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Chapter 2. Information Activities and Tasks
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Information Activities and Tasks

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1. Introduction

In this chapter, we are concerned with 'work,' that is with "activity involving mental or physical effort done in order to achieve a result" which is typically interpreted as the "task or tasks to be undertaken" (Work, n.d.). In our information and knowledge intensive economy today, most jobs involve activities and tasks that create, manipulate, interpret and use information. In an analysis of job activities and tasks in the UK, Brinkley et al (2009) found that 60% of jobs required some to high knowledge content that used primarily tacit knowledge, that is knowledge stored in head (rather codified knowledge). Nearly a decade later, we consider information activities and information tasks to be central to most of the undertakings within a workplace.

In this chapter, we deconstruct work from an information centric perspective. We start by examining work as a generic process involving a series of activities that drive tasks, sub-tasks and their associated human actions, interconnected in hierarchical or network-like structures. This is the essence of what is done in the workplace. Next we consider three distinct but essential elements that impact how those activities and tasks are completed:

a) an information flow that emerges as streams of data and information from multiple units of the organisation (both internally and externally), and upon which multiple actions may take place from the flow's origination to its destination;
b) information processes that act on data and information while they are 'stationary', sometimes to create new information;
c) interactive activities that involve people and objects (from informational to physical) working with information processes using that data and information.

Notably, all of these elements are deployed to service organizational goals and objectives.

One must not forget that work and its associated activities and tasks are not isolated and independent, but sit within an ecosystem — a social, cultural and legislative milieu (see for example, Suchman, 1987; Button & Sharrock, 2009) that is intersected by technologies and the work that needs to be done. That discussion is outside the scope of this chapter. In a holistic view of work within the workplace, we would need also to consider the organizational, functional and process workflow views as well as the information flow (Durugbo, Tiwari & Alcock, 2013) discussed here, and distinguish information processes from functional, behavioural and organizational processes (Curtis, Kellner & Over, 1992). But our focus is on the information work activities and tasks, and thus this chapter has isolated for further examination the threads that are the most tightly connected to that topic.

2. Data, Information and Knowledge — the Fuel that drives Information Work

Intrinsic to work, and thus, to each of are data and/or information — the raw materials essential for work, and therefore to the activities and tasks. Much has been written about the meaning of data, information and knowledge, and unfortunately, often those words are used interchangeably. For the purposes of this chapter, we have defined each of these concepts in a concrete way so that we can use the terms to explain the other concepts discussed in this chapter (see Marchionini (2010) for a good discussion of these terms). See Figure 1 for an illustration of the relationship amongst the three.

Figure 1. Showing data as a set of numbers, characters and codes converted to information which is then integrated by workers with their existing knowledge to create new knowledge ©E. Toms, 2018.

We consider data to be anything that can be expressed as a quantitative or qualitative value. Numbers, characters of text, audio signals, and pixels, for example, are all data, merely signals that are looking for meaning. The digits, "1 1 4 2 2 2 3 4 4 1", are simply a set of numbers, until identified as a phone number (in the UK), or a product code, or even a cryptic code used in a puzzle. Those digits (i.e., bytes) are raw or unprocessed data until we afford some sort of interpretation. With very few exceptions, most work involves using data that has already been ascribed a meaning using metadata. In the case of the example, the element, phone number or product code, is the metadata used to describe the string of raw data. Most work will need the metadata to make sense of the data.

Data become information when we interpret the signal, and ascribe the set, a humanly interpretable meaning (which is what metadata is). Those streams of signals or bytes may be used by multiple processes to create new information and reused in many different ways. For example, the data that represents an office address may be used by a delivery service to delivery an item, the fire service to assess its safety reach, the builder to reassess its building cladding, or a mapping service to map GPS coordinates to service locations in an app. This is the information that workers create, interpret, and readily exchange. The boundary between data and information is very blurred and thus used interchangeably (especially in an era of 'big data'). In this chapter, data and information have been combined with only the concept, information, used in referencing what is typically called data (i.e., anything in numbers or codes) and what is typically called information (i.e., anything in text, audio or video).

Knowledge, on the other hand, is the understanding that people have when they assimilate and absorb information and integrate and process it alongside existing information and knowledge stored in internal memory. Knowledge "empowers actors with the capacity for intellectual or physical activity" and enables them to think and interpret (Brinkley et al, 2009). Knowledge is the stuff encoded in head, and may be either tacit or codified. Information, on the other hand, can be stored and readily communicated; its meaning is the interpretation or explanation that comes with it, or that an individual brings to it. Two people may not necessarily have precisely the same tacit knowledge about the same information event or object, although potentially they have or have access to the same codified knowledge – the recorded knowledge about that information event or object that is readily transferable (Choo, 2002; OECD, 1996).

While information is easy to communicate, knowledge, particularly tacit knowledge, may be difficult to pass on to others (and may leave a workplace with a worker's departure). For example, while the information may be readily available for using the new travel reimbursement system, and an informative set of procedures may exist on how to use the system, the one person (now on annual leave) may be the only one with the knowledge to deal with the idiosyncrasies of the system in concert with those workplace procedures. Thus in this chapter, we rarely reference knowledge as that will be the combination of information, skills and experiences that is intrinsic to the individual (and/or team). Instead we will primarily use information – codified knowledge – in discussing work.

In summary, in this chapter we think of data as simply streams of digits and codes, information as the meaningful data that can be recorded and meaningfully transferred from person to person and system to system, and knowledge as the unwritten and potentially unspoken storehouse held by the worker.

3. About Work and Examples of Work

Work has been conceptualized as "a collection of tightly inter-linked human activities with explicitly or implicitly understood purposes, meaning, and values" (Huvila, 2008, p801). We often think of work as those undertakings that occur within the workplace, but any series of activities involving effort is work, regardless of whether that work is formally compensated or not. In this chapter, we focus only on work done in workplaces.

In the past century, work has evolved from a mechanistic approach (Taylor, 1911) to semi-automation (i.e., skilled), and now to augmentation (Davenport & Kirby, 2015). That early work involved managing primarily physical work that had been subdivided into discrete and highly structured, assembly-line style tasks. In the current information-dominated era, work is less physical, and more cognitively complex and intensive. It is supported by a range of technologies that vary from simple automation to perform basic tasks such as word lookup and calculations, to more sophisticated technologies that handle complex problems such as searching for fuzzy topics and running health economic models. The tasks left to people require more intellectual work, that is, require more conceptual knowledge and cognitive skills that aid human decision making (Vicente, 1999, p18).

In positioning the concept of work and its activities and tasks, it is important to think of it with respect to today's information worker who arguably is anyone who creates and/or uses information to assist in making decisions and in problem solving. To explain the key concept, we relate them to two examples derived from an examination of environmental workers in government agencies. Each represents a composite of the role, i.e., a persona, so as to provide the richest examples to illustrate what we mean by information work. While their jobs are in environmental management, the types of information tasks and activities that make up their work are not unlike that of many other office workers.

The first example represents a manager. Mary is a regional manager of a government agency that deals with environmental problems, and her core responsibilities concern operations at the natural ecosystem level. Thus, her activities include managing the staff who work with her on ecosystem issues; interacting with and supporting technically, financially and scientifically 16 community-based activist groups; setting priorities for ecosystem management; initiating action at the local level within her region; and formally responding to issues directed from the national level. Her activities range from developing policies and procedures for dealing with a wide portfolio of environmental issues, from aquaculture and offshore oil and gas, to building dams, coastal erosion, and pollution control. Given her role, she is often called on to provide 'briefing notes' – recommendations to the national level. All of her activities use data and information, and result in reports and presentations for local, national and international consumption. These activities generate a myriad of information processes, that require digesting information provided by staff which she has to integrate into a single report. Sometimes, time is her enemy as she has to deliver an evidence-based response to her superiors at the national level for political (and thus potentially public) use. These time constraints with partial evidence means that she provides a 'best guess,' based not just on the evidence, but on her own knowledge developed from her years in the field.

The second example is a mid-level information worker. Bill is a coastal zone advisor who also manages a small staff, and is also required to work with multiple levels of government, and various sorts of local groups. Bill's activities are much more targeted and usually result from directives from his superiors. One of his most recent activities required that he assess the coastal setback problem in a local bay, that is, how far homes and infrastructures are located from the crumbling seashore and what the short term and long term consequences will be. He deconstructed this core activity into a number of tasks that include finding the setback policies in other jurisdictions on the continent using a number of data sources; identifying what scientifically is known about coastal erosion given the particular geophysical characteristics of the area, using scientific databases of research; finding the key geophysical parameters of the local area (e.g., bathymetry, and soil composition) using a number of databanks; and, modelling various parameters such as wind and waves using modelling and data analysis applications. He needed to find all of this information before he could proceed. He evaluated his finds from authoritative sources, and quickly dismissed non-governmental reports that he thought might be biased. He did various types of data analyses, contacted reliable colleagues for expert opinion, and chased some probable and improbable leads. In the course of all these tasks, he made copious notes about these various information artefacts. To do this, he subdivided those four huge tasks into multiple sub-tasks (which he did almost in an auto-processing-like way). Using knowledge gained during his 11 years in the job, he integrated and interpreted the information from multiple sources to produce a set of recommendations for a possible course of action. Before he submitted his report, he contacted his trusted network for a second opinion.

Mary's and Bill's job roles define their core work activities which are primarily, almost totally, information activities that use a lot of data, stored information, and their own tacit knowledge. Their activities logically prescribe a range of tasks which in turn generate many different information processes that require interacting with many types of technologies, from searching in authoritative databases and serendipitous browsing and scanning, to note taking, data analysis, and so on. All of these consume information, some of which is available directly using internal systems, and some they find external to the organisation. In addition, both communicate with other people, e.g., external and internal experts, and colleagues over the course of the work, and also interact with a variety of types of technologies.

4. The Workplace

We first start with the world in which work occurs, the workplace, which has been aptly characterised by Vicente (1999, p 14-16) as having the following attributes:
1. it is composed of large complex socio-technical systems (composed of people and objects);

2. each system may contain many workers requiring good communication channels and effective coordination of actions and interactions;
3. each system tends to be heterogeneous in discipline, experience, background and culture which thus impacts the common ground that workers need to share;
4. each system maybe geographically distributed, separated by physical space and time zone;
5. each system tends to be dynamic; some may require immediate response while others may have a lag time such that a response for future action needs to be predicted;
6. each system will have risks against which to mitigate; these may range from easy-to-recover-from low level risk actions/events, to those that may have devastating effects on public safety, the economy, the natural/physical environment, etc.
7. each system uses some form of automation because the system is so complex and the resource (e.g., data and information) needs so large that no single worker can directly interact with those resources and achieve the common goal; that automation will have built in redundancies, imperfections and variability that must be monitored and controlled by workers;
8. each system is unlikely to be highly structured such that an element of flexibility is required to deal with unexpected events; each system cannot be characterised only by expected or frequently encountered events but needs to be flexible enough to deal with contingencies.

Each of these can readily be applied to the governmental agency for which Mary and Bill work.

This world is the one which shapes the work and its activities and tasks to achieve organisational goals. It is an Information Ecology (Davenport & Prusak, 1997; Nardi & O'Day, 1999) interwoven with Taylor's (1986 pp. 25-26; 1991 p. 218) Information Use Environment (IUE). Taylor characterised it as elements "that (a) affect the flow and use of information messages into, within, and out of any definable entity; and (b) determine the criteria by which the value of the messages will be judged." Vicente (1999) and Taylor (1991) concur on workers and the setting, and thus the context in which work is performed. But Taylor takes an information centric approach in contrast to Vicente's ecologically driven, task perspective. However, it is generally agreed that the context — the information use environment — shapes and constrains how the work is performed and completed (see for example, Stammers & Shepherd, 1995; Allen, 1996; Sonnenwald, 1999; Vincente, 1999).

What makes the workplace distinctly different from other types of information use environments is that the work system (and not the workers) determine the work goals (as argued by Diaper, 2004). The worker evaluates whether and when the task is complete, and decides on the best approach to achieve those goals. For example, if the work role requires a coastal zone advisor to recommend the best location for a power generating wave turbine farm, it is the goal of the advisor's work role and not the particular coastal zone advisor. Any other coastal zone advisor could have been assigned the same task. The same goal will be achieved, but the pathway for achieving it may differ depending on each advisor's knowledge. In the case of our personas, each is assigned activities and tasks by the respective job roles or their line manager, but each will decide on how best to achieve the goal.

5. Deconstructing Work

The next four sections will examine work starting with the activities and tasks that make up work, and then examine the three interconnecting elements that are essential for those activities and tasks to be accomplished. In examining each, we need to note that each is ameliorated by the workplace context — the information use environment— in which that work is performed.

5.1 Work as Activity and Task

All work is driven by organizational objectives and goals that are achieved through a series of activities — those that are defined within the scope of a worker's job description. When we typically think of work, it is this set of activities (such as Bill's requirement to identify and resolve coast zone issues, or Mary's setting priorities for ecosystem management) to which we refer. Activities are those elements at the highest level of task hierarchies (Norman, 2005) providing the goals for individual work roles, such as setting priorities for coastal management. Each activity necessitates one or more tasks, a concept that emerged from ergonomics and work analysis (see for example Taylor, 1912; Vicente, 1999), and each task uses information processes (e.g., procedures for manipulating the information), and actions (i.e., low level operations such as mouse clicks and keystrokes) (Norman, 2005). See Figure 2 for the relationships amongst these concepts.

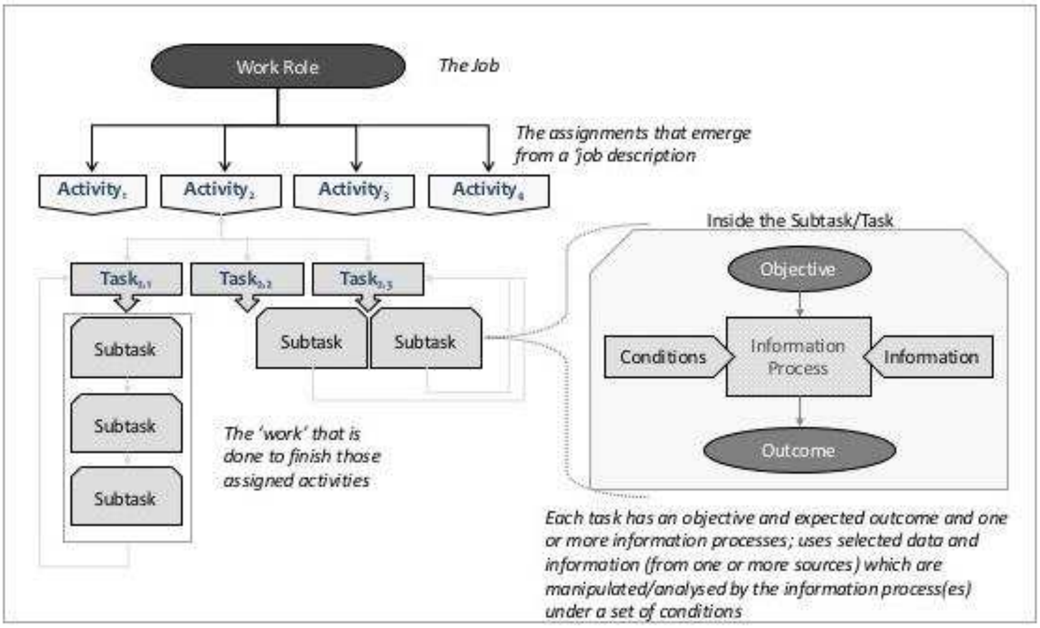

Figure 2. Illustrating the relationship among work role, activities, tasks, and processes. ©E. Toms, 2018.

Activities are always implicit in discussions of work as they tend to emanate from the job description (although these are not considered in the Leckie, Pettigrew and Sylvain (1999) model of information use in the workplace). However, when we discuss work, we are more likely to concentrate on the task level — the operational level, which contains many instances of task, e.g., "write a report on…, a letter to…, a proposal for…" A task may range from almost automatic processing requiring little thought, to very complex decision-making (Byström & Hansen, 2005). We generally associate a task with its resolution and not with the actions required to reach that resolution (Toms, 2011), unlike, for example, mechanised work in which each action and operation is well-documented. In general, each task has a goal to be attained, and a set of instructions to be followed (see for example, Hackman, 1969; Drury et al, 1987; Hackos & Reddish, 1998; Byström & Järvelin, 1995; Freund, 2008). Each task will use specific tools that drive specific processes, and use variable information from particular sources/resources. Certain conditions and restrictions may be placed on how the task is to be completed, or on what an acceptable outcome is considered to be.

At its simplest, a task may contain a single action, which is mostly “non-decomposable primitives” (Sutcliffe 1997, p. 39). Tasks such as “What is the meaning of the word, ecosystem?” and “Where is the location for Friday’s meeting?” are designed with a definitive path to a solution. Thus, at the lowest level of a task hierarchy, each sub-task will be structured, e.g., enter the keywords into a search box, press the submit button to perform a statistical analysis. At its most complex, a task will need to be decomposed into multiple subtasks that may be further decomposed into more subtasks. At the very lowest level, the decomposition of a multi-part task into these ‘atomic units’ will turn what appears to be an unstructured task into a set of structured ones. Thus in the most complex cases, the solutions to multiple subtasks may need to be integrated in order to finish the task. Perhaps the best, published example of a task decomposed into its respective units is the analysis of the actions required to do a functional analysis of a gene (see Bartlett & Toms, 2005) which contains a set of multiple subtasks, each requiring specific data, tools and processes.

In general tasks may be considered structured or unstructured, and instructional or constraints-based, as the examples in Figure 3 illustrate. Structured tasks are primarily instructional leaving little discretion to the worker (Vicente, 1999). For example, extract a citation from the reference list at the end of the paper. Arguably, fact-finding and word look-up are also tasks of this sort. But the tasks that use a constraints-based approach (Vicente, 1999) are the ones that epitomise cognitive work, and the ones that we most associate with an information work environment. The ‘answer’ is not present in head, and may not be readily available in any stored form; it may need to be created or calculated or interpreted from existing information in some fashion, as the examples in Figure 3 illustrate. Unlike those of an instructional type, the answer may not be definitive but approximated, and indeed may have multiple possible ‘right’ answers. In this case, usually only guidance on how to do the task can be provided, and a set of constraints or conditions focuses the task. These unstructured tasks require significant mental effort in combination with knowledge and skills.

When that very structured task is hierarchically decomposed into subtasks as illustrated in Figure 2, some of those sub-tasks may be unstructured requiring multiple interventions of human decision-making. For example, one key subtask in locating an ideal site for a fish farm is “what are the characteristics of the bay” which results in a further set of subtasks to identify various parameters from water circulation, to habitat and recreational activities. All of these then need to be humanly explored, digested and interpreted, and merged before the composite task is complete.

	Structured	**Unstructured**	
Instructional	Locate a map of the XYZ shoreline Submit travel expense claim Download and view the PDF version of the paper What is the fish catch in the XYZ Bay?	Compare published policies on shoreline setback in clay-based cliff areas in any political jurisdiction. What is the best location for a wave turbine farm? What will be the long term effects of the oil spill in the XYZ Bay?	**Constraints-based**

Figure 3. Tasks may be structured or unstructured, but structured tend to be instructional and unstructured constraints-based, unless the worker's knowledge or lack thereof. ©E. Toms, 2018.

From a worker's perspective, a task may be routine, repetitive and well known to the worker who follows a predefined set of rules – an internal procedure. Thus, regardless of whether it could be construed as instructional or constraints-based, it will appear to the worker as 'structured.' At the other extreme will be the non-routine task that is novel and perhaps performed only occasionally. On the surface it may appear to be structured, but to the worker, its complexity in combination with the worker's knowledge (or lack thereof) may render it difficult. Thus, a third element in considering task will be that level of complexity (Campbell, 1988; Wildemuth & Freund, 2009) which may be interpreted in two ways: physically (Gwizdka & Spence, 2006) and cognitively (Byström & Järvelin, 1995). Consider, for example, a task that may appear to be constraints-based and unstructured, but is also routine to a worker. For our persona, Bill, this may be assessing a location for its potential for fish farming, a task that he has done many times for the environmental agency. This appears to be a physically and cognitively complex, constraints-based task. For him, this is a very routine, structured task, as it is something that he frequently is asked to do and now uses the tacit knowledge that he has acquired to develop a 'structured' approach for resolving it. Thus, we can classify tasks in a multitude of ways, but their accomplishment will depend to a large extent on the capabilities of the human worker.

While a structured and instructional task may have one or more specific operations before completion, unstructured tasks may have many possible pathways to task completion. The worker's knowledge and experience inform how the task is to be completed; and, the worker ultimately decides that an 'answer' has been found. In the course of task completion, the worker may 'satisfice,' when an optimal solution is not easy to establish (Simon, 1956). Constraints-based work allows for more variability in how the work is to be done and thus, more worker discretion in what makes for a good solution. As a result, different workers may not always use the same information or the same operations and processes for the same task and may achieve different but acceptable solutions. In a highly structured task such as "submit travel expenses," or "do a time-series analysis of wind and wave action," the procedure will be repetitious and invariant, and the solution always the same. In an unstructured task, the worker will use mental resources to engage in a range of human information processing, such as interpreting, calculating, and comprehending. Such is the typical workplace problem solving when solutions are not obvious. For example, in the case of Bill, the coastal zone advisor, with the coastal erosion problem, the generic problem (i.e., coastal erosion) was well understood, but the most appropriate response with respect to the particular bay was not obvious as each set of circumstances (e.g., clay versus rocky cliffs, weather patterns and wave action) varies from context to context.

Work tasks have been generically presented in a number of classifications to date:

- Production tasks, Discussion tasks and Problem Solving tasks (Hackman, 1969)
- Decision, Judgment, Problem, and Fuzzy (Campbell, 1988)
- Administrative and Communicative/Facilitative tasks; Information Manipulative, Analytic, Strategic Formulative/Design; Operative/Generative tasks (Algon, 1999).

But, there is at present no standard, best practice in the classification of work tasks. In addition to the sets above, other task conceptualisations have been descriptive of the task, defining a characteristic of a task rather than classifying the task according to its intent. Consider Qiu's (1993) general and specific tasks; Kim's (2006) factual, interpretive, and exploratory tasks; and Broeder's (2002) informational, transactional and navigational tasks, for example.

Overall, the tasks defined by work roles maybe primarily administrative, professional or managerial. Often some combination of the three may be found in the same work role. Administrative tasks tend to be structured, routine and repetitive while professional tasks tend to be unstructured requiring creativity, flexibility, problem solving, etc. Managers do the greatest mix of tasks, contending also with the need for concurrent and interrelated tasks (Te'eni, Carey & Zhang, 2007). But the point they all share in common is the extensive use of information in order to achieve their goals. Within the workplace, these tasks may be conducted by the individual, or within work teams, or other work units, and thus the success of task completion may also be influenced by the human factor, e.g., extent of collaboration; type of leadership; organisational culture; the physical infrastructure e.g., effectiveness of technologies implemented to assist the work; physical work environment; and the organisational structure, e.g., hierarchical, matrix (all of which is outside the scope of this chapter).

While the focus has been on information work tasks, the concept of an 'information task' has emerged also to reflect the number of variants on seeking, finding and using information. Today, it is difficult to find a task that could not also be characterised as an information task which is rendering this concept somewhat redundant. The concept of search task is the best known of the so-called information tasks, characterized over the decades in a number of ways (see for example, Meadow (1992); Marchionini (1989); Choo (2001); Ingwersen & Järvelin, 2005); Wildemuth & Freund (2009)). The distinction between an information-centric work task, and an information task may be skewed by the abstract space in which the work is being done. Perhaps information tasks are not just generic processes, but represent digital tools, e.g., search engine, digital dictionary, and reference recommender.

5.2. Work as Information Processes

As noted in the precious section, tasks use one or more information processes. A process is defined as "a set of partially ordered steps intended to reach a goal" (Feiler & Humphrey, 1993) such as doing a Google search, or analysing a set of data, or developing a reference list for a paper. Information processes, thus, are those actions and operations that modify and/or augment information such that the original unit of data or information changes in some fashion, or is used in conjunction with other units of data or information to create new information (Curtis, Kellner & Over, 1992). Information processing is generally associated with acquiring, recording, organising, retrieving, sharing, displaying, disseminating, and using information. The best known information process model is that of Choo (2002) who identified information processes at the organisational level.

Information processes delineates the procedural elements of a work task. The previous section discussed the concept of tasks in a generic fashion although the implications were clear — it was all about the work, the substance of the organisation's raison d'*être* — and we typically call those tasks, work tasks (Byström & Hansen, 2005; Ingwersen & Järvelin, 2005). All work tasks (at least in the context of this book) are also information-centric tasks that use information processes to meet the goal. An information process will use one or more tool(s) to execute that process. Finding the definition of a word, searching the Web for information, analyzing sets of data, and monitoring the news on a topic are information processes that use as tools, respectively, an online dictionary, a search engine, statistical analysis application, and news notification.

Characteristically, we associate an information process with traditional information searching or browsing. Information searching is usually interpreted as having three core subtasks: understand the problem, plan and execute, and evaluate and use (Marchionini, 1995), each of which may have additional sub-tasks. Browsing on the other hand, is a non-goal-based, scanning process (Toms, 2000) in which people skim, select, examine and use or abandon (Bates, 2007). Both processes have defined procedures and sometimes the same tools, but they also differ on the presence or absence of a defined goal. Both are critical to completing information work tasks.

In addition to the searching and browsing, other information processes have been delineated including:

- browse, chain, monitor, differentiate, extract, verify (Ellis,1989)
- explain, stimulate, discriminate, orientate, etc. (Prefontaine, Bartlett, & Toms, 2001);
- navigation, verification, comparisons, accretion, etc. (Marchionini, 2006) ;
- connection, suggestion, simplification, etc. (Gilbert, McCay-Peet & Toms, 2010)
- fact-find, how to, re-find, keep track, make sense, decision support, entertain (Toze, 2014);
- find facts, how to, make a decision, solve problem, learn (Freund, 2008);
- standalone informational, monitoring, sentiment/opinion finding, sensemaking of conversations, people search, querying social network, refinding (Elsweiler & Harvey, 2014)

In general, information processes act on information to produce new information or identify information for use in another process. This is a classic but not exhaustive list of what we do to 'process' information in various work tasks:
a) locate, collect, organise and store either temporarily or permanently for future use;
b) compare and/or linking two or more documents or other information bearing objects;
c) synthesize units of data and information to understand something;
d) use in analyses, either or both of quantitative or qualitative to summarise a large quantity of information so that it is humanly digestible;
e) create information from existing data, and/or modify, enrich and augment information to create new information;
f) monitor information about people, events, and information objects, but not necessarily extract or filter the information;
g) integrate or combine in some way to deliver an 'answer' which may be a decision, a plan, etc.
h) disseminate, including presenting, sharing, etc.

The two personas discussed earlier are actively engaged in these processes within their work roles. Searching for specific chunks of information, interlinking sets of citations, and comparing the results presented in various documents are very typical of the processes they use to complete tasks.

Each process has a set of actions and operations. Arguably, search tactics (e.g., find, reduce, and block) designed first by Bates (1979a, 1979b, 1987), and later modified by Smith (2012) specify what could also be interpreted as discrete but low-level processes that one would take in searching for information. Multiple actions such as mouse clicks and keystrokes are also used to activate the various processes.

The definitive set of information processes has yet to be conceived, but we can safely say that anything that manipulates data and/or information such that some sort of transformation takes place can be considered an information process. Here we think of task as having a specific goal, and these processes will be specifying the various procedures and actions that are required to complete the task to meet its goals.

5.3. Work as information flow

The concept of information flow is typically discussed in system to system or person to person communication, but data and information can be considered independent of, and exist external to, systems and people. Information flow is considered a significant part of all work flows (Al-Hakim, 2008). Think of the information flow from customer to waiter, to the kitchen, and back again in placing and filling a food order, which also includes the acquisition of the food elements and their processing. If we strip away the physical activities and tasks that make up this work, we are left with information regarding those transactions as well as the meal production.

Within every organisation is a stream of data and information intertwined across the organisation that touches on every functional unit (e.g., human resources, finance, planning) within that organisation (see for example, Nissen (2002); Krovi, Chandra & Rajagopalan (2003); Eppinger (2001); Al-Hakim 2008)), and with filters, connects to external systems. Data and information both inside or outside the organisation emerge from a source point(s) and are transferred to a receiver(s). Both source and receiver may be a person or system, and the flow streams through an organisation following formal channels, e.g., digital systems and their conditional structures, and informal channels, e.g., from person to person. Data and information may be created from within the organization, and merged with streams of data entering from outside the organisation, such as specialised environmental data databases, technical reports, news feeds, and social media. During and at the end of any activity, the data and information may be stored internally, may be passed directly to clients and external organisations, or temporarily stored and/or archived in the 'cloud.'

Analogically, we can compare the information flow within an organization to a water flow or stream in the physical world. A stream meanders across the landscape until disturbed (or controlled) by 'stones' and 'tree branches' that divert the flow in different directions along 'tributaries'. So too with respect to information flows within organisations. Stones and tree branches are now the people and systems that become gatekeepers (Allen, 1996), controlling for security, compliance, and confidentiality (Blumenthal et al. (2006), and/or hoarders who block access knowingly and unknowingly (Lin & Huang, 2010). Maintaining reliability, credibility, and integrity of the data and information stream thus becomes crucial to the subsequent effective use of that data and information by processes within tasks and activities. Mary, the regional manager, often had to contend with legislation that prevented the development of an optimal solution, and noted that colleagues in other branches of government would serve sometimes formally (with security status) as gatekeepers to information access, and sometimes informally, as hoarders to control the distribution of information that they perceive give them personal power.

Along the flow, one or more transformations may take place when the data or information are plucked from the stream for use in different processes (such as data analyses, data update/enrichment, and data creation) that are being performed to complete a task. Sometimes the same data are plucked from the flow to service different task goals, and sometimes those data are transformed and/or augmented before being reinserted in the flow. For example, employee information retained by human resources moves along the flow for re-use by finance to reimburse worker travel expenses, and for use in annual performance reviews that re-enter the stream to update employee records. Thus at many places along the stream, data and information may be filtered or extracted from the stream for integration or syntheses and used to complete tasks, from the preparation of contracts and cases by lawyers, to the analysis of time-series data, and authoritative interpretations of research by environmental scientists. If the worker is restricted from accessing the data/information (e.g., lacks the necessary access privileges or security clearances), then some data/information will be 'loss' in the task completion. Thus, when colleagues hoard the information, and systems put up artificial barriers to access, the flow of information internally is disrupted, and task completion is compromised. Consequently, how data and information flow within an organisation can influence task completion, and that flow is influential to how and whether an organization achieves its objectives.

Except for database construction, or data and information archiving, we rarely isolate data and information for this level of scrutiny. Data and information are mostly described as information resources or databases used by the organization, and simply taken for granted. But data and information have a life outside of those fixed units, and that life is dynamic, adapting to situations, and enhanced and augmented by work activities and tasks, sometimes automatically and sometimes with human intervention. Sometimes modifications to data and information may not be captured within the data flow, and may remain inaccessible in silo applications and technologies, or even inside a worker's head. Sometimes that data flow is subjected to reliability attacks that compromise the integrity of the data/information. When we isolate the data and information as a dynamic flow that interconnects all of the various functional units within an organisation, we begin to see its full value as a critical and essential organisational resource – the fuel, that is fundamental to work, and thus also to activity and task, and not simply just information.

5.4. Work as Interaction with Objects

So far, we have viewed the workplace as a set of activities and tasks, as a suite of information processes and tasks, and as a stream of data and information used by those processes and tasks. Work activities trigger the need for a work task(s) to be done which in turn activates a set of processes which in turn activates a series of actions. But, all of these also involve a series of interactions between/among workers and objects (e.g., systems, tools, and content sources, cf. Chapter 5 on Information artefacts). Without interaction, no processes or tasks would be completed, and the data would remain in the stream, and the process illustrated in Figure 2 could not be achieved.

Interaction is "a special kind of action that involves two or more entities and a set of reciprocities that effect changes to each entity." (Marchionini, 2008, p. 170). This concerns the worker's engagement with the tool regardless of whether it is analogue, e.g., printed books and newspapers; or digital, e.g., desktops, databases and devices. The worker physically activates an element of the object, e.g., opens a book or selects a key on the keyboard, and responds accordingly to the object as illustrated in Figure 4. These sorts of transactions are repeated until the worker decides to stop. This process of interaction has been described as a “Gulf of Execution,” that is a two-part flow of information between worker and tool, in which the worker attempts to make sense of the interface to engage with the objects, and the “Gulf of Evaluation” when the worker interprets the display and compares the response to the initial goal (Norman, 1986).

In addition, this interaction involves and activates human information processing (as described in any typical cognitive psychology text) during which the human interacts with the object using one or more senses, and interprets and stores the signals emanating from the object. This well documented human process is an internal system that controls attention, perception, memory, etc. such that the human’s sensory system and its mental processes engage with the stored material (e.g., books, report), and eventually output a response of some sort. Today the human information processing system engages with a computer information processing system that manipulates digital data, and displays and/or transforms it into an output. Examples of these processes include information retrieval, data analysis, and simple word processing. In an effective system, the computer information processes should simplify how much mental processing the human needs to do, and streamline the process. Accordingly, in the completion of any task, information processes activate a set of human and computer information processes, both of which work in concert to achieve the task goals.

Unlike the physical and sometimes mindless interaction with physical devices, information interaction is a more cognitively intensive type of interaction (Marchionini, 2008). In this case, the worker engages with the content of that object. It may be reading or scanning the print object. In the case of the digital object, the worker engages with the content rendered on the display which may include reading and scanning as well as a number of computer input actions. In addition to reading and scanning, the interaction may include interpreting and using access tools, such as menus or search boxes, or examining semantic content, e.g., a contract, a database result display, a consultant’s report. The success of that interaction depends on the affordances (Gibson, 1977) that the display (i.e., the interface) transmits, helping the user to interpret and navigate the various levels of the system. Likewise, the textual affordances present in the content provide a similar type of semantic cue that may act as a landmark within streams of content directing the worker to view and interact with the content in a particular way (Toms, 2000).

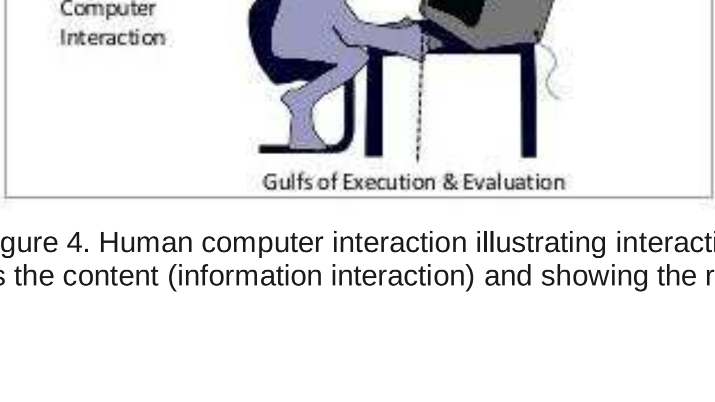

Figure 4. Human computer interaction illustrating interacting with the device, as well as the content (information interaction) and showing the role of human information

processing with that process. ©E. Toms, 2018.

This interactivity in which the worker engages with data and information within an information process is the essence of the work that information workers do. The processes are either formulated as a digital tool (e.g., search engine, web-based dictionary, email, idea mapping), or packaged together in a suite of tools (e.g., data analysis software, office suite, project management, accounting). Thus the worker engages with the processes discussed earlier by interacting with a digital device. The distinction between the tool and what it does is now blurring with the emergence of suites of apps and likely this will continue as the device-function-information boundaries dissolve (Russell & Moskowitz, 2016).

This human-computer interactivity and the concept of information interaction (see for example, Marchionini, 2008; Fidel, 2012) have been well documented and researched. Workers bring to this interactivity their experience, skills and knowledge, which varies from worker to worker. But, they also bring some build-in human 'technology': mental models, cognitive and physical abilities, emotion, personality, etc., all of which also influence how the interactivity unfolds. In addition, attitude, and 'digital dexterity' also influence how effectively the interaction takes place.

How effectively that interaction occurs is not only up to the worker. Technologies that support and facilitate work are notorious for the variability in both their functionality and usability. While the system may be perfectly functional, it may be almost unusable affecting worker performance and productivity in task completion. While an interface may appear excessively complex, it may be the only way to decompose a task into humanly digestible components. At the same time, software functionality and thus, interaction are limited by human capability. Not surprisingly, human capability is at same level as it was a century or more ago, while technologies have reinvented themselves many times in the past couple of decades. An interface can only deliver effectively what humans are capable of absorbing and understanding.

How does interaction fit with the previous three interpretations of work presented thus far? The worker interacts with an application that was designed to support the work task. The application extracts data and information from the data flow, and activates an information process. The worker interacts with the process (embedded as a computer function) to manipulate the data and information. Over the course of working through the task requirements, the worker engages with the content, recognising those textual affordances that direct attention. Depending on the complexity of the task, multiple applications (e.g., word processing, data analysis and project management) may be interacted with at the same time, as the worker works through all of the processes required to complete each tasks/sub-tasks.

In addition to the interaction with devices, worker-to-worker interactions are conducted sometimes in person, and sometimes synchronously or asynchronously using a technology (such as telephone, messaging application, or collaborative system) to facilitate and support the interaction. This interactivity is influenced by the work culture, social milieu and governance structure in which the workers are involved (cf. Chapter 3 on Information culture).

5.5. Summary

The concepts that describe the undertakings around activities, tasks, processes, flows and interactions can best be illustrated by one of the personas. Bill, in his work role as the coastal zone advisor, has been charged with activities concerning the coastal zone which include the impact of any man-made object or event on the coastal zone. This has led to his examination of the effects of introducing wave turbines in a local bay for power generation. He approaches this task by subdividing it into a number of sub-tasks, each of which uses a number of information processes including extracting an earlier report that recommended this particular location as a wave power generation site; developing a simulation to ascertain future effects; comparing two simulation modelling techniques; extracting baseline data from the internal information flows to feed the simulation model; using special monitoring equipment to monitor the fish movement in the proposed areas for use in his simulation; and so on. All of these processes extract data and information from existing databanks and databases, and all require interaction with a variety of tools and people, before the results from all tasks are integrated and interpreted, and a report is produced.

In information science, we have yet to articulate a clear framework for how all of these various concepts (e.g., activities, tasks, processes, actions, operations) fit together, especially at the operational level.

6. Conclusion

As pointed out in the introduction, we must not forget that this level of activity takes place within a large dynamic work ecosystem. How workers participate in activities and complete tasks varies with their experience and knowledge. Their level of participation also changes with the intensity required to complete the work task. This may be exacerbated by the particular situation in which the worker is involved and the technologies that are provided to facilitate the work. Rather than the assembly line process we noted in the beginning, task completion in information work is fluid, with changing goals (see for example, Xie, 1997; Pharo, 2004; Hider, 2007), that affect how and when the particular task is finished.

The importance of data and information, and the source of that information must not be under-estimated. Without data or information, there would be no activities or tasks or information processes and no need for interactions, and thus no work. In addition, these activities and tasks are deployed strictly to accomplish workplace goals and objectives which are established, not by the worker, but by the organisation.

This look inside what constitute information work as product and production has illuminated the core elements contained in how we describe and research information work. Task and activity are central to this analysis, but often information science in particular limits the study to information behaviour or information seeking and use. Yet work activities and task drive that need for information in the first place (Marchionini, 2008; Ingwersen & Järvelin, 2005). Except for searching and browsing, our previous research deals only in a limited fashion with information processes. We are more likely to think solely of information processing as a computer operation, or the substantive and well-researched, cognitive perspective on human information processing. Yet those information processes are the critical procedures for manipulating and augmenting information, and form the foundation for emerging apps that focus on, in particular, unstructured tasks. We tend to think of data and information as omnipresent, but the way in which data and information have been used and abused by the tech industry (from Facebook and WhatsApp to, Google and Amazon) has highlighted the life of data as a valuable essential resource, and certainly has provided the evidence for data as flow and not as static resource. While human computer interaction (HCI) and computer supported cooperative work (CSCW) have provided the frameworks for how we think about interaction, their work has tended to focus on interacting with the technology. Yet we must not forget that information is an object with which we interact, and how we interact with information will be very different than with the tool that facilitates that interaction.

7. Future Directions

Given the summary in the previous section, there is clearly scope for significant research in this particular area. But the research will need to be agile and nimble to keep up with the ever changing technologies that stretches the research agenda and real-world implementations.

We are being challenged by seemingly annual technological developments, from cloud computing that is driving 'Software as Service' and work – anyplace, anytime, to the sensor-driven, Internet of Things (IoT). Every action we take is being mined with deep data/text mining that has emerged to characterize even who we are as individuals.

At the same time, new developments in artificial intelligence (AI) and robotics promise to make work more efficient, effective, convenient and safe, and relieve the human of the drudgery of work. This is now a common place theme in the public press. The promise of these technologies is to extend a machine's role from that of a human apprentice to worker-machine collaboration — an equal partnership in the meeting of organisational goals and objectives. Forrester speculatively has proposed that will advance to the integration of human brain with computers, or "neural lace," a seamless blending of human capability with technology (Gualtieri, 2017) for a unified human-machine approach to task completion.

In future, these developments may be used to decide how work should(can) be allocated between human and robotic workers. In the not too distant future, robots will aid the human, and likely handle or partially handle much of this interaction. The current developments in personal digital assistants (such as Alexa, Siri and Google) for consumers foretells the likely developments that we can now expect to find in the workplace.

All of this begs the question about ethics and the value of being human within the workplace. We have yet to define where the human ends (or should end) and the machine starts in the production of work, or indeed who or which has or should have the overall responsibility. Will those digital assistants remain just assistants? This intersects with considerations for the workplace as an information ecology. What will be that social/professional interaction in a mixed human-robot world?

Technology is pushing the redesign of work. We are at a bit of a cross-roads with respect to the pathway that we take which will affect how humans work, and indeed, the involvement of humans in work. In an analysis of work in 46 countries McKinsey found that only 5% of jobs can be fully automated today, but that 60% of the jobs had 30% of tasks that were automatable based on current technological developments (Manyika, 2017). The 'sweet spot' will be in how information processes are automated and tools built to support and combine those features. Rather than waiting for the technological development, ideally we should be specifying the requirements for those information processes now, so that the technologies will fit and support human capabilities, and design the most effective ways of meeting organizational goals.

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