Beyond knowledge visualization usability: toward a better understanding of business diagram adoption

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Abstract

Information visualization research typically focuses on the formal aspects of specific graphic solutions in terms of their thinking and/or communication support. This type of analysis often focuses on quantitative diagrams and emphasizes their attributes for specific tasks. Our contribution, by contrast, focuses on qualitative visual solutions and the factors that contribute to their wider diffusion. As many knowledge visualization solutions have not achieved wider use, the question of which factors foster diagram adoption seems to be a particularly relevant but under-researched topic. In this paper we develop and discuss three dimensions that foster knowledge visualization adoption: perceived ease of use, perceived usefulness and perceived authority. We base our analysis on the Technology Adoption Model by Davis and the Perceived Characteristics of Innovations by Rogers. We illustrate these dimensions and their items through examples of business diagrams that have received wide recognition and we contrast them with negative examples.

Keywords: knowledge visualization, business diagrams, Technology Acceptance Model, Diffusion of Innovation, visual representation

1. Introduction

Business meetings in organizations are increasingly supported by information and knowledge visualizations that help aggregating and synthesizing information. Diagrams are used to facilitate discussions with the goal of making better and more efficient decisions. There is a vast body of literature containing analyses of the efficacy of visual representations of large quantities of data [1-4]. However, thus far, few researchers have examined the adoption of visualizations that represent mostly qualitative information (such as options, scenarios, arguments, strategies, relations, etc.). In this paper, we focus on identifying critical factors that foster the adoption of such diagrams in organizations. We aim to provide a first set of factors to take into consideration when developing or improving diagrams to be used in organizations (especially for supporting decision making). To understand the relevance of diagrams in the business world, we consider examples that have become widely used and recognized, if not a standard, in business administration classes and in strategic analysis tasks within companies. Such examples include the BCG Matrix, Gartner's Hype Curve, Porter's Five Forces, Technology Roadmaps, Mind Maps, or Flow charts, etc. In figures 1to 3 we show two examples of such famous diagrams (the Hype Curve and the Five Forces diagram) and one lesser known diagram, an argument map.

The theoretical bases of our analysis are to be found in Davis' Technology Acceptance Model [5] and Rogers' Diffusion of Innovations theory [6]. Davis found two main drivers of technology acceptance: "perceived usefulness" and "perceived ease of use". In particular, perceived usefulness as a scale is measured with the following items: work more quickly, job performance, increase productivity, effectiveness, makes job easier, useful. Ease of use is composed of: easy to learn, controllable, clear & understandable, flexible, easy to become skillful, easy to use. We also take Rogers' Diffusion of Innovation theory into consideration, which classifies "attributes of innovation", namely: rate of adoption, relative advantage, compatibility, complexity, trialability and observability.

We have chosen to base our analysis on Davis' and Rogers' theories because they have been extensively validated and because they seem particularly relevant for the analysis of diagram adoption as an innovative business practice. However, these two useful and seminal theories, to our knowledge, have never been applied to the study of diagrams. In the next section, we propose a classification of key factors that support the success of a diagram in the business world, focusing in particular on diagrams that function as a support for discussion and decision making and not just mere presentation. In the third section, we provide illustrative examples of both successful and unsuccessful diagrams in the organizational context, with the aim of comparing and extracting relevant items. Finally, in the last section, we discuss the implications of our findings, the limitations of our approach and provide a conclusion.

2. Key factors fostering diagram adoption

Based on the application of Davis' and Rogers' theories to the context of diagram adoption, we were able to identify twelve possible factors that may influence the success of a diagram in terms of its adoption by users in organizations. We have classified these factors into three main dimensions: *perceived usability*, *perceived usefulness* and *perceived authority*. The first two categories are taken directly from Davis' Technology Acceptance Model [5]. His model stipulates that perceived usefulness and perceived ease of use are the fundamental determinants of user acceptance. We apply his strong and consistent findings in technology acceptance to the specific area of diagram adoption. However, we recognize – based on the insights of Roger's theory of innovation diffusion and its emphasis on communication – that there is another important category to be considered, which we name *perceived authority* of a diagram. This dimension consists of the prominence of the endorsers, the rigor and explicitness of the diagram's methodology and the promotion activities for the diagram [7]. We argue that these three dimensions play a crucial part in the adoption process of diagrams and that they all need to coexist together to allow the wide adoption of a diagram.

This implies that if a diagram is useful, but its usability is low and it is not supported by any promotion or branding effort, then it is unlikely that it will achieve a substantial diffusion or adoption. An example of this is 3D visualization, which has been hyped for a long time, but never achieved diffusion because of the intrinsic difficulties in manipulating 3D space. Another example are causal loops diagrams (system dynamics), which are very powerful tools, but have not been widely adopted, as they are rather complex to create and understand, and require extensive training. Similarly, even diagrams with high usability, but that are not especially useful for a purpose, are very unlikely to become widely adopted. An example is the flow chart: vastly adopted in engineering and computer science, it failed to be attractive as a support for strategic decisions, as the visualization is extremely schematized, not natural, and forcing the users to externalize basic or obvious implicit steps. Finally the promotion and diffusion of innovation principles apply to diagrams as well: diagrams could be useful and usable, but if there is no proper communication of their benefits, or no authoritative endorsers (in terms of people and brands), it is very unlikely that a diagram can achieve widespread use. A positive example of this effect can be seen in the wide spread adoption of mind mapping and mind mapping software. Mind maps were first made famous by the bestselling books of Tony Buzan [8] that had great mass appeal. Buzan thus became a public authority on creativity and note taking which in turn facilitated the adoption of mind mapping in organizations. Another example is Novak's Concept Mapping method [9] which received authority not only through the credentials of its originator, but also through numerous scientific evaluation studies [10, 11] (there are now more than 60'000 websites covering Novak's concept mapping method, listed in Google).

This reasoning could also be validated empirically in future adoption case studies or experiments (see the final section).

In more detail, the three dimensions can be decomposed into twelve key factors. In the next table (Table 1) we provide a schematic classification of the factors and subsequently a definition and a description (with references) of each dimension and factor specific to the diagram context.

Perceived Usability	**Perceived Usefulness**	**Perceived Authority**
1. Easy to understand	5. Allows to work faster	9. Name and promotion (branding)
2. Easy to learn	6. Improves job performances	10. Prominent endorsers
3. Content categories relevance	7. Immediate insights	11. Documented methodology
4. Aesthetic value	8. Adaptability to tasks	12. Positive network effects

Table 1 Classification of key factors influencing diagram adoption

Perceived Usability: "The degree to which a person believes that using a particular system would be free of effort" (original definition in [5]).

1. *Easy to understand*: little previous knowledge is required [5, 6, 12, 13]
2. *Easy to learn*: the operations with the diagram are easy to manipulate [5, 14]
3. *Content categories relevance*: the pre-defined categories structure the content meaningfully [15]
4. *Aesthetic value*: the diagram is a pleasure to the eye [16]

Perceived Usefulness: "The degree to which a person believes that using a particular system would enhance his or her job performance" (original definition in [5]).

5. *Allows to work faster*: the diagram helps to focus on relevant aspects and speeds up the analysis process [5]
6. *Improves job performances*: the diagram helps augment reasoning and coordination processes in terms of their quality [5, 6]
7. *Immediate insight*: the predefined form of the diagram leads to the emergence of free riders,

changes in perspective, or new insights into a problem [15] [17]

8. *Adaptability to task*: the diagram can be easily adapted to a specific usage [18]

Perceived Authority: the degree to which a person is confident that using a particular system is a good choice (our definition).

9. *Name and promotion*: the name is innovative, clear, short, and informative, and designates its main function [19]; the diagram is promoted through relevant channels
10. *Prominent endorsers*: the diagram is backed and promoted by a respected person or institution with a large audience [20], or a famous and trusted brand
11. *Rigorous methodology*: the rules for the development, production and use of the diagram are rigorous, consistent and transparent [3]
12. *Positive network effects*: the peer use of the system increases its perception regarding reliability and usefulness. Innovators start to use the system, setting the trend and creating useful diagram templates for the user community [6]

3. Illustrative examples

We now provide examples on how the previously defined key factors can be used. Two positive cases contrast with a negative one, specific to the business context.

The first example is the Hype Cycle diagram (Figure 1), which is a conceptual representation produced by the analyst and consulting firm Gartner, depicting the assessment and life cycle of technologies: it serves as an evaluation tool for investors and IT specialists [21]. Hype Cycles offer a snapshot of the relative maturity of technologies, IT methodologies and management disciplines [22]. They characterize the typical progression of an emerging technology, from over-enthusiasm through a period of disillusionment to an eventual understanding of the technology's relevance and definitive role in a market or domain.

The second case is Michael Porter's Five Forces diagram (Figure 2), a visualization representing Porter's framework of the five main forces in any industry that determine the competitive intensity and therefore attractiveness of a market. The five forces are: suppliers, customers, new entrants, substitutes and the industry itself (competition) [23]. It is a model used for industry analysis and business strategy development, commonly used in companies and taught in any business course at universities.

Finally, the negative example we consider is argument mapping (Figure 3), which has thus far not received wide use in business contexts (as it is not taught in Business schools, achieves a much lower ranking in Google and is not included in most business software packages). It is, however, supported by a few educational software tools, both commercial (e.g., IBIS argument map) and non-commercial ones (e.g., Araucaria). An argument map visualizes the structure of an argumentation, which is typically composed of premises, conclusions, objections, rebuttals, etc. The aim of argument mapping is to externalize individual thinking and reasoning processes in order to reflect on them (something of extreme value to any organization). In the following table (Table 2) we schematically compare the three diagrams with the twelve previously outlined factors.

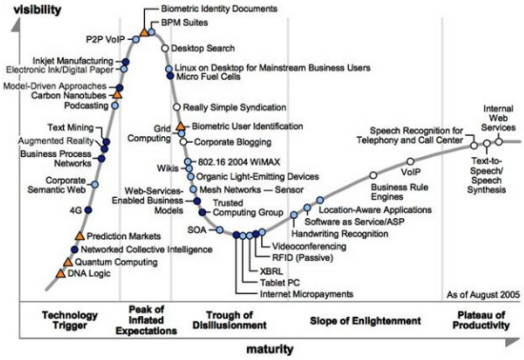

Figure 1 Gartner Hype Cycle

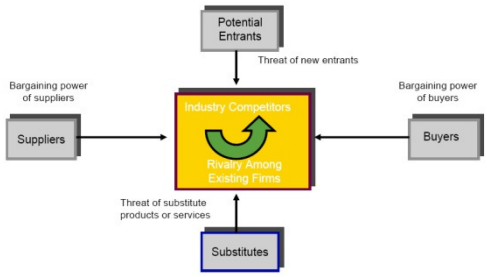

Figure 2 Porter's Five Forces

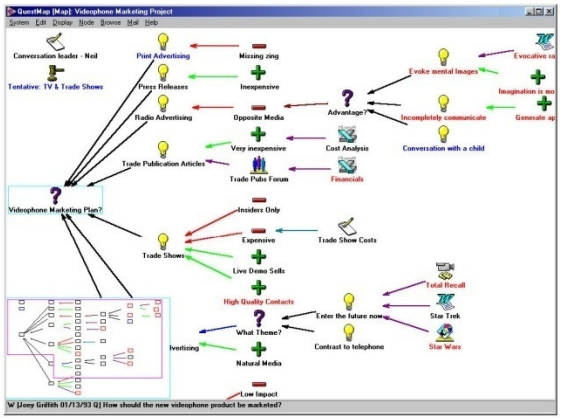

Figure 3 IBIS Argument Map

	Positive example I: Gartner Hype Cycle	Positive example II: Porter 5 Forces	Negative example: Argument Map
Perceived ease of use			
1. Easy to understand	The standard 2D coordinate format and its few labels are easy to understand	Straightforward box and arrow format with clear relationships among the few elements	Knowledge of linguistics or argumentation is needed to understand the many elements
2.Easy to learn	Basic knowledge of innovation diffusion is helpful but not mandatory	Basic knowledge of industrial economics is helpful, but not mandatory	Understanding argument schemes is a prerequisite
3.Content categories relevance	The well worded phases of a typical hype provide a useful orientation framework	The five forces capture key players and their relationships within an industry	The categories capture abstract concepts that may not be familiar to lay people
4.Aesthetic value	The space is all filled with information (text, color, shapes)	The few items are visualized in a very simple manner	Symbols and colors provide a playful look
Perceived usefulness			
5.Allows to work faster	The diagram synthesize several information pieces in few elements on the curve	The framework provides a guidance to the most relevant elements to be considered	The process of making explicit every argument increases the amount of time needed
6. Improves job performances	It allows for quick comparisons so decisions can be taken efficiently	The diagram provides a guide to consider only the relevant items	Very accurate analysis are enabled but require a considerable time investment
7.Immediate insight	Just looking at the relative position, it is easy to compare technologies	The predefined form structures the relevant information providing quick insights on what dominates an industry	One can see whether pro or contra arguments dominate, but it is necessary to read the texts and deduce overall implications
8.Adaptability to tasks	It is task specific: it can be applied to different technology areas (within IT)	It is task specific (industry analysis), but additional forces can be added	Can be used for reasoning and argumentation regarding any task or context
Perceived authority			
9.Name and promotion	The name is short, descriptive and distinctive.	The name designates the components and recalls Porter's popular theory	Various names are used: dialogue/ argument map, IBIS map, Toulmin chart
10.Prominent endorsers	Gartner is the biggest IT analyst company and it uses hype curves in many of its reports	Michael Porter is a Harvard Business School professor and as such highly visible in the field	There are no famous endorsers in the business community
11.Rigorous methodology	Gartner has issued several white papers explaining the underlying methodology	The background is described in detail in Porter's book on competitive strategy	The method is well documented, but inaccessible to business because of its jargon
12.Positive network effect	It is used by most of the major companies in the world and has become part of the business language	The Five Forces are basic knowledge that is taught in any BA or MBA class worldwide	They are often only used by scholars although the use in educational contexts is increasing

Table 2 Schematic comparison of three diagrams based on 12 key adoption factors

From these three examples, we can see that the first two diagrams are strong in all three factors of perceived usability, usefulness and authority, while the third example, the argument map, is rather weak in all three. First, argument maps can be used to represent any kind of reasoning, but they require a considerable amount of time to make the heuristics people normally use explicit. This process can eventually lead to a more precise schema, but requiring a significant time investment, creating a conflict regarding usefulness. Second, usability is low, as familiarity with argumentation schemes is necessary to understand and use argument maps, while this is not the case with the first two examples, which are understandable without extensive background knowledge. The many names to address argument maps and the lack of world renowned endorsers have not helped the adoption of the diagram either, whilst the Five Forces are widely discussed in Porter's own seminal book, and Gartner is using the hype cycle as a standard tool to inform its clients.

Finally we can notice that the adaptability to different tasks is low in the successful examples and high for the generic tools of argument maps. This could mean that less flexibility (i.e., less degrees of freedom) actually increases the usability and the usefulness (specificity for an activity) and may therefore be conducive to diagram success.

4 Conclusions

Our contribution aims to increase the understanding of the factors that drive diagram adoption in organizations. We have identified twelve adoption factors based on two existing seminal theories and we have applied these factors to qualitative diagrams, including positive and negative examples.

The theoretical contribution of our work is to be found in the advancement of diagram understanding (in the business context), specifically their factors of adoption. Moreover, we have extended the application of Davis' categories on the perceived ease of use and perceived usefulness to the area of information visualization. We also introduced the category of perceived diagram authority, which is significant in sustaining diagram adoption in organizations. Our contribution to the practice of information visualization is to provide guidelines or factors to be considered during the creation, adaption or the distribution of new visualization applications.

The limitations of our research include the scope, which has been limited to analyzing diagrams in the area of strategic analysis in business settings, the small sample of diagrams considered, and the lack of empirical validation. In addition, we have applied inherently broad and abstract dimensions (those of Rogers and Davis) to a new, specific context, namely the use of qualitative business diagrams.

Future research should thus focus on validating and expanding the identified adoption factors. Possible methods to conduct such studies include experiments (e.g., testing for isolated effects, such as perceived diagram authority on propensity to use), case studies or longitudinal adoption studies (in order to examine changes over time in the identified twelve factors). Another future research challenge is to translate the identified adoption factors into more specific guidelines for diagram and software developers and promoters.

Information and knowledge visualization are two fields with great potential, as demonstrated by numerous innovations over the last twenty years. To realize this potential, and to bring it to users in organizations, however, it is not sufficient – we have argued in this paper – to only conduct usability evaluations for new applications. Communicative aspects, such as the perceived or portrayed specificity or authority of a visual solution must also be evaluated, and subsequently positioned and signaled in the right manner. Addressing these 'market' issues will ultimately move the discipline of visualization forward and will enable it further to make a relevant and *recognized* contribution to solving today's challenges.

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