Making Thinking Visible: Growth in Graphical Literacy, Grades 3 to 4

Yongcheng Gan, Marlene Scardamalia, Huang-Yao Hong, Jianwei Zhang
Ontario Institute for Studies in Education, University of Toronto,
252 Bloor Street West, Toronto, Ontario, M5S 1V6, Canada
Email: yongcheng.gan@utoronto.ca, mscardamalia@kf.oise.utoronto.ca,
huangyao.hong@utoronto.ca, jw.zhang@utoronto.ca

Abstract: This study provides a new coding scheme to analyze growth in seven components of graphical literacy for 22 students who used an online multimedia environment--Knowledge Forum®--across two years (grades 3 and 4) to advance their theories in science and history. Students received no instruction in graphical literacy and were free to express their ideas in text or graphics. Results show increases in all components of graphical literacy over this time span.

Introduction

Graphical literacy refers to the ability to construct, produce, present, read and interpret charts, maps, graphs, and other visual presentations and graphical inscriptions (Readence, et al., 2004). It is a visual, abstract language for enhancing learning. According to dual-coding theory, information is easier to retain and retrieve when it is coded both verbally and visually (Paivio, 1991). Adding graphics to text can improve learning (Clark & Mayer, 2002), and visualization is also a powerful cognitive tool in scientific discovery and invention, and essential to problem solving in daily life as it provides concrete means to interpret abstract images (Rieber, 1995).

While there is a growing need for graphical/visual literacy, there is less attention paid to it at the elementary level than there is to reading and writing. There is evidence that higher order visual literacy skills do not develop unless they are identified and "taught" (Avgerinou & Ericson, 1997). Visual presentations of abstract concepts tend to be difficult for students yet ignored in basals and other school texts (Readence, et al., 2004). Educational researchers are calling for increased attention to graphical inscriptions to help students become literate in practices related to the production and interpretation of graphics (Roth, 2002).

Over the two years of educational work reported in this study students were engaged in knowledge building--the creation and continual improvement of ideas through transformative discourse (Scardamalia & Bereiter, 1994). Knowledge Forum, a knowledge building environment, was integral to their work. It includes tools for graphical as well as textual representation of ideas. Students choose the representational form best suited to the expression of their ideas. In knowledge building practices, students assume collective responsibility for communicating, elaborating, evaluating, and improving ideas, working in a public forum where they build on, comment, and in other ways help each other advance their understanding, They received no instruction in use of graphics, but are supported in the expression of ideas by peer feedback and an easy-to-use graphics palette that allows them to co-author and revise graphics. A coding scheme was designed to assess the extent to which they use graphics and advance in graphical expressiveness.

Method

Participants were 22 students from the Institute of Child Study, University of Toronto, using knowledge building pedagogy and Knowledge Forum software for their work in science and history. Quantitative results are reported and content analysis (Chi, 1997) was used to assess the quality of graphical content across grades 3 and 4. The coding scheme identified seven components of graphical literacy growth (Table 1); each graphical representation was rated for each dimension: Basic, 1 point; Intermediate, 2 points; Advanced, 3 points.

Table 1: Graphical Literacy Coding Scheme.

Category	Specification
1. Graphics Production/ Drawing Skills	Use of line, dot, shape, color, basic shape, etc; Combinations of different color, shape, label, title, etc.; Complex or abstract graphics conveying harmony, clarity in conceptual content, etc.
2. Graphical Representation	Use of a graphical representation to convey a concept, theory, experiment, procedure, etc.
3. Resources	Use of references and links to source material of peers or from the Internet to reference rather

Reference	than copy graphics.
4.Captions	Use of clear, correct, and accurate captions to complement and elaborate ideas in pictures.
5. Revision/ Elaboration	Revision or elaboration of pictures or relevant captions over time to provide increasingly clear and accurate accounts.
6. Aesthetics/ Clarity	Use of color, layer, rendering, etc. to make graphic attractive; effective use of titles, labels, tags, and other devices to create pictures that are reader-friendly and accurate.
7. Judgment/ Reflection	Use of interpretive comments and summaries to convey the essence of graphical representations, including processes conveyed by the picture.

Data analysis and results

Grade 3 students created 556 notes in total, with 68 graphical representations. In grade 4, students created 470 notes in total, with 123 graphical representations. The average number of graphical representations per student rose from 3.1 to 5.5, and the ratio of graphical representations to the total number of notes rose from 12.2% to 26%. All but one student used more graphical representations in grade 4 than in grade 3.

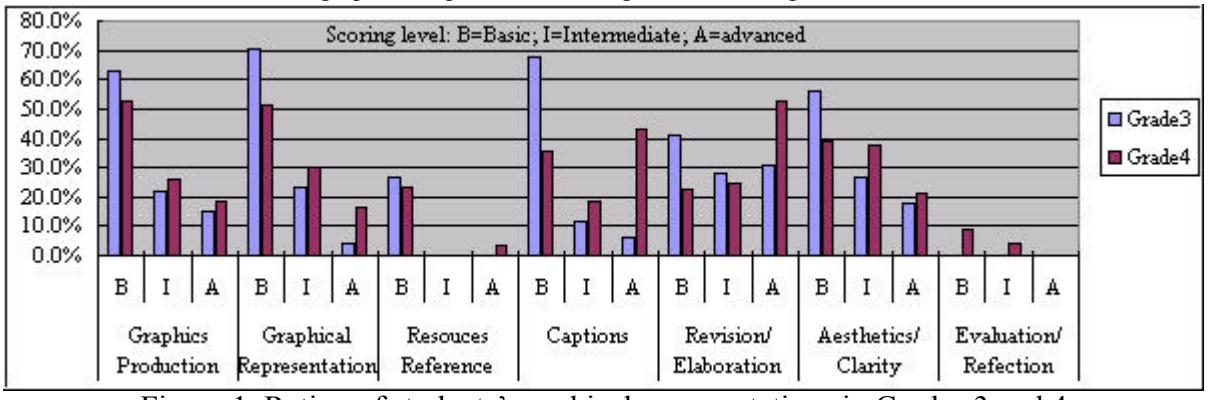

Figure 1. Rating of students' graphical representations in Grades 3 and 4.

Figure 1 shows the results of content analyses of students' graphical representations over the two school years (inter-rater reliability over 30 sampled graphical representations r=0.84, with differences resolved through discussion). The number of graphical representations rated as "Intermediate" and "Advanced" in six categories increased but one "Intermediate" level decreased in "Evaluation/reflection. The three areas of greatest increase in "Advanced" ratings were "Graphical representation", "Captions" and "Revision/elaboration," with corresponding decrease in the "Basic" levels in these same areas. There were no incidents of "Resources reference" and "Evaluation/reflection" in grade 3; but both appeared in grade 4. Paired *t*-tests of students' total scores in each category showed significant increases ($p<0.05$) between the two school years.

In the course of their knowledge building, students raised questions and worked together, as authors contributing notes to their collective space for shared understanding and as co-authors to continually improve ideas represented in their graphics. They also used "rise aboves," a note-type that allowed them to collect notes into an integrated, higher-order framework (see Figure 2).

Graphical representation, text and collaboration: The number of words per text note rose from 22.5 in grade 3 to 48.4 (doubled) in grade 4, and the number of words in captions, labels, and textual elements linked to graphics rose from 24.7 in grade 3 to 74.6 (tripled) in grade 4. These text elements were used to convey complex processes, experiments, models, and so forth, and in other ways elaborate abstract ideas conveyed in graphics. In grade 3, 17.6% of graphical representations were co-authored, and close to half (45.5%) of the students collaborated in the production of a graphical representation; in grade 4, the percentage is doubled (35.0%), and all but one student (n=21) co-authored graphical representations; suggesting that students had a stronger sense of collaboration surrounding their graphical work in grade 4.

Discussion

Quantitative and qualitative analyses of graphical representations showed increases in graphical literacy according to the coding scheme used to evaluate seven aspects of graphical literacy. A separate study by Zhang, et al., (in press) analyzed knowledge gains for the same students in the same class; these showed significant advances

for individual students in their understanding of optics. Thus there is some suggestion that students use of text and graphics support content learning. Contributions of the current study include: (1) *Coding scheme.* Graphical literacy is seldom assessed in elementary schools and there are few studies to provide developmental accounts of graphical literacy. The current study provides a coding scheme that proved useful in assessing the work of students in grades 3 and 4 in an online learning environment; (2) *Literacy as a by-product of knowledge building*. Scardamalia (2003) proposed that knowledge building, with focus on conceptual advances related to core content, and conducted in a medium that requires multiple literacies for the expression and continual improvement of ideas, would result in increases in literacy, as a by-product of content learning. Previous studies (e.g. Sun, et al., under review) indicate this is the case for textual literacy. This study suggests that graphical literacy is another important by-product of knowledge building. A weakness of the current study is that there is no control data. Nonetheless, the study provides the basis for follow-up work aimed at assessing growth in graphical literacy, using both control data and assessments across a greater variety of classroom settings.

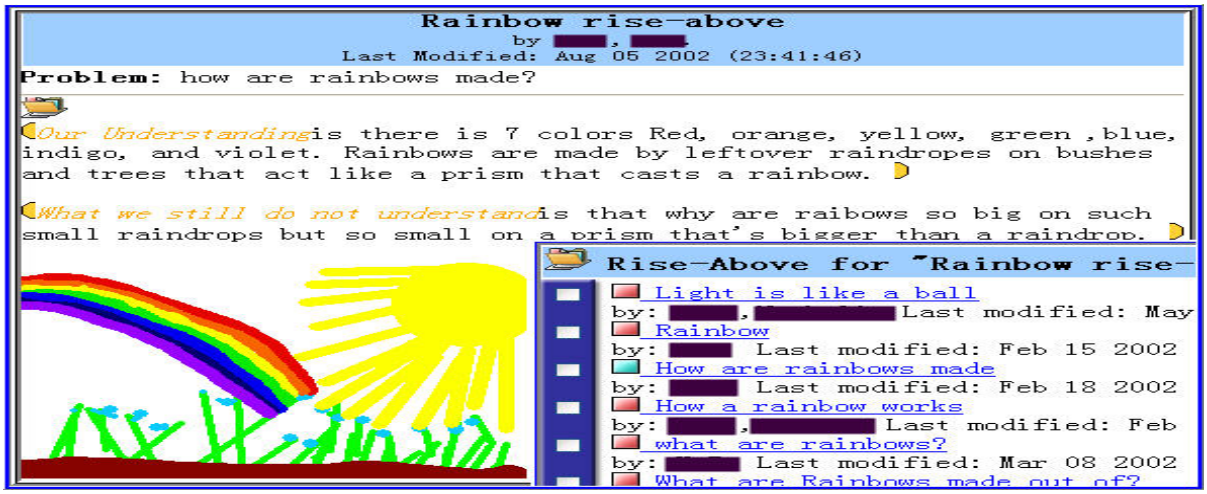

Figure 2. A rise-above note on "rainbows" in the "Colors of Light" view in Knowledge Forum.

Acknowledgments

This research was funded by the Social Sciences and Humanities Research Council of Canada, grant 512-2002-1016. We own special thanks to the students, teachers, and principal of the Institute of Child Study, University of Toronto, for the insights and accomplishments that enabled this research.

References

Avgerinou, M. & Ericson, J. (1997). A review of the concept of visual literacy. *British Journal of Educational Technology,* 1997. 28(4), 280-291.

Chi, M. T. H. (1997). Quantifying qualitative analysis of verbal data. *Journal of the Learning Sciences, 6*, 271-315.

Clark, R. C. & Mayer, R. E. (2002). *E-learning and the science of instruction: proven guidelines for consumers and designers of multimedia learning.* San Francisco: Jossey-Bass Pfeiffer.

Paivio, A. (1991). Dual coding theory: retrospect and current status. *Canadian Journal of Psychology,* 45, 255-87

Readence, J., Bean, T., & Baldwin, S. (2004). *Content area literacy: an integrated approach,* eighth edition. Dubuque, IA: Kendall-Hunt, 260.

Rieber, L. P. (1995). A historical review of visualisation in human cognition. *Educational Technology, Research and Development,* 43(1), 1042-1629.

Roth, W. (2002). Reading graphs: contributions to an integrative concept of literacy. *Journal of Curriculum Studies,* 34 (1), 1-24.

Scardamalia, M. (2003). Crossing the digital divide: Literacy as by-product of knowledge building. *Journal of Distance Education,* 17 (Supplement. 3, Learning Technology Innovation in Canada), 78-81.

Scardamalia, M. & Bereiter, C. (1994). Computer support for knowledge building communities. *The Journal of the Learning Sciences,* 3(3), 265-283.

Sun, Y., Zhang, J., & Scardamalia, M. (under review). Literacy as a by-product of knowledge building. Journal of Literacy Research.

Zhang, J., Scardamalia, M., Lamon, M., Messina, R., & Reeve, R. (in press). Socio-cognitive dynamics of knowledge building in the work of 9- and 10-year-olds. *Educational Technology Research and Development.*