PACIS 1997 Proceedings

Pacific Asia Conference on Information Systems (PACIS)

December 1997

# The Nature of Data, Information and Knowledge Exchanges in Business Processes: Implications for Process Improvement and Organisational Learning

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# The Nature of Data, Information and Knowledge Exchanges in Business Processes: Implications for Process Improvement and Organisational Learning

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**Keywords:** Brazil, New Zealand, Action Research, Process Improvement, Business Process Re-engineering,Organisational

**Executive Summary**

A number of assumptions in the past have been made about how business process improvement and re-engineering, and organisational learning should take place in organisations. Although a number of these assumptions have been framed on theoretical models, few have been based on the empirical analysis of the nature of actual business processes. This paper tries to fill this gap with an analysis of data, information and knowledge exchanges in 22 business processes from three organisations. This analysis points to a number of characteristics that appear to be contradictory with some current organisational practices, and that can be helpful to inform future developments in the fields of business process improvement, re-engineering and organisational learning. Two relevant characteristics are a much higher proportion of data over material exchanges in business processes, and a higher proportion of knowledge exchanges in improvement over core and support processes.

From a normative perspective, two main implications emerge from the findings of this study. The first is that organisations can benefit by first monitoring their mix of data, information and knowledge transfers between and within processes. This will not only help identify the types of processes they engage in (core, support, or improvement), but it will identify their "information exchange thresholds" as well. Once this is done, steps can be taken to improve identified processes. For example, a low "information exchange threshold" (i.e. a high proportion of knowledge exchanges) in a core process may suggest the need for extra training targeting the learning of process-related knowledge by those functions causing the high proportion of knowledge exchanges in the process. By the same token, a high number of functions in a core process, which is likely to be linked to a intense information flow, may call for specific improvement strategies such as: (a) The optimisation of the information flow in the process, e.g. by eliminating irrelevant information in bottom-up reports; and (b) A focus on core competencies, e.g. by outsourcing support functions in the process. This outlines perhaps a different approach for organisational learning and the use of what is learned to improve embedded processes, compared with more traditional approaches.

The second main implication is that business process improvement can be a powerful tool for knowledge communication and the consequent building of shared knowledge among different departments in organisations. Although the main goal of process improvement is not knowledge communication, it can be seen as a legitimate means for shared knowledge building with inherent extra bonuses (e.g. process quality and productivity improvement). The findings of this study allow us to believe that the creation of a "process improvement culture" in organisations can itself lead to an increase in the "information exchange threshold" of core and support processes, by fostering knowledge communication "outside" those processes. This is *per se* likely to lead, in an indirect way, to more efficient and effective core and support processes, even if no "visible" improvement accrues from the redesign of the processes targeted in process improvement attempts.

**Abstract**
A number of assumptions in the past have been made about how business process improvement and re-engineering, and organisational learning should take place in organisations. Although a number of these assumptions have been framed on theoretical models, few have been based on the empirical analysis of the nature of actual business processes. This paper tries to fill this gap with an analysis of data, information and knowledge exchanges in 22 business processes from three organisations. This analysis points to a number of characteristics that appear to be contradictory with some current organisational practices, and that can be helpful to inform future developments in the fields of business process improvement, re-engineering and organisational learning. Two relevant characteristics are a much higher proportion of data over material exchanges in business processes, and a higher proportion of knowledge exchanges in improvement over core and support processes.

**Introduction**
Business-related knowledge has been identified as the single most important factor ultimately defining organisational competitiveness (Drucker 1989; Kock, McQueen and Baker 1996). The speeding up of new product design and delivery has led to an increase in the a demand for knowledge workers and an increase in the knowledge-intensive labour component of products (Boland and Tenkasi 1995). The same phenomenon, combined with the emergence of automation technologies, has been argued as having forced organisations into expanding their information processing and service departments, while at the same time considerably reducing the number of material handling workers. As (Drucker 1993) points out:

> In 1880, about nine out of 10 workers made and moved things; today, that is down to one out of five. The other four out of five are knowledge people or service workers. These workers converse on the phone, write reports, attend meetings...(Drucker 1993, p. 1.)

But have organisational practices adapted to these changes? A number of proponents of contemporary managerial approaches would argue that "yes, we are moving towards knowledge-oriented practices". This move, however, has apparently relied mostly on either opinions professed by management gurus or abstract theoretical speculations, and very little on the analysis of actual organisational practices and how these practices can be improved within the new knowledge-oriented business context.

We try in this paper to fill this gap by examining how data, information and knowledge flow in organisations. Our examination is framed on a construct which, while having recently attracted the attention of management academics and practitioners particularly due to the business process re-engineering movement (Hammer and Champy 1993), has seldom been used as a unit of analysis in organisational research studies. Such construct is the *business process*.

Given the large amount of research in the broad field of organisational cognition, particularly since the 1980s, and the variety of research frameworks applied, our study may be seen as merely adding a new idiosyncratic, perspective dependent, study to that field. In fact, the field of organisational cognition has been criticised by its diverse language and imprecise thinking, by being a field of study where researchers have been working "alone together" since the 1950s (Walsh 1995). Even though we understand that the approach used in this study is relatively new from an organisational cognition research perspective, an therefore might be seen as idiosyncratic, we believe that this approach is likely to benefit from two contemporary factors. The first is the novelty represented by the recent focus of the management and IT research community on business processes (Davenport 1993), (Hammer and Champy 1993), (Davenport and Stoddard 1994) and (Kock 1995). The second is the consequent increasing importance of the business process concept within construct as our main unit of analysis - we hope that our findings and their implications will be of particular interest to both the organisational research and business communities.

We initially discuss three basic concepts used in this study: data, information and knowledge. Following this discussion, we describe the basic unit of analysis of our study - the business process. Then we describe the findings of an analysis of 22 business processes, whose research data was obtained from three organisations - one in Brazil, and two in New Zealand. This analysis focuses on data, information and knowledge exchanges in the 22 business processes. Finally, possible explanations for the findings and implications for business process redesign and organisational learning are examined.

**Knowledge, Information And Data**

The concepts of knowledge, information and data are closely related. Although distinct, these three abstract concepts are often confused. As commonplace as the confusion of data and information, is the confusion of knowledge and information, nurtured even by prominent thinkers, who themselves pioneered the idea of information-based organisations[e.g. 1, pp. 207-208]. For the purposes of this study, we have defined these three concepts as follows (Kock, McQueen and Baker 1996).

*Data.* Data is a carrier of knowledge and information, a means through which knowledge and information can be stored and transferred. Both information and knowledge are communicated through data, and by means of data storage and transfer devices and systems. In this sense, a piece of data only becomes information or knowledge when it is interpreted by its receiver (Kock, McQueen and Baker 1996). In the same sense, information and knowledge held by a person can only be communicated to another person after they are encoded as data. Printed paper and computer disks are examples of data storage devices. A corporate e-mail and the international airmail systems are examples of data storage and transfer systems.

*Knowledge and information.* While information is descriptive, that is, it relates to the past and the present, knowledge is eminently predictive, that is, it provides the basis for the prediction of the future with a certain degree of certainty based on information about the past and the present (Dubin 1976), (Camerer and Johnson 1991) From this perspective, statements of the type "the aluminium smelter's temperature has been set at 300 degrees Celsius" convey information, whereas statements of the type "if the aluminium smelter temperature is set at 1,000 degrees Celsius, then all the aluminium in the smelter will be smelted in 30 minutes" convey knowledge. This occurs whether these statements are true or false, since the truth of knowledge and information is relative - e.g. the Newtonian theory of mechanics led to statements about objects that where true only when those objects moved at speeds considerably lower than the speed of light.

Knowledge and information flow between functions, or roles, in organisations. These functions are played by staff (or, in a few cases, by computer systems) engaged in the execution of interrelated activities with the use of tools. Sets of interrelated activities provided the basic framework against which research data was collected in our study. The main component of this basic framework is an abstract entity called "business process", defined in the next section.

**Business Processes**

Business processes have been traditionally defined as sets of interrelated activities, or work flows (Harrington 1994), (White and Fischer 1994). We understand, however, that the scope of the business process construct can be broadened by considering elements associated with its activities in a way that turns the business process construct into a rich unit of analysis in organisational studies. In this sense a business process can also be seen as comprising the functions (carried out by organisational staff) and tools involved in the execution of the activities in a process. Moreover, the business process concept can be seen as comprising the product flow between activities, and the suppliers and customers of the process. This generic view of business processes is illustrated through the "receive materials" process of a hypothetical chimney manufacturer, shown in Figure 1.

The process shown in the figure comprises four functions, namely acquisitions assistant, quality inspector, stock assistant and sales assistant. Phone, e-mail, quality inspection equipment, mail, fax, internal mail, fork lift, and computer stock system are tools used in the process. Aluminium tubes, accessory parts, delivery form, materials receipt, replacement order, quality inspection report, and stock data are products - some of them are data, and some material products - that flow between functions in the process. Finally, Aluminium & Co. and Chimney Accessories & Co. are suppliers of the process, whereas the production manager of the chimney manufacturer is the customer of the process.

The main unit of analysis of this study was the business process. The conceptualisation proposed above provided the basic framework for the analysis of the data flow, through the analysis of discrete data exchanges, between functions in business processes. The data flow was then compared with the material flow, calculated based on the analysis of discrete material exchanges in the processes. The data flow was then decomposed according to its information and knowledge content, which allowed for the analysis of the flow of information and knowledge in the business processes. The way those analyses have been carried out is explained in the next section, within the context of the research method.

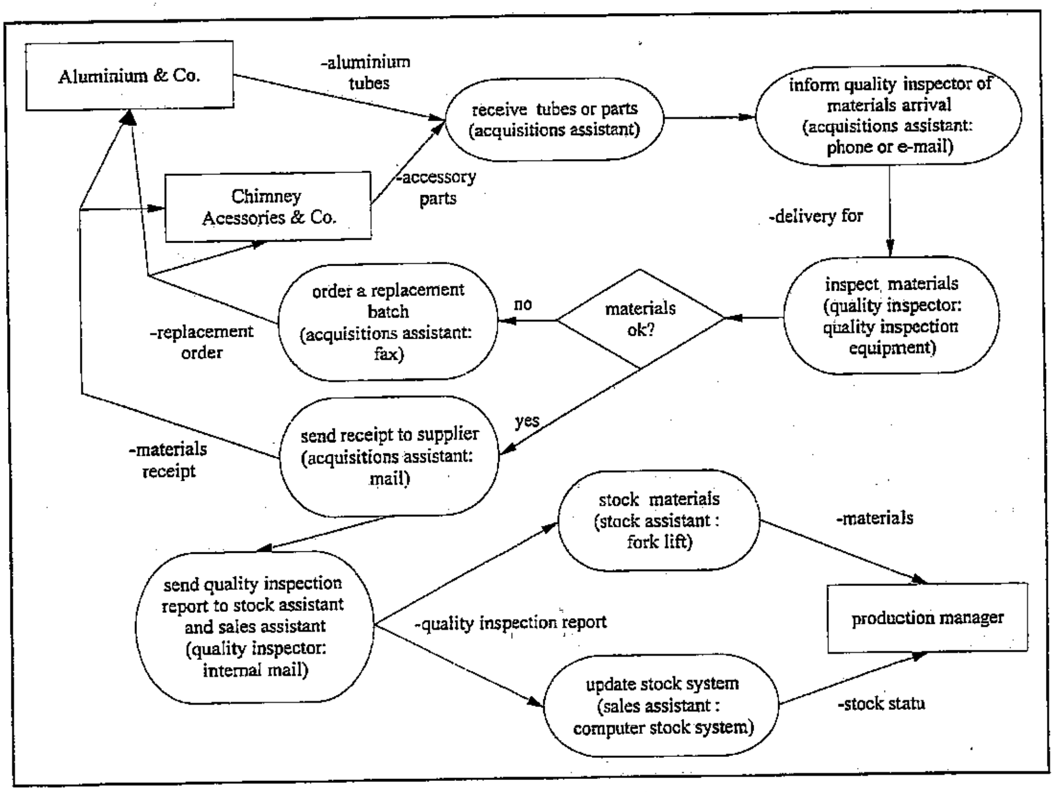


**Figure 1:** "Receive materials" process of a hypothetical chimney manufacturer

**Research Method**

Cross-sectional research data about 22 instances of business processes was collected and analysed in the socio-technical environments of three organisations: a Brazilian plant of Westaflex, an international car parts manufacturer; University (pseudonym), a New Zealand University; and MAF Quality Management (MQM), a semi-autonomous branch of the New Zealand Ministry of Agriculture and Fisheries.

Business processes have been classified as: core, support, and improvement. Core processes are those directly involved in the generation of products targeted at the external customers of the organisation. Support processes are those involved in the generation of products for internal customers. Improvement processes are those whose main goal is to improve existing processes in the organisations, whether these are core or support processes. No management processes were analysed. The general goals, number of functions involved, types, and organisations of the 22 business processes studied are described in Table 1.

Research data about seven processes was obtained from Westaflex; about three processes from University; and about twelve processes from MQM. As shown in Table 1, eight processes were core organisational processes; seven were improvement processes; and seven were support processes. For those processes whose research data was obtained in the context of process redesign work, the process configuration considered in our study was the one prior to the redesign.

Research data collection took place in the context of organisational development projects with action research characteristics (Jonsonn 1991), (Francis 1991), (Elden and Chisholm 1993), (Gustavsen 1993) (Karlsen 1991), (Kock, McQueen and Fernandes 1995). That is, the researcher (first author of this paper) had a dual goal in those projects - to improve the participant organisations and, at the same time, collect and reflect on field research data to generate scientific knowledge. We believe that the researcher's dual goal, i.e. action and research, fostered a better understanding of contextual characteristics relevant to the interpretation of field research data, than the one likely to be achieved in other approaches where the researcher assumes a more disengaged perspective, such as case and survey research approaches (McClintock and Maynard-Moody 1979), (Doolin 1995) (Kock, McQueen and Fernandes 1995).

| Process goal | Number of functions | Process type | Organ-isation |
|---|---|---|---|
| Product design | 5 | Core | Westaflex |
| Parts manufacturing | 4 | Core | Westaflex |
| Order delivery | 8 | Core | Westaflex |
| Raw material purchase | 6 | Core | Westaflex |
| University course preparation | 3 | Core | University |
| University course teaching | 3 | Core | University |
| Communication of a pest/disease outbreak | 5 | Core | MQM |
| Quality management consulting | 5 | Core | MQM |
| University course improvement | 8 | Improv. | University |
| Software support improvement | 3 | Improv. | MQM |
| Newspaper editing improvement | 4 | Improv. | MQM |
| Pest/disease outbreak communication improvement | 2 | Improv. | MQM |
| Quality management consulting improvement | 6 | Improv. | MQM |
| IT users support improvement | 11 | Improv. | MQM |
| Staff training and development improvement | 6 | Improv. | MQM |
| Quality inspection of parts/materials | 3 | Support | Westaflex |
| Plant machinery maintenance | 2 | Support | Westaflex |
| Equipment adaptation for new product | 3 | Support | Westaflex |
| Software support for users | 3 | Support | MQM |
| Internal newspaper editing | 5 | Support | MQM |
| IT users support | 5 | Support | MQM |
| Staff training and development | 5 | Support | MQM |

**Table 1**: General description of the processes studied

At Westaflex the researcher collected research data over a four-month period during which 33 structured interviews were conducted with management and line staff. Those interviews were based on open-ended questions focusing on Westaflex's processes, and were targeted at the identification of characteristics relevant to the implementation of a quality management system based on the ISO 9001 standard. This implementation was the "action" component of the action research project in that organisation.

At University and MQM the researcher was the facilitator of seven business process improvement groups that modelled, analysed and redesigned eight business processes. All groups followed the same process redesign methodology (Kock 1995) with the help of the researcher. One group redesigned two business processes at University over a period of 33 days. Six groups redesigned one process each at MQM and have been facilitated over a period of four months. Research data was collected in the form of transcripts of: (a) structured interviews (eleven); (b) responses to questionnaires with open-ended questions (seven); (c) group discussions; (d) unstructured interview (thirty-six) and participant observation notes.

Processes have been graphically modelled using a flow charting tool (see Kock 1995 for a description of the simplified subset of symbols used). Activities were described in terms of tasks performed, functions involved in their execution (e.g. salesperson, quality manager), and tools used (e.g. lathe, CAD software). The flow chart models were then used to count the number of functions involved in each process and to generate a quality flow matrix for each of the processes.

Quality flow matrices are simple display aids to understand the flow of products through processes. These matrices have been devised by (Kock and Tomelin 1993) based on (Juran's 1989) view of quality as flowing in organisations through products that move from suppliers or producers to customers, whether these suppliers and customers are internal or external to the organisation. By modelling the processes through quality flow matrices we have been able to count exchanges of material objects (e.g. equipment, raw materials, manufactured parts) and data objects (e.g. order delivery forms, purchase orders, e-mail messages) between functions in the processes. These counts have then been used: (a) in simple correctional analyses; (b) to calculate the proportion of the material and data exchanges in the processes; and (c) to calculate the proportion of exchanges of information and knowledge through data in the processes.

**Research Findings**

Three main types of research findings are discussed in this section. The first type concerns the proportion of data and material exchanges in the processes studied. The second type concerns the proportion of information and knowledge exchanges in the processes, which occur through the exchange of data. Finally, we discuss the research findings concerning correlation's between number of functions, material exchanges, information exchanges and knowledge exchanges in the processes.

**Data and material exchanges across different process types**

The analysis of the proportion of data and material exchanges in the processes suggested a remarkable predominance of data over material exchanges, even though almost a third of the processes studied were from a manufacturing organisation. This predominance is illustrated in Figure 2. When all processes were considered together, approximately 90 per cent of product exchanges in the processes have been found to be data exchanges. Only about 10 per cent of product exchanges have been found to be material exchanges.

The difference in the proportion of data exchanges was higher, in comparison to material exchanges, for improvement processes (100 to 0 per cent, i.e. only data was exchanged), and lower for support (81.40 to 18.60 per cent) and core processes (83.33 to 16.67 per cent). Even when improvement processes are not considered, the proportion of data exchanges in the processes is remarkably high - more than 80 per cent.

One of the reasons for the confusion between data and information, discussed previously in this paper, may be the widespread and intuitive assumption that information is the main component of what is communicated through data. Our study suggests that this assumption is true. This assumption is examined next, where we look at the proportion of information and knowledge transferred through data.

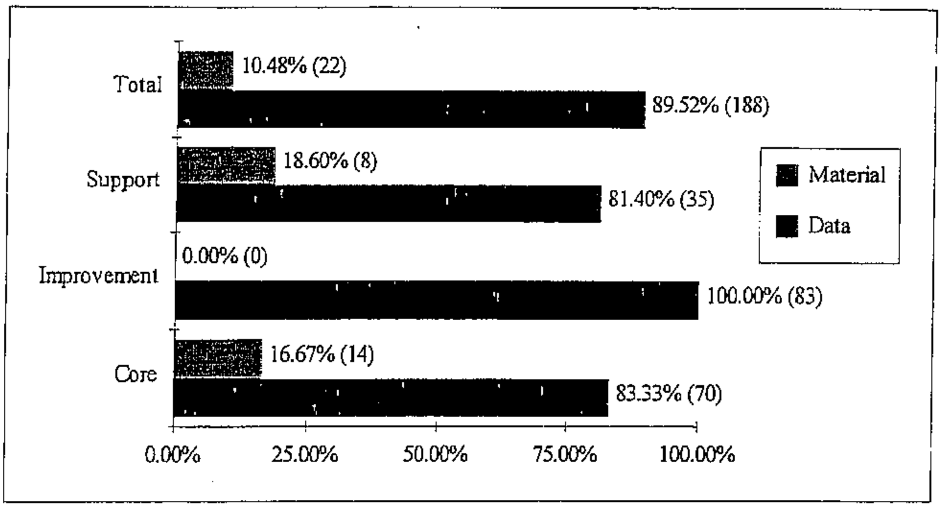


**Figure 2**: Proportions and absolute numbers of data and material exchanges across different process types

**Information and knowledge exchanges across different process types**

The intuitive, but nevertheless remarkable, results concerning the proportion of data exchanges in processes called for a further look at the nature of those data exchanges. With this purpose in mind we analysed the information and knowledge content of data exchanges based on the definitions of information and knowledge discussed previously in this paper. A given data exchange was considered as comprising information if it contained descriptive elements in the form of facts; and knowledge, if it contained predictive elements in the form of predictive rule structures (Kock, McQueen and Baker 1996). This analysis revealed a predominance of information over knowledge in data exchanges. That predominance is more accentuated in support and core processes, than in improvement processes, as illustrated in Figure 3.

It is curious that the proportions of information and knowledge were exactly the same for support and core processes (85.37 and 14.63 per cent). The information and knowledge exchange counts that have been used to calculated those proportions, however, were different, being at 35 and 6, for support processes, and 70 and 12 for core processes. Those identical proportions indicate a similarity in the pattern of information and knowledge exchanges for support and core processes.

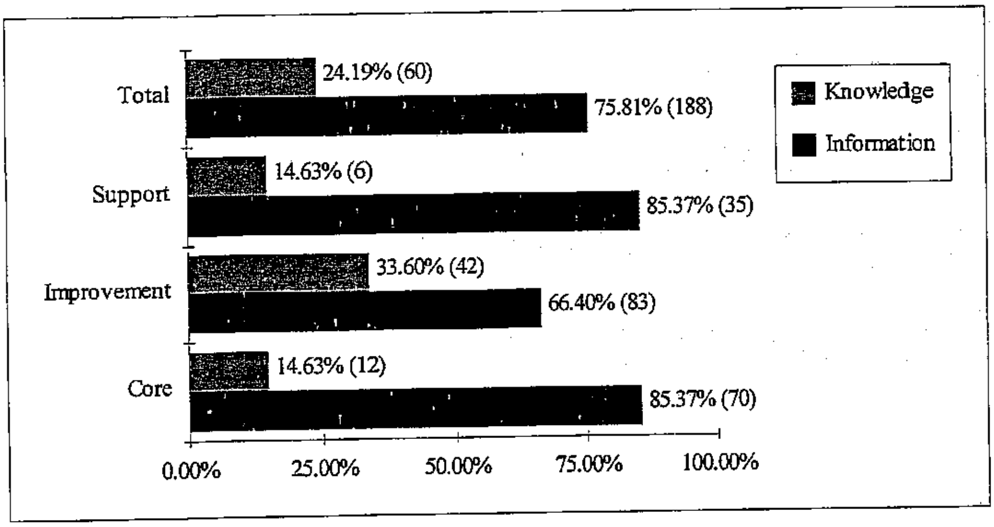


**Figure 3**: Proportions and absolute numbers of information and knowledge exchanges across different process types

**Correlation between number of functions and exchanges of different types**

The preliminary findings of a correctional analysis conducted previously by us on similar research data revealed an interesting correlation between functional heterogeneity and information flow in business processes (Kock and McQueen 1996). We decided to replicate and extend that analysis by conducting a correctional analysis involving the variables number of functions, material exchanges, information exchanges and knowledge exchanges. This analysis suggested a strong correlation (at least twenty per cent above the necessary to reject the null hypothesis at a 0.05 level of significance) between: (a) The number of functions in a process and the number of information exchanges in the process (r = 0.86); and (b) The number of information and knowledge exchanges in a process (r = 0.75). The coefficients of correlation (Pearson) calculated are shown in Table 2 (we included only those deemed relevant in the context of this study).

| Number of | Material exchanges | Information exchanges | Knowledge exchanges |
|---|---|---|---|
| Functions | 0.11 | 0.86 | 0.56 |
| Material exchanges | - | - | 0.32 |
| Information exchanges | - | - | 0.75 |

**Table 2**: Pearson correlation coefficients table

The strong correlation between the number of information and knowledge exchanges suggests that an increase in information exchanges is likely to be followed by an increase in knowledge exchanges. This curious result called for a further analysis of the processes, which indicated that knowledge exchanges occurred always together with information exchanges. On the other hand, information exchanges often occurred alone. That is, none of the data exchanges carried only knowledge, whereas several data exchanges carried only information. This rules out the hypothesis that some knowledge is always transferred together with information, and points towards the existence of an information exchange threshold above which knowledge exchanges are likely to happen.

**Discussion**

The predominance of data over material exchanges in the processes studied and the higher information than knowledge content of those exchanges seem to confirm the claims, particularly since the 1970s, that we are now living in an information society (Toffler 1970), (Toffler 1991) that society has been undergoing an information explosion where more and more people are working in the "information sector" (Hirschheim 1985), and that organisations have become "information organisations" (Drucker 1989).

It is curious, however, that the high proportion of data exchanges in the processes studied seems at odds with the current emphasis of business process redesign practitioners on work flows (Soles 1994). For example, most of today's business process redesign practice focus on the analysis of business processes as sets of interrelated activities (as in Figure 1), a practice apparently inherited from the industrial revolution and that is based on a mechanistic view of business processes (Kock, McQueen 1996). Little attention, however, is paid to the analysis of data flow in those processes. This is reflected in the most widely adopted normative frameworks for business process redesign, such as (Harrington's 1991) and (Hammer and Champy's Hammer and Champy 1993). (Harrington 1991, p. 108) goes to the point of stating that data flow analysis is of "more interest to computer programmers and automated systems analysts than to managers and employees charting business activities". These two normative frameworks top the list of frameworks used by over twenty business process re-engineering consulting companies in UK, Europe and USA - almost half of the organisations surveyed by (Archer and Bowker 1995). Our findings regarding the proportion of data exchanges in business processes support the claim made in previous studies (Kock 1995), (Kock, McQueen and Baker 1996), (Kock and McQueen 1996) for a shift in the focus of much of the current business redesign practice, from work flows to data flows (or information and knowledge flows).

The similarity between the proportions of information and knowledge exchanges in core and support processes, and their contrast with the proportions in the improvement processes (66.40 and 33.60 per cent), is an indication of the distinctive nature of improvement processes. In fact, the proportion of knowledge exchanges in these processes is more than twice that found in support and core processes. The main explanation for this discrepancy is that in core and support processes staff possess specialised knowledge inherent in their functions. This knowledge is rarely communicated unless it is necessary to solve a problem (often caused by lack of knowledge sharing between different functions), review a specific procedure, or train a new staff member in the execution of process activities. Information, on the other hand, is always communicated, irrespective of process type - e.g. in Figure 1 the delivery form and replacement order are likely to carry information, not knowledge (reports are more likely to convey knowledge together with information). In improvement processes, however, those involved need first to share knowledge, such as process-related knowledge in the process analysis stage (see Kock 1995), to be able to effectively redesign a process.

This distinctive characteristic of improvement processes makes this type of process particularly suited to what (Boland and Tenkasi 1995) refer to as "perspective taking", and organisational learning (Argyris 1977) - particularly "double-loop learning" (Argyris 1977), (Argyris 1996). This distinctive characteristic of improvement processes may be seen as an indication that (Coulson-Thomas' 1996) position that there is no relationship between discontinuous business process redesign (e.g. business process re-engineering) and organisational learning should be re-examined, as discontinuous process redesign typically takes place through processes very similar to those used by process improvement groups in our study. On the other hand, the discontinuous nature of approaches such as re-engineering may prevent these approaches from contributing to organisational learning as much as continuous improvement approaches such as *kaizen* could, particularly due to the longer time span between process improvement attempts.

The strong correlation between the number of functions in a process and the number of information exchanges may be explained by an underlying correlation between knowledge specialisation and information flow. Functional diversification occurs in organisations because different types of expertise are necessary to execute distinct activities in processes, which leads to knowledge specialisation. Therefore, a strong correlation between number of functions and information exchanges can be interpreted as a strong correlation between knowledge specialisation and the number of information exchanges (which can be used to measure information flow). One of the implications of this interpretation is that whether organisations are static and very organised, such as bureaucracies (Weiss and Barton 1980), or dynamic and "disorganised", such as *adhocracies* (Toffler 1970), the flow of information in these organisations is likely to be equally intense. This occurs in bureaucracies because of the large (and often unnecessary) number of functions and functional departments, and in *adhocracies* because of the high number of knowledge workers with expertise in specialised fields.

Moreover, the current trend towards knowledge specialisation is likely to compound this situation in the future, as new knowledge and new knowledge specialisation's are created everyday at an astonishing rate (Toffler 1991).

The strong correlation between the number of information and knowledge exchanges along with the finding that knowledge is always exchanged together with information may be explained by the existence of an information exchange threshold above which knowledge is more likely to be exchanged. The existence of this threshold suggests that as the exchange of information between organisational staff increases, so does the chance that complementary knowledge will become necessary for staff involved to assure common meaning and implications associated with the information being exchanged. One of the implications of this finding is that shared knowledge among co-operating functions should be built into organisations if information and knowledge exchange losses are to be minimised. Since information exchanges cannot always be reduced to a point below the threshold discussed before, it is likely that shared knowledge will minimise the need for knowledge exchanges, even when the number of information exchanges grows above the threshold - i.e. "preventive" knowledge sharing can push that threshold upwards. This is particularly important in processes whose execution time minimisation can be translated into competitive gains (e.g. order delivery, product assembly, customer service), and is essentially what the CEO's of Peters and Waterman's (Peters and Waterman 1982) group of excellent organisations did when they built strategic *views* of their organisations and communicated those *views* effectively to their staff. Those *views* can be seen as bodies of shared knowledge that would enable staff to take decisions based on information, with minimal transfer of knowledge - i.e. based on knowledge previously transferred in an efficient and effective way, such as in the courses for new staff at Disney University for example.

**Conclusion And Implications For Practitioners**

Business processes can be seen as sets of interrelated activities, carried out by functions using tools. Functions are typically characterised by the specialised bodies of knowledge necessary to carry them out, which are held by the organisational staff who perform those functions. Different functions must exchange materials and data in order to execute activities in business processes.

The exchange of data between functions in business processes seems to be considerably higher than the exchange of materials. For example, when all 22 processes were considered together in our study, approximately 90 per cent of product exchanges have been found to be data exchanges. This finding confirms the claim, particularly since the 1970s, that society and organisations have become increasingly data-oriented. The same findings, however, seem to be at odds with the current emphasis placed by business process redesign practitioners on work flows, rather than data (or information and knowledge) flows. The focus on work flows, an inheritance of the industrial revolution that is based on a mechanistic view of business processes, is an outdated practice that is incompatible with today's information (knowledge)-intensive nature of business processes.

When the content of data exchanges is split into information and knowledge, it becomes clear that the proportion of information exchanges in business processes is considerably higher (more than 75 per cent) than that of knowledge exchanges. In addition, knowledge exchanges seem to occur more often in improvement processes than in core and support processes. This latter finding suggests that improvement processes foster perspective taking between different functions and organisational learning, which contradicts, to a certain extent, the position expressed by some business process redesign practitioners that there is no correlation between discontinuous process redesign (e.g. business process re-engineering) and organisational learning.

There seems to be a strong correlation between the number of business process functions and information exchanges. This can be explained by an underlying correlation between knowledge specialisation and information flow. Functional diversification occurs in organisations because different types of expertise are necessary to execute distinct activities in processes, which leads to knowledge specialisation. One of the implications of this finding is that an intense flow of information is likely to occur in bureaucracies and *adhocracies* alike. This occurs in bureaucracies because of the large (and often unnecessary) number of functions and functional departments, and in *adhocracies* because of the high number of knowledge workers with expertise in specialised fields.

There seems to be a strong correlation between the number of information and knowledge exchanges in business processes. Since information is often transferred alone in data exchanges, without knowledge, but knowledge appears to always be transferred together with information, this strong correlation indicates the existence of an information exchange threshold above which knowledge is likely to be transferred as well. While this threshold is likely to exist, it can be "pushed up" in organisations, by the effective communication of relevant knowledge to staff. The reason why this threshold should be pushed up is simple - the need for knowledge exchanges, particularly in core and support processes, is likely to lead to a lack of competitiveness. For example, if a staff member does not have the knowledge to make a decision based on information at hand, the process instance in which he or she is involved is likely to be delayed, which can generate productivity losses and low quality. This is particularly important in processes whose execution time minimisation can be translated into competitive gains (e.g. order delivery, product assembly, customer service).

From a normative perspective, two main implications emerge from the findings of this study. The first is that organisations can benefit by first monitoring their mix of data, information and knowledge transfers between and within processes. This will not only help identify the types of processes they engage in (core, support, or improvement), but it will identify their "information exchange thresholds" as well. Once this is done, steps can be taken to improve identified processes. For example, a low "information exchange threshold" (i.e. a high proportion of knowledge exchanges) in a core process may suggest the need for extra training targeting the learning of process-related knowledge by those functions causing the high proportion of knowledge exchanges in the process. By the same token, a high number of functions in a core process, which is likely to be linked to a intense information flow, may call for specific improvement strategies such as: (a) The optimisation of the information flow in the process, e.g. by eliminating irrelevant information in bottom-up reports; and (b) A focus on core competencies, e.g. by outsourcing support functions in the process. This outlines perhaps a different approach for organisational learning and the use of what is learned to improve embedded processes, compared with more traditional approaches.

The second main implication is that business process improvement can be a powerful tool for knowledge communication and the consequent building of shared knowledge among different departments in organisations. Although the main goal of process improvement is not knowledge communication, it can be seen as a legitimate means for shared knowledge building with inherent extra bonuses (e.g. process quality and productivity improvement). The findings of this study allow us to believe that the creation of a "process improvement culture" in organisations can itself lead to an increase in the "information exchange threshold" of core and support processes, by fostering knowledge communication "outside" those processes. This is *per se* likely to lead, in an indirect way, to more efficient and effective core and support processes, even if no "visible" improvement accrues from the redesign of the processes targeted in process improvement attempts.

**Acknowledgments**
We would like to thank Westaflex, University and MQM for their participation in the action research projects whose results have been partially reported in this paper.

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