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Information and the gaining of understanding

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Abstract
It is suggested that, in addition to data, information and knowledge, the information sciences should focus on understanding, understood as a higher-order knowledge, with coherent and explanatory potential. The limited ways in which understanding has been addressed in the design of information systems, in studies of information behaviour, in formulations of information literacy, and in impact studies are briefly reviewed, and future prospects considered. The paper is an extended version of a keynote presentation given at the i3 conference in June 2015.

Keywords
Understanding; information systems; information behaviour; information literacy; impact; i3 conference

1. Introduction

> The noblest pleasure is the joy of understanding - Leonardo da Vinci

This paper is an expanded version of a keynote talk given at the i3 conference at Robert Gordon University, Aberdeen, in June 2015. The intention of the talk was to focus on the nexus of the main topics of that conference – interactive information systems, information behaviour, information literacy, and impact of information – by examining how they relate to the idea of 'understanding'. This has received little attention in the information sciences, by comparison with the attention given to data, information, and knowledge, and this paper sets out to redress this. It covers a wide area in outline, rather than in detail, and brings in insights from commentators far removed from the information disciplines.

The paper is divided into five main sectors. An initial analysis of the idea of understanding is followed by a consideration of how information systems are beginning to address it, and how they may do so in the future. There follow sections on understanding and information behaviour, and on understanding and information literacy. The final main section considers what may be the impacts of development of understanding.

2. Understanding

The typical dictionary definition, in this case from Chambers English Dictionary, is:

> to comprehend; to grasp with the mind; to know the meaning of; to realize; to have knowledge of, or information that; to have been informed; etc.

This reinforces the commonsense idea that understanding is something to do with information, knowledge and meaning, but is hardly precise. Unfortunately, when we try to reach a more specific definition, we find that it is lacking. As Smith [1] puts it: "There is presently no agreed upon account of what understanding is, which creates difficulties for the precise use of this concept".

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Inasmuch as it is linked with information and knowledge, there appears to be, in common usage, a kind of quality hierarchy: it is somehow better to understand than to be knowledgeable, and that in turn is better than to be well-informed. This puts us in mind of the well-known data-information-knowledge-wisdom hierarchy. It is often not appreciated that Russell Ackhoff, generally credited with the original idea for this hierarchy, included understanding as an additional layer, between knowledge and wisdom [2]. He characterised understanding as an "appreciation of why", and wisdom as "evaluated understanding". This seems to have been lost from most subsequent presentation of the hierarchy. Rowley points out that most commentators have suggested that understanding is not a separate level [3], while Frické simply notes that it is not typically included [4]. And certainly, understanding is not a distinct state, divorced from the others: as Winograd and Flores put it, "what we understand is based on what we know, and what we already know comes from being able to understand" [5].

However, recent developments suggest that the dropping of understanding from the hierarchy may not be helpful, as there is increasing interest in the idea of understanding be associated with explanation; very much Ackhoff idea of appreciating why. Studies have shown that that there is a general belief that an ability to explain something is a mark of understanding it; see, for example, Wilkenfeld, Plunkett and Lombrozo [6]. The physicist/philosopher David Deutch writes of understanding rather than mere knowing; it is about knowing why, about deep explanations, about the inner working of things, about coherence, elegance and simplicity [7]. We will note later that Deutsch believes that this kind of understanding may have dramatic impacts.

There is an increased interest in understanding, generally regarded as a special form of knowledge, within philosophy. In addition to Smith, quoted above, others who have discussed the issue include Greco [8], de Ridder [9], who regards understanding as a kind of higher-order knowledge, in a network of knowledge with internal coherence and explanatory potential, Kvanvig [10], who see understanding as requiring the grasping of explanatory and other coherence-making relationships in a large and comprehensive body of information, and Floridi [11], who writes of a web of mutual relations within a body of knowledge that allows one part of it to account for another.

So it is reasonable to consider how well current information systems support their users in developing this kind of deep coherent knowledge, or understanding.

3. Information systems and understanding

On the whole, we have to conclude that most current information systems are ineffective at supporting the gaining of understanding. This is not because they are poorly designed, or badly implemented, but simply because they do not address this issue at all. They intended to return relevant documents, to provide facts and figures, to answer specific questions, or, at best, to give fragments, or snippets, of knowledge. These things they may do well, but they offer little or no direct support to their users in building up a coherent, explanatory knowledge-base.

There are, however, some examples of systems, generally at the research stage, which are beginning to support this. Such support might encompass a variety of aspects, including, though not limited to, such aspects as: screening and filtering; relating and comparing; visualizing; analyzing; giving reasons and explanations; summarizing and reviewing, chunking; finding facets, themes and analogies; showing similarity and dissimilarity; and identifying links, outliers and exceptions. A small selection, not intended to be at all comprehensive, is now presented, to illustrate what a system to support the development of understanding might be like. They fall in three categories.

First, there are systems whose *raison d'être* is to present to their users unanticipated connections and inter-relations between between seemingly isolated pieces of information. The best known of the these are based on the approach originated by Swanson, in his 'literature-based discovery', identifying linkages between the medical literature on the basis techniques for identifying and displaying terms in text and indexing, which are in common in different areas of knowledge. These methods have since been developed and since applied more widely [12].

Second, there are systems aiming to help their users to make a rapid review and synthesis of very large bodies of information expressed in text documents, by allowing searching, screening and display of results; the results of such as review conform to the idea of understanding noted above. This type of system and approach is exemplified by the 'rapid review' method of Jahangirian et al. [13].

Third, there are systems which use an integrated battery of techniques including text analytics and visualization to enable comprehension of a collection of information expressed in document. This is exemplified by the system of Donne, Shneiderman, Gove, Klavans, and Dorr [14], which explicitly claims to aid the rapid understanding of set of literature.

We should note that one other category of information system has emphasised explanation, which we have seen is closely related to understanding; the 'expert' or 'knowledge-based' system. Since their introduction in the 1980s,

accompanied by a great deal of hype and exaggerated promise, they have achieved quite wide use in narrow and specific contexts, typically diagnosis, e.g. medical diagnosis or technical fault finding, reminder systems, e.g. reminding a doctor to check immunisation status, and decision support, e.g. financial decision making. Explanation is a component of all such systems, but is generally rather limited in scope. Four main forms of explanation may be provided: reasoning trace, explaining how the system reached its conclusions; justification, explaining the system's reasoning in terms of domain knowledge; strategic, providing information about the problem solving process; and terminological, providing knowledge about the concepts and relationships of a domain. Of these, the reasoning trace type is most common, the other three being too complicated and too domain-specific to implement effectively [15, 16, 17]. The justification type of explanation, involving "descriptive facts about the application domain such as causal relationships [and] classification hierarchies" seems relevant to development of understanding, but is complicated to implement [16]. Terminological explanation seems particularly relevant, but is seen as relevant only to novices, and is therefore often not included, or included only in a rudimentary way, e.g. by reliance on data from a single textbook, and is little used when it is provided [17].

There are three general reasons why users of such systems may seek explanation, one of which is understanding; the other two being verifying, i.e. checking the validity of the conclusions reached, and resolving contradictions, where the system's conclusions differ from those of its user [15, 16]. However, the 'understanding' implied here is rather limited in scope, being "an understanding of how the system reached its conclusion and the significance of the conclusion" [16], or, more fully, "understanding the significance or relevance of a conclusion [and] understanding the reasoning process of a conclusion whose significance was understood"[15]. The understanding here is understanding of the system processes, rather than understanding of the domain itself.

It is worth emphasising that no single technique within an information system is likely, in isolation, to bring about understanding. For example, visualization is often, and rightly, claimed as a powerful aid to understanding, but Chen, Floridi and Borgo argue that, rather than providing insight, the main value of visualization alone is time-saving [18]. If systems are to directly address the issue of developing understanding, rather than simply providing their users with the facts and information-bearing documents which the recipients may use to develop understanding bottom-up for themselves, the will almost certainly have to include a variety of complementary methods, as do the examples above.

Future developments in technology may also lead to information systems being more effective at promoting understanding. *Star Trek* aficionados will know that the original series had a variety of systems, including iPad-like Personal Access Display Devices, fixed status displays and large viewscreens, able to provide large volumes of information and data. By the *Next Generation* series, these had been supplemented by the holodeck, and immersive virtual environment which allowed participants to fully experience a situation, and thereby arguably gain a fuller understanding of it [19]. In the real world, a similar development may be seen, as an integration of ubiquitous media, multi-sensory interfaces, and interactive narratives leads to a new generation of 'immersive documents' [20, 21]. It may be that it is the development of such technologies which will enable information systems to play a fuller part in developing the understanding of their users.

Given that information systems are, as yet, not well developed for aiding the development of understanding, it is worth considering whether any particular human information behaviours have been identified which have especially relevance to understanding.

4. Information behaviour and understanding

The majority of the information behaviour models in the literature do not feature development of understanding as a component, being more focused on searching for information to fulfill a specific need. Development of a coherent explanatory knowledge based on information this found is relegated to an area outside the model. Understanding as an explicit concept does not figure at all in the most comprehensive overview of information behaviour [22]. For the most part, we seek in vain for components of information behaviour models such as "looking for a good explanation" or "trying to fit it all together".

Understanding, or something very similar, does feature in some models and analyses of information behaviour. The 'consolidation' phase of Foster's non-linear model [23], equating to an appreciation that one knows enough, and hence, perhaps although Foster does not put it in this way, can explain it what one knows, approach the idea of understanding presented here. So do some aspects of the various 'sense-making' approaches to information behaviour [22].

As yet, the only information behaviour model which explicitly includes elements related to understanding is the Informational Balance model, which applied principles of the Slow Movement to information behaviour [24]. This

included 'reflecting' and 'considering' as elements of a style of behaviour conducing to developing an integration of information in personally meaningful synthesis.

In terms of the individual styles of information behaviour which have been identified, while none equate to understanding, there are some which seem relevant. 'Squirrelling', setting aside a hoard of information for subsequent contemplation, seems like a necessary precursor to developing an overall understanding of an area. The same may be true of general, perhaps personality-related, approaches to information seeking, such as the 'broad scanning' identified by Heinström [25]. The various behaviours described as 'browsing', 'encountering' and 'serendipity' [26, 27, 28] are also relevant in as much as they open the way to identification of unanticipated linkages and connections, which can be very fruitful for developing a deep explanatory knowledge in a wide context.

The adoption of ideas around understanding in information behaviour studies and models is therefore limited. We turn to the related area of information literacy, to see if the same may be true.

5. Information literacy and understanding

Somewhat similar to the information behaviour situation, in the case of information literacy most of the process models, lists of information-related competences and skills, and lists of threshold concepts, do not address directly and explicitly the development of understanding, in the sense of gaining coherent explanatory knowledge. While 'evaluation', 'critical thinking' and the like, which are present in most information literacy formulations, have some relevance, they are generally focused on dealing on dealing with specific and isolated information and documents. It could be argued that 'use', which often features as the final element in process models, could encompass developing understanding, but this is too inexplicit to be helpful.

The closest which the information literacy formulations get to addressing this issue is with the approach pioneered by Paul Gilster in his original formulation of 'digital literacy' [29]. This had a component of 'knowledge assembly', the accumulation of a 'reliable hoard' of knowledge from diverse sources, which gives the promise of a good basis or developing understanding. Christine Bruce's 'knowledge construction' [30] has some similarity, as does the ability to 'synthesis complex information, in SCONUL's seven pillars model [31], and the 'information fluency' formulation, which emphasises an initial understanding of the information environment *per se* [32].

As to what might be included in a 'developing understanding' component of information literacy, a detail suggestion would require an precise concept of understanding than we presently have. However, it seems clear that it would have to involve ways and means for making structuring and making connections within available information. A wide variety of such intellectual tools are known, including variants of reviewing, analysis and synthesis [33], and devising widely applicable and accessible forms of these, perhaps allied to the development of supporting technical systems, seems a good way forward. It may also necessary to give particular attention to ways of developing the sustained engagement with information which appears to be necessary for understanding to develop, in a digital information environment which encourages the absorption of snippets and fragments of information [34].

Of course, before recommending any such development, it is necessary to have an appreciation of the value and impact of developing understanding, as distinct from just providing information, and this is the topic of the next section.

6. Impact of understanding

That there have been no studies focusing explicitly on the value and impact of the development of understanding by information systems and services is not surprising, considering the lack of clarity around the concept, the lack of attention given to it by the information sciences, and difficulties of assessing impact of simpler information provision. The impacts of developing understanding are likely to be diffuse and long-term, but they are also likely to be highly significant, since a change in understanding is likely to provide changes to a much greater extent than is simply acquiring information. This should therefore be a priority for the future. An indication that it is possible is given by a study of the nature of the value provided by public library services to their patrons, in which interviewees volunteered that their understanding of topics and issues had increased [35].

We might finally note that David Deutsch, mentioned above, has set out what may perhaps be the ultimate impact of knowledge: the changing the physical universe. Deutsch was an early exponent of the view, now becoming more popular, that information is a fundamental and objective physical quantity [36]. He has devised a 'constructor theory' seeks to recast the most fundamental laws of physics in term of information [37, 38]. Deutsch also holds that 'constructors', the abstract forces that cause all physical changes, are made of information, and that therefore explanatory knowledge, i,e, understanding, is the most powerful force in the physical universe.

Almost any [part of the universe] would, if the right [explanatory] knowledge ever reached it, instantly and irrevocably burst into a radically different type of physical activity - David Deutsch [37]

Surely, this is the ultimate impact of understanding.

7. Conclusions

The information sciences have focused on managing and retrieving information, on managing knowledge, and data, and on understanding the behaviours and literacies around information. Perhaps now it is time to restore the layer that has been removed from Ackhoff's pyramid, and focus more on understanding.

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