Proceedings of the 2000 Conference on Information Quality

# CAN INFORMATION ENGINEERING ENHANCE INFORMATION QUALITY FOR EFFECTIVE DECISION-MAKING IN TEXTILES?[1]

Yatin Karpe*
Neil Cahill**
George Hodge*
William Oxenham*

*North Carolina State University
**Institute of Textile Technology

**Abstract**

*Information Engineering* can be defined as a technique for extracting the "meaning" contained in information to allow the understanding needed by a user to make a "right" decision. This paper discusses the conceptual theory behind *Information Engineering* and its use in analyzing and understanding the Data-To-Decision cycle model, created by Mr. Cahill. It also emphasizes the role and application of *Information Engineering* in effective decision-making. Decision effectiveness has been a critical area, especially in textiles, that needs to be addressed at the earliest to successfully compete in the present globalization era.

The information technologies developed over the last 30 years have been heavily technology based, while decision-making remained a human thinking process. As particular users desired/ needed information to make decisions, they "tapped" the pipeline through which information flowed past the various users in the organization. Unfortunately, as businesses became more complex, and information generation increased, the users' capacity to select and digest the right information was limited and led to a communications barrier.

Information has no use, and therefore no value, until it is utilized by a decision-maker. The ability of the users to make "right" decisions does not depend on information itself, but on the meaning and understanding derived from that information. The design of an interface whereby the human decision-maker "taps" into the information system could influence the proficiency of converting information into decisions. It is here that *Information Engineering* plays a vital role, thus creating a new opportunity for enhanced decision making in the textile industry.

## 1. Introduction

The information revolution is sweeping through the global economy. No industry can escape its effects. Dramatic changes in the cost of obtaining, processing and transmitting information are changing the way we do business. Through a combination of economic progress, trade liberalization and changing technology, markets, industries and distribution channels are globalizing and the nature of both supply and demand are changing. Overall, the environment in which firms are operating is becoming increasingly dynamic, diverse, complex and hostile. In this environment, the need for relevant, timely, accurate and cost-effective information is paramount.

[1] This paper was presented at the Textile Institute World Conference, April 2000

In order to create a successful, high performance textile company of the future, certain transformations need to be undertaken. The two key enablers facilitating the transformation are information technology and management practices. These optimize use of the two key assets of an enterprise - information and people (1). All around the world, textile companies are competing in an increasingly turbulent environment that is requiring improved information management capabilities to support effective decision-making. However, despite the information revolution of the last two decades, utilization of information by firms has not kept pace with the technological ability to capture and process data. The full benefits of Information Technology will only be realized by a system that can manipulate captured data to ensure that only appropriate information is directed in a timely fashion to decision-makers.

The United States Integrated Textile Complex is facing stiff competitive pressures in the global marketplace and is constantly being forced to explore innovative ways to compete. The U.S. textile firms continue to recognize that information-related technologies are vital to the strength and competitiveness of their businesses. These textile companies are spending increasingly more money on information systems. A survey conducted by Kurt Salmon Associates indicates that Information Technology spending as a percent of sales in the US textile & apparel industry is gradually increasing (2). Another survey by IBM and the Textile Institute (UK) indicated that information technology is the key to improving competitiveness through improved decision-making, production quality, speed, flexibility and customer service (3). All these parameters are influenced by the speed with which the system (including personnel) can respond to necessary changes. Maximum benefits will only be achieved from the large investments made in sophisticated monitoring and testing equipment, by manipulating the data to provide the necessary, correctly packaged information.

Previous research related to IT in the textile industry has focussed mainly on the identification of data requirements and analyzing data to find the usefulness of the various data elements for process monitoring and control. Attempts to apply Data Mining (which is the automatic extraction of patterns of information from historical data, enabling companies to focus on the most important aspects of their business) and Data Warehousing (which is a repository of data) concepts to the textile industry have also been partially successful. But all these methodologies have only concentrated on filtering and coordinating the data to make decisions, while not addressing the concept of understanding the "meaning content" of the information obtained. These approaches address only the two extreme ends of the Data-to-Decision model, which will be explained in the latter half of the paper. *Information Engineering* would be a step beyond just data mining, which would channelize the right information to the right user.

In the present era of automation, the US textile industry can move forward as a leader in the 21$^{st}$ Century by adopting a unique and distinct approach of *Information Engineering* and thus gain a global competitive edge. This approach, which is a technique for identifying appropriate information for specific sets of decisions, and then tailoring and relaying this information to support effective management, will assist in the decision-making process and respond quickly to the ever-changing needs of the US F-T-A-R (Fiber, Textile, Apparel, Retail) supply chain. It could prove to be a tool in knowledge mobilization, one of the twenty-four “Critical Business Practices” identified for the creation of an agile enterprise (4). Computers currently are used in the industry to automate information-processing tasks; however, in the future, their use will be geared towards knowledge management or processing with the aid of intelligent agents, one of which could be *Information Engineering*.

## 2. Information Technology

Information technology (IT) is justifiably considered to offer far-reaching solutions to a wide range of manufacturing and management problems encountered in almost every industry. Yet, although many significant efforts have been made in the field of technology management, it is evident that in many organizations information technology is not being used effectively, efficiently or economically. This observation seems to hold true for the textile industry. Introducing information technologies and computer based information systems into textile production processes can achieve a substantial increase in productivity and quality of work.

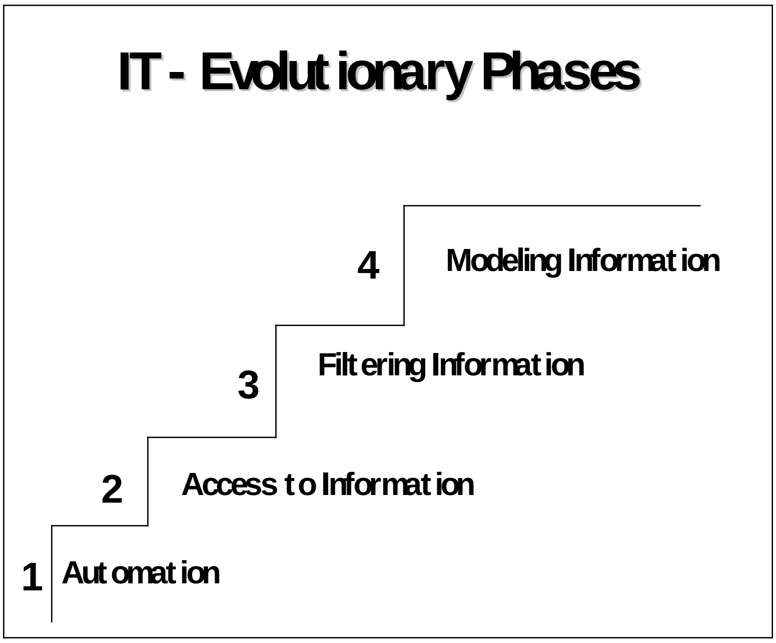


**Figure 2.1: IT Evolutionary Phases**

According to Benjamin and Blunt (5), currently we are in the third stage of a four-stage evolution of conceptual thinking in the IT function (figure 2.1). These stages bear a close resemblance to the manner in which IT applications evolved and exist in today's textile and apparel supply chain. Each stage is defined by what the IT function has to deliver in order to support the organization effectively. They are as follows:

1. Automation: Initially, application design was directed at automating existing manual systems. Progress could easily be measured by monitoring the systems portfolio. Masses of information were made available, but access was, and largely still is, exceedingly difficult. Much of the data was locked up in files accessed only by particular programs. Information could not be shared across applications or platforms. The dominant method of giving out information to its users was as line printer reports that found their most productive use as children's drawing paper.

2. Access to Information: Before automation could be completed, it became clear that we were better at collecting information than disseminating it. Since about 1970, the primary concern of IT groups has been to reverse this trend. On-line systems replaced batch systems. PC's and workstations are no longer stand-alone devices. Data modeling and database management systems are enabling the integration of information at appropriate levels in order to support the organizations information needs. The problem of providing secure information access is a dominant driver of IT investment toady and will continue to be a major consideration.
3. Filtering Information: Today, instead of being starved for information, managers and workers are in danger of dying from a surfeit of communication. Data overload and effective data utilization are key issues facing almost every industry, including the textile industry. The average information content of "information" is rapidly falling. To stay productive, organizations are going to have to invest in the development of unique forms of active information filtering. If information access is a key driver of current investment, providing the right information filtering capabilities emerges as a major challenge. Researchers at the College of Textiles, North Carolina State University have conducted research in conjunction with the American Textile Manufacturers Institute (ATMI) in identifying data requirements (for spinning) and analyzing data to find the usefulness of the various data elements for process monitoring and control (6).
4. Modeling Information: When information is accessible and filtered, then the question must be asked, "What do I do with it?" Expert systems, modeling systems and executive and managerial support systems such as MRP, MRPII, ERP, APS, MES and others have a role to play in modeling information to make it more useful. In this stage too, researchers at the College of Textiles have conducted research in information modeling, data analysis and decision-making with regards to the different textile manufacturing processes (CIM in the FTA Industrial Complex, Design of Supply Chain Systems for the Textile Manufacturing Complex, Knitting Data Model, Enterprise Modeling and so on) (7,8,9). The application of information models will require a proactive effort far beyond that required to order and filter data, but it will be necessary to ensure a good fit with business processes.

Information modeling cannot be managed without bringing together all three application segments – business operations, information repositories and personal support systems (10). In addition, information modeling will require development of new models that integrate business processes and system designs. It is here that *Information Engineering* will play a vital role.

## 3. Information Engineering

### 3.1 "Self-Generated" Information

Before computers became a primary source of information to production managers, these managers relied extensively on "self-generated" information such as machine changeover schedules that were often determined by counting the number of "boxes" of yarn available in the spinning room (11). But as automated sensing replace human observation, the managers began to lose the personal sensitivity between what the "numbers" meant and their personal awareness of the plant "situation". Furthermore, as computers were used as "data-digesters", this personal sensitivity to numbers was further reduced. This gap between what computerized information "tells" a manager and what the manager "needs to know" is a major impediment to the use value of information.

### 3.2 The Information "Gap"

This gap, which presently exists in many information systems in textiles, must be converted into an interface. A "gap" means that there is an open space between two different parts of the system, in this case, the user and the information source. An interface, however, is a point of contact between two different functions where an efficient transfer occurs between these two functions. Changing this gap into an interface is perhaps one of the most important issues in the design of an efficient and effective information system.

In 1965 it had been anticipated that the success of an information system would not be its ability to generate large quantities of information, but its ability to integrate the human user into the system (11). It is only when the user, the decision-maker, becomes an involved participant in the information system can information begin to approach its full use potential. As the human decision-maker is progressively integrated into the system, that system then evolves from being an Information system into a communication system.

### 3.3 The Information Dilemma

The information systems developed over the last 30 years have been heavily technology based, while decision-making remained a human thinking process (11). It can be envisioned that the information system was a sort of a pipeline through which information would flow past various users in the organization. As particular users desired/needed some information to make decisions, they "tapped" the pipeline. This basic approach of people tapping the information flow as needed to make decisions is basically the same today.

Unfortunately, as businesses became more complex and the system could generate increasing quantities of information, then the discriminating power of the user to select and digest the "right" information was stretched to the limit. As this dilemma of the information system and the human user increased, it evidently developed into a communication "barrier".

### 3.4 Communication "barrier" – What is it?

A communication barrier exists when a human user is impeded from gaining the full "use value" of the information available to him. Such barriers are a natural byproduct of attempting to bring together such dissimilar functions such as information technology and human decision making. In order to smoothly bring together dissimilar functions it is necessary to convert the barrier into an interface. The peculiar characteristic of an interface is that it allows smooth and efficient flow, which in this case is flow of information from the system to the user. It is the design of this interface between the technology of the information system and the human decision-maker, which will greatly determine the value realized from that information (11).

**3.5 Information ≠ Communication**

Information systems primarily involve generating and distributing information throughout an organization. Such information transmission is the necessary first step in developing any communications capability. But information has no use, and therefore no value, until it is utilized by a decision-maker. It is the human decision-maker who constitutes the second component of a communications system. The point of integration, as seen in figure 3.1, where the human decision-maker "taps" into the information system is what forms the interface. And the design of this interface will influence the proficiency of converting information into decisions.

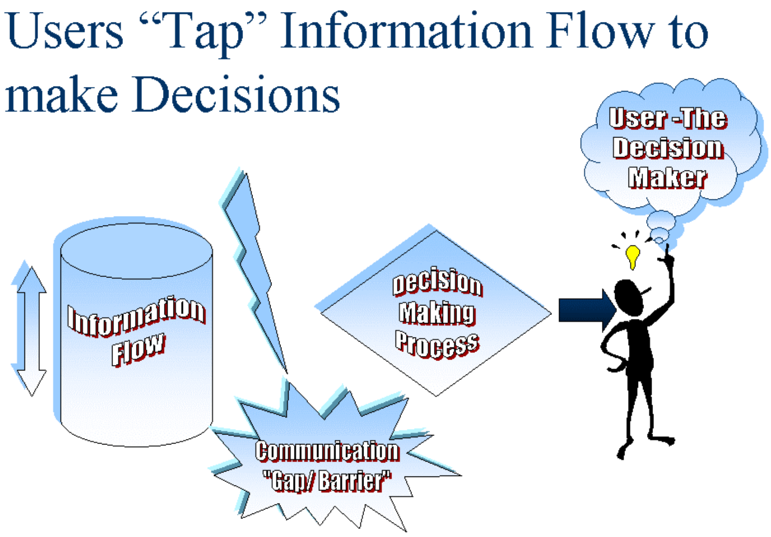


**Figure 3.1:** A typical communication system

**3.6 Decision-Making**

Decision-making is one of the main tasks of a manager. Whether it is at the department level, facility management level or enterprise management level, some form of manufacturing information in some level of detail is a key requirement. Davenport & Prusak also reiterate this fact in their book, "Working Knowledge: How Organizations manage what they know?" Data are objective description of facts, and information is the subjective interpretation of that data. Decision-Making requires up-to-date and accurate information. Data must be meaningful and understandable and also relevant to the problem or decision. The Knowledge pyramid in figure 3.2 clearly indicates that information and data are needed to gain knowledge and make the right decision.

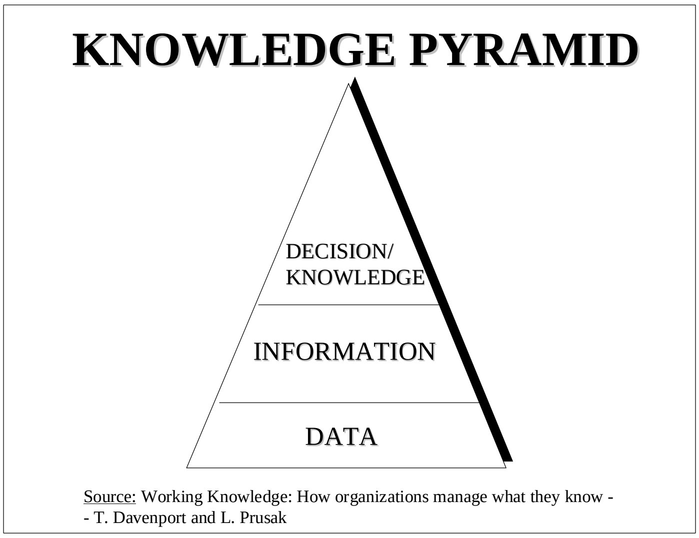


**Figure 3.2: The Knowledge/ Decision Pyramid**

The success of a company is strongly related to the successful decisions of its managerial team. For decision-making procedures to be kept active there is a continuous need of information acquisition and processing. The final information to be provided to the particular levels has to be precise, complete, ready at the right time and free of excessive element (redundant information). The ability of the users to make "right" decisions does not depend on information itself, but on the meaning and understanding derived from that information. If information access is a key driver, providing the right information filtering capabilities emerges as a major challenge. It is here that *Information Engineering* plays a vital role.

### 3.7 Information Engineering

*Information Engineering* can be defined as a technique for extracting the "meaning" contained in information to allow the understanding needed by a user to make a "right" decision. Another definition could be providing the right information, in the right form, quantity, quality and the right time, so as to enable the manager to efficiently and effectively perform his/her job. It is *Information Engineering* that allows a computer to digest the constant stream of data being generated by the computerized sensors and monitors of the plant, and then extract from that information that has some meaning content. According to one of the authors (Neil Cahill) "When one has to make a decision, it is the meaning contained in the information that is needed to make a "right" decision, and not the information alone. Of all the information available in existing plant reports today, only about 10-15% of the information contained in these reports is actually utilized. This low information utilization occurs due to the desired information (vital information) being buried in the report and requiring more diagnostic time than the user can provide" (12). It must be realized that 80% plus of the time to reach a decision is used simply to find the right information. According to Myers, "While all communication contains information, not all information has communication value" (13). Therefore, the goal should be to optimize the quality of the messages transmitted through the interface from the information system to human user. *Information Engineering* assists in this process.

### 3.8 Message Interface

The ability of the user to make "right" decisions does not depend on information itself, but on the "meaning and understanding" derived from that information. The sender attempts to convey meaning through the message of the information. It is the message contained in the information that transfers meaning. This suggests that one way to improve the value of information is the designing of a message interface. This interface enhances the meaning of information in order for the user to better understand the business situation in which he/she must make a decision.

The information contained in a report describes various characteristics about a business situation. However, the information content of a report does not ensure that the user has grasped the meaning of the situation. In other words, the user may have the information, but he may not have the "message". Every report containing information has a message. If it didn't, then the report would have no intended purpose. Therefore, messages can be thought of as the intended meaning to be conveyed by the information in the report. When the user of that report grasps the intended meaning, it can be said that he "gets the message". The transmission and reception of the messages is the communication process.

### 3.9 Message Content

Information is the raw material of the human thinking. But it is the "meaning and understanding" that is the raw material of decision thinking. Information by itself has no meaning or understanding. The human decision-maker acquires meaning and understanding not from the raw information, but rather from the "message content" of that information. This conversion process by which raw data is translated into decisions is the Data-to-Decision cycle model (figure 3.3), and one way of utilizing the *Information Engineering* approach is by analyzing and understanding this model.

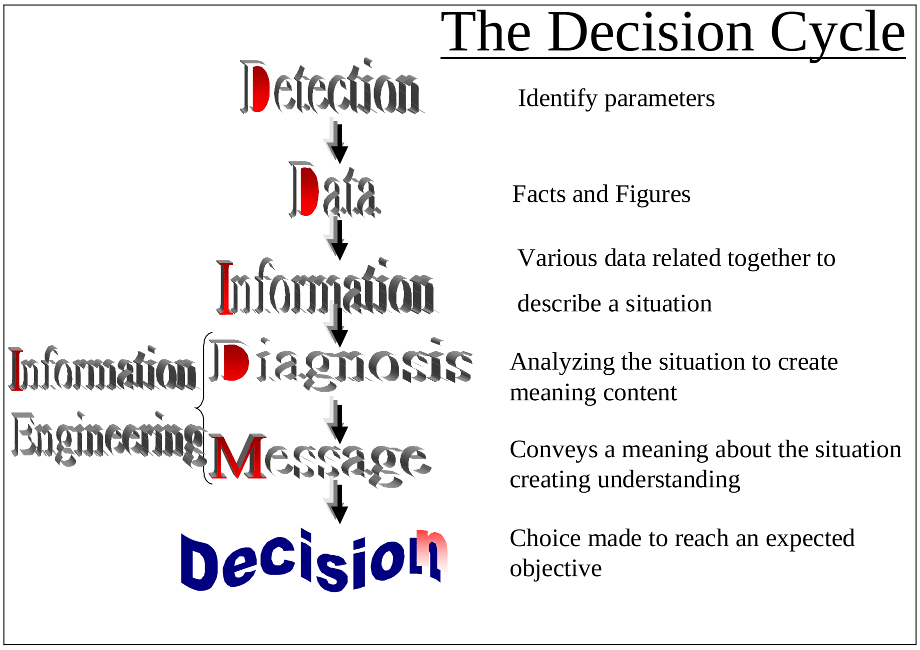


**Figure 3.3:** Data-to-Decision Cycle Model (7,11)

In this model of a communication system, the goal is to optimize the quality of the message transmitted through the interface from the information system to the human user. One primary consideration is to assess both the "message" and the quality of the interface. Since message quality and content deal with the degree of meaning conveyed to the decision-maker, it becomes evident that the decision-maker must be actively involved in the design of this message interface.

The "Detection" and "Data" parts of the model represent a data warehouse, which is a repository of the company's historical data. The "Information" part of the model is comparable to data mining, which involves extraction of meaningful and useful information. The "Decision and Action" parts at the other end of the model are synonymous with expert systems (decision support tools relying on the concept of Artificial Intelligence and going beyond just programmable decisions). While the data being generated and information processed is at one end, the outcome of the decision being made is on the other end. But if we look at the center of the cycle, we realize that right decisions are not made merely by obtaining information, but by the correct diagnosis of the meaning of that information. If we interpret the meaning correctly, then we get the right message, which means we will probably make the right decision. It is here, in the center of the Decision cycle that machine intelligence can be created and it is here that *Information Engineering* can be applied to the manufacturing system. *Information Engineering* can thus be used to bridge the gap between the Data to Decision phases. It is the right decision that leads to favorable outcomes for that company and this is where information actually creates value (14).

## 4. Future Research

In summary, it can be clearly seen that *Information Engineering* seems to be an effective tool in enhancing and improving the decision-making capability of the user. In addition to the ongoing research efforts that have been primarily aimed at the Detection and Data phases of the Data-to-Detection Model, researchers at the North Carolina State University, College of textiles are using the *Information Engineering* approach to develop a fundamentally unique methodology for rationalizing the data so as to reduce the overload that tends to occur and make it simple for the personnel to make a right decision. For this purpose, surveys will be conducted with personnel, both on the plant and management level to identify the user requirements. Data collection and control profiles for the manufacturing processes will be defined and the various types of data generated and information required to manage the textile processes will be evaluated. The Data-to-Decision Cycle model will be utilized to understand and gauge the extent of information generated. The final goal will be to optimize the quality of the "message" to create a sound understanding for effective decision making. The *Information Engineering* methodology will be validated and its feasibility gauged by applying to specific areas of the textile manufacturing process as deemed necessary by industry experts and will build on existing partnerships with textile companies.

---

## ACKNOWLEDGEMENTS

The authors would like to thank the National Textile Center (NTC) for providing the required support for this research.

## REFERENCES

1. Jayaraman ,S. "Textiles and the Next Millenium", ATI, PP 73-74 , ATI, February 1996.
2. Karpe Y, Little T & Hodge, G. " Is Quick Response 'the strategy" of the 21st Century for the textile and apparel supply chain?", Proceedings of the 79th World Conference of the Textile Institute, Madras, India, February 1999.
3. Anon, "IBM and the TI – Information Technology Survey", Textile Horizons, PP 54-55, February 1994.
4. Dove, R & Hartman, S. "An Agile Enterprise Reference Model". Available: http://www.parshift.com/aermodA0.html
5. Benjamin, R & Blunt, J. "Critical IT Issues: The Next Ten Years", Sloan Management Review, PP 7-17, Summer 1992.
6. Oxenham, W, Hodge, G. & Rasmovich, J. "Data Requirements for Staple Spinning Systems". Proceedings of the 77th Textile Institute Conference, Greece, May 1997.
7. Hodge, G, Oxenham, W, Cahill, N. & Karpe, Y. "*Information Engineering*: Textile Industry's value-adding key to effective decision-making", NTC Annual Briefs, 1999.
8. Campos, J, "Weft Knit Data Modeling for CIM", MS Thesis, NCSU,1991.
9. Hodge, G. "Enterprise Modeling", Journal of the Textile Institute, Vol. 88, Part 2, No. 1, 1997.
10. Veryard, R, "Information Modeling", Prentice Hall International (UK) Ltd., 1992.
11. Cahill, N, "*Information Engineering*: Concepts and Techniques, Institute of Textile Technology, VA, March 1988.
12. Cahill, N, "Analyzing textile plants of the 21st. Century", ISA - textile division, June 1997.

13. Cahill, N. “*Information Engineering* – Measuring use value of information”, ITT Report, 1985.
14. Cahill, N, “Analytical Techniques to assess information use value”, ITT Report, 1985.

**Correspondence Addresses:**
*Dr. George Hodge, Dr. William Oxenham & Mr. Yatin Karpe*
College of Textiles, North Carolina State University,
Raleigh, NC-27695, USA

*Mr. Neil Cahill*
Institute of Textile Technology, 2551 Ivy Road
Charlottesville, VA 22903-4614, USA