A framework to maximise the communicative power of knowledge visualisations

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A Framework to Maximise the Communicative Power of Knowledge Visualisations

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ABSTRACT

Knowledge visualisation, in the field of information systems, is both a process and a product, and is informed by the closely aligned fields of information visualisation and knowledge management. Knowledge visualisation has untapped potential within the purview of knowledge communication. Even so, there is little evidence of knowledge visualisations being deployed. This might be due to a lack of evidence-based guidance to inform their creation. To improve this situation, we derived a number of "lenses" that can be used to reveal essential perspectives and feed into the visualisation production process.

We propose a conceptual framework which incorporates these lenses to guide producers of knowledge visualisations. This framework uses the different lenses to reveal critical perspectives that need to be considered during the design process. We conclude by demonstrating how this framework could be used to produce an knowledge visualisation with maximum communicative power .

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1 INTRODUCTION

The capacity to create and utilise knowledge is considered to be one of the most important sources of a firm's sustainable competitive advantage [91]. Organisations need to ensure that such knowledge is accessible and available to the right people, at the right time, because humans rely on knowledge that is stored in the collective mind [105]. Wersig [120] points out that the sheer volume of knowledge makes this challenging. Rubenstein-Montano *et al.* [100] emphasise the need to develop strategies to ensure that ideas and knowledge are communicated in organisations. The importance of effective knowledge transfer and communication has also been highlighted by researchers in a variety of different contexts, including: education [41], management [3, 7, 36], medicine [16] and project management [54] (to mention but a few).

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Knowledge visualisations have the potential to assist in knowledge transfer and communication [32, 37, 38] but those who wish to visualise knowledge face a number of challenges. These include making sense of widely divergent definitions, finding assistance in the somewhat sparse literature and working within an environment characterised by a dearth of tools, models and guidance [18]. Moreover, the visualisation needs to align with the needs of both the knowledge transmitter and the knowledge recipient [32], and this is particularly challenging if the knowledge itself, or part thereof, is tacit. Hence the unguided knowledge visualisation producer works somewhat "in the dark" producing visualisations that might not have the requisite communicative power.

Our aim, in carrying out this research, was to provide a more structured way for visualisers to produce *effective* visualisations. By 'effective' we mean that they demonstrate maximal communicative power. We hope to facilitate a wider deployment of knowledge visualisations to ease, encourage the deployment of, and facilitate knowledge communication. The rest of this paper is structured as follows:

Justification (Section 2): This section explains the need for more guidance towards the development of effective knowledge visualisations i.e. those with high communicative power.

Exploration (Section 3): We carried out a systematic literature review in order to gain insights into all extant literature related to knowledge visualisation frameworks and models. We also explored the literature to explore the meaning of the term "communicative power" in the knowledge visualisation context.

Outcome (Section 4): We propose a framework which encourages visualisers to use four different lenses to reveal the different stakeholder dimensions. This process can inform and guide the development of knowledge visualisations in a structured and rigorous way. We provide an example of how the framework delivers value in the field of information systems (Section 4).

Section 5 concludes by discussing and reflecting on the use of the framework, and suggests anticipated future research directions.

2 JUSTIFICATION: WHY A FRAMEWORK?

Knowledge is visualised to enhance and support knowledge communication and management. Knowledge visualisation relates to the process of visualising knowledge in order to exploit human visual processing capabilities and strengths in order to make such communication as effective and efficient as possible. The deployment of visualisations is of interest to those who need to communicate knowledge in all fields of human endeavour.

Knowledge visualisation, as a field of research, experienced a brief flurry of interest in the early part of the 21st century. Over the last few years, this interest appears to have waned, despite

knowledge visualisation's proven ability to enhance and improve knowledge communication [6, 17, 38]. The closely-related field of information visualisation is mature with well-established guidelines and practices. Knowledge visualisation, in contrast, is a relatively new area of research [26, 98].

Scagnetti [101] provides a few examples of the deployment of visualisations under other labels, in a wide variety of fields, including 'Visual Analytics' [80], 'Mapping of Controvosies' [68] or 'Mapping the Republic of Letters' [29]. All use visualisations as communicative artifacts.

As will become clear from the literature, there are known pitfalls in deploying knowledge visualisations [21]. Some guidelines have been published to support visualisers, but those are either limited to a specific area (for example, [17, 65, 77, 81, 116]), very general (for example, [19, 25]) or do not distinguish between information and knowledge visualisation guidelines (for example, [35]). We thus propose a consolidated set of lenses as a novel contribution in providing an evidence-based, structured process to support and foster production of effective knowledge visualisations.

3 EXPLORATION: CORE CONCEPTS

Knowledge itself can be considered a *product* or a *process*, and knowledge visualisation also spans both (Figure 1). A knowledge visualisation does not result from a big-bang type event; but is rather the product of an iterative process, incorporating successive refinements and improvements in order to maximise the communicative power of the final visualisation.

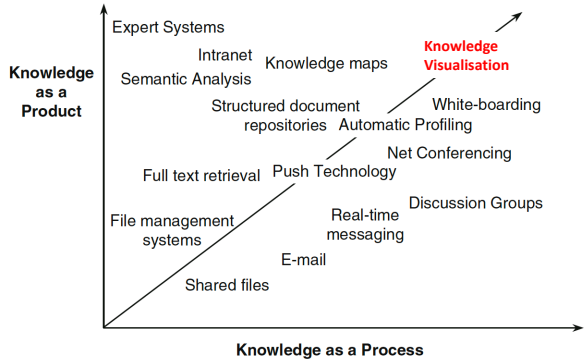

Figure 1: Knowledge Visualisation as a Knowledge Management Tool (adapted from [1, p. 715])

Before we start, it is necessary to lay the groundwork: defining 'knowledge' and 'knowledge visualisation' and explaining how we plan to structure the discussion.

Knowledge Definition: Du [32] reviews a number of different schools of thought when it comes to an understanding of what knowledge is, and explains how difficult it is to choose tools for knowledge visualisation when there is such wide disagreement on what knowledge actually is. Du proposes moving the focus from this nebulous concept to that of the *knower*. He argues that it is they who hold knowledge that they wish to communicate to recipients. In this case, definitions might well become less than helpful given the wide range of knowledge and contexts. Our framework will thus characterise the knower as the **designer** of the visualisation who, for some purpose, wishes to communicate knowledge. The recipients are the **audience**. These are the first two lenses for our framework: the 'WHY' and the 'FOR WHOM'.

Knowledge Visualisation Definition: Renaud and Van Biljon [98] derived a comprehensive definition of the term "Knowledge Visualisation", consolidating the concepts encapsulated in all previous definitions as: "*the use of graphical means to communicate experiences, insights and potentially complex knowledge. Such means should be flexible enough to accommodate changing insights, and facilitate conversations. Such representations facilitate and expedite the creation and transfer of knowledge between people by improving and promoting knowledge processing and comprehension*".

This suggests some more elements for our framework. First, the **knowledge** itself (the 'WHAT'), and the **visualisation** thereof (the 'HOW'). Moreover, since all knowledge is inherently contextual [96], we need to situate knowledge within **context** because, as Lewi [71] argues, the quality of a diagram depicting knowledge cannot be fully appreciated without also knowing the historical, social and economic context of the situated knowledge.

These definitions serve to identify the core lenses to be incorporated into our proposed framework: (1) ***why***, (2) ***what*** (which includes context), (3) ***how*** and (4) ***for whom***.

3.1 Lenses

Our definitions suggested the use of four lenses to reveal the perspectives that need to be considered when producing a visualisation. We now consider other knowledge visualisation frameworks to see which lenses/perspectives they use. Ward [119] proposes a framework for knowledge mobilisers based on the same four perspectives. Kernbach and Nabergoj [62] propose a set of lenses which, although differently titled, also encapsulate a notion of considering who the audience will be, what knowledge needs to be communicated in visual format, thinking about how to visualise the knowledge, and translating the ideas into a visualisation. Eilouti [34] proposes a framework for producing visualisations with three stages: deriving the knowledge (*what*), formulating the concept (considering metaphors, symbols and contexts, amongst others) and translating this to a visualisation (*how*). Finally, Kingston and Macintosh [64] suggest a number of perspectives to be considered by knowledge management systems. They also mention the *why, what, how* and *for whom* perspectives, although the latter refers to the depictions of the actions of the agents in the visualisation, not the perspectives of the visualiser him or herself, or that of the audience. Their list also includes *where* and *when*, perhaps because their framework is specific to the activity visualisation context.

We thus propose our framework to inform the production of knowledge visualisations, with the following lenses: (1) the **WHY** (knower purpose), (2) the **WHAT** (knowledge within a particular context), (3) the **HOW** (visualisation), and (4) the **FOR WHOM** (audience) (Figure 2).

3.2 Systematic Literature Review

To commence, we first gauge research interest in the field, as reflected by the number of research publications in successive years.

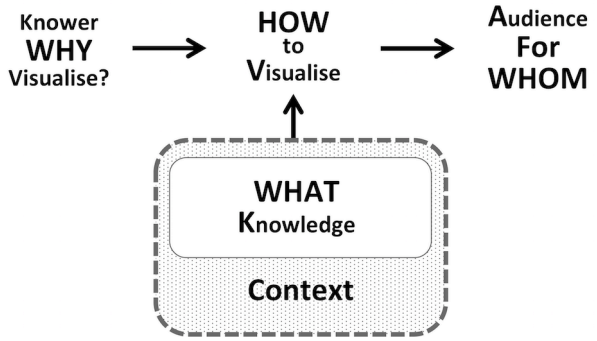

Figure 2: Visualisation Framework: Knower has Knowledge (within Context), which he/she wishes to convey to an intended Audience. A visualisation is produced to ease and facilitate knowledge transfer.

We then proceed to report on a systematic literature review of knowledge visualisation research in order to appraise the current state of the field, as reflected by peer-reviewed publications over the last decade. Finally, we seek to capture the essence of communicative power by delineating the qualities effective visualisations exhibit that maximise this.

3.3 Research Activity

The field of knowledge visualisation is not as mature as the information visualisation field, as demonstrated by the number of research publications in each field over the past few years, shown in Figure 3.

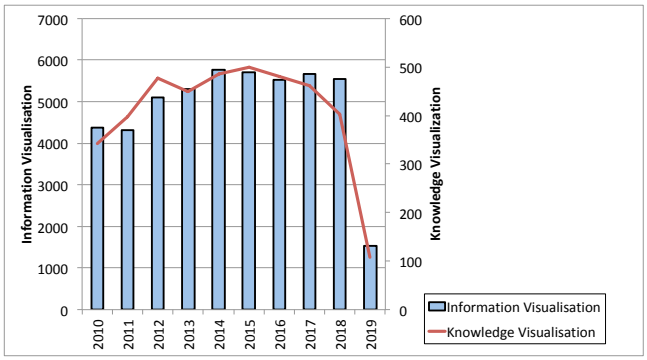

Figure 3: Number of Information and Knowledge Visualisation Publications on Google Scholar per year (excluding Patents and Citations — search on 11/5/2019)

3.4 Systematic Literature Review of Knowledge Visualisation

Grant and Booth [47] published a typology based on the analysis of 14 review types; we elected to use a 'systematic review'. This kind of review systematically searches for, appraises and synthesises research evidence comprehensively, constrained by a clear set of criteria. The purpose of a systematic literature review is to gather published research in a rigorous and systematic way, to remove the irrelevant and redundant and to summarise the most applicable to capture the essence of the topic [47, 95]. We now detail the criteria we used in our review.

Choose Databases: Papers published in academic journals were collected from electronic databases, including ACM, IEEE Explore, Scopus, Springer, Web of Science and AISel.

Choose Keywords: Keywords used for the searches were 'knowledge visualisation' or 'knowledge visualization' and ('model' or 'framework').

Choose Time Range: The search was restricted to papers published in English, between 2010 and 2019.

Choose Inclusion and Exclusion Criteria: Blogs, patents, chapters, and inaccessible papers were excluded. Papers that presented a theoretical abstraction to help us to build a model or framework of knowledge visualisation were included.

Search & Record: For each paper, the following information was recorded: author(s), year of publication, journal or conference the paper appeared in. Each paper was categorised based on the *why*, the *what* (including context), the *how* and the *for whom* of knowledge visualisation.

Exclusion: Many papers reported on the simple use of a picture or a diagram for visualisation, but there was no theoretical abstraction involved in creating the model. These were excluded. Others created models of frameworks but these were not 'knowledge' visualisation frameworks, but rather aimed to inform information visualisation designers. Some authors appeared to conflate information and knowledge visualisation. We eliminated all information visualisation papers.

Analysis: The titles and abstracts of these papers were tabulated, after which the papers were read to derive the different themes.

We first worked through the papers in order to identify those that could help us to build our contextual framework, asking the *why, what (& context), how* and *for whom* questions.

Two authors then worked through each paper using these lenses to interrogate the knowledge visualisations. The formulations were entered into a table for each paper.

We used bottom-up coding so that the codes are suggested by the data, rather than making use of pre-existing labels from the literature. The labels were agreed upon by the authors and those with similar meaning combined to arrive at the categories depicted below.

Outcome: Table 1 shows how many papers were found, how many were eliminated, and how many were retained to support analysis.

Following the process depicted in Figure 2, we will present the themes that emerged related to the lenses of: the ***why***, the ***what*** (including context), the ***how*** and the ***for whom***.

WHY is Knowledge Visualised? (Designer). We assigned a descriptive label to each entry, and during this process the three categories emerged (Table 2). For example, we assigned *view* to those papers describing visualisations for read-only consumption.

Some publications motivate the use of visualisations, as opposed to the use of plain text (Table 3).

Table 1: Papers Identified from Databases

Database	Number	Rejected (Exclusion)	Analysed	Rejected (Off Topic)	Retained
IEEE	62	51	11	1	10
ACM	14	6	6	4	4
SCOPUS	58	3	54	16	38
Springer	57	41	13	7	6
Web of Science	43	39	3	1	2
AISel	112	3	107	102	7

Table 2: WHY: Purpose of Knowledge Visualisation

VIEW:	
Knowledge transfer	[5, 8, 15, 20, 25, 30, 31, 43, 50, 53, 61, 73, 83, 87, 117, 129, 130].
EXPLORE-ENGAGE:	
Knowledge exploration & discovery	[2, 12, 49, 52, 60, 76, 108, 109]
Revealing different dimensions of knowledge	[46, 72, 93]
Reveal ontology	[40]
Mapping different kinds of knowledge	[75]
MANAGE-EXTEND:	
Knowledge organisation	[27, 28, 33, 55, 82, 126]
Knowledge manipulation	[23, 128]
Knowledge extension	[118]

Table 3: Why Visualisations (not text)?

Improve comprehension	[8, 27, 30, 33, 40, 43, 49, 53, 57, 60, 83, 93, 118, 129, 130]
To ease reuse	[108]
Stimulate imagination and new ideas	[20, 93, 117]
Improve access across platforms	[56]
Minimise redundancy, ambiguity	[30, 43]
Encourage development of mental models	[73, 126]
Engage people	[126]
To use modern tools	[51, 87]
Manage large data volumes	[78]
Cope with fast changing environments	[58]
Facilitate cross community learning	[92]

WHAT type of knowledge is being visualised? We used the categories proposed by Ward [119] to describe the kinds of knowledge being visualised since those had been tested through peer review and were more credible than newly-derived categories. This was the only dimension where Ward's categories could be applied to this collection of publications. Other categories were newly derived from the data.

(1) *Technical* [15, 20, 25, 28, 31, 43, 49, 51, 57, 70, 106, 117, 118, 122, 124, 125, 127, 128]
(2) *Scientific* [5, 12, 40, 46, 52, 53, 55, 56, 60, 72, 73, 75, 93, 108, 109, 126, 129, 130].
(3) *Practical Wisdom & Organisational* [2, 4, 8, 10, 23, 30, 33, 40, 50, 61, 76, 83, 85–87, 123].
(4) *Personal:* Health [45, 67, 103], education [39].

Knowledge context: It is not helpful or appropriate to enumerate all possible contexts here. What is essential, however, is to ensure that the context is considered first and foremost, and pinned down by the knowledge visualiser.

HOW is knowledge visualised? Our coding of the papers revealed a relatively small number of visualisation techniques:

(1) Knowledge map [33, 43, 70, 124].
(2) Sketches and Diagrams [12, 25, 30, 31, 87, 123, 124, 127].
(3) Visual metaphors [124, 126].
(4) Google maps [56, 73, 127].
(5) Flowcharts [50, 57].
(6) Cognitive level map [2, 60, 83, 117, 118, 122, 125, 130].

FOR WHOM is the knowledge visualised (Audience). We assigned a descriptive label to each entry to reflect the primary consumer of the visualisation.

(1) *Managers, directors, decision makers* [33, 43, 53, 123]
(2) *Researchers and End-Users* [2, 8, 28, 46, 49, 56, 57, 70, 73, 75, 83, 93, 106, 109, 118, 122, 126, 127, 130].
(3) *Practitioners* [20, 75].

We depict an overview of the activity reflected in the research literature in Figure 4. We next consider the literature on communicative power, since the framework seeks to support designers in maximising this essential quality in their visualisations.

3.5 Effectiveness (Communicative Power)

Visualisations can condense complex knowledge, facilitate comprehension and engage [11], and have significant *communicative power* [22]. Baule *et al.* [11, p. 2] state that "*A phenomenon, especially when complex, can be better analyzed, observed, and understood through the development of visual constructs*". They claim that the strength of a visualisation lies in its ability to act as a mediator with explicative functions. The communicative power of a visualisation, then, measures this ability to impart the knowledge to an audience.

Researchers have specifically considered the *communicative power* of other artifacts, such as gestures [13], metaphors [104] and movement [112]. Gestures and movement, in particular, attempt to communicate without speech, which means they have lessons for us to learn in this context. Moreover, many visualisations will harness icons as metaphors, once again meaning we can benefit from their experiences. Investigations into the communicative power of visual artifacts have studied product packaging [114], health communication [9], speculative visualisation [63], the visualisation of ancient architectures [107] and information visualisation [89], to mention but a few.

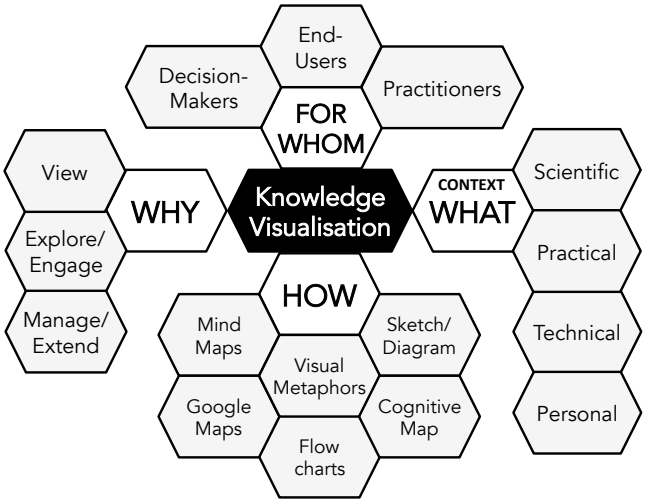

Figure 4: Knowledge Visualisation Literature: Depicting lenses representing knowledge within context, for the purpose of [WHY] to communicate knowledge to [WHOM], by visualising the knowing [HOW]

Communicative power researchers suggest the following qualities of artifacts that maximise this quality:

The WHY (Designer): A visualisation, in essence, builds a visual rhetoric by using graphical elements to convey a message to a selected audience [69, 101].

The WHAT (Knowledge): In communicating without speech, as visualisations do, it is essential to consider exactly *what* is going to be communicated by the speech-less medium [59, 115]. This sounds obvious but, given the fact that no explanatory narrative is possible, choosing *what* to visualise and what to omit, is non-trivial.

The CONTEXT (Context): All knowledge is contextual [96] and such context should be made salient in the visualisation.

The HOW (Visualisation Qualities):

Clarity & Consistency: Strothotte *et al.* [107] highlight the importance of clarity in visualisations. There is a need for transparency of design so that audiences are not puzzled by the visualisation. This need is confirmed by [19, 24, 84, 94, 99]. Consistency is also crucially important to prevent confusion [19, 25].

Manning [79] explains that meaning depends on ultimate semantic units or components used in a visualisation. Gross [48] points out that common use should be respected. The example he cites is that an upward trending graph line depicts increasing quantity, the uppermost level in an organisational chart depicts the highest status. Gross points out the importance of symbol position and relative area, in terms of communicating values to the audience.

Aesthetics: This is critical for visualisations with communicative power [111] (cited by [9]). Kallick-Wakker [59] claims that it is the aesthetics of a visualisation that makes their representation appropriate. This is confirmed by [66, 89]. It is not, therefore, an optional add-on as one might intuitively think. Gavrilova *et al.* [44] review the cognitive aspects of knowledge diagram design, aligning these with Gestalt psychology, towards producing aesthetic diagrams.

Text: Welles [42] highlights the importance of including descriptive text (he calls it a caption) within the image itself to ensure that the visualisation communicates its meaning effectively.

Simplicity: Welles [42] explains that humans tend to want to simplify things, because that makes them easier to process. He does warn, however, that simplification should not be taken too far. A visualisation that is simplified too extensively risks diluting its power to communicate and becoming obscure. This is confirmed by [44].

The FOR WHOM (Audience):

Anchor & Extend: A visual message communicates with an audience in two ways. The first is by 'hooking into' their own life experience, and the second by mediating their immediate experience with a brand package [114]. A visualisation with communicative power allows people to anchor within their own experience but then uses carefully chosen symbols to mediate their immediate experience [107] to build on, and extend their existing experiences. Along these same lines [63], in discussing speculative visualisation, talks about the visualisation "*referencing established or accepted values and attributing those values to the new subject*". This point is also made by [42], who argues that visualisations that are easy to objectify and anchor will be more favourably received.

Familiarity: This theme is strongly related to the previous one. Underwood *et al.* [114] explains that a visual message has to make the audience experience a sense of familiarity (personal experience). Welles [42] explains that the familiarity of a visualisation lends credibility to the subject matter. This requirement is confirmed by [24, 84, 110].

3.6 Summary

We have explored the core concepts of *knowledge visualisation* (Section 3.4) and *communicative power* (Section 3.5). Figure 4 provides an overview of the research activity revealed by the systematic literature review. Figure 5 summarises the communicative power quality constructs derived from the literature. We now have all the insights we need to outline our knowledge visualisation framework.

4 OUTCOME: FRAMEWORK

Using the insights from the analysis detailed in the previous sections, we derived the framework shown in Figure 5 to guide the production of knowledge visualisations.

The framework incorporates a three-stage process:

(1) **Prepare** — Having decided WHY to visualise, the designer asks and answers questions about WHAT knowledge is to be visualised, and the CONTEXT within which it resides. Then the visualiser asks questions about WHOM the knowledge is being visualised for, because that informs the next stage.
(2) **Design** — Having constrained the visualisation in the previous stage, the designer proceeds to craft the visualisation. In deciding on the HOW, it is important to maximise communicative power, so we carefully consider qualities that will achieve this.

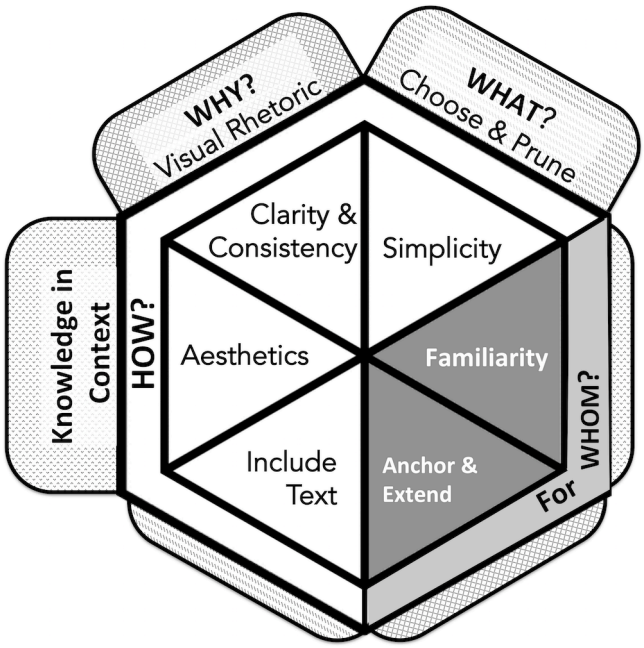

Figure 5: Visualisation individual HOW & For WHOM Communicative Power Qualities, with Three Cross-Cutting Themes: CONTEXT, WHY & WHAT

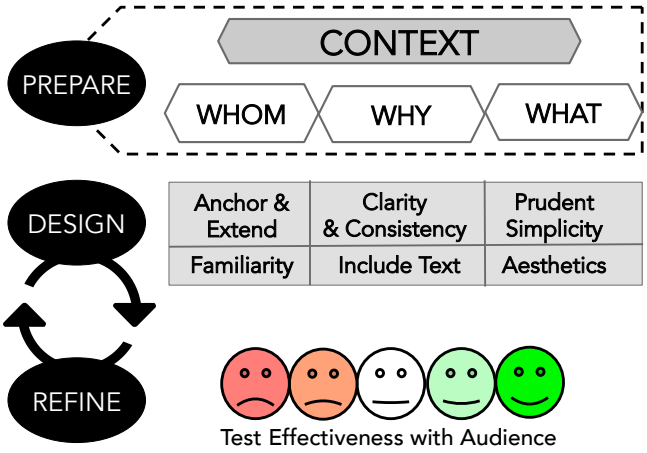

Figure 6: The Framework: Designer prepares by considering the Knowledge within Context to be visualised for an intended Audience. Designger then designs a visualiation and refines it with members of said Audience.

(3) **Refine** — Kernbach and Nabergoj [62] argue for the need to refine a visualisation. Bertshi [14] suggests that the effectiveness of a knowledge visualization can be tested by asking someone seriously to examine the visualisation and to consider whether they understand the underlying circumstances and contexts in which they are produced and received (p. 343). This involves asking members of the targeted audience to interrogate the visualisation [102, 121]. We have to determine whether they do indeed understand the knowledge within the context that it is conveying. They will be asked to evaluate the visualisation in terms of how well it communicates the knowledge i.e. its communicative power. It is likely that the designer will iterate between Stages 2 and 3 until the visualisation possesses the requisite power to communicate.

Framework Application

To illustrate the application of the framework, let us consider one of the most well-known and effective knowledge visualisations: the one designed and developed by Florence Nightingale (Figure 7). This visualisation was particularly effective, in that it changed the way military hospitals were run. If we imagine how she might have gone about creating her visualisation, it seems to align well with our framework:

Prepare:

- The **why** of deploying a visualisation was that she was crusading for better sanitation in hospitals. She knew that mere words would not work because she had previously written, in 1855, to Lord Raglan, the British commander in the Crimea [88]. General Sir John Burgoyne refused to believe her claims that the soldiers were dying of disease rather than being killed by soldiers from the other side. He claimed that the hospitals were in excellent order. It is likely that Florence Nightingale knew that she would have to use something more powerful to get those with political clout to take notice. In so doing, she became one of the pioneers of medical statistics [71].
- The **what** knowledge that Florence Nightingale had gained, from her work during the Crimean war, was that soldiers died from malnutrition, poor sanitation, and lack of activity [113]. The **context** of the knowledge was the military hospitals when Britain was at war.
- The **whom** were influential politicians [71] with the clout to make changes happen in military hospitals.

Design:

In terms of **how**, Florence Nightingale developed what is now called a 'Coxcomb' diagram (Figure 7). Nightingale's graph is similar to a pie chart. The slices of the chart represent deaths in each of the twelve months of one year. The outward reach of each slice shows the number of deaths occurring in that month. The progression from the small slices in April, May and June of 1854 are starkly contrasted to the number of deaths after the troops landed in the Crimea.

If we consider how her diagram exhibits the design qualities depicted in Figure 5:

Familiarity: William Playfair is credited with inventing the pie chart in 1801 [97]. So, when Florence Nightingale was creating her Coxcomb over 50 years later, it is likely that the foundational chart would have been familiar to educated people. The Coxcomb chart thus builds on familiary territory.

Anchor & Extend: The charts depicted deaths of soldiers and when this chart was published it is likely that many people in Britain would have lost a family member or acquaintance during

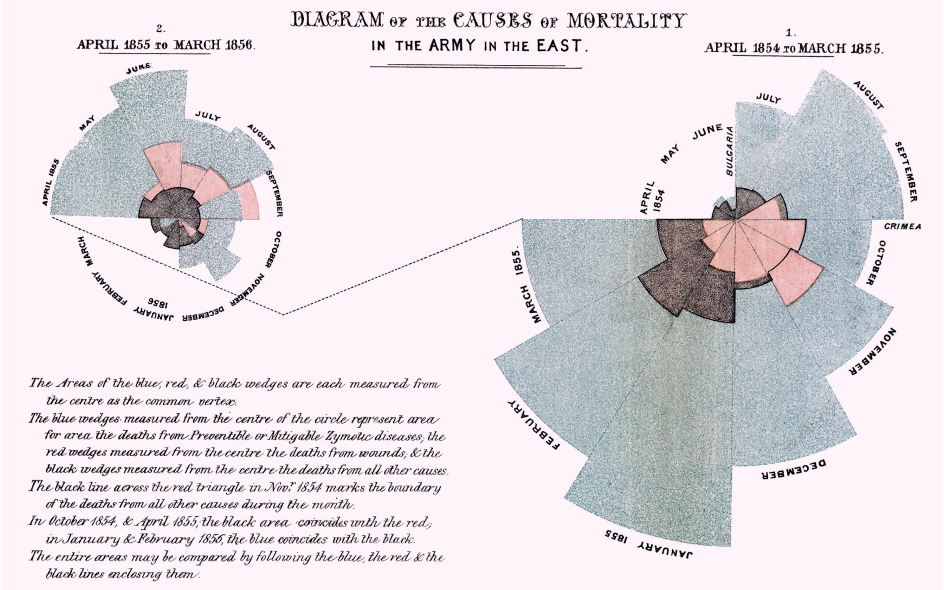

Figure 7: Modified image of the first of the two Coxcomb Charts provided by Florence Nightingale in 1858 [90] (described by [74])

the recent war. This would have made it easier to anchor their interest. The context is provided by the title of the chart.

Include Text: this is included as a legend, and the slices are also helpfully labelled.

Aesthetics: When it comes to aesthetics this visualisation is particularly interesting. Gavrilova *et al.* [44] suggest that diagrams ought to be symmetrical, balanced, regular and complete. This, they explain, is because of the human preference for these kinds of shapes. Yet none of these terms describe Florence Nightingale's Coxcomb. It is asymmetrical, irregular and unbalanced. Yet this diagram achieved its purpose: was it specifically designed to jar and make the intended audience take notice?

Clarity & Consistency: the diagram does not require any specialised knowledge of symbols, and does not confuse.

Simplicity: The linear graph in Figure 8 is simpler than the Coxcomb but loses some communicative power. The Coxcomb diagram is less simple but also not too complex. One of the most powerful aspects of the Coxcomb diagram is that each slice has three sections, very neatly communicating the causes of death: battle wounds, disease and 'other', and the ratios of each to the other.

Florence Nightingale's diagrams made it impossible for the military to fool themselves about what the soldiers were dying from. Battle deaths were clearly outweighed by deaths from disease. When the military saw the chart, the modern army hospital system was born. Florence Nightingale's charts were effective and had high communicative power.

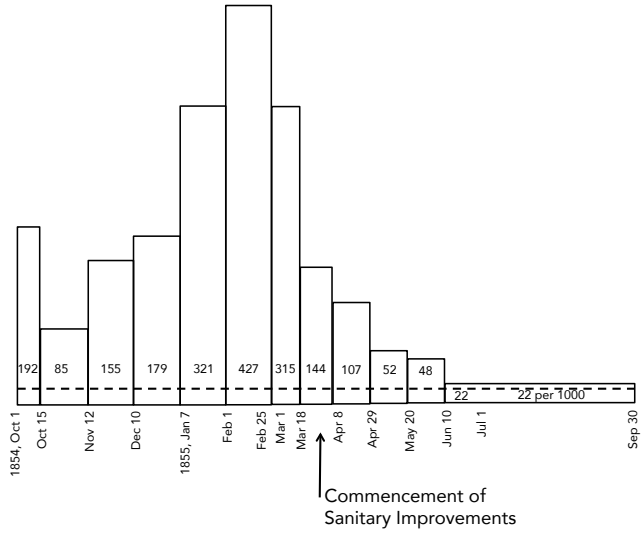

Figure 8: (Rectangular diagram showing the mortality (extrapolated to an annual yearly basis per 1,000 wounded) at the army hospitals at Scutari and Kulali (near Constantinople) during the Crimean War, from October 1854 to September 1855. [snip] The dotted line indicates the yearly mortality rate in the army hospitals in London around the same time, which was 20.9 per thousand) Fig 5.4 replicated from [71, p. 21]

5 CONCLUSION & FUTURE WORK

In this paper, we report on research we engaged in, in order to address the lack of guidance for knowledge communicators wishing to deploy knowledge visualisations to facilitate this communication. We used a systematic literature review to gauge research activity in this field and to flesh out the four lenses that ought to be used by knowledge visualisers in crafting their visualisations. Our primary

contribution is the proposed framework, comprised of three stages which, if followed, will improve the communicative power of knowledge visualisations. A next step with future research would be to formalise Stage 3 further. Moreover, we hope to carry out some experiments with knowledge visualisation designers themselves in order to validate the efficacy and value of our framework.

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