al. (2006), Ferreira and Otley (2009) and Königer and Janowitz (1995), the key to effective information use is structure, both in the creation of information as well as in its distribution and reception. Without that structure, information does not arrive where and when it is needed, resulting in a
sensation of information scarcity. In addition, unsuitable structuring or an overall lack of structure diminishes people’s ability to handle or process information and to extract knowledge or make founded decisions based on that information (Himma & Tavani, 2008; Königer & Janowitz, 1995; Schick et al., 1990). This in turn result in the receivers of the information feeling overwhelmed, hence explaining the perceived information overload. So, people – in and outside of organizations – need sufficient structure in order to be able to process the (performance) information intended to result in performance improvements.

This notion of the essence of structure combined with the idea that organizations experience information related problems, suggests that in these organizations adequate or sufficient structure is lacking. This is remarkable since many large manufacturing organizations are characterized by high levels of structure and formalization. These organizations often pursue data-driven improvement and use structured performance improvement methodologies like Lean Manufacturing, Six Sigma or Total Productive Maintenance to guide their efforts (de Mast & Lokkerbol, 2012). This suggests that either these methodologies are somehow not sufficiently able to provide the structure required to facilitate effective information based improvements, or that the organizations are not using them correctly.

In order to determine what is needed to improve the overall structuring in organizations in relation to information distribution and processing are steps in the overall process of (organizational) information management and, as any organizational process, require structure to control and enable the transformation of input (information) to output (knowledge). A distribution structure can ‘work’...

In order to answer this question, this paper is structured as follows: in section 2 we discuss the research approach, namely a progressive case-study. Then in section 3 the theoretical concepts used to develop a theoretical lens are discussed. Specification of the lens is done by means of a qualitative case-study in Section 4. Section 5 gives the conclusions and suggestions for further research.

2 Research approach

In order to answer the formulated research questions, an exploratory research will be conducted. To provide both the desired generalizability and practical applicability combination of theoretical and empirical research is used to conduct a progressive case-study approach.

Steenhuis and Bruijn (2006) describe the approach as: “[…] an inductive (theory developing) case-study approach that is oriented in the interpretivist paradigm where the outcome is some theory that should not be considered validated but rather it contains concepts and possible relationships which creates new insight (grounded in empirical data) and that can be tested in subsequent research.” (p. 7). There are several benefits to the use of this approach over the more well-known approaches as discussed by for example Yin (2013) or Strauss and Corbin (1990), who discuss using case-studies for theory-testing and theory-developing respectively. Firstly, the use of theory for the development of a theoretical framework or model limits the changes of conducting research that is already known, like is the risk with theory-developing studies. Secondly, by allowing for empirical notions to serve a complementary function rather than a mere confirmatory one, we tap into a secondary source of insights.

3 Theoretical foundations

3.1 Information distribution in organizations

Information distribution (or transmission) and processing are steps in the overall process of (organizational) information management and, as any organizational process, require structure to control and enable the transformation of input (information) to output (knowledge). A distribution structure can ‘work’...
by explicating the process of distribution (who gets send what, when and how) or by explicating distribution as a state or outcome (who should have what information eventually). The latter aspect of information distribution, i.e. the information flows that are in place in an organization, is seen by academics as one of the primary issues that need to be addressed in order for organizations to effectively improve their performance (Ferreira & Otley, 2009).

### 3.2 A user-centered approach to structuring

Structuring is believed to be a critical attribute for an organization’s capacity to learn, as it implies the ability to extract meaning from data (Choo, 2002). In the simplest form, this structuring can be done by creating information about information. Roughly three approaches to developing such a structure can be identified: a technology-centered approach, a data-centered approach and a user-centered approach. A technology-centered approach refers to designing based on sensors and systems that are in place for the generation of information. A possible distribution structure would then be based on the capabilities of the existing technology, for instance the amount of data they can gather or the software that is in place to represent it. Secondly, a data-centered approach takes the data (or information) that is available in the organization as a point of departure and thus attempts to build structure based on that. Over the past years improvement efforts or changes in the area of organizational information management generally involve either creating more information, or implementing additional or new information (management) systems (Hicks, 2007). As a result, more information is available than can actually be processed in the organizations, resulting in problems like information overload.

Based on the above it may be argued that structuring in organizations should result in a that the input of the information that is being processed in the organization is in line with its information processing capacity (IPC) of the organization. Assuming that all the information processing is done by people in the organization, i.e. the employees, this organizational IPC can be seen as equal to the information processing capacity of the people that do the processing.

Endsley (2011) regards this user-centeredness as a challenge for designers to mold their design around the capabilities and needs of users, rather than around the technology that produces the data or the generally huge amounts of data that are already produced as it is. The origins of user-centered research in the area of information can be traced back to Pea (1987), who suggests that the design of information systems (i.e. the systems that are needed for information management) should focus on the objectives of users and the activities they need to obtain those objectives. In the context of this research a possible point of departure is determining the current IPC of the organization by determining the IPC of its employees. Driver and Streufert (1969) state that an individual's information processing capacity is reflected in his or her information-seeking behavior. They explain that the information that a person seeks will never exceed his or her processing capabilities. Based on this notion it can be derived that the current maximum information processing capacity of an organization can be approximated by assessing what information a user would seek if given the freedom to do so. The field of study that looks at how and why users seek, obtain and use information is called information behavior or information seeking behavior.

### 3.3 Information behavior of individuals in an organization

Wilson (1981, 1997, 1999, 2000) is believed to have written the founding literature on the information seeking behavior of individuals and the drivers thereof. His theories and models are also often seen in research on the information behavior of individuals in organizations, like Al-Suqri (2015), Afifi and Weiner (2004), Case (2012), Johnson et al. (1995) and Reddy (2003). According to Wilson, there are three contextual factors – environment, social role and person - that lead to an individual perceiving a need for information. In addition, these same factors affect the extent in which that individual is translating these needs to actual information seeking behavior (see figure 1).
The information seeking behavior that follows from the perceived information need then leads to demand on the information system(s) or other information sources. Information that is successfully obtained from either will then be used and possibly transferred, see figure 2.

Although the general character of the models concepts leaves considerable room for interpretation, Wilsons theoretical notions do provide a point of departure: the information seeking behavior of organizational users is driven by information needs, and results in information use and possible information exchange. These information needs, in turn, follow from the ‘work-role’ that an employee has in an organization, i.e. the overall set of tasks that an employee has to perform in order to fulfill their responsibility in the organization (Li & Belkin, 2008; Savolainen, 2012). Based on Wilsons theory it can be derived that besides the work-role, the information needs of an employee are the result of two other factors as well: his or her (organizational or work) environment and the personal aspects of that employee. Although some authors, like e.g. Kuruppu (1999), state that environment and personal factors like interest and experience are indeed of influence, most of the body of knowledge in this field focusses on one of Wilson’s factors; the work-role of an employee is seen as most affective of that employee’s information needs, hence their seeking behavior (e.g. Cayir et al., 2010; Ingwersen, 1992; Kuruppu, 1999; Leckie et al., 1996; Reddy, 2003; Vakkari, 2003). Wilson himself also emphasizes that the contextual elements affecting information needs particularly originate from people’s work-role in organizations (as cited in Savolainen, 2012). In this research this general understanding of the drivers of information needs is adopted.

Work-role and resulting information requirements

The work-role(s) of an employee, i.e. the part he or she plays in the organization, can, in context of information seeking, be represented as the a set of activities that result in information-related tasks (IRT) an employee performs in order to fulfill the responsibility they have in the organization (Li & Belkin, 2008; Savolainen, 2012). Tasks in general can be regarded as: activities that are to be performed in order to accomplish a goal (Vakkari, 2003). By extension, information related tasks may be considered as the information related activities that need to be performed in order to accomplish a certain goal, i.e. the acquisition, transformation and transmission of information (Kmetz, 1998). The information need following from these tasks can be regarded as the gap between the information required by the individual to satisfy the information requirements posed by IRT’s, and the individual’s existing knowledge (Byström & Järvelin, 1995). Different users with similar tasks may thus have different information requirements.

Based on the above it could be stated that the information seeking of an organizational user is driven by the information related tasks which result in information requirements. Therefore, knowing the information related tasks of users, as well as the information requirements that follow from these tasks is needed to develop a user-centered information distribution structure. Ideally the existing information structuring in organizations would be assessed for creating an information allocation that is in line with all the information requirements of users based on their tasks. However, when attempting to describe tasks and information requirements conceptually, an issues arises. The content of tasks are very dependent on the organization and the way it translated its objectives in

Figure 1 – Wilsons model of information seeking behavior

Figure 2 – Wilsons model of information behavior
activities, and the way it allocated responsibilities of these activities to users, making it difficult to derive the exact tasks of users conceptually. Therefore, instead of assessing existing structuring for describing information related tasks and the distribution of information, the structuring is assessed for aspects that indicate differentiation in the tasks, and with that in the information requirements of users.

3.4 Structuring in organizations

Honig and Kolfschoten define structures in organizations as “coherent sets of written and unwritten rules that provide coordination in the organization” (2012, p. 82). A common source of structure in organizations is the organizational design.

Organizational design

The design (or structure) of an organization can in simple terms be described as ‘the sum total of ways in which the organization divides it labor into distinct tasks and then achieves co-ordination among them’ (Mintzberg, 1979, p. 2). Division of labor is needed to realize objectives and perform activities that go beyond the capabilities of one person, while coordination (or integration) of these activities is required to offset the differentiation resulting from the divided labor (Buelens et al., 2006). Division of labor is the element of the organizational design that describes ‘who does what’ in an organization. The work is divided by translating the objectives of the organization to sub-objectives, translating these objectives to tasks that need to be performed and allocating the tasks to people.

The overall design of an organization can be derived by looking at a number of contingency factors: age & size (large and old vs. small and young), technical system (high or low levels of technological sophistication1), environment (stability and complexity) and power (external influences that affect the activities of the organization, e.g. from shareholders, parent organization or government) (Mintzberg, 1979). Manufacturing organizations are often large and old, active in simple and stable environments and have limited sophistication in their technical systems. These characteristics are generally linked to highly formalized organizations, high levels of task specialization and little to no decentralization. So, the characteristics an information distribution structure, according to the congruence principle, should be in line with this as well.

Indicators of task differentiation

From the work of e.g. Mintzberg (1979) it two main aspects of the OD can be derived that indicate the existence of task differentiation: specialization and departmentalization.

Specialization in an organization refers to the extent in which people grow specialized in the execution of a task, and whether or not they only perform a small amount of tasks repeatedly. The level of specialization is not the same throughout the organization; it generally differs throughout the hierarchy (Buelens et al., 2006). The least specialization is commonly found in the top-levels of the organization, whereas the highest specification occurs at the operational level. Organizations with tall hierarchies can thus be considered as having more different levels of specialization throughout the organization, hence more vertical task differentiation.

A second indicator of task differentiation may be found in how the organization is divided in departments, i.e. how the employees (and their tasks) are grouped. Three main ways of departmentalization can be identified: functional, product-based, geographical, and matrix departmentalization. Functional departmentalization implies that the people and tasks are grouped by the function they have in the organization, like ‘finance’, ‘marketing’, ‘production’ or ‘research and design’. In the case of product departmentalization, the grouping is done based on a specific product. One product-based department could then consist of the marketing, R&D and production of one product, while a second department has their own units for another product. Geographical departmentalization

1 The technical sophistication does not refer to the amount of automation that is in place, but to the level of automation. Highly sophisticated systems have high levels of automation, meaning that hardly any human intervention is required. Low sophisticated systems can still have a lot of machines that do the work, but that require a lot of human control.
is in place when organizations that have operations in multiple regions produce their products or services also locally, and where things like R&D and marketing are also done per region. The way the organization is departmentalized indicates what kind of common denominator the employees of a certain group have, and what the organizational focus of their tasks is. Different groups have task with different focus, indicating horizontal task differentiation.

Based on the above, the amount of differentiation between the tasks of different users in an organization can thus be predicted by looking at the specialization and departmentalization as they follow from the OD. The next question is how these indicators can be translated to differentiation in information requirements.

From differentiation in tasks to differentiation in information requirements

Academic research shows that there exists a relation between the information requirements of an employee’s relative vertical position in the organizational hierarchy (DOFA, 2015; Gelinas, Dull, & Wheeler, 2011). The differences in information requirements resulting from different organizational levels can be translated into a number of attributes, as is illustrated in Figure 3.

Although the list of attributes shown in the figure may not be exhaustive, it does indicate that higher up in the organization the information requirements of individuals are relatively low on specificity. This compared to the lower organizational levels, which require more specified information the closer they are to the operational level. And, the taller the organization, the larger the expected differences in information requirements between the highest and the lowest level.

If in an organization we can identify multiple organizational levels, this will thus likely reflect in some way in certain attributes of the information requirements of employees. However, the attributes as they are presented are not very operational and with that not quite usable. So instead of adopting them directly, we will use the case-study to derive operational attributes to define the information requirements of users. To structure our efforts, we focus on deriving attributes that relate to two general information characteristics: the scope of the requirements, referring to what the information is about, and level of detail of the requirements, referring to specificity of the information and the unit of analysis.

The above is summarized in figure 5.

![Figure 3 – Information requirement differentiation throughout the hierarchy](image)

The figure shows illustrates what is believed to be a specification of the translation from work-role to information requirements. Understanding of these requirements is needed to assess the extent in which current structuring result in the distribution of information in a way that is in line with these requirements, i.e. with the information processing capacity of users. However, the concepts of ‘scope’ and ‘detail’ are not yet specific enough to be measurable in an organization. To specify this further, a case study was conducted.

### 4 Case study results

A case study was conducted at a large manufacturing organization in the Netherlands. During the study no explicit information structuring mechanism was found. However, a mechanism that does so in effect was: a formal meeting system. This meeting system prescribes when information is exchanged and who is involved in this exchange. Exchanging information implies that first information needs to be acquired. So, by formalizing the exchange of information, a certain distribution of information is realized. This distribution was not fully made explicit and thus had to be ascertained in another way. Therefore the actual information use of the actors in the meeting system was assessed for indicators of ‘scope’ and ‘detail’. The study resulted in six information
attributes that could be used to describe the information requirements of employees:

1. **System scope**, referring to the overall width of the information requirements of a user in terms of what part of the technical system he requires information about. For example: the performance of a department, sub-department or production line.

2. **Time scope**, referring to the overall time-span of the information requirements of a user’s information requirements. For example: the monthly or daily performance.

3. **Subject scope**, referring to the differentiation and comprehensiveness of the reports in terms of the number of performance areas that the user requires information about, i.e. what 'kind' of performance. For example, some users may be interested in multiple performance aspects (efficiency, water consumption or product quality) or only one specific element.

4. **System Unit of Analysis**, referring to the level of detail in which users review the system. For example, the performance of the department can be decomposed into sub-departments or into the production lines that the sub-department consists of.

5. **Time Unit of Analysis**, referring to the level of detail in which users review the selected time span. For example, last month's performance can be reviewed per day, rendering 30 data points, or per shift, which leads to 90 data-points.

6. **Subject Unit of Analysis**, referring to level of detail in which a performance area is reviewed. Every subject as discussed above is translated to KPI's or PI's, which in turn are decomposed in so-called control indicators (CI) that indicate which aspects of the system are responsible for high or low values on that KPI.

These six attributes can be regarded as the relevant characteristics of information requirements that are expected to be affected by differentiation in tasks. In other words, different users are expected to require different information in terms of system scope and UoA, time scope and UoA, and subject scope and UoA.

Operationalization and use of the attributes

Assuming that 1) these attributes can be used to describe the reports (i.e. the information) acquired by employees, 2) these reports are acquired as a result of information requirements perceived by those employees and 3) those requirements follow from the information related tasks that employees have in a meeting, these six attributes can be used to describe the information requirements of different employees during meetings. This in turn allows for comparison between these requirements, hence an assessment of the differentiation between the requirements of employees (or information users) in relation to their work-roles. And in order to do so the attributes should be operationalized further into measurable values. This can be done by determining possible values for each of the attributes. This is illustrated in Figure 6.

The actual amount of levels, horizons and subjects depends on the organization. Indications for this can be derived from the performance reports and the different ways that the attributes are substantiated.

**Further application of the attributes and overall lens**

Based on the specification of the core-concepts thus far, levels of specialization were identified as well as organizational groups to substantiate the focus. In addition we looked at which information is currently acquired by users in the organization. The distilled attributes can be used to explicate the information related tasks of information users, and with the information requirements and information processing capacity. The combination of the different levels can be seen as possible perspectives on the system. An organization could use these to determine at which levels they want to monitor the performance, and create an information exchange system (i.e. meeting system) around this.

**5 Conclusion and further research**
This paper had as an aim to explore the structuring of information distribution in large manufacturing organizations and to the existence of improvement potential therein. Literature in the fields of organizational information behavior and organizational design was used to develop the foundations of a lens for user-centered information distribution. The lens conceptualizes a relation between the differentiation in the work-role of information users, the information requirements that follow from this and their information processing capacity. The information processing capacity is seen as an possible point of departure for the development of a user-centered structure.

The theoretical lens was further developed by using a case-study to specify some of the core concepts. By analyzing the information currently used by the organizational users, i.e. the manifestation of the current structuring mechanisms, six attributes were derived that can used to describe the information requirements of users, and with that the differentiation between those requirements.

In order to effectively deploy the lens and determine its validity, additional research is needed.

**Directions for further research**

The exploratory nature of the study makes that the insights of the research have not been validated. This, as well as assessment of potential for further deployment of the lens are the main recommendations for further research:

- **Validation of the information attributes obtained from the empirical study**
  The progressive case study as it was performed here has as a downside that validation is difficult. Traditional case studies are generally used to test hypothesis derived from theory, or to derive hypothesis that are then validated by related literature. In this research we did neither. Additional case studies should be conducted to assess if the six attributes that were abstracted are indeed usable outside of the context of the used case.

- **Validation of the use of ‘work-role’ as an indication of the information processing capacity of organizational information users.**

In this research we theorized that the work-role as defined in this research can be used as an determinant of information requirements, and that these information requirements reflect the information processing capacity of such users. While this has been substantiated by theoretical models, it is also a rather free translation of the theory in terms that there are several other components that may affect the information processing capacity of users. That said, this does not mean that the work-role is not a good indicator. This should however be validated. An example of such research could entail a comparison between the knowledge that people with different work-roles can derive from the same information.

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