Thinking about Diagrams: A General Diagrammatic Literacy

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Abstract
This paper builds on previous research into the development of a coherent model of diagrammatic literacy. Exactly how to define a ‘diagram’ and how to usefully categorise diagrams within that definition has long been a vexed issue. The theoretical model developed offers a way through the difficulties of categorising what a diagram is by defining diagrams by function, not form.

The proposed model for categorising diagrams is simple, coherent, and immediately useful in the sense that it enables a means of thinking consistently and critically about any given diagram. The model also includes consideration of the crucial role of linguistic content and/or context in the definition and function of diagrams. Importantly, coming from the field of education, the model is relatively simple to teach.

Diagrams can take often highly contentious ideas and present them in a fashion that substantially short-circuits our ability to think clearly about what we are being ‘told’ because a diagram does not apparently ‘tell’ us much at all: instead, it ‘shows’ us. Diagrams frequently assert a lot more than what they purport to merely represent. This model allows us to locate and analyse those assertions. In an age where the transmission of information is ever more visual (tablet computing, touch-screen phones, PowerPoint presentations, the internet in general) and ever more important within public discourse and policy, our ability to learn to think critically about visual information is more important than ever.

This paper presents a coherent and useful functional based definition of what a diagram is, and presents some examples of how that definition can enable us to think consciously about the ‘visual rhetoric’ of diagrams and their problematic relationship to the verbal contentions they visually represent.

Key Words: Diagrams, critical thinking, visual literacy, diagrammatic literacy, visual theory, education.

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1. Introduction
Our reliance as a society on visually communicating information has never been greater and is, if anything, increasing. Therefore a coherent theory of diagrammatic literacy is essential. Unfortunately that theory, inasmuch as it exists at all, is badly under-developed. As students we are, throughout our education, exposed to diagrams of various types in various contexts. These diagrams will be
explained to varying degrees within the context of a given subject (eg. mathematics, geography). We then blithely assume that we will, at some point, have developed a level of diagrammatic literacy that will enable us to think critically and accurately about almost any diagram in any context. This is a dangerous assumption, given the importance of diagrams in learning, communication and decision making processes, all the way from climate science through to stock prices: diagrams, even of hard data, are rarely neutral, are 'used as a communication medium or rhetorical device for presenting a particular analysis of the data.'

How can we learn to analyse this visual 'rhetoric'? How can we approach diagrams in such a way as to encourage a general diagrammatic literacy that will allow for diagrams to be considered in a consistently critical way? This paper is an attempt to answer those questions.

2. Defining Diagrams by Function

The variety of forms of diagram is so broad and heterogeneous that it is effectively infinite, therefore the attempt to classify them by form is futile: 'research on the cognitive mechanisms underlying multimodal integration is currently in a premature state due to abundant possible variations of the external representations and the modes of communication.'

While a chart of the share price of a company over time is radically different from the strategic policy roadmap or decision-making flow-chart used by the management of that same company, we still recognize them all as 'diagrams.' What definition can we come up with that covers all, without that definition being so loose as to include a photograph of a sunset or a Vermeer?

All diagrams are a visual representations of something, however not all visual representations qualify as diagrams. Diagrams, therefore, are a specific subset of visual representations in general. Given this, a way forward can be found by defining the boundaries of that subset, defining diagrams by the kind of things they represent, rather than by the form which that representation takes. That is, we can classify diagrams by function, not form, by the classes of thing they show, not the specifics of how they show it.

All diagrams, in terms of how they function, are visual representations of at least one of the following:

1) data
2) system(s) and/or processes
3) conceptual relationship(s)

It is useful to think of these three types of diagrams existing on a continuum representing the range of what can be (and intuitively is) defined as a ‘diagram:’
We can see how this framework locates the point at which a visual representation becomes a diagram in the following example: a satellite photograph of the continent of Australia is not a diagram any more than a photograph of a tree is. A stylised line-drawing of the continent of Australia is not necessarily a diagram either, is merely a stylised picture of the same. In certain contexts that stylised picture may function as a symbol, but its ability to function as a symbol does not make it a diagram. If, however, we draw objects onto that stylised picture that represent state boundaries, roads, cities, contours, and so forth, we now have a diagram, because we have a visual representation of a number of systems (political, spatial, social, structural), commonly referred to as a 'map'. This functional framework helps us see that what makes an architectural drawing of a house a diagram is that it presents a house not as a single entity but as a specific system of components.

In most cases a diagram will fit with apparent ease into one of the three basic categories: stock chart (data), flow chart (process/system), mind-map (conceptual relationships). However any given diagram can and usually will be visually representing more than one of these three classes at a time. Fig. 1, for example, is in one sense a visual representation of a system and in another sense is a representation of relationships between concepts.

In addition to delineating diagrams from visual representation in general, this framework, therefore, offers three different ways of approaching and thinking about any given diagram in context. The aim of the functional definition of diagrams is not simply to define what a diagram is, but to encourage us to consciously interrogate all of the different ways that a given diagram does, in practice, function. Because it is not just that we can think about a given diagram in more than one of the three paradigmatic ways, we frequently do so without the slippage from, say, data to process being subjected to any conscious or explicit
interrogation. It is this which gives diagrams their power, this slippage which is the basis of their visual rhetoric.

Consider the following set of diagrams:
All of these diagrams are visual representations of (the same) data. However, we should not stop with answering that question. Do these diagrams also function as visual representations of process? In all cases the answer to that is ‘yes’. The degree to which the various diagrams assert process, however, differs – the first chart weakly asserts process – the last very strongly asserts process. So asking the question not only alerts us to the assertion of process itself but focuses our attention on the manner in which the visual rhetoric of the diagram makes that assertion. Paradoxically, the more overt the assertion of process is, the less we consider it as an assertion. That interpretation of the data is done on the page for us and our visual system does not perceive an interpretation. Rather, we ‘see’ a self-evident fact.

3. Defining Diagrams by Context

The vast majority of diagrams are explicitly contained within a linguistic context. The context is either given with annotatory text within the visual space of the diagram itself, or in accompanying text (or speech) within which the diagram is presented. The presence of a context is not a trivial observation, nor is the fact that the context is almost invariably verbal.

Even when diagrams are completely wordless within their visual boundaries they can only function as diagrams if they are connected to a known and pre-defined context – it is in relating the diagram to its context that the possible meanings of a diagram are heavily restricted in a way that Van Gogh's Church at Auvers is not. Even in the case of 'pure' mathematical geometrical diagrams, it is notable that the 'interaction between diagrams and language appears to have been what gave rise to the first invention of proof in Greek geometry.'

As an example of the necessity of a known context for the definition of a 'diagram', consider the following two images, which we could describe as 'wordless diagrams':

(Fig 3)

As those images stand they could coherently and accurately refer to almost anything. In fact, the only reason we might feel tempted to define these images as 'diagrams' at all is that, in form, they are similar to various diagrammatic conventions that we are familiar with. However, because the lack of contextual definition prevents them having any definable function they are not, in this definition, diagrams at all.
These images are not hypothetical examples. They are found in a letter written by Joseph Conrad to his friend H.G. Wells, presented in the following way:

*Graphically our convictions are like that*

![Diagram 1](image1)

*Not like this:*

![Diagram 2](image2)

Now these images are diagrams. They are constrained in meaning within a defined context. W and C represent Wells and Conrad. The lines represent their convictions, and the diagrams tell us something quite specific about the nature of their relationship. They represent something definite because they have been restricted by context and are therefore diagrams.

Perhaps even more obviously, the diagrammatic definition of diagrams given in Fig 1 above is itself obviously a diagram. This, however, is not:

![Diagram 3](image3)

Without any contextual definition of what the shapes mean the diagram has no definite or defensible signification, can not function as a representation of data, system or conceptual relationship. It is therefore not a diagram.
Due to the fact that diagrams are uniquely visual we tend to focus on that visual component. Clichés abound: ‘a picture is worth a thousand words’, ‘diagrams do things language can’t’ etc. However, while it is true that diagrams do things language can’t, it is also true that diagrams cannot function as diagrams without a defined context, and as that defined context is (almost invariably) ultimately verbal, it is just as true to say that while diagrams do things that language cannot, what diagrams do cannot be done without language.

Failure to appreciate the ramifications of this observation is one of the causes for the present lack of a coherent theory of diagrammatic literacy.

As children we learn relatively early on that what people tell us is not always true – we also discover very quickly that it is possible to lie. Therefore a certain scepticism about language is fundamental to our experience of it, a scepticism which is the root of critical thought about language.

It is even more fundamental to not be sceptical about what we see. We quickly learn that if it looks like a long way down there is no real need to test it by jumping off the roof. It is positively dangerous to be sceptical about what we see – crossing the road would be a perilous exercise if we were.

Sven Bertel remarked that

> It is one characteristic of reasoning with diagrams that the human visual system is highly involved in the process. Due to an analogicity between problem domain and pictorial format, much of the mental apparatus designed for perceiving and making sense of the visual world can be rather directly employed for problem solving.\(^9\)

The visual component of a diagram, in other words, causes us to use the very fundamental part of our brain that we rely on to avoid walking into walls. Yet that visual component relies on context, that is, language, to have any meaning. Which means, among many other things, that it is possible to encode highly dubious ideas in a visual form: once visual, we struggle to see them as dubious. It is the way in which the visual and verbal components of diagrams work together that gives this form of representation so much power.

Therefore our final definition of a diagram is that it is a visual representation of at least one of the following three things: data, systems/processes, or conceptual relationships. Moreover it is a visual representation of at least one of these things that is constrained within a certain conceptual context (almost invariably verbal) that must be understood by its audience in order for that visual representation to qualify as a diagram.
4. Bringing it all Together: an Example

The following diagram was developed by Florence Nightingale in order to represent visually the statistics of the Royal Commission she headed into the medical care of British soldiers:

(Fig 6)

The key to the diagram explains the mathematical relationship between the data and the diagram, but the most significant component of the Victorian verbiage is the way it describes what each colour represents:

Blue: Deaths from Preventable or Mitigable Zymotic Diseases
Red: Deaths from wounds
Black: Deaths from all other causes

The phrase ‘deaths from wounds’ is morally neutral. The phrase ‘deaths from all other causes’ is morally neutral. The phrase ‘deaths from Preventable or Mitigable Zymotic Diseases’ is not morally neutral (they are not merely deaths, they are ‘preventable’ deaths). Defining the blue area in the key as ‘preventable’ death encourages the audience of the diagram to read the data in a quite specific way and immediately begs a big question: why weren’t they prevented? It as much an exercise in marketing or politics as a simple representation of data.

An astonishingly high rate of mortality for soldiers with 'zymotic diseases' all the way from gangrene through to dysentery was, at the time, ‘business as usual.’ The argument that all of that death was preventable was therefore radical and
contentious. However, part of what makes diagrams so effective is that they form a 'puzzle' which we have to solve,\textsuperscript{10} and as noted, we are strongly inclined to believe what we see. We see all the blue in Florence’s diagram, search for a definition of it and find 'preventable death.' Because the ‘preventable death’ is presented visually our own cognitive processes incline us to ‘see’ a fact rather than read a contention.

Once we have pinned down the way the verbal context structures our reading of this diagram we can then ask the three questions that form the basis of this functional theory of diagrammatic literacy:

1. Is it a visual representation of data? Yes, very clearly – but formally asking that question encourages us to think about the data itself and the choices made in its selection. What if Florence had done the obvious thing and individually represented the mortality statistics for each different 'zymotic disease' on the graphic (gangrene, dysentery, typhoid etc.) rather than grouping them together as ‘preventable’? The raw data would have been exactly the same but would its presentation have encouraged change? What are the 'rhetorical' effects of the choices Nightingale made in what data was represented and how?

2. Is it a visual representation of a system or a process? Again, the answer is yes. It is not obviously so, but a large part of the power of this diagram comes not from its representation of data but from its representation of a system of medical care that is far more effective at killing soldiers than the enemy.

3. Is it a visual representation of some kind of conceptual relationship(s)? Again, the answer is yes. Again it is not obvious. And again, the power of this diagram lies in the non-obvious, in what we are inclined not to consciously consider, lies in the fact that it sets up a conceptual relationship between two forms of combat fatalities: one is morally acceptable and the other is not. Without consciously noticing it we are powerfully affected by the way this diagram splits the single category of wartime deaths into two, one of which we cannot tolerate. This was a radical notion at the time, yet because the diagram causes the viewer to ‘see it’ rather than consider it, it stopped being radical. It became the truth.

5. Conclusion

Diagrams are frequently constructed in such a way as that they are heavily biased towards a certain interpretation. Being able to perceive this bias and understand how it works is an important ability, as important as being able to think critically about a novel, poem, newspaper article, advertising claim, political speech, or any of the other cultural artefacts that we routinely teach students to think critically about.
Despite the ubiquity of diagrams throughout all levels of society, the guidance given to students on understanding diagrams as a general category is limited, and the guidance give to teachers even more so. It is hoped that the theoretical framework provided in this paper can be the beginning of a less fragmented and more systematic approach to diagrammatic literacy.

We have offered a definition of what constitutes a diagram as a theoretical framework for the development of general diagrammatic literacy. This definition is based on the function of diagrams, not their form. We have shown how paying attention to function allows us to consciously foreground thinking about the diagrammatic rhetoric of what are apparently neutral quantitative displays. This definition allows us to do two things:

1. Encourage readers of diagrams to ask the question of how can (or does) a given diagram function as a representation of data, of process/system, of conceptual relationship(s)?
2. Encourage readers of diagrams to subject the linguistic components and/or context of a given diagram to the same kind of critical consideration they would give a newspaper editorial.

This provides a robust foundation for a diagrammatic literacy that enables us to approach any diagram in any context with some degree of confidence and critical consistency.

Notes


3 Mike Scaife and Yvonne Rogers 'External cognition, interactivity and graphical representations,' in Proceedings of the IEE Colloquium: Thinking with diagrams (1996), 8/2.

4 Stephanie Elzer, Sandra Carberry and Seniz Demir, 'Communicative Signals as the Key to Automated Understanding of Simple Bar Charts', in Diagrams 2006, 25.


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