

## The big picture: designing infographics in mathematics education

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As designers of Cambridge Mathematics' *Espressos*, we reviewed the literature around infographic design and considered ways in which infographics might be useful to teachers, especially as part of a process of knowledge brokering. Here, we outline different conceptions of infographic design and use, concluding with our own design principles placed in context of the work of others. We use our experiences to offer a possible set of criteria to determine an effective infographic for communicating educational research.

**Keywords: infographic; design; knowledge brokering; images; diagrams**

### Introduction

Designing effective infographics to communicate research findings in mathematics education is a detailed and fascinating endeavour. Where design of infographics generally is complex enough - containing many instances of design decision points with important hypothesised effects on the audience - designing infographics to support research dissemination is still more complex, and working within the space of mathematics education adds a further level of responsibility to practice as well as preach ideas of clear, concise and truthful data-telling - with the embedded assumption that there is a single 'mathematical' truth to tell, which we problematise. This combination of nuance and responsibility creates a design scenario where we, as designers, feel both empowered and constrained in our aim to design the highest quality infographics in *Espressos* (research summaries for mathematics teachers) and the ways in which we respond to, reflect on, and ultimately aim to resolve the dilemmas that emerge as part of this process. In this paper, we aim to move the discussion around infographics forward by considering criteria for a 'good' infographic.

### What is an infographic?

Infographics are not simply information placed next to, or expressed in, graphics. There are various definitions of an infographic in the literature, which can be categorised as follows according to different areas of emphasis:

Emphasis	Example	Source
Multimodality	"a larger graphic design that combines data visualizations, illustrations, text, and images together"	(Krum, 2013, p. 6)
Storytelling	"a narrative process that involves representation and interpretation to develop and convey an idea"	(Dunlap & Lowenthal, 2016, p. 55)
Argumentation	"a claim expressed through visual metaphor, conveying the creator's fresh understanding of relationships, expressed through a judicious selection and arrangement of visuals,	(Abilock & Williams, 2014, p. 46)

	evidence, and text acquired during inquiry research within a discipline.”	
Relations	“graphics such as bar charts and line graphs that depict attributes of entities and relations among entities.”	(Carberry et al., 2006, p. 581)
Collection/curation	“a collection of one or more visualisations that have been manually modified or adorned to highlight specific points about the data”	(Harrison et al., 2015, p. 1187)

Table 1: different emphases in definitions of infographic

We see no contradiction between these conceptions, and indeed several of these definitions clearly overlap. One of the most important aspects of infographics in the literature is the focus on storytelling and argumentation, notable because it presents a view of statistical diagram that creates a tension with ideas of ‘neutrality’ or ‘objectivity’. For example, Li et al (2018) set neutral, technical scientific discourse in opposition to ‘societal debate’ when designing statistical diagrams. We refute this false dichotomy; infographics can be used to spread misinformation (Burrows, 2023) and are never neutral, though often presented as such by invoking the ‘god trick’ of appearing to view data from an overhead, objective perspective (Haraway, 2016). D’Ignazio and Klein (2020, p. 76) explore this tension, suggesting that “persuasion is everywhere, even in spreadsheets” and the idea of emotional response to data is not only inevitable but encouraged. This idea of visualisation as rhetoric can be extended to the beautiful concept of *data visceralization*: reducing abstraction and emphasising a human connection to the data (B. Lee et al., 2021); maintaining a critical orientation to data and resisting its power to dehumanise (Bench & Elswit, 2023); constructing representations of data that the whole body can experience, emotionally as well as physically, which also supports more accessible infographic design (D’Ignazio & Klein, 2020). We are currently working on another, related project which seeks to increase the accessibility of our infographics - and *Espressos* as a whole - in this way.

### What are infographics for?

Definitions of infographics are clearly related to their power and purpose. Dunlap and Lowenthal argue that “the power of infographics is that...they can quickly tell a story, show relationships, and reveal structure.” (2016, p. 42); Li et al (2018) agree that *revealing* is a key goal of an infographic, in this case revealing data patterns as part of empowering audiences to make decisions. This is related to the discussion above with regards to the plurality of truths in data: for us, the telling of a story with data, or data-telling, is an interpretative process that carries with it the great responsibility of using embedded and contextual expertise to reveal enough of a narrative that the audience may be interested, but not so much that there are no alternative readings or space for critical dialogue.

Dunlap and Lowenthal (2016) suggest that infographics are a way of delivering the maximum amount of content in the least amount of space while still being precise and clear, subscribing to the utilitarian approach introduced by Tufte (1983, p. 6) who famously wrote that “Graphical excellence is that which gives to the viewer the greatest number of ideas in the shortest time with the least ink in the smallest space.” We are interested in particular in the idea of ‘space’, especially given that principles of good graphic design suggest that compression into a small amount of space is not always the best way to present information; rather that negative space is intentionally used to indicate hierarchy of information and improve readability, signal breaks or changes, and give room for the eye (and the brain) to rest (D. Lee, 2007).

It has been suggested (e.g. Cain, 2015) that there are different ways teachers use research to make decisions, for example: instrumental (a linear, ‘engineering’ and practical model); and conceptual (a more indirect, philosophical and complex model). We see the process of transforming data into an infographic as a type of knowledge brokering (Rycroft-Smith & Stylianides, 2022) as it is a process whereby an expert with double identity transforms knowledge from research into useful or usable content for practitioners. However, our main intention is not that *Espressos* are used instrumentally, rather that they be used conceptually, a use which for us embodies ideas of dialogue, enlightenment and question-raising; in other words offering, rather than telling. As part of resisting instrumental use paradigms we have consciously designed in particular ways, which we characterise further a little later in this work.

### **What is considered effective in infographic design?**

Several researchers foreground the role of metaphor and representation in understanding abstract concepts. For example, Khatin-Zadeh et al. (2023) highlight the effectiveness of representational metaphor in supporting conceptual understanding of mathematical ideas. They argue that creating representations like infographics is an isomorphic move from one concrete representation to another, to better grasp the underlying abstract concepts. Others focus on structural guidelines for creating infographics. Kos and Sims (2014) propose a structure similar to a 5-paragraph essay for creating infographics. They provide general rubrics for assessing infographics based on ‘content and information’ and ‘design and aesthetic’ criteria. Davidson (2014), in an article regarding the use of infographics in the science classroom, emphasises that a good infographic represents a story and should have a suitable title, legible and eye-catching text, clear and relevant images, and consistent elements. Davidson proposes a rubric with task-specific and general criteria, such as creativity, storytelling, perspective, and information flow and clarity

Dunlap and Lowenthal (2016) used the following five components of the aesthetic learning experience to analyse popular infographics:

**Coherence** (for example, the infographic includes relevant text and images; the infographic presents a complete message)

- **Resonance** (for example, the infographic is credible; the infographic helps users to see how content is relevant to them)
- **Malleability** (for example, the infographic allows users to determine their own personal meaning and relevance)
- **Immediacy** (for example, the infographic creates a sense of excitement)
- **Compellingness** (for example, the infographic shares a provocative idea or problem)

However, in reviewing these criteria, we found very little of practical use when either designing or evaluating infographics. We hypothesise that this is due to three important tensions:

1. Whether an infographic is relevant or exciting to the user is subjective and user-dependent
2. It is unclear in the research as to the purpose of the infographics examined, which could be varied and even contradictory; this is because the purpose of an infographic is highly related to the values of the designer (for example, the argument we outlined earlier in relation to instrumental versus conceptual use of research)

3. What constitutes useful interpretation in creating a narrative versus designing with bias (and when this is desirable/undesirable) is unclear

With this in mind, we turned to our own experiences in infographic design to examine some of the properties, principles and criteria we use when making design decisions.

**Principles for infographic design in our work**

Between us, we have now designed a total of 47 infographics which have been published in *Espressos* and used widely. We examined and discussed these artefacts, drawing out principles which relate to our intended use and hypothesised relationship to the reader:

- We try to use infographics for provocation, collecting and collating ideas around a concept
- We use the idea of offering information through particular perspectives by the use of analogy and metaphor, creating a narrative that invites questions as well as supplies (possible) answers
- We write a clear, concise heading which offers a way to see the data
- We use fonts, spacing and graphology to differentiate ideas
- We use metaphor or analogy to highlight properties and relationships
- We choose and/or constitute ‘data’ for infographics creatively, considering what might be of the most interest or illumination to the audience and what the visual medium might offer in terms of clarity
- We emphasise sense-making and coherence by using colour to highlight connections
- We use space carefully - to provoke thought, to provide rest, to prompt consideration, to allow the reader to be present on the page
- We use images, icons and/or diagrams to offer coherent or complementary perspectives
- We refute the false dichotomy of affective vs cognitive, suggesting that good infographic design takes account of both, and therefore designing to take the reader both by the heart and the head into the ideas – a *data visceralisation* approach

An example is shown in Figure 1.

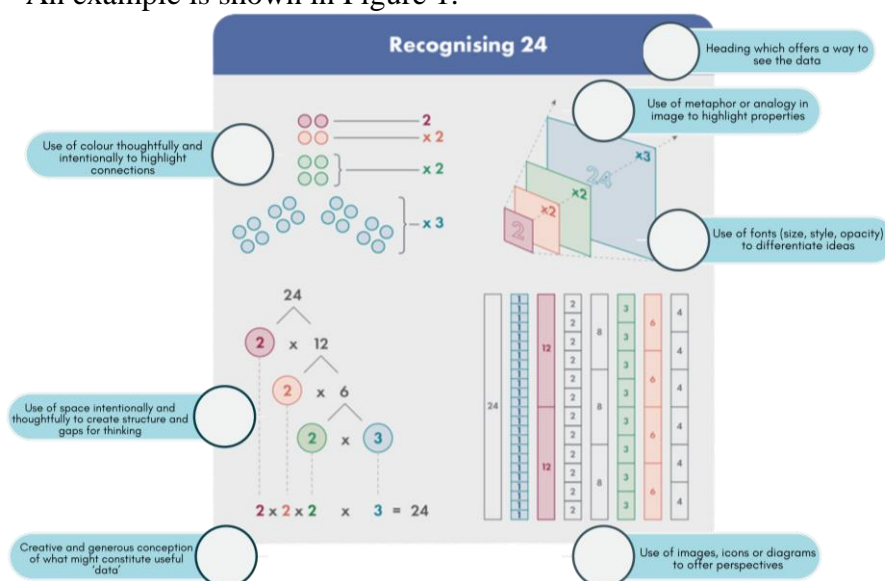


Figure 1: Elements of a successful infographic according to our design principles

## Conclusion

Collating these principles helped to clarify for us one of the fundamental issues when applying design principles to infographics: rather than a ticklist of criteria, we find instead that a menu or buffet of options instead applies – what has been termed a ‘clustered concept’ model (Weber, 2014), where prototypical examples of a successful infographic are likely to contain most, but not necessarily all, of the possible elements. Further, we agree with D’Ignazio and Klein (2020, p. 86) that “when visualizing data, the only certifiable fact is that it’s impossible to avoid interpretation” and Stray (2016) that “the constraints of truth leave a very wide space for interpretation.” Since there are many stories about data that can be true, it is the privilege and responsibility of the infographic designer to choose and represent one that is both true *and* meaningful for the audience, requiring a dual identity that is grounded in being both teller and listener; in this case mathematics education researcher and teacher.

Further examples of our infographics can be found at <https://www.cambridgemaths.org/for-teachers-and-practitioners/espresso/>.

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