Charting the Path towards Effective Knowledge Visualisations

Karen Renaud
University of Glasgow & South Africa
Glasgow, Scotland
karen.renaud@glasgow.ac.uk

Judy van Biljon
University of South Africa
Pretoria, South Africa
vbilija@unisa.ac.za

ABSTRACT
Knowledge visualisation is enjoying increasing attention from researchers and organisations, due to its potential for expediting knowledge transfer. Despite the availability of many information visualisation guidelines, those who are tasked to produce knowledge visualisations currently do so without any formal guidance. These unguided efforts do not reliably deliver efficacious visualisations.

The research reported in this paper sought first to delineate the essence of knowledge visualisation. We captured this essence in the form of a comprehensive definition as well as a list of essential criteria exhibited by effective knowledge visualisations. Using these, we moved on to address the lack of guidance by producing a set of knowledge visualisation guidelines. We report on how we derived and evaluated these guidelines.

The guidelines, despite the rigorous derivation process, did not help the evaluators to produce effective visualisations. We reflect on the reasons for this and report on a number of lessons learned during the process. We conclude by suggesting a direction for future research.

CCS CONCEPTS
- Human-centered computing → Visualization theory, concepts and paradigms; Visualization design and evaluation methods; Empirical studies in visualization;

KEYWORDS
Knowledge Visualisation; Visualisation Characteristics; Visualisation Criteria; Visualisation Guideline Evaluation

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1 INTRODUCTION
It is no longer possible to read all new publications in a particular area, due to the sheer number of research papers appearing daily.

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[62]. This makes it increasingly challenging for subject experts to keep up with the knowledge development in any given area [35]. Researchers suggest that knowledge can be transferred more effectively, and efficiently, if the author includes well-crafted visualisations to condense the knowledge into an easily processed unit: a knowledge visualisation [1, 5, 25]. The inclusion of a knowledge visualisation makes it possible for a subject expert quickly to gain a sense of the paper, and thus stay apprised of the latest developments.

It is non-trivial to craft effective knowledge visualisations [50], so those wishing to craft visualisations would benefit from a widely-applicable set of guidelines to guide their development.

Visualisation, as a scientific field, is a mature scientific discipline [11]. It has accumulated a resource base of approved methods and rigorous processes. This includes guidelines to inform the development of data and information visualisations [13, 20, 36, 67]. Knowledge visualisation is much less mature field [12]. Hence no widely-applicable set of knowledge visualisation guidelines has yet emerged [48], a deficiency that we seek to address to reduce the incidence of ineffective visualisations [40].

This research investigated knowledge visualisation, with the aim of supporting knowledge visualisation designers. The first step, therefore was to explore the essence of knowledge visualisation (Section 3), and then, secondly, formulate a set of knowledge visualisation guidelines to inform designers (Section 4). Finally, in Section 5, we explain how we evaluated these guidelines. We reflect on our findings and report on some lessons learned in Section 6. We suggest a way forward before concluding in Section 7.

2 RESEARCH DESIGN
The research design comprised three stages. This included two systematic literature reviews and an empirical evaluation of the guidelines, as depicted in Figure 1:

Stage 1: Delineating the Essence

(1) We carried out a review of the literature to find papers that provided definitions of ‘knowledge’ and of ‘knowledge visualisation’. Papers published in academic journals were collected from electronic databases, including ACM, IEEE Explore, Scopus, Springer and Web of Science. The keywords used for the searches were (‘knowledge visualisation’ or ‘knowledge visualization’) and ‘definition’. The search was restricted to papers published between 2004 and 2016 in English, excluding blogs, patents and book chapters. We commenced searching in 2004 because that is when the Eppler [21] published the seminal paper on knowledge visualisation.

(2) We synthesised all the definitions and derived an initial set of criteria for knowledge visualisations,
Delineating Knowledge Visualisation Essence:
The Cambridge dictionary defines essence as "the basic or most important idea or quality of something". To capture the concept of quality, we have to identify a set of criteria demonstrated by a ‘high quality’ knowledge visualisation. A comprehensive definition then incorporates the sense of these criteria.

- **C1**: A list of the criteria for effective knowledge visualisations;
- **C2**: A comprehensive definition of “knowledge visualisation”;

Deriving & Evaluating Knowledge Visualisation Guidelines: Having encapsulated the essence within a list of desirable criteria and a comprehensive definition, we derived guidelines to help knowledge visualisers. This stage included the following activities:

- **C3**: A segmentation of the extant literature related to knowledge visualisation guidelines, on two dimensions;
- **C4**: A set of context-aware knowledge visualisation guidelines;
- **C5**: An evaluation of the guidelines;
- **C6**: A reflection on the essence of guidelines and a suggestion for future development of knowledge visualisation guidelines.

### 3 STAGE 1: ESSENCE

Knowledge can be tacit, explicit or codified [61]. Tacit knowledge refers to the knowledge held in practitioners’ heads [46]. Some researchers refer to this as implicit knowledge [59]. Tacit knowledge is not always articulated but, when it is, it is referred to as explicit knowledge. When explicit knowledge is documented, perhaps by producing a visualisation, it becomes codified.

McInerny [46] argues for the need to understand the essence and dynamic nature of knowledge, before any attempt to manage such knowledge is attempted. We thus proceed to explore the nature of knowledge in the following section.

#### 3.1 Knowledge

Knowledge is always constructed with a purpose in mind [33]. Knowledge results from human cognition [33], from someone forging new connections [43], identifying concepts or finding evidence of the existence of something previously uncovered [57]. Knowledge is inherently contextual [56], a particularly important feature, and a theme we will return to in our final reflection.

When someone carries out research to discover new knowledge, or has experiences that result in new knowledge, they effectively internalise their new understanding. The knowledge is tacit or implicit. This knowledge then has to be communicated to an interested audience: it has to be externalised i.e. made explicit.

Externalising knowledge is challenging: it is surprisingly difficult to articulate and share some kinds of knowledge, especially using the written word [16, 18]. Eppler [21] explains that knowledge communication includes the know-how, know-why, know-what, know-where and know-who of knowledge. A failure to convey any of these adequately renders the communication process inefficient.

In summary, knowledge is complex, multi-connected, the result of reasoning and begets more knowledge. This makes the codification, effective communication and transfer of knowledge non-trivial. Visualisations can maximise the effectiveness and efficiency...
of knowledge communication, and we explore their nature in the next section.

3.2 Knowledge Visualisation

Knowledge visualisation is a relatively new field that focuses on the use of visualisation to facilitate effective and speedy knowledge transfer [8, 12, 22, 33, 53] with the sole aim of transferring knowledge from visualisation author to viewer [19]. Effective visualisation of knowledge is non-trivial [33] but, if done well, can exploit key strengths of the human cognitive processing system to enhance communication [37].

3.2.1 Definition.

A very simple definition of knowledge visualisation would be "Visual Representations of Knowledge". While accurate, this definition does not really capture the essence, nature and capabilities of knowledge visualisation. It is thus helpful to derive a more comprehensive definition. To do this, we conducted a systematic literature review as described in the research design section under Stage 1.

We identified the following publications: [7, 8, 14, 26, 28, 29, 47, 66, 71–73]. We grouped the delineating concepts in these definitions into the categories shown in Table 1.

<table>
<thead>
<tr>
<th>Purpose — The Why</th>
<th>INTENDED AUDIENCE — FOR WHOM</th>
</tr>
</thead>
<tbody>
<tr>
<td>transfer and creation of knowledge [7, 8, 21]</td>
<td>at least two persons [28]</td>
</tr>
<tr>
<td>instrument for knowledge processing [26]</td>
<td></td>
</tr>
<tr>
<td>augmenting knowledge-intensive communication between individuals [47, 66]</td>
<td></td>
</tr>
</tbody>
</table>

3.2.2 Knowledge Visualisation Examples.

In order to test the comprehensiveness and applicability of our list of our criteria we sought out examples of ‘good’ and ‘bad’ knowledge visualisations. The former were of high quality and the latter of low quality, in terms of effectiveness. We classified them in terms of how well they communicated the ‘who’, ‘what’, ‘where’, ‘why’, ‘when’ and ‘how’ of the underlying knowledge [31], as judged by the two authors (neither of whom are subject experts in the knowledge being depicted). This exercise helped us to identify additional quality criteria that should augment our visualisation criteria. Due to space limitations we provide only a small sample to demonstrate particular qualities.

All visualisations in this section depict knowledge visually, aim to facilitate useful conversations and support knowledge communication.

3.2.2.1 Effective Visualisations.

One of the most effective and famous uses of knowledge visualisation is the Coxcomb diagram invented by Florence Nightingale (Figure 2). She wanted the army generals to understand what was really killing the soldiers. Nightingale’s graph makes it clear that the Russians were killing far fewer soldiers than cholera, typhus, and dysentery. It is unlikely that the generals would have gained the same insight from descriptive texts, nor felt compelled to take action to establish field hospitals, without the understanding fostered by this diagram.

A well known example of a good knowledge visualisation emerging from an initial poor one is the London subway map. The map shown in Figure 3 was the first of its kind. This was an accurate depiction but it was also unhelpful to commuters. What was not initially understood was that different stakeholders had different needs. The maintenance and management teams did indeed need this kind of visualisation but the commuter wanted to interrogate the map.
for a different purpose: to find out how to get from one point to another. The current visualisation is a model of economy (Figure 4). All extraneous details that would interfere with the commuter’s need to navigate London are omitted; only necessary details are retained. This is a superb knowledge visualisation, crafted specifically to support knowledge transfer from the creator to the viewer.

Ineffective Visualisations.

Darrell Huff published a seminal book in 1954 [32], demonstrating some very poor knowledge visualisations, many of which seem designed to mislead.

At the top of Figure 5, Huff provides a map published by Newsweek to show that the United States federal government is taking the incomes of the majority of states. The same data can be depicted as shown in the map at the bottom, but this visualisation is less compelling so did not serve the alarmist purposes of those who published the top map.

3.2.3 Augmenting the Criteria.

The importance of a number of Eppler’s criteria was confirmed by these visualisations:

- They are all visual and purport to exist in order to transfer knowledge.
- Meet Audience Need: The main problem with the map at the top of Figure 4 is that it was produced for the subway planners, and included information that was important to them in terms of rail maintenance. The later map, at the bottom of Figure 4, presents the information to support the commuter’s task, and does so admirably.

- Essence: Figure 4 does not present the lay of the land, the depths of the tunnels or accurate depictions of journey lengths. That is not essential to support the commuter’s task. Such details are extraneous and thus omitted.
- Simplicity: It could have been tempting to use images of soldiers in Figure 2, as is done in http://rhystat.blogspot.com/. It might well have been more appealing emotionally, but Florence Nightingale wisely produced a very simple visualisation.

Some new criteria emerged:

- Context: It is interesting to note that the author of Figure 5 provides a geographical context. This confirms the arguments of [24] with respect to the importance of context.
- Exploit Familiarity: Figure 2 adapted the well-known pie chart. The generals would have been familiar with that kind of diagram so the enhancements Florence Nightingale made would have improved the diagram, and not overwhelmed them by using a completely different kind of diagram that they would first have had to try to comprehend. Figure 5 exploits the familiarity of the map of the USA to convey the knowledge.
- Integrity: Figure 5 constitutes a warning in terms of how not to craft a knowledge visualisation. The aim is to transfer knowledge honestly, not to use visualisations to promote personal agendas.

The criteria to be satisfied are depicted in Figure 6.
3.2.4 Final Definition.

We now further refine our definition to produce the following comprehensive definition of knowledge visualisation:

**Knowledge Visualisation** is the use of graphical means to communicate experiences, insights and potentially complex knowledge in context, and to do so with integrity. 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.

This definition includes all the essential features of a knowledge visualisation’s key characteristics but it does not explain how to craft visualisations that display these.

4 STAGE 2: GUIDELINES

We firstly sought guidance for what should be included in our knowledge visualisation guidelines. Craft and Cairns [15] explain that visualisation guidelines should encapsulate the following: (1) suggest a number of useful techniques; (2) be measurably valid; (3) be developed with the target user in mind; (4) provide a step-by-step approach; and (5) be useful for both novices and experts.

These are feasible as a long-term vision rather than constituting a helpful set of guidelines. We thus realised the need first to interrogate the literature on published knowledge visualisation guidelines.

4.1 Guideline Publications

We conducted a systematic literature review as described under the research design section in Stage 2. The guideline-related literature we gathered included: [4, 6, 9, 17, 34, 38, 39, 44, 45, 49, 55, 58, 60, 63, 66].

Classifying Guidelines.

The first important aspect that emerged from our perusal of these papers is the importance of context [3, 64]. Jonasson argues that contextualisation is essential if recipients are to be able to make sense of the knowledge being depicted [34]. Moreover, this confirms the importance of context, as captured in our definition of knowledge visualisation.

The other aspect is the fact that some guidelines were overarching and non-specific [6, 8] whereas others focused on minutaie and specifics of visualisation aspects [9, 10, 15, 25, 49, 58, 63].

We segmented the guideline-related publications in terms of these two dimensions. The first considers whether they are contextual or context-neutral. The other dimension is related to whether the publications offer overarching principles to direct visualisations, or whether they attempted to be more specific in their directives.

The final segmentation is depicted in Table 3.

4.2 Choosing a Quadrant

The first step was to decide which quadrant in Table 3 to focus on. The more abstract the guidelines, the less helpful they can be to someone learning how to produce knowledge visualisations. On the other hand, the more context-specific guidelines are, the less generalisable they might be to different contexts. Hence the upper two quadrants might not be generic enough to be applicable in multiple contexts.

The bottom left quadrant is context neutral and, because knowledge itself is context-rich, this quadrant did not serve our purposes. The context-aware quadrant is conspicuously empty. It is this quadrant that we wish to focus on. We aim to craft a set of guidelines that will be tailorable to the context of the applicable knowledge domain. On the other hand, the guidelines should be equally applicable to a wide range of different contexts.
Table 3: A Segmented Overview of Knowledge Visualization Guidelines on Two Dimensions: Context and Specificity

<table>
<thead>
<tr>
<th>Context-Neutral</th>
<th>Contextual</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Specific</strong></td>
<td></td>
</tr>
<tr>
<td>Visual Notations [49]</td>
<td>Business Intelligence [60]</td>
</tr>
<tr>
<td>Perceptual Principles [58]</td>
<td>Learning [38, 45, 65]</td>
</tr>
<tr>
<td>Diagram Understandability [63]</td>
<td>Inspection of Knowledge Bases [4]</td>
</tr>
<tr>
<td><strong>Over-Arching</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Problems [34]</td>
</tr>
<tr>
<td></td>
<td>Personal Learning [55]</td>
</tr>
</tbody>
</table>

4.3 Deriving Context-Aware Guidelines

We wanted the guidelines to be context-aware, but not context-specific, so we provided two sub-components.

The first component supports delineation of context [3]. Here the focus is on the visualisation audience, the kind of knowledge to be visualised and the function of the visualisation. Here, too, the visualiser is required to make a broad decision related to the type of diagram to be used.

The second component focuses on specificity of the visualisation, informed by the previous step that established the overarching context. There is also some advice about including a legend and the use of textual labels.

4.3.1 Guideline Contents:

We extracted advice and guidelines from the research publications discussed in the previous section. We were also mindful of the criteria depicted in Figure 6. We first checked to see how many of the criteria were mentioned by the guideline publications. They were sparsely covered. Two mentioned three of the criteria [9, 55], two mentioned two [5, 44]. Most of the rest mentioned only one (usually the fact that it was visual) with only two mentioning none. This emphasised the need for a comprehensive set of guidelines.

We allocated guidelines gathered from the publications to two categories: (1) those that were related to context, and (2) those related to actual visualisation techniques. The former were included in the first component (Establishing Context) and the latter in the second component (Visualisation Techniques).

This pair of components encapsulates the criteria reflected in the definition of knowledge visualisation proposed in Section 3.2.3 and the insights of the knowledge visualisation publications we reviewed.

To support a step-by-step approach in following these guidelines we provided two accompanying checklists so that designers could chart their progress in working through the components [27].

4.3.2 Component 1: Establishing Context.

The need to establish context is related to the nature of knowledge as explained in Section 3. We provided guidance to help the designer delineate the context of the visualisation.

The final categories are shown in Table 4, with mappings to the criteria identified in Figure 6.

Table 4: Component 1: Establishing Context

<table>
<thead>
<tr>
<th>QUESTION</th>
<th>CRITERION</th>
</tr>
</thead>
<tbody>
<tr>
<td>What is the function of the visualisation? [10, 25]</td>
<td>Knowledge Transfer (Why)</td>
</tr>
<tr>
<td>What type of knowledge are you visualising? [8, 15, 25]</td>
<td>Essence (What)</td>
</tr>
<tr>
<td>For whom? [10, 25]</td>
<td>Meet Audience Need (Whom)</td>
</tr>
<tr>
<td>Visualisation format [10, 25]</td>
<td>Visual (How)</td>
</tr>
</tbody>
</table>

This aims to focus the designer’s attention on the target of the visualisation [15]. We wanted them to ask themselves why they were producing the visualisation, what type of knowledge was being visualised, who the target viewer was, and how the knowledge ought to be presented. Visual examples were provided of a visual metaphor [8, 54], a diagram [8], a pictorial story [2] and a knowledge map [30].

4.3.3 Component 2: Visualisation Techniques.

This component gives advice about various features of symbols that could be used in the visualisation. Table 5 shows mappings to the criteria identified in Figure 6. In the actual guidelines a visual example was provided of something that demonstrated the quality. So, for example, next to “semantic transparency” we explained that a Skull and Crossbones (Figure 8) was widely understood but other symbols, such as the Eye of Horus (Figure 7), would not demonstrate semantic transparency.

The advice is based on well-known perceptual principles and insights gained by those who have investigated knowledge visualisations. Following it can maximise knowledge transfer efficacy.
Table 5: Component 2: Focusing on Symbol Choice in Visualisations (The How)

<table>
<thead>
<tr>
<th>FEATURE</th>
<th>CRITERION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clarity (symbol meaning should be clear)</td>
<td>Simplicity</td>
</tr>
<tr>
<td>Consistency (one symbol = one concept)</td>
<td>Simplicity</td>
</tr>
<tr>
<td>Semantic Transparency (exploit symbol familiarity)</td>
<td>Familiarity</td>
</tr>
<tr>
<td>Complexity Management (Everything Should Be Made as Simple as Possible, But Not Simpler)</td>
<td>Simplicity</td>
</tr>
<tr>
<td>Reduce Information Overload (Consider separate overview and detail diagrams)</td>
<td>Simplicity</td>
</tr>
<tr>
<td>Dual Coding (use text and visuals)</td>
<td>Knowledge Transfer</td>
</tr>
<tr>
<td>Legend and Textual Description must be provided</td>
<td>Knowledge Transfer</td>
</tr>
</tbody>
</table>

5 STAGE 3: EVALUATION

Twenty three teams of designers (two or three per team) were asked to find a way to use the smart city concept to solve a big city’s problems. They were given a faux map of the city in question to work with. We thus gave them the context by instructing them to superimpose their solution over a map of the centre of the city.

Firstly they had to identify the problems of the given city, and then come up with a way that ubiquitously-sensed information could be used to solve the problem. Using the ‘establishing context’ table (Table 4) with the accompanying checklist, we expected them to narrow down the context as follows:

The Why: a problem communicating new insights. The What: communicate what the solution delivers, how it achieves this & where it is positioned in terms of the map (context). For Whom: This was tightly specified it was to be communicated to an expert (the course instructor).

The How: superimpose their visualisation over the provided map. Hence they could feasibly use a sketch, diagram or story. They were free to choose particular symbols to represent concepts on the map, as explained by the ‘visualisation detail’ table (Table 5) and recorded in the accompanying checklist.

5.1 The Produced Visualisations

We assessed the visualisations in terms of how well they conveyed the essence of the solution, how simple yet understandable the diagram was, and how well it served the purpose of knowledge transfer. The visualisations were generally poorly done. One or two were very good but these were a minority. Many who did provide context by superimposing their solution over a map of the city sometimes simply provided a map with some lines drawn on it, without any explanations, so that the essence was not communicated effectively. These solutions communicated the where but not the what or how.

Others failed to meet the criteria for knowledge visualisations for a number of reasons.

**Insufficient Essence:** Many did not communicate the essence of their solution, focusing instead on the software solution depicting their mechanism for solving the problem. Some teams produced UML diagrams or flowcharts depicting their system design. Some depicted the flow of the software solution, showing how data would flow from one software component to the next. Some provided screen shots of mocked-up Smartphone Apps. They focused on what, but did not provide how or where.

Many who did provide context by superimposing their solution over a map of the city sometimes simply provided a map with some lines drawn on it, without any explanations, so that the essence was not communicated effectively. These solutions communicated the where but not the what or how.

**Focus on Aesthetics:** Some teams thought the visualisations were for aesthetic purposes, and provided images of people using their solution. Some produced an aesthetically pleasing visualisation which gave the illusion of depicting the solution but, when examined, left many details of the actual solution unspecified. These solutions missed the point, and failed to communicate any of what, how or why.

**No Knowledge Transfer:** Some put symbols onto the map but did not explain how these were connected (lack of clarity). Some provided a map depicting the problem e.g. at-risk health zones, but these omitted the solution from the map (poor essence). These
solutions also failed to communicate any of what, how or where with any level of efficacy.

One team simply included a map screenshot obtained from Google with no attempt at superimposing their solution onto it (context without solution). Very few included a legend or caption despite the fact that the guidelines specifically advised this. This is a failure to communicate the what.

5.2 Questionnaire

We asked the designers to give us feedback about the visualisations and their helpfulness. 22 designers (about a third) responded. They unanimously rated the guidelines as unhelpful. The only part of the guidelines that they approved of was the instruction about avoiding information overload and some of them appreciated being told to include a legend and textual labels. They were fairly scathing in their responses: “I didn’t find them applicable”, “These guidelines provided little clarity for our team”, “The guidelines would have been more useful if it included examples of good practice, exemplar visualisations, etc.”

6 REFLECTION

Based on the evaluation of our guidelines we concluded that they fell far short of meeting the needs of our evaluators: novice knowledge visualisation designers. We now consider why this was so.

Choice of Quadrant.

The first consideration was to re-examine our quadrant focus choice. In terms of strategy, targeting the upper right quadrant of Figure 3 does not seem to be a wise alternative course of action. Knowledge is complex, diverse and unpredictably interconnected, and this approach would lead to a multitude of very specific guidelines with no possible emergence of “good practice” to inform the field of knowledge visualisation. This would leave us without any guidance for novice designers crafting a visualisation of a previously-uncharted knowledge domain.

The left-hand quadrants are also infeasible because knowledge is inherently contextual and visualisation thereof must be informed by this reality.

Hence our focus on the right-hand bottom quadrant still seems wise, but we have to find a better way of intertwining context with specific guidance to inform and assist knowledge visualisers. What we need to do is to find the link between context awareness and context specificity. We are fully cognisant of the difficulty of achieving this, and we suggest a way forward later in this section.

Complexity & Context.

To acknowledge the importance of context (context-awareness), but also to refrain from making the guidelines too context-specific, we produced a two-component guideline, the first to inform context delineation, the second focused on the specifics of the visualisation. The pair of guidelines themselves aimed to be both context-aware and overarching.

Such an approach might well be unrealistic. We thought we could ensure the prominence of context with our first component. The fact that so many of our knowledge visualisation producers failed to understand the importance of context shows that our approach, in this respect, was less than optimal.

The use of two seemingly disjointed guideline components is likely to have added too much complexity to the guidelines. If we continue with two components we should provide a mapping, to help the designers to understand the connections between them. We need to make the impact of the context clear and unambiguous, rather than nuanced. Context must be an integral part of the guidelines rather than being an add-on.

Essence of Knowledge Visualisation.

It became clear, during the re-evaluation of our guidelines, that knowledge visualisations are profoundly different from information visualisations. The latter are used during the course of research in order to interrogate, explore and spot interesting trends and patterns in large amounts of information. Knowledge visualisations are created once the research has been completed, and the resulting knowledge needs to be made explicit and codified, i.e. communicated.

This difference implies that whereas one over-arching set of information visualisation guidelines is indeed feasible and helpful, this might not be the case for knowledge visualisation guidelines. If we reconsider Table 3 it might be that we need a hybrid set of guidelines, neither context-aware nor context-specific, but rather context-aligned.

It might be necessary to have a suite of guidelines, with some inbuilt notion of context to support choice of the appropriate set to inform visualisation a particular kind of knowledge.

The Evaluation.

The evaluation of the guidelines was, in retrospect, unrealistic. We asked the teams to produce the knowledge and to visualise it. There were thus two tasks, with the success of the second being wholly dependent on the first. In future evaluations it would be better to give the required knowledge to the evaluators and then to ask them to use guidelines to visualise it.

Summary & Lessons Learned.

Our first insight was that it might be unrealistic to expect one set of knowledge guidelines to guide the development of all possible knowledge visualisations.

The second insight is that context is not merely important but the foundation upon which knowledge visualisations are constructed. Knowledge visualisation guidelines must make the central role of context prominent, salient and compelling.

The third insight is that the guidelines themselves ought to demonstrate the same simplicity that should characterise the visualisations themselves.

In retrospect, we conclude that it might make more sense to move away from a linear set of guidelines to a set of knowledge visualisation patterns. This mechanism is particularly suitable in terms of making context prominent and ensuring that the solution aligns with the context in the visualisation solution. The positioning of such patterns is depicted in Figure 10. Developing such a set of patterns is the focus of a future research project, and out of scope for this paper, but one that we intend pursuing in the near future.

7 CONCLUSION AND FUTURE WORK

Our main aim was to help knowledge workers to communicate their knowledge more efficiently using visualisations. We produced a
definition of knowledge visualisation, enumerated the criteria of an effective visualisation and derived guidelines from the literature. Yet our guidelines did not serve their intended purpose. The experience was not without value, however, because it delivered a confirmation, an epiphany and an admonition.

The confirmation was that most people cannot intuitively produce a “good” visualisation. The epiphany was that the structure of the guidance, and the extent to which it supports context, is critical. Guidance must provide far more than a table saying what criteria the visualisation ought to satisfy; it needs to be far more prescriptive and provide more detailed instructions.

To provide such meaningful guidance we might have to structure the guidelines as individual patterns, which lend themselves particularly well to context alignment. Such solutions are chosen according to context, giving context the primary role that it ought to have in the visualisation crafting process.

Finally, the admonition is that guideline evaluations ought to evaluate the impact of guidelines on knowledge visualisation production only. The participant task should not require knowledge production in addition to knowledge visualisation.

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