Darwin College Research Report

Choosing visualisations for collaborative work and meetings:
A guide to usability dimensions

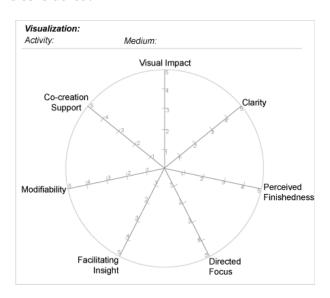**Sabrina Bresciani, Alan Blackwell and Martin Eppler**

February 2008

Choosing visualisations for collaborative work and meetings: A guide to usability dimensions

Sabrina Bresciani[1], Alan Blackwell[2], Martin J. Eppler[3]

How do you choose the best visualisation format when people need to work together for assessments, planning, decision making or design? PowerPoint presentations are good for some kinds of meeting, while scribbling on a whiteboard is best for others. But there are many possibilities in between. Each has some advantages and disadvantages, depending on what you want to achieve. None is perfect for all situations. This short guide provides a summary of the different factors that you should take into account when making a choice. The factors have been carefully designed as independent and (hopefully) comprehensive dimensions, based on years of psychological and organisational research. References to some of that research are provided in footnotes. Our own research, from which this guide was developed, is described in a longer paper[4], but the guide itself is designed to be a self-contained resource. Please pass it on to others (respecting our copyright and authorship), and let us know about your experiences using it.

Overview of the dimensions considered:

1. Visual Impact	How attractive is the visualization?
2. Clarity	Is the visualization easily understandable with low cognitive effort?
3. Perceived Finishedness	Does the visualization invite contributions and modifications or does it resemble a finished, polished product?
4. Directed Focus	Does the visualization direct the attention to the main item(s) of a discussion?
5. Facilitated Insight	Are new insights generated as a result of the visualization form?
6. Modifiability	Can the items of the visualization be modified in response to the dynamics of the discussion?
7. Group Interaction Support	Does the visualization help in facilitating or structuring the interaction of a group of people?

---

[1] University of Lugano, Switzerland (email: brescias@lu.unisi.ch)
[2] University of Cambridge, UK (email: Alan.Blackwell@cl.cam.ac.uk)
[3] University of Lugano, Switzerland (email: martin.eppler@lu.unisi.ch)
[4] Bresciani et.al. 2008. Note that full publication references can be found on the last page of this guide

1. Visual Impact

How attractive is the visualization?

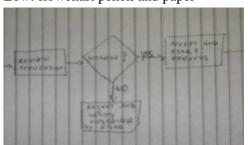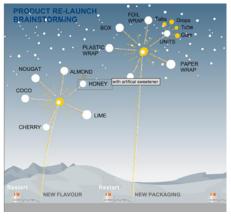|	
Explanation	This dimension relates to the graphic characteristics of a visualization. Visual Impact is high if the visualization is eye catching, memorable, emotionally evocative, or resembles an artistic work. It is low if the visualization is simple or low quality. High Visual Impact can be counterproductive because it might disperse attention. A pleasurable visualization is more likely to attract the attention of the viewer and create a positive halo effect on the other aspects of the visualization, inspire creativity and gives emotions, therefore increasing its mnemonic support.
Similar dimensions in literature	Visual impetus[5] : "How attractive and inviting to action and further exploration is a visualization"; Story content[6]; Role Expressiveness[7]; Memorability[8]
Quotes from practitioners and researchers	"I use cartoons, it's my style: it's fun and people like it" "How pleasing and attractive the diagram is to the end-user and how encouraging it is to use."
Design implications	A visualization that scores low on visual impact can be improved by using conventional restricted (i.e., hue-based) color palette, icons, and symbols. A high level is given by distinctive visual items, unconventional or sophisticated drawings that deliver surprise or emotion: visual metaphors, artistic drawings, eyes, faces, edgy shapes. Emphasized contours, symmetries, and golden ratios also evoke impressions of beauty.
Tradeoffs	Low visual impact can be disappointing or produce boredom. An appropriate amount of visual impact can support directed focus (as for example icons and conventional symbols), but a very high and inappropriate level (such as a visualization that resembles a piece of art) can be distracting. The appropriate amount is not determined a priori but depends on the activity and the goal of the collaboration.
Scale	1: Generic/low quality, 2: basic, 3: average, 4: distinctive, 5:resemble an artistic work
Example	Low: flowchart pencil and paper High: Idea fireworks visual metaphor

---

[5] Karabeg 2006
[6] Hundhausen 2005
[7] Green 1989
[8] Eppler 2004

2. Clarity

Is the visualization easily understandable with low cognitive effort?

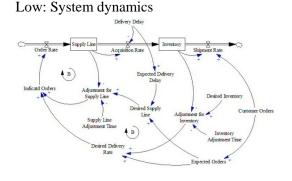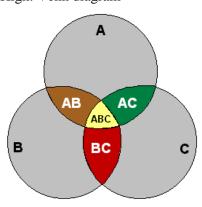|	
Explanation	Clarity is high if the meaning of the visualization can be understood at first sight. It is low if the visualization requires time and concentration in order to understand it. Low Clarity might be necessary when the represented concept is very complex, if high Clarity could lead to oversimplification.
	It is related to audience familiarity with conventions, the complexity and completeness, and the consistency of the elements. Difficulty in understanding is not always negative, as oversimplification of reality may lead to inaccurate understanding and therefore wrong judgments.
Similar dimensions in literature	Visual immediacy[9]: "The first impression; characteristic that enables the viewer to perceive and recognize *at a glance*" Visibility[10]: "Ability to view components easily"
Quotes from practitioners and researchers	"If the diagram is too complicated, people just switch off" "What works depends on the group and on the purpose: if the diagram has a life of five minutes or if it has to be shared and distributed; if the target is only the people who created it or also a broader public"
Design implications	If different elements are depicted in similar ways, and vice versa, if similar elements are depicted in different ways, clarity is compromised. The possibility to easily make comparisons (though juxtaposition) improves clarity. A familiar visualization may be clearer, but on the downside it does not always support the discovery of new insights. Ambiguity can be helpful in supporting divergent thinking, because the elements can be interpreted differently.
Tradeoffs	There are tradeoffs between clarity and *visual impact*: a visualization designed to be clear should not include excess decoration or artistic elements. Finally, high clarity provides rapid understanding but may lead to oversimplification.
Scale	1: confusing, 2: hard to grasp, 3: quite clear, 4: very clear, 5: clear at a glance
Example	Low: System dynamics High: Venn diagram

---

[9] Karabeg 2006
[10] Green 1996

3. Perceived Finishedness

Does the visualization invite contributions and modifications or does it resemble a finished polished product?

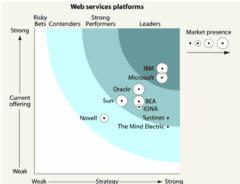|	
Explanation	This dimension is high if the visualization appears like a finished illustration or a graph in a book. When Perceived Finishedness is low, the visualization resembles a sketch or provisional work, for example made with post-it notes or with pencil. It strongly influences the group willingness to interact, question and modify the diagram. The perception of finishedness should be consistent with the actual possibility of modification.
Similar dimensions in literature	Provisionality[11]: "Degree of commitment to actions or marks" Fluid-Frozen[12]: "Materials are observed to be treated both as frozen, and hence unavailable for change; and as fluid, open and dynamic."
Quotes from practitioners and researchers	"Drawing on the whiteboard is temporary and so people will take more risks. It is better for prototyping and exploration, then when you are comfortable you take a photograph or you make a final draft on a flip chart" "It is important to make clear whether the visualization is frozen or not, signal it unambiguously if it's a draft or a final work"
Design implications	On a continuum of media that support the "finished" look of a visualization we have at the low end pen and paper, all the way to high end with beamed software-based presentations, such as Power Points, or printed graphs resembling a piece of desktop publishing.
Tradeoffs	The perception of finishedness is influenced by the *medium*, the *modifiability* level, and the *visual impact*, because a neatly designed diagram that resembles a piece of desktop publishing is perceived as having high finishedness.
Scale	1: perceived as in progress, 2: perceived as sketchy, 3: perceived as changeable, 4: perceived as finished, 5: perceived as polished
Example	Low: Roadmapping work sheets High: Forrester's Wave

---

[11] Green 1996
[12] Whyte et al. 2007

4. Directed Focus

Does the visualization direct the attention to the main item(s) of a discussion?

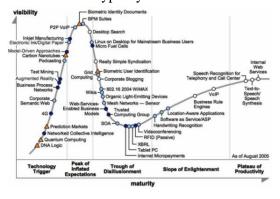|	
Explanation	Directed Focus is high when the attention of the participants is directed only to the main (relevant) item or items of the discussion.
	When there is no focus at all, or the focus is dispersed on many items, the Directed Focus is low. Low Directed Focus can be useful when divergent thinking is required. A smart graphic that focuses on one or few relevant items, can help the group keep the centre of the discussion. Salience is a fundamental issue to be considered, as it can switch attention from the content to the graphical form. Focus can be usefully dispersed when seeking divergent thinking or different alternative needs to be considered. As a consequence of a non-conventional focus, new discoveries can arise (leading to high inference support).
Similar dimensions in literature	Focus[13]: "Draw attention on the issue"
	Salience[14]: "Whatever an end user focuses on during the process of construction a visualization tends to become the focus of subsequent discussions mediated by the visualization"
	Secondary notation[15] "Extra information in means other than formal syntax"
Quotes from practitioners and researchers	"It's a problem when you get more engaged with the visual model instead of the idea"
Design implications	Using a distinctive color, or bold font, position (centre), zoning an item (with a square or a circle around it), naturally direct the attention to that item as the central point of the discussion; placing various items of the same size and color at the same distance disperse the focus.
	In a visualization the focus can be imposed (for example when printed on a paper) or it can be a changed to fit the dynamic of the discussion (when some items can interactively be highlighted, circled or coloured).
Tradeoffs	A moderate amount of focus increase *clarity*, but focus on too many items lower it, because there is a competition for focus.
Scale	1: none, 2: on many items (dispersed), 3: on several items, 4: on few items, 5: on one main item
Example	Low: Gartner Hype Cycle High: modified Gartner Magic Quadrant

---

[13] Eppler 2004
[14] Hundhausen 2005
[15] Green 1996

5. Facilitated Insight

Are new insights generated as a result of the visualization form?

Explanation	When new understanding is generated "for free" by using visualizations or changing the focus (stand back and see the big picture), or the representational constraints, then the Facilitating Insight dimension is high. If the visualization does not help in gaining new insights or understanding, it is low.
	This dimension relates to the potential of a visualization to help uncover novel patterns or relationships. It describes the ability of the visualization to aid thinking and discovery processes. Facilitating insight is a core differentiator and added value of visualization over text: it allows to gain new understanding "for free" just by changing the visualization type, the focus, or the representational constraints.
Similar dimensions in literature	Free riders[16] "particular way in which a structural constraint governing representations matches with a constraint governing the targets of representation". Free riders[17]: "New information is generated as a result of following the notational rules". Computational efficiency[18]: through perceptual enhancement
Quotes from practitioners and researchers	"It is important to find new insights, to go in search of the mapping which is illumination or explaining." "Another good case is brainstorming, when patterns emerge."
Design implications	To increase the ability to generate new insights, various implications are possible such as: making relationships graphically explicit and thus allow multiple comparisons (i.e., among positions, scales, distances, sizes, etc.); or grouping all needed information that is used together in an easily accessible manner.
	Or also provide interactive functions to zoom in or zoom out (change scales) or see details in context, relate elements directly (filter or combine) or to change perspectives. Finally a very efficient measure is to enrich items by embedding multiple dimensions for each element (through colours, size, position, symbols, animation, mouse-over comments, etc.)
Tradeoffs	Seeking insight often leads to reduced *Clarity*, because of unconventional or unfamiliar way of visualizing information. Visualization forms that support inference generation are generally not concerned or do not perform well in terms of *Visual Impact*.
Scale	1: none, 2: some insights, 3: several insights, 4: many evident insights, 5: breakthrough insights
Example	Low: cube diagram High: criteria-based decision table

---

[16] Shimojima 1999
[17] Blackwell et al. 2001
[18] Larkin and Simon 1987

6. Modifiability

Can the items of the visualization be modified in response to the dynamics of the discussion?

Explanation   Modifiability is high if each item of the image can be changed easily (move, delete, substitute). If the items are hard to change or modifications are not possible, then Modifiability is low. Low modifiability can be useful as it encourages second thought before making modifications, while high modifiability enhances the possibility of interaction.

Similar dimensions in literature   Rootedness[19]: "Resistance to movement of objects or their arrangement"

Viscosity[20]: "Resistance to change"

Useful awkwardness[21]: "Awkward interfaces can force the user to reflect on the task, with an overall gain in efficiency"

Quotes from practitioners and researchers   "In a typical scenario one person draws something on the whiteboard, then if another person doesn't agree or has something to point out or to add, he or she is invited to go to the board and modify the diagram. It encourages other people to build together a shared picture"

Design implications   Pen and paper is a much less modifiable medium than a drawing software (although ironically their finishedness can be perceived as the opposite of what it really is). Software scores high in modifiability because the items can be moved, deleted, and copied very easily. However projected presentations (for example PowerPoint slides) are mot readily modifiable by the group, because the presentation is controlled by a facilitator and often just projected on the wall. Drawing on paper (such as a flipchart) with felt-tip pen is not highly modifiable because items can only be added, but not deleted or moved, while this could be made possible using a pencil or drawing on a whiteboard.

Tradeoffs   Modifiability affects *group interaction support* and *perceived finishedness*: a highly modifiable environment encourages a higher level of contribution, because changes can be made easily therefore people take more risk and contribute more often.

Scale   1: not possible, 2 :difficult, 3: possible, 4: easy, 5: easy and fast

Example   Low: sketched diagram, pen on paper

High: post-its and erasable comments on whiteboard

---

[19] Edge and Blackwell 2006
[20] Green 1996
[21] Blackwell 2000

7. Group Interaction Support

Does the visualization help in facilitating or structuring the interaction of a group of people?

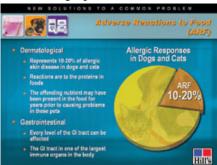|	
Explanation	This dimension describes the capacity to keep group interaction and discussion on the right track.
	If the visualization allows indicators such as tracking participants' contribution, progressive evaluation of the discussion development, replay and simultaneous/sequential modification patterns, then Group Interaction Support is high. If there are no indicators supported, it is low. Other elements that provide Group Interaction Support are the referencability of the items in the diagram (pointing or recalling) for facilitating participants' reference to the elements of the visualization, and documentation, that allows participants to go back to a certain point in time (history) or replay the whole interaction.
Similar dimensions in literature	Referencability[22] : Reflects the ease with which conversational participants can refer to elements of the visualization
	Controllability[23]: Facilitates communication by enabling a presenter to dynamically respond to a group's questions
Quotes from practitioners and researchers	"It is a very bad setting if everyone gets some paper to draw on it; then it is not possible to share."
Design implications	Progressive evaluation can be tracked by a visual metaphor such as an arrow hitting a target or a thermometer. Traceability can be obtained for example by using different colors for each person's contribution or using specific templates that are designed for supporting coordination by focusing on a pre-ordered contribution model.
Tradeoffs	The *medium* has a strong influence on group interaction support, as software based interactions can be more easily documented and often support history saving; specific software applications for collaborative work have special support for progressive evaluation, traceability and history replay.
Scale	1: none, 2: very limited, 3:some, 4: extensive, 5: very extensive
Example	Low: projected presentation with embedded graphs High: template poster with post-its notes

---

[22] Hundhausen 2005
[23] Ibid.

References

Blackwell, A. F., Britton, C., Cox, A., Green, T. R. G., C.A., G., Kadoda, G. F., et al. (2001). Cognitive dimensions of notations: design tools for cognitive technology. In M. Beynon, Nehaniv, C.L., Dautenhahn, K. (Ed.), *Cognitive Technology* (pp. 325-341). Berlin: Springer.

Bresciani, S., Blackwell, A.F. and Eppler, M. (2008). A Collaborative Dimensions Framework: Understanding the mediating role of conceptual visualizations in collaborative knowledge work. Proc. 41st Hawaii International Conference on System Sciences (HICCS 08), pp. 180-189.

Bresciani, S., & Eppler, M. (2007). *Usability of Diagrams for Group Knowledge Work: Toward an Analytic Description.* Paper presented at the I-KNOW, Graz, Austria.

Edge, D., & Blackwell, A. F. (2006). Correlates of the cognitive dimensions for tangible user interface. *Journal of Visual Languages & Computing 17 (4), 366-394.*

Eppler, M. J. (2004, June 30 - July 2, 2004). *Facilitating Knowledge Communication through Joint Interactive Visualization,* Paper presented at the I-KNOW '04, Graz, Austria.

Green, T. R. G. (1989). Cognitive Dimensions of Notations. In L. M. E. A. Sutcliffe (Ed.), *People and Computers V*. Cambridge: Cambridge University Press.

Green, T. R. G., & Petre, M. (1996). Usability Analysis of Visual Programming Environments: a 'cognitive dimensions' framework. *Journal of Visual Languages and Computing, 7,* 131-174.

Larkin, J. H., & Simon, H. (1987). Why a Diagram is (Sometimes) Worth Ten Thousand Words, *Cognitive Science, 11*, 65-99.

Hundhausen, C. (2005). Using End User Visualization Environments to Mediate Conversations: A 'Communicative Dimensions' Framework. *Journal of Visual Languages & Computing, 16*(3), 153-185.

Karabeg, A. (2006). *Value Creation and its Visualization in E-business.* Paper presented at the Ninth International Conference on Information Visualisation (IV'06), Graz (Austria).

Shimojima, A. (1999). *On the Efficacy of Representation.* Indiana University.

Whyte, J. K., Ewenstein, B., Hales, M., & Tidd, J. (2007). Visual practices and the objects used in design. *Building Research & Information, 35*(1), 18-27.