Graphicacy: What Does the Learner Bring to a Graphic?

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Abstract. This paper identifies the interpretation and the generation of graphics as key abilities constitutive of graphicacy. Researchers currently lack a standardized way to assess learners' graphicacy. As a first heuristic step, we describe the two abilities and suggest possible test items. Our goal is to raise issues that we hope will provoke energetic discussion amongst researchers who deal with the comprehension of graphics.

Keywords: graphicacy; interpretation; generation; research methodology; assessment instrument

Introduction

Educational research increasingly calls into question the popular wisdom that 'a picture is worth a thousand words'. Rather than being solutions, some graphics can be a source of educational problems. In former times, this was not necessarily a cause for concern. Traditional materials such as textbooks tended to treat graphics as secondary adjuncts to text. However, the advent of educational multimedia stimulated an increased reliance on graphics as information sources in their own right. For a full characterization of graphic comprehension, we need to consider the three different elements involved in semiotic activity – symbol, thought and referent, (or representamen, interpretant, and object; Peirce, 1931-1958). In other words, we need to acknowledge that a well designed graphic may still be ineffective if the *learner* lacks the capacity to make good use of it. In the present paper, we focus on what the learner brings to a graphic and consider graphicacy as a psychometric construct.

What Graphicacy is (and isn't)

Although the terms *literacy* and *numeracy* are far more familiar, occasional references to *graphicacy* have appeared in the literature over the years (e.g., Boardman, 1976). By analogy with the first two concepts, we adopt the view that graphicacy concerns the abilities to *interpret* and *generate* graphical representations, such as charts, diagrams, maps, and graphs. Graphicacy therefore involves both receiving and producing messages that, compared to text, are depictive rather than descriptive (Schnotz, 2001) and that rely on a spatial medium (Bertin, 1983). We regard graphicacy as a learned capacity that develops over time depending on available opportunities. Further, we suggest that it should be considered as distinct from other learner characteristics such as level of prior domain-specific knowledge and spatial ability. The neglect of participants' graphicacy could therefore be seen as a methodological limitation in present approaches to research on learning with graphics.

Assessment of Graphicacy

Although some measurement instruments used in educational research incorporate graphics, the great majority rely on text-based questions and answers. At present, perhaps our closest approximation to standardized graphicacy assessments are some items found in national and international testing programs (e.g., NAPLAN, PISA). However, their primary purpose is not to assess graphicacy *per se*, but to test literacy or numeracy. We suggest that a credible measure of graphicacy requires test items that minimise reliance on verbal information. Thus, the essence of a test question should be presented via graphic information and the respondent's answer should be given via some form of graphic output. But what might such test items be like and how could they work? The lack of precedents means there are no easy answers but we suggest some hypothetical examples. Both would be computer-based.

Measuring Graphicacy as Interpretation

The receptive aspect of graphicacy concerns a learner's ability to make effective use of pre-existing graphics, such as those found in textbooks and educational websites. Making sense of a configuration of markings involves segmentation into units and recombining these into appropriate higher order structures (Winn, 1993). In addition to bottom-up influences, this is highly dependent on previous exposure to, and acquired knowledge of, representational systems. Graphics come in different genres (charts, graphs, maps, life cycles, etc.) which can be generic (bar charts) or domain-specific (electrical circuit diagrams) and can have an informal character (sketch, illustration) or comply with a formal representational system (flowchart, spectrum). Genre knowledge is the cultural component of graphicacy (Postigo & Pozo, 2004) that influences the meaning an individual learner attributes to a graphical configuration or to its individual constituents. An instrument for measuring the interpretative component of graphicacy should draw upon this kind of representational knowledge.

Our suggestion for an interpretative graphicacy item is based on a house floor plan. The question presents such a plan with a number of distinctive rooms that can be identified by characteristics such as their position, size and contents. For example, a kitchen is located near the dining area, is of medium size, and contains symbols for kitchen equipment. Along side the floor plan is a set of pictures that do or do not belong in the house - a toaster would not belong to a house plan without a kitchen and a set of curtains would not belong in a house plan without windows. Respondents would be asked to identify the item that did not belong in the house plan, answer by clicking on it, and so demonstrate the level of graphicacy required to interpret the specialized symbols and conventions that are used in house plans. Variants of this item could involve clicking items and dragging them to correct house plan locations.

Measuring Graphicacy as Generation

The productive aspect of graphicacy concerns a learner's ability to generate original graphic representations. In pre-computer times, all components of such representations would essentially have been generated by the learner alone. However, today, generative graphicacy includes the ability to produce a unique composition of pre-existing graphic entities. Indeed, many learning environments contain tools for producing boxes and arrow diagrams, such as concept maps, argumentation diagrams, and models of dynamic phenomena. Producing an adequate graphic involves selecting appropriate graphic entities and arranging them into a configuration. Representational knowledge is needed to assure that the produced configuration expresses the desired meaning for an intended audience. In fact, a graphic may be produced for elaborating an idea for oneself, for expressing an idea to someone else, or for computational purposes, i.e. in order to produce new information. Cultural conventions play different roles in different situations depending on the function and the audiences of a graphic. Thus, the constructive component of graphicacy includes operational knowledge of graphic genres, i.e. the ability to produce a situation-appropriate graphic according to the conventions of a particular genre. An instrument for measuring the constructive component of graphicacy should provide opportunities for exhibiting such knowledge through the manipulation of graphic entities in a tool that allows violation of genre-specific conventions (cultural conventions should *not* be built into the tool). Thus, learner-produced graphics may vary in the degree to which they comply with representational formats. They may also represent information that is irrelevant for the genre at hand, such as spatial configuration and physical appearance in a concept map. Of course, disrespecting formatting prescriptions (or representing irrelevant information) could be interpreted either as *inventive* or as *incorrect* use of a graphical tool. Compared with graphicacy's interpretative aspect, this generative aspect remains relatively neglected.

Our suggestion for a generative item targets representational knowledge of organizational charts. The question relates to a row of human icons varying in size, gender, colour, etc. representing individuals in a workplace and their respective attributes. For example, size could indicate position in the workplace hierarchy (so, the largest icon represents the head of the organization). The respondents' task is to use an interactive boxes-and-lines tool to construct the nodes and links of an organizational chart depicting the working relationships between the individuals. Respondents indicate the identity of individuals by dragging the relevant icon from the original row into its corresponding box. Answers would be evaluated according to how well they exhibit existing conventions.

Conclusion

Our examples are not intended to be definitive but instead offer some initial ideas to provoke energetic discussion about how graphicacy items might be designed. We foresee three potential debates on measuring representational knowledge because it may be confounded with, or should be distinguished from, 1) domain knowledge, 2) spatial ability, and 3) cultural background. For example, a test for graphicacy must deal with different graphic genres such as cross-sections, time series, and hierarchies, but at the same time control for the possible confounding effect of domain-specific knowledge. Furthermore, any graphicacy item necessarily involves some spatial configuration of selected graphic entities which, from certain cultural viewpoints, could express particular conceptual content. Taking into account the three elements of semiotic activity – symbol, thought, referent – implies that a test for graphicacy would best be a collection of items that spans a palette of educationally relevant graphic genres while each item individually represents a carefully balanced mixture of representational format, conceptual content, and cultural viewpoint. Although we have given some simple examples, the design of the whole set of items that together constitute an instrument for measuring graphicacy seems a challenging exercise. We think it is not only worth trying as a research activity in itself but crucial to our understanding of future successes and failures of the use of graphics for learning.

References

Bertin, J. (1983). *Semiology of Graphics*. Madison: University of Wisconsin Press.

Boardman, D. J. (1976). Graphicacy in the curriculum. *Educational Review, 28*, 118-125.

Winn, W.D. (1993). An account for how people search for information in diagrams. *Contemporary Educational Psychology, 18*, 162-185.

Peirce, C. S. (1931-1958). *Collected Papers (CP) of Charles Sanders Peirce*, eds. C. Hartshorne, P. Weiss (Vols. 1-6) and A. Burks (Vols. 7-8). Cambridge : Harvard University Press.

Postigo, Y. & Pozo, J. I. (2004). On the road to graphicacy: The learning of graphical representation systems. *Educational Psychology, 24*, 623-644.

Schnotz, W. (2001). Sign systems, technologies, and the acquisition of knowledge. In J.-F. Rouet, J. J. Levonen, & A. Biardeau (Eds.), *Multimedia learning: Cognitive and instructional issues* (pp. 9-29). London: Pergamon.