International Journal of Industrial Ergonomics 43 (2013) 304–313

Contents lists available at SciVerse ScienceDirect

International Journal of Industrial Ergonomics

journal homepage: www.elsevier.com/locate/ergon

Cognitive mapping: Revealing the links between human factors and strategic goals in organizations

Judy Village*, Filippo A. Salustri, W. Patrick Neumann

Human Factors Engineering Lab, Department of Mechanical and Industrial Engineering, Ryerson University, 350 Victoria St., Toronto, Ontario M5B 2K3, Canada

ARTICLE INFO

Article history:
Received 15 April 2012
Received in revised form
16 January 2013
Accepted 7 May 2013
Available online 19 June 2013

Keywords:
Cognitive mapping
Strategic goals
Human factors
Macroergonomics

ABSTRACT

The authors propose cognitive mapping (CM), a tool used in operations and management research, as a way for Human Factors (HF) Engineers to understand the HF perspective of senior managers and others in manufacturing industries, and how HF aligns with strategic goals in the organization. This paper first presents a methodological review of various mapping methods. Options are summarized with respect to: how to elicit information; the role of the facilitator; mapping methods and analyses; and interpretation of the data. Second, we choose a mapping method and demonstrate its utility with a single participant. Results from the illustrative example show the visual nature of the tool in summarizing the perceptions of the participant. We suggest CM methods can help HF Engineers and others work with industry to identify actionable steps to integrate HF into daily practice in ways that support strategic organizational goals.

Relevance to industry: : Aligning human factors to organizations' corporate strategies will enhance its application, and therefore effectiveness. Such macroergonomic tools are needed to facilitate understanding by senior management of the strategic potential for human factors and to help create aligned HF initiatives. This paper presents a methodological review and illustrative example using cognitive mapping for this purpose.

1. Introduction and background

1.1. The need for a tool to link human factors to an organizations' strategy

Dul and Neumann (2009) suggest that human factors (HF) considerations would be more accepted and better internalized in organizations if they were understood by managers to contribute directly to the companies' strategies. HF groups generally want to be proactively involved in design activities to prevent problems and they want to contribute to the organization's goals. However, the challenge is that in their often limited "support" role, HF groups are frequently disconnected from management strategies and others affecting business such as engineering groups (Perrow, 1983; Dixon et al., 2009; Jensen, 2002). HF groups may be unaware of perceptions held by managers and engineers concerning HF, and how best to help achieve strategic goals. HF engineers (used synonymously here with Ergonomists) may be perceived as defenders of operators (Perrow, 1983), rather than being essential to achieving the organizations objectives, or integrated throughout the production systems design.

While there is evidence that engineering changes are more difficult and costly when HF considerations are incorporated late in the design lifecycle (Miles and Swift, 1998; Seim and Broberg, 2010), HF engineers have difficulty accessing design groups. HF engineers are often consulted too late in the design process; they are seen as critical of the design (Broberg, 2007; Kirwan, 2000; Hendrick, 2008), thereby increasing costs and delays (Perrow, 1983). HF engineers can reduce the conflict described if they know the strategic goals of the design process and align HF with these goals.

Waterson and Kolose (2010), in a large scale military defense organization, discussed some of the challenges experienced by the HF team with management perceptions of their function and purpose. Although the team had been in existence and had supported many functions for several years, the authors reported that it still lacked visibility and prominence in the overall organizational structure. It was referred to as a "bubble" on a flow diagram of an organization chart. It appeared that others in the organization were unaware of the value of involving the HF team.

* Corresponding author. 2220 Badger Rd, North Vancouver, British Columbia V7G 1T1, Canada. Tel.: +1 604 929 7243; fax: +1 604 929 7280.
E-mail addresses: jvillage@ryerson.ca, jvillage@shaw.ca (J. Village).

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http://dx.doi.org/10.1016/j.ergon.2013.05.001

Integrating HF into an organization, like other business re-engineering and quality efforts, is really an "organizational change" initiative because they affect multiple levels in an organization and require the interaction of different agents. The research on organizational change strongly suggests that the successful initiatives are the ones that are integrated into the "psychological" dimension, or mindset, of the organization (Zink et al., 2008). Similarly, to facilitate integration of HF among groups and functions throughout an organization, and especially to gain management commitment, HF must be aligned with the strategic objectives and business function strategies (Dul and Neumann, 2009; Drury, 2000; Genaidy et al., 2009; Neumann et al., 1999).

The task for HF Engineers is the practical one of finding ways to gain management support and facilitate alignment of HF considerations with the strategic goals and business outcomes of the organization. This paper adapts "cognitive mapping," from the operations management field, and provides an illustrative example of its use in HF. The goal of this methodological paper is to demonstrate a practical macroergonomics method for HF Engineers to facilitate alignment of HF considerations with strategic goals of senior management and engineers.

1.2. Objectives

The objectives of this paper are to:

- Introduce the cognitive mapping technique that can make apparent the perceptions about HF and how it relates to a company's strategic goals;
- Review methodological options for applying the cognitive mapping technique;
- Choose one method of cognitive mapping for use by HF Engineers and demonstrate it with an illustrative example; and
- Recommend how HF Engineers could use cognitive mapping collaboratively with senior management and other agents to improve discussion of and action on HF implementation.

2. Methodological review of cognitive mapping

2.1. What is cognitive mapping?

A cognitive map is a graphical representation, or visual picture, of the content and structure of an individual's belief system (Eden et al., 1992). The process of cognitive mapping was introduced into the management science field by Axelrod in 1976 (Markoczy and Goldberg, 1995). The basis of the theory originates in the psychological "personal construct theory" (Kelly, 1955). The personal construct theory posits that humans are scientists who are constantly trying to make sense of the world in order to act within and upon it. In trying to make sense of the world, people use a *construct system*, then compare any new information for similarities and differences and map these relationships to form their perceptions. The process is one of reflective comparison between currently held concepts and new information.

The process of eliciting the map is most commonly performed using interview techniques and open-ended questions about a specific problem or issue. Participants provide their perceptions, known as "concepts." The concepts are written down, and refined through more open-ended questions. Relationships between concepts are identified (for example *causality* – where one concept leads to or influences another). Concepts are considered "nodes" and the relationship between concepts are considered "links." Links have arrowheads that show the causative direction (for example, see Fig. 2). Typically, individual maps contain up to 100 nodes and group maps that are made by merging individual maps may contain as many as 800 nodes (Eden, 1988).

The notion of team or group maps began in the 1990's with the idea of helping teams negotiate consensus and commitment to a portfolio of actions (Eden, 1988). Because it makes explicit the concepts of different individuals, cognitive mapping helps facilitate decision-making by promoting a shared understanding of potential problems and design choices (Swan, 1997). With a wider understanding of the issues, negotiation can occur more easily and decision makers can jointly understand the complexity and consequences of a decision (Shaw et al., 2009). The use of a group strategy map also removes individual ownership of the issues, creating some distance to see and discuss the problem in new ways, thereby facilitating organizational change.

2.2. Review of cognitive mapping methodologies

In this section we will present some of the key methodological choices in creating and analyzing cognitive maps, with an emphasis on techniques that are most likely to be of practical use in the context of human factors in manufacturing environments. This section will include: methods to elicit information; the role of the facilitator; mapping methods (software or paper and pencil); and methods for analysis and interpretation of maps.

The choice of technique for any given context depends on a number of variables, including the likelihood of producing valid and reliable data, logistical considerations such as the time and extent of participation, and seniority of the participants. Other variables include the complexity of the problem, the interest of the practitioner/researcher, and the scope of analysis. It is important to consider the overall purpose and intent of the map, for example, in this case, to prioritize human factors efforts to support the organizational strategy. Note that none of the methods presume one must have a strong knowledge of the HF.

2.2.1. Choose the method of eliciting information

Information can be elicited either through open-ended questions, or through pre-selected "closed" questions. Using an open-ended question, such as "How may one improve customer service?", tends to result in wide-ranging and distinctive maps for any given individual. Alternatively, the researcher may use a more closed structure to provide a set of pre-selected concepts based on the literature and their domain knowledge of the situation, that the participants link or rank by importance (see Markoczy and Goldberg, 1995). One example of a closed structure is *pairwise comparison*, where participants make judgments of the positive or negative influence of one variable on another in a pairwise fashion (Hodgkinson et al., 2004). Another example of a closed structure is the *repertory grid*, an early cognitive mapping technique that involves a very structured approach for clustering and rating concepts (Eden, 1988; Swan, 1995). The advantage of closed questions is that they make merging of individual maps easier because the concepts are all similar. The disadvantages are that they do not facilitate a rich subjective reflection on the topic, and they presuppose prior knowledge of all relevant domain elements. While either open or closed questions can work, open questions allow individuals to view their responses, re-evaluate, make new links, and at times discover emergent themes that would not be otherwise captured.

2.2.2. Consider the role of the facilitator

The role of the facilitator is an important consideration as it influences the mapping outcome, and it varies widely across different techniques. Some of the methods are executed exclusively by the facilitator/researcher; others are facilitator-led but