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Visualizing the critique: Integrating quantitative reasoning with the design process

Kathryn Weinstein, Queens College, CUNY, USA

Abstract

In the age of "Big Data," information is often quantitative in nature. The ability to analyze information through the sifting of data has been identified as a core competency for success in navigating daily life and participation in the contemporary workforce. This skill, known as Quantitative Reasoning (QR), is characterized by the ability to integrate arithmetic, statistics, visualizations and models for the analysis and interpretation of information. For students of graphic design, QR competencies are essential for the design of effective visual displays of information.

This case study provides design educators with an assignment that introduces data analytics and visualization strategies to the design critique. The study describes how, in two sections of an undergraduate Information Design course, the traditional delivery of feedback through verbal dialogue was replaced with an anonymous survey. Responses were collated, stripped of identifiers, and distributed to the class with directions to create data visualizations of the critique. Students employed various mapping strategies in their visualizations and successful projects demonstrate acquisition of skills related to the analysis and interpretation of data.

Additionally, the assignment clarifies the criteria of success of design assignments and delivers focused feedback on student work.

Keywords

Quantitative Reasoning; information design; graphic design; pedagogy; data visualization; design critique; feedback; assessment.

Introduction

> All (students) should be able to use simple math tools to reason—to understand, interpret, critique, debunk, challenge, explicate, and draw conclusions. In short, college graduates should be able to evaluate the crush of quantitative data modern life throws at all literate citizens. (Simpson, 1999, p. 2)

This paper presents a case study of a modified critique process that was introduced in an Information Design course (Fall 2013 and Spring 2015) taught in an undergraduate graphic design program. For the final critique of a midterm project, an anonymous survey replaced the traditional verbal group critique. Data from the surveys were collated into sets for each student project, stripped of identifiers and distributed to the class with instructions to create data visualizations of

the survey results. *Visualizing the Critique* is an assignment that design educators can utilize to facilitate student understanding of Quantitative Reasoning (QR) though the collection, analysis, and visualization of data.

Additionally, the survey assignment elucidates information about the criteria for success of a particular project and documents the evaluation process, activities that may be lost or glossed over the traditional verbal critique, and integrates student feedback into the design process. The resulting visualizations have the potential to serve as student-designed assessment tools, providing teacher and student a means to quickly identify learning gaps for an individual student or those encountered by the entire class.

Background

Research has documented a widespread quantitative literacy gap throughout the United States (Kutner, Mark et al., 2007), resulting in leading educational associations and policy-makers identifying QR as a primary learning outcome for 21st century undergraduate education (Association of American Colleges and Universities, 2007; Elrod, 2014). Quantitative Reasoning, also referred to as Quantitative Literacy or Quantitative Fluency, is characterized by the ability to integrate arithmetic, statistics, visualizations and models (formulas, graphs, tables and schematics) in the analysis and interpretation of quantitative information (Mathematics Association of America, 2015).

Quantification, a process that requires conceptualization and reconceptualization in relation to the object (or phenomenon) being quantified, is a leap from the tangible to the abstract and back to the tangible, or from context to determination of equations and back to context (Thompson, 2012). QR is characterized by two attributes applied to the quantification process: first, a comfort level with numbers that enables an individual to cope with the practical demands of life; and second, some appreciation and understanding of information which is presented in mathematical terms (Cockcroft, 1992). Applications may be as mundane as calculating a tip as a percentage of a bill or as sophisticated as the ability to draw conclusions about race and poverty from tables of unemployment rates.

QR has no specific locus in college degree programs and often is mistakenly assumed to fall within the discipline of mathematics. In fact, undergraduate introductory courses in mathematics tend to focus on abstractness and specialized language whereas QR, by definition, is a broad set of practical skills (Davidson & McKinney, 2001) and anchored in real-world data within a specific context (Steen, 2009).

Graphic design programs, often presumed to be a safe haven for math-phobic students, may prove to be one pedagogic space for the development and refinement of QR skills at the undergraduate level. Graphic designers, specifically information designers, are charged with the task of giving visual form to data to produce visualizations of statistical data to reveal patterns and relationships that would not be easily ascertained without the aid of visual representation (Meirelles, 2013). Reducing frustration and promoting the understanding of complex information is the ultimate goal of information design. The challenge of translating data to a new visual language, often employing metaphor and semiotics in the process, requires designers to possess a degree of fluency with numeracy.

Context

Queens College is one of the senior colleges of the City University of New York. The college offers a Bachelor of Science degree in Graphic Design, with upwards of 300 declared majors (QC at a Glance, 2015). Information Design, an upper-division design elective offered every third semester, explores the display of information and introduces strategies for designing effective visual communications appropriate for various users, audiences, and platforms. The course integrates lectures and exercises designed specifically to build QR competencies, including: review of mathematical equations for the calculation of fractions and percentages; an overview of statistical literacy; retrieval and analysis of data tables; and graphing and mapping methodologies.

Fourteen students were enrolled in Information Design, Fall 2013 and 16 were enrolled Spring 2015. A diagnostic quiz (See APPENDIX A) to gauge student abilities to calculate fractions, percentages and basic graphing techniques was administered on the first day of class. Only 13 percent of the students (2 of the 15 enrolled) from the Fall 2013 and 30 percent of students (5 of the 17 enrolled) from Spring 2015 could successfully answer all of the diagnostic quiz questions, indicating the majority of students enrolled in the course lacked basic competencies in QR skills.

The Design Critique

The design critique is a widely used assessment tool in design studio classes and arguably the single most consistently employed classroom activity students encounter in an undergraduate design program. Traditionally, the critique consists of project presentations at various stages of completion, and the subsequent verbal feedback is provided through peers, teachers, and invited guest critics. A basic tenet of the critique is that the individual and the group benefit from the process; students demonstrate an understanding of design principles and strategies through their work and through the questions, comments, and ensuing dialogue. The objective of the process is to create a collaborative environment that facilitates the development of design and presentation skills, and provides a means to gauge success for a particular project.

Schrand and Eliason's (2012) research indicates that the design critique does not always allow all types of students to participate, and students who are not confident enough to ask questions are left behind. Barrett (2000) and Percy (2004) cite frustration, alienation, and lack of student participation as outcomes of the traditional design critique. Further research yields a list of factors that may impede student learning, including the size (Blair, 2006) and dynamics of the group (Gray, 2013); language and cultural competencies (Lasserre, 2010; Wong 2011); and perceived self-efficacy (Gaffney, 2011).

Building upon Davies' (1996) observations that the traditional design critique tends to encourage surface learning by the emphasis of the designed artifact rather than the process of learning, the integration of alternative forms of assessment into design course work has been explored as a means to create transparency of the evaluation process, encourage peer interaction and foster a deeper approach towards learning (Giloit & du Toit, 2013). Research on peer assessment has focused on written and verbal interventions (Ehman 2005; Ellmers, Foley & Bennett, 2008), whereas *Visualizing the Critique* utilizes data collection and interpretation to integrate assessment with the design process.

The Assignment: Visualizing the Critique

For the third and final critique of a midterm project, the traditional critique was replaced with a nonverbal assessment and developed into a fourth class assignment, *Visualizing the Critique*. Like a traditional critique, the activity began with students pinning their work to the display board for the group to assess. A survey with questions regarding research, originality of topic and solution, and the relative success of each project was distributed for the review of students' projects. Students were encouraged to ask questions to clarify the survey questions, but were instructed to refrain from verbally commenting on the projects or leaving any identifying information on the surveys. After the completion and collection of a set of surveys, the group repeated the process for each student project.

The teacher collected and collated the sets of surveys, generating a numbering system to identify the projects to minimize the possibility of identification of individuals with survey responses.

Data sets for the collated surveys were distributed to students the following week with a group discussion on the method of collection, and assessment of the quality of the data and a short lecture on normal (Gaussian) distribution. The next step required students to create a data visualization of the collected data. Projects were presented to the class and critiqued in the traditional manner of verbal exchange within a group setting. Upon completion of the assignment, students were privately informed of which data set was associated with each of their midterm projects.

Results and Discussion

Table 1 records the responses of 13 students to the 9 midterm projects presented Fall 2013. Nine questions were listed on the survey and the options for response were: (Y), no (N), or no answer (NA). Table 2 records the survey responses of 12 students to the 12 midterm projects presented Spring 2015. Three questions were added to the second survey to distinguish the use of color, typography and development of hierarchy in the projects.

	Q1 Y(N)NA	**Q2**	**Q3** Y(N)NA	**Q4** Y(N)NA	**Q5** Y(N)NA	**Q6** Y(N)NA	**Q7** Y(N)NA	**Q8** Y(N)NA	**Q9** Y(N)NA
P1	3(7)3	5(3)5	10(-)3	9(1)3	1(7)5	2(6)5	4(7)3	6(5)2	2(7)4
P2	9(3)2	6(5)2	10(1)2	7(3)3	3(6)4	6(4)3	3(10) -	9(2)2	4(7)2
P3	6(6)1	3(9)1	10(1)2	9(3) -	3(9)-	- (10)3	6(5)2	10(2)1	4(8)1
P4	11(2)1	7(4)2	13(-) -	11(1)1	2(7)3	6(5)2	8(4)1	12(1) -	4(8)1
P5	6(7) -	- (12)1	10(2)1	4(8)1	2(11) -	9(3)1	- (12)1	4(9) -	3(8)2
P6	8(2)3	6(4)3	10(1)2	9(1)3	3(4)6	5(6)2	7(2)4	9(1)3	6(3)4
P7	6(6)1	2(9)2	10(1)2	9(3) -	3(10) -	1(10)2	6(5)2	10(2)1	4(8)1
P8	13(-) -	11(2) -	12(1) -	12(1) -	6(7) -	5(5)3	7(4)2	13(-) -	12(1) -
P9	13(-) -	12(1) -	13(-) -	13(-) -	6(4)3	10(2)1	11(3) -	10(2)1	10(2)1

Table 1. Survey Responses, Fall 2013

P=Project; Q=Question; Y=Yes; (N=No); NA=No Answer

Source: Survey responses collected during critique of midterm project (Information Design, Spring 2015).

9 midterm projects were presented and 13 students completed surveys.

Questions of the Survey: *Q1. Is the topic original? Q2. Is the project ambitious? Q3. Is the designer interested in the project? Q4. Did the designer research the project? Q5. Did the designer explore multiple solutions? Q6. Is the solution original? Q7. Is the project well designed (consider use of color, typography, hierarchy)? Q8. Does the project capture your interest? Q9. Does the project require you to think?*

	Q1 Y(N)NA	**Q2** Y(N)NA	**Q3** Y(N)NA	**Q4** Y(N)NA	**Q5** Y(N)NA	**Q6** Y(N)NA	**Q7** Y(N)NA	**Q8** Y(N)NA	**Q9**	**Q10** Y(N)NA	**Q11** Y(N)NA
P1	9(2)1	2(8)2	9(2)1	9(2)1	1(9)2	4(7)1	10(1)1	6(4)2	*	8(3)1	5(6)1
P2	4(7)1	9(2)1	10(1)1	11(0)1	8(3)1	9(2)1	7(4)1	8(3)1	*	10(1)1	11(0)1
P3	2(9)1	10(1)1	11(0)1	11(0)1	8(3)1	9(2)1	10(1)1	11(0)1	*	11(0)1	7(4)1
P4	5(6)1	1(10)1	8(3)1	3(8)1	0(10)2	7(4)1	9(2)1	6(5)1	*	2(9)1	3(8)1
P5	12(0)0	6(6)0	12(0)0	2(10)0	3(9)0	8(4)0	12(0)0	11(0)1	*	10(2)0	3(9)0
P6	7(5)0	6(6)0	8(4)0	12(0)0	6(6)0	5(7)0	9(3)0	9(3)0	*	7(5)0	8(4)0
P7	6(5)1	3(8)1	8(3)1	11(0)1	1(10)1	3(8)1	8(3)1	5(6)1	*	4(7)1	11(0)1
P8	7(5)0	7(5)0	10(2)0	9(3)0	5(6)1	8(3)1	7(4)1	*	*	9(3)0	4(8)0
P9	8(4)0	8(4)0	11(1)0	2(10)0	3(8)1	7(5)0	0(12)0	10(0)2	*	10(2)0	6(6)0
P10	8(4)0	5(7)0	9(3)0	5(7)0	6(6)0	8(4)0	8(4)0	4(8)0	*	6(6)0	6(6)0
P11	10(1)1	8(3)1	11(0)1	3(7)2	7(3)2	8(3)1	4(7)1	6(5)1	*	9(2)1	9(2)1
P12	10(2)0	9(3)9	12(0)0	12(0)0	9(3)0	8(3)1	12(0)0	11(1)0	*	11(1)0	5(7)0

Table 2. Survey Responses, Spring 2015

P=Project; Q=Question; Y=Yes; (N=No); NA=No Answer; * Responses removed due to recording error.

Source: Survey responses collected during critique of midterm project (Information Design, Spring 2015).

12 midterm projects presented, 12 students completed surveys.

Questions of the Survey: *Q1. Is the topic original? Q2. Is the project ambitious? Q3. Is the designer interested in the project? Q4. Did the designer research the project? Q5. Did the designer explore multiple solutions? Q6. Is the solution original? Q7. Effective use of hierarchy (clarity of information)? Q8. Is the typography effective and appropriate to project? Q9. Effective use of color? Q10. Does the project capture your interest? Q11. Does the project require you to think?*

Class discussions on the quality of the data, possible anomalies and the impact of sample size accompanied the distribution of the survey results. When asked if the survey exercise prompted a more honest evaluation of student work, both classes unanimously agreed that their responses on the survey were more honest than their personal verbal feedback delivered in a traditional critique. Students raised questions on the possible interpretations of no answer responses and concluded

that this was not an error in data collection, but reflected a response that differed from a yes or no, and should be included in the data visualizations.

As a group discussion, the data was assessed to determine what type of information might be gleaned from the data sets, and how the data might be viewed to gauge relative success of a project by an individual or as a group. Students found that reading across the rows shows the results of the survey per student project. As shown in Table 1, consensus of success (P8) or needed improvement (P5) was reached on some projects, but most received mixed feedback—success in some areas and needed improvement in other areas. When the class was asked if they believed the survey results would personally help them in their own design efforts, students tended to agree that the results may help pinpoint areas of needed improvement, but pointed out that the traditional critique was of enormous benefit for the specific suggestions on how to improve work. From student comments, it appeared that students might look to critiques for concrete direction for a particular project rather than a greater understanding of their personal design process— an observation that supports Davies' (1996) claim that the traditional design critique tends to emphasize of the designed artifact rather than the process of learning.

The class discussions turned to how a teacher might benefit from the results of the survey by reading down the columns and identifying gaps in student progress. For example, reading down the columns in Table 1 reveals that while the majority of students found that most projects demonstrated interest by the designer (Q3. *Is the designer interested in the project?*), most projects did not demonstrate enough exploration of solutions (Q5*. Did the designer explore multiple solutions?*). These responses could be interpreted as the teacher having successfully developed assignments to pique student interest, but highlighted the need for the teacher to emphasize multiple solutions as a priority in the design process of an assignment.

The responses of Spring 2015 survey (Table 2) and the ensuing class discussion parallel the observations of the Fall 2013 cohort, but with a greater emphasis on the possible meanings of mixed positive and negative responses per project. This class discussed whether mixed responses were reflective of survey-takers inclination of responding to questions in a positive or negative manner, rather than a neutral evaluation of the quality of student projects. Students agreed that some projects received a majority of yes responses (P3 and P12) or *no* responses (P4 and P8) and concluded that the survey responses were not arbitrary, the variation evidenced in the data and the consensus reached on particular projects demonstrated responses were based on responses to the work displayed. One student observed that the survey results began to parallel the grading system of evaluation, as the number of *yes* answers could be equated as points achieved for a particular project. For example, projects (P3 and P12) with the greatest percentage of yes responses were deemed successful and should receive the highest grades, all other projects required varying degrees of improvement and could be graded based on the percentage of yes responses to the survey. Students seemed to agree that the survey was a good indicator of how their own work might be received by the public-at-large or by a potential employer, and concluded that mixed results were an indication that a project should not be included in a portfolio.

Students were assigned to create a data visualization of the collected data without any restrictions to format or media. As shown in Figures 1-5, the projects created for the assignment demonstrate a wide range of solutions and a variety of lenses through which the data may be assessed. Since the

introductory diagnostic quiz of the first class, students demonstrated an increased 'at homeness with numbers' as evidenced by student ease in the reading of tables; calculation of fractions and percentages; and the development of mapping and graphing strategies. Through the integration of QR skills and those associated with graphic design - choice of color, typography, development of hierarchy through scale, and use of positive and negative space - student projects translate data to visualizations that effectively reveal relationships and patterns found within survey results.

Most students tended to initiate the project through a direct interpretation of the results utilizing color and shapes to correspond to every survey response, but many developed visualizations that incorporated arithmetic calculations and graphing techniques to create richer content, establishing visual comparisons of the class performance by question or by project. Figure 1 shows a literal interpretation of the survey results with a circle representing every response and color used to distinguish the types of responses. Information is organized and a clear hierarchy is established through use of typography and scale creating an accessible design and connoting credibility; however, the amount information communicated is limited due to the lack of computation or analysis. At best, a viewer can scan the visualization and estimate, or manually count, which projects received a greater number of yes or no responses through the color-coding of responses.

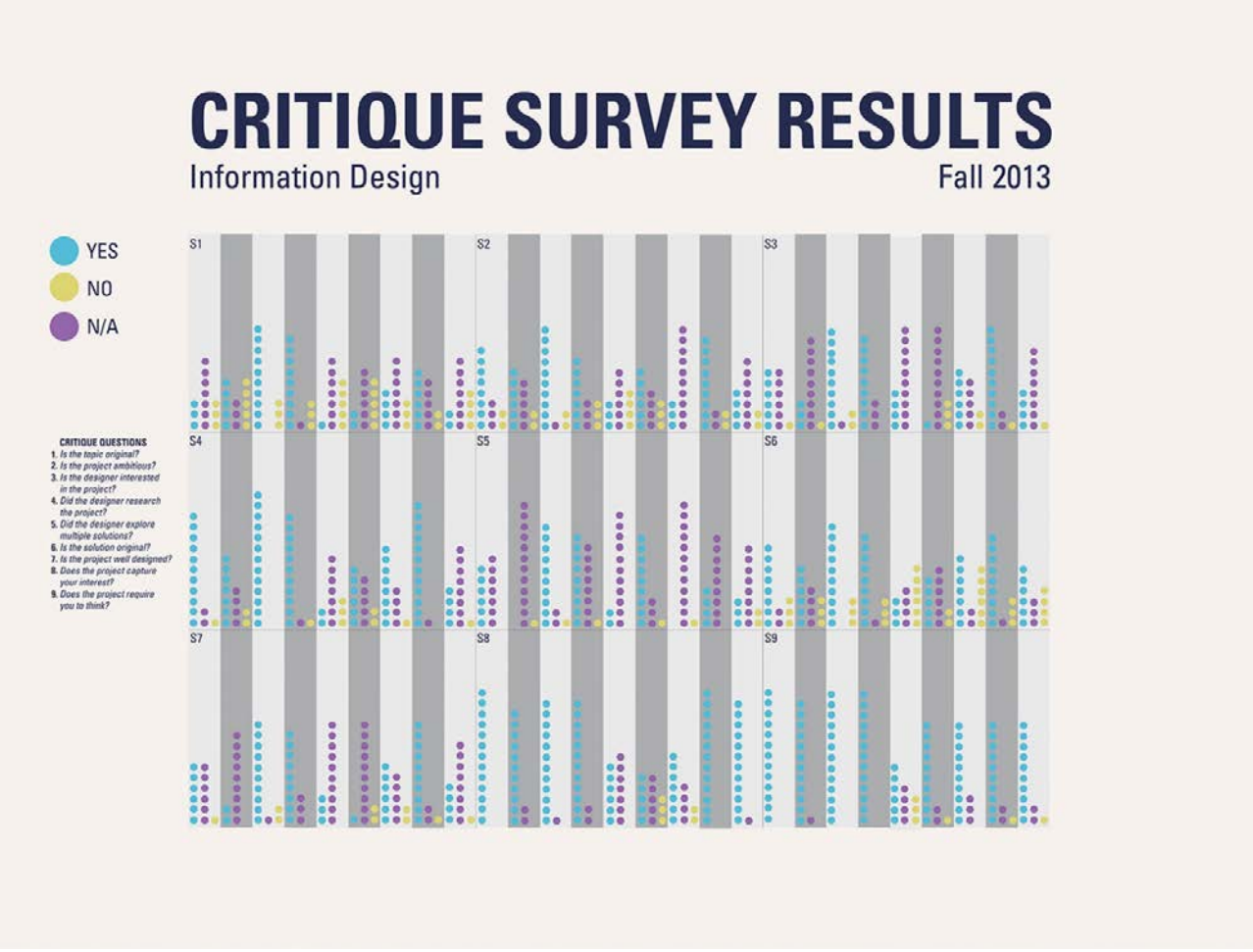

Figure 1. Madison Chajon, Fall 2013.

Figure 2 shows a minimal approach to the mapping of the responses with the use of a series of vertical lines. The vertical sweep of the lines moves the eye down the page and upon inspection; each line is composed of discrete units displaying a literal interpretation of the survey results per project and per question. Results per question can be read by reading down the page and project results can be determined by reading across. Adding additional information to the visualization, a summation of the results of the entire class is depicted by a stacked bar graph. The size and placement of the bar graph, invites the eye to travel across the page, and the list of questions beneath the bar graph anchors the design.

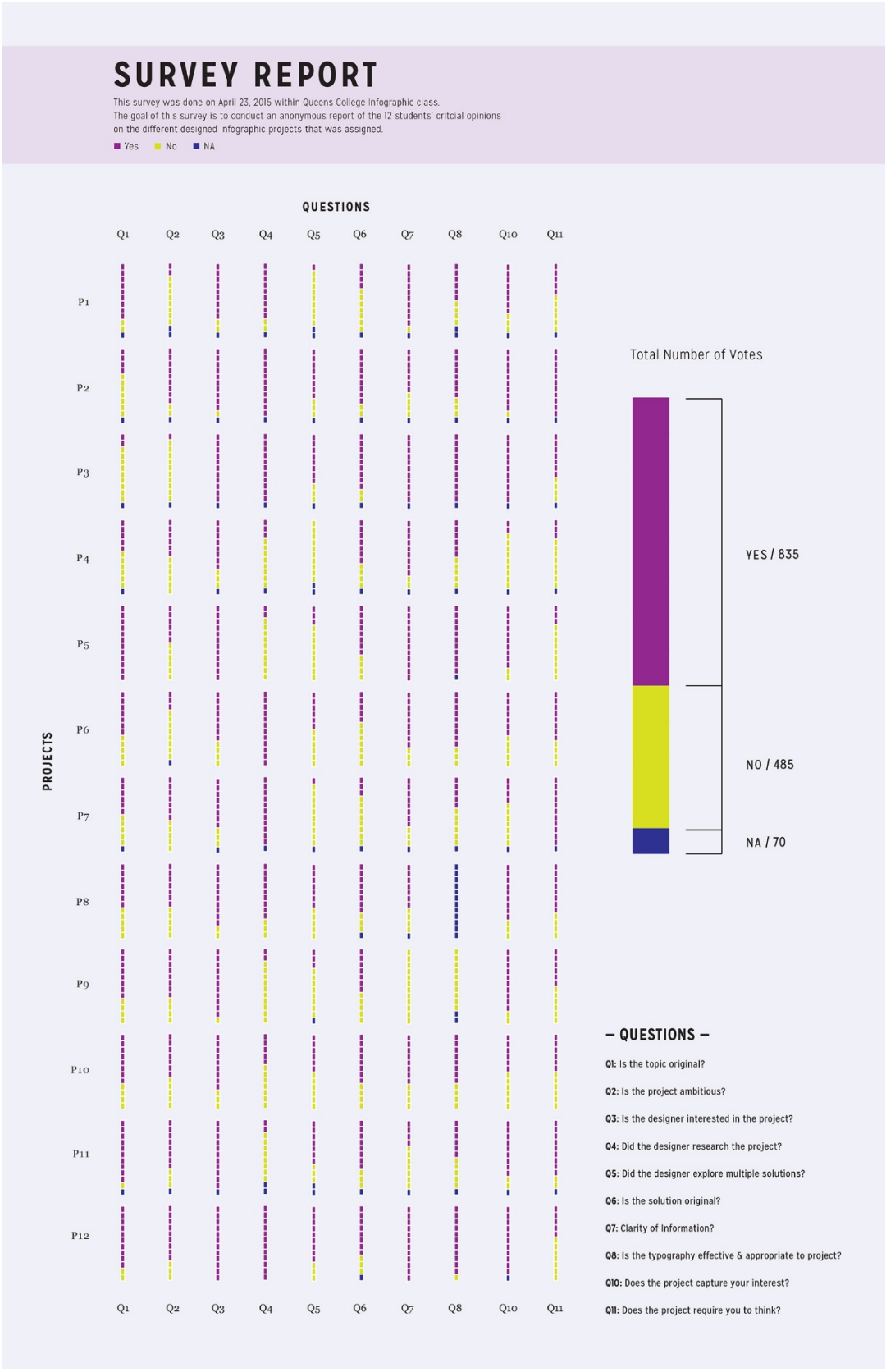

Figure 2. Qiong Lee, Spring 2015.

Figure 3 shows a project that uses area; similar to the use of area in a horizontal stacked bar graph, to communicate percentages of yes, no or no answer responses. Each graph includes the numeric values color-coded to the graphs, substantiating the visual depiction of the results. Reading across, a viewer can determine the results per project for each category of question and reading down the viewer can view the results of each question per project. Separated by space and the introduction of a new color, the bottom row and last column displays the cumulative results of questions and projects; facilitating comparisons of individual projects with class results.

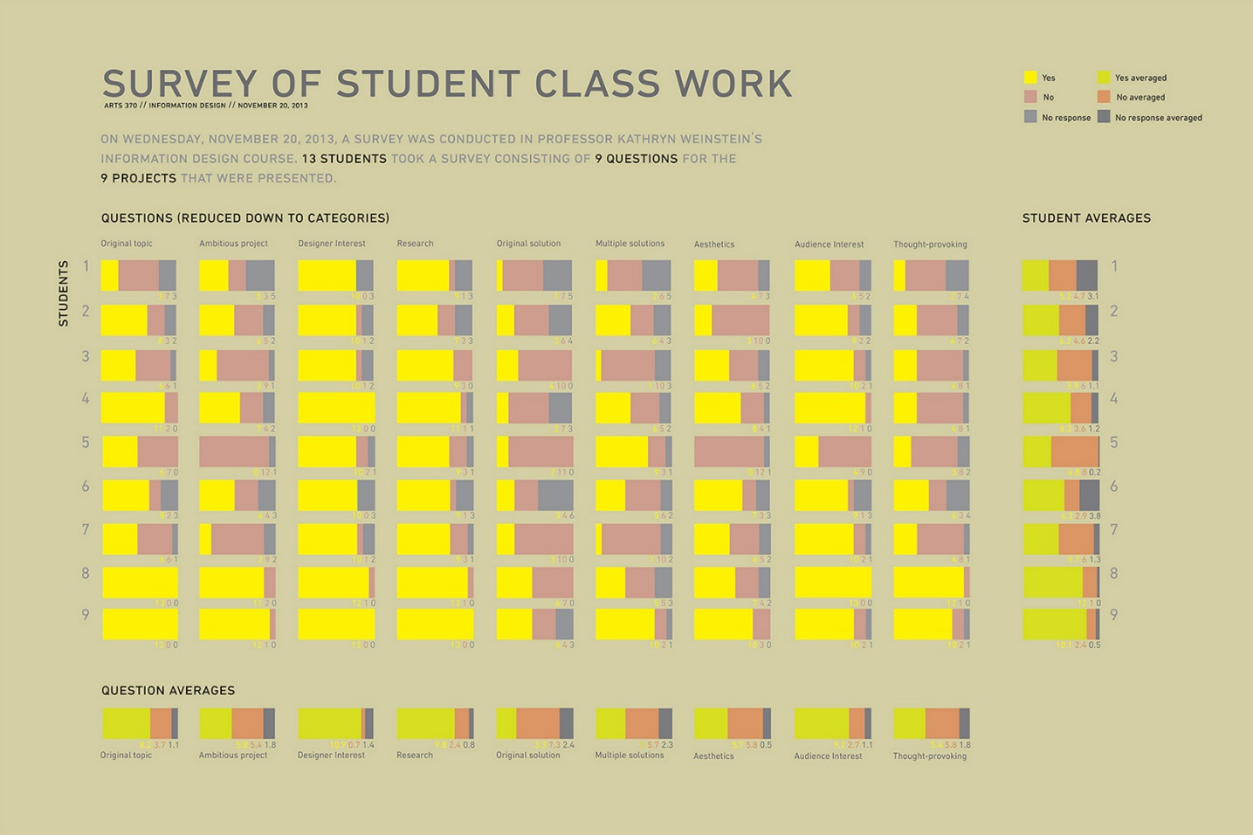

Figure 3. Praveena Persuad, Fall 2013.

The project shown in Figure 4 utilizes three graphing techniques to represent different types of information and the design leads the viewer from an overview to specifics. An area graph at the top creates a snapshot of the responses for the entire class and below is a series of stacked bar graphs paired with donut graphs to represent all responses per question per project as well as an overview of each project. Although the graphs represent different types of information, the consistent use of color for each response facilitates the reading of each type of graph and the text contributes a secondary level of information that contextualizes the graphs.

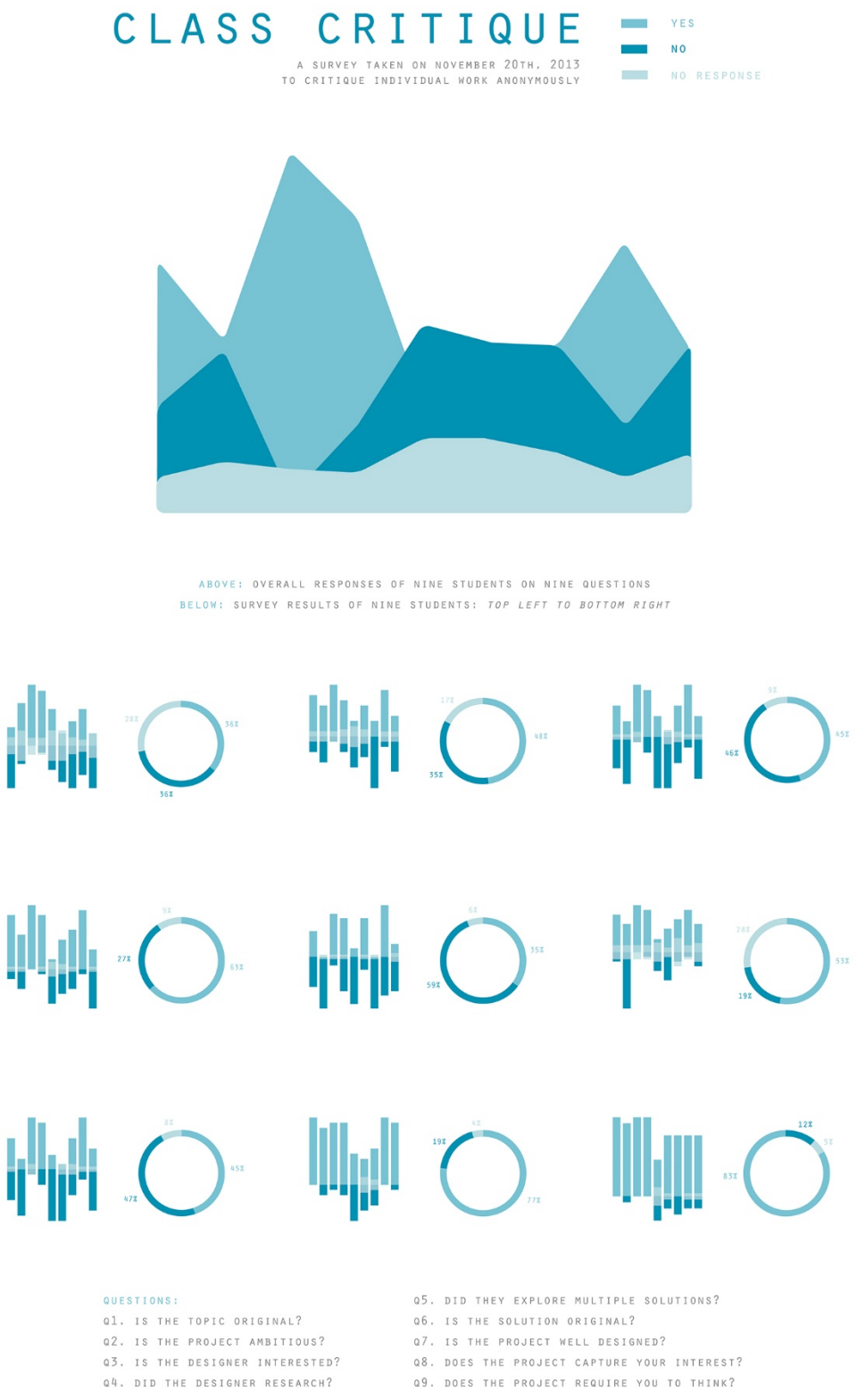

Figure 4. Serom Lee, Fall 2013.

The project in Figure 5 resembles a polar-area diagram with the entire class results represented as a circle. Like a cross-sectioned orange, the circle is composed of 14 sections with 12 projects of equal area and two smaller sections that identify questions listed below the graph. The circle is divided the questions that radiate outwards from the center creating one graph that displays the entire class results, and simultaneously presents each project with specific responses to each question.

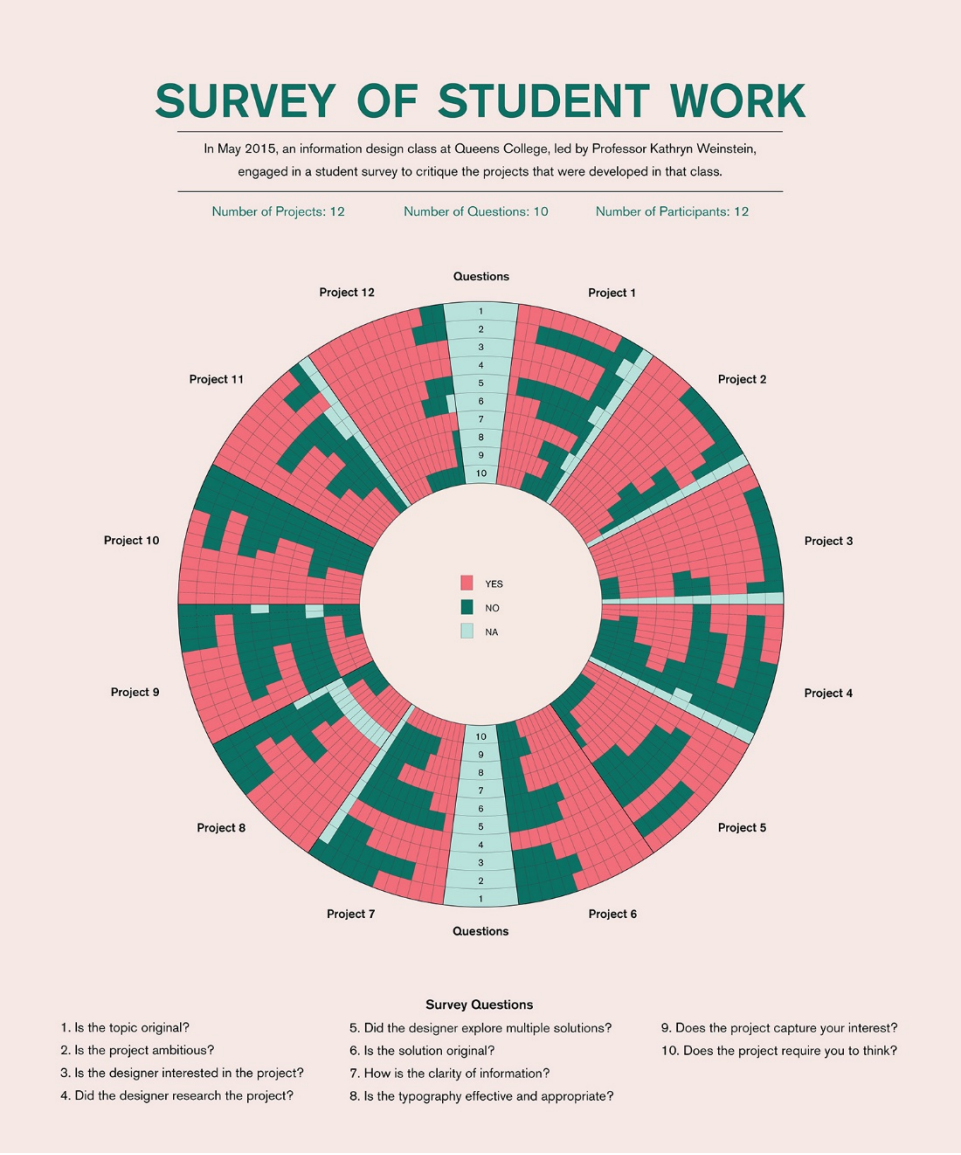

Figure 5. Samiah Meah, Spring 2015.

The verbal critique during project presentations revealed a shifting of priorities by students when evaluating work, placing coherence and accuracy over aesthetics. Students were quick to point out flaws in equations or mapping techniques and equally quick to praise effective and innovative approaches to the displays of information.

Visualizing the Critique provides teachers with a tool to democratize the critique process. In addition to the traditional forms of design critique, the survey provides a venue for students who typically

refrain from verbal exchange in a group setting to express their opinions. All opinions are recorded and carry equal weight, fostering a sense of contribution and participation. The student work and the ensuing critiques throughout the remainder of the semester seemed to be energized by the survey experiment, as demonstrated by a greater degree of verbal participation from all students without prompting and a greater range of opinions confidently expressed, than experienced in earlier classes.

Conclusion

The assignment, *Visualizing the Critique*, introduces students to data collection and analysis in an area in which all students possess a degree of authority: critiquing one another's projects. The assignment provides an opportunity for students to participate in the collection of data and question the methodology and integrity of the data collected, and then proceed to work with collected data and decide how best to visually represent the information. This process requires students to navigate from the tangible (survey results) to the abstract (determination of equations) and back to a tangible (visual presentation of the data). Through the use of calculations and graphing techniques explored throughout the course, students created information-rich visualizations with the potential to serve as an assessment tool by classmates and teacher. In short, *Visualizing the Critique* provides an opportunity for students to scaffold skills learned from previous exercises within the course and provides a format for students to demonstrate the refinement of QR skills.

Further, *Visualizing the Critique* provides teachers with a tool to expand and enhance the traditional forms of feedback through the verbal design critique, and creates a platform that documents and values all student opinions equally. The assignment engenders student reflection of assessment and fosters inquiry about the various types of assessments students encounter within their design studies and how to best utilize feedback for personal development. Further research is recommended to assess whether the experience of the assignment fosters a sense of inclusiveness for design students who are typically left out of traditional critiques, and whether this newly found engagement is sustained in new classroom environments.

Hattie & Timperly (2007) note that most assessments are in effect "accountability thermometers" based on recall and providing little feedback; whereas, feedback devices that are integrated into the teaching and learning process, promote enhanced and consolidated learning by teachers and students. *Visualizing the Critique* integrates feedback into several activities to clarify and strengthen the design process: the introduction and participation in a survey that elucidates criteria of success for a particular project, the challenge of designing visualizations of the feedback, and finally, the presentation and discussion of classmates' visualizations. The final artifact is of potential value to students and teachers as a tool to highlight the areas of success or needed improvement per student, or as a group. Further research is recommended to assess whether students utilize the feedback from the visualizations and apply the knowledge to future design projects.

References

Association of American Colleges and Universities. 2007. *College Learning for the New Global Century: A Report from the National Leadership Council for Liberal Education and America's Promise*.

Washington, DC. Accessed November 28, 2015. http://www.aacu.org/leap/documents/GlobalCentury_final.pdf

Barrett, T. (2000). Studio critiques of student art: As they are, as they could be with mentoring. *Theory into Practice*, 39(1), 29-35.

Blair, B. (2006). At the end of a huge crit in the summer, it was "crap" – I'd worked really hard but all she said was "fine" and I was gutted. *Art, Design & Communication in Higher Education*, 5(2), 83-95.

Cockcroft, W. (1982). Mathematics counts: Report of the Committee of Inquiry into the Teaching of Mathematics in Schools. London: hmso. 10-11.

Gaffney, A. L. (2011). Measuring students' self-efficacy for communication. *International Journal of Art & Design Education*, 30(2), 211-225.

Davidson, M., and McKinney, G. (2001). Quantitative reasoning: an overview. *Dialogue, 8*, 1-5. Retrieved July 16, 2015 from http://www.wwu.edu/vpue/documents/issue8.pdf.

Davies, A. (1996). Assessment and transferable skills in art and design. *International Journal of Art and Design Education*, 3, 327-331.

Ehmann, D. (2005). Using assessment to engage graphic design students in their learning experience. In *2005 evaluations and assessment conference*. University of Technology Sydney, 107-113.

Ellmers, G., Foley, M. & Bennett, S. (2008) Graphic design education: a revised assessment approach to encourage deep learning, *Journal of University Teaching and Learning Practice*, 5(1), 77–87.

Elrod, Susan. 2014. Quantitative reasoning: The next 'across-the curriculum' movement. *Peer Review* 16(3), 48.

Giloi, S. and du Toit, P. (2013), Current approaches to the assessment of graphic design in a higher education context. *International Journal of Art & Design Education*, 32, 256–268.

Gray, C. M. (2013). Informal peer critique and the negotiation of habitus in a design studio. *Art, Design & Communication in Higher Education*, 12(2), 195-209.

Hattie, J. & Timperley, H., (2007). The power of feedback. *Review of Educational Research*, 77(1), 81-112.

Kutner, M., Greenberg E., Jin, J., Boyle, B., Hsu, Y., Dunleavy. E., & White, S.(2007). Literacy in everyday life: Results from the 2003 national assessment of adult literacy. *Institute of Education Sciences National Center for Education Statistics*. Washington, DC: United States Department of Education, 286–367.

Lasserre, B. (2010). Speaking the critique in graphic design: The role of metaphor. *Art, Design & Communication in Higher Education*, 10(1), 51-66.

Mathematical Association of America. (2015). Quantitative reasoning for college graduates. Retrieved December 12, 2015 from http://www.maa.org/programs/faculty-and-departments/curriculum-department-guidelines-recommendations/quantitative-literacy/quantitative-reasoning-college-graduates#Part2

Meirelles, I. (2013). *Design for information: An introduction to the histories, theories, and best practices behind effective information visualizations*. Beverly, MA: Rockport. p.11.

Percy, C. (2004). Critical absence versus critical engagement. Problematics of the crit in design learning and teaching. *Art, Design & Communication in Higher Education* 2(3), 143-154.

Simpson, C. (1999). *Quantitative reasoning (QR) progress report*. Bellingham: Office of Institutional Research and Resource Planning, Western Washington University. p. 2.

QC at a Glance, Queens College, CUNY, 2015. Retrieved November 28, 2015 from http://www.qc.cuny.edu/about/Glance/Pages/default.aspx.

Schrand, T., & Eliason, J. (2012). Feedback practices and signature pedagogies: What can the liberal arts learn from the design critique? *Teaching in Higher Education*, 17(1), 51-62.

Thompson, P.W. (2011). Quantitative reasoning and mathematical modeling. In L. L. Hatfield, S. Chamberlain & S. Belbase (Eds.), *New perspectives and directions for collaborative research in mathematics education* WISDOMe Monographs (Vol. 1, pp. 33-57). Laramie, WY: University of Wyoming Press.

Wong, H. L. H. (2011). Critique: A communicative event in design education. *Visible Language*, 45(3), 222-247.

APPENDIX A

Diagnostic Quiz Distributed to Students of Information Design on the First Day of Class

1. If ¼" =.25", 1/8" = ?
2. If 18 out of 22 students have brown eyes, what is the percentage of brown-eyed students in the class? What is the percentage of non-brown-eyed students?
3. Create a graph of last week's temperatures (F): Mon (!0); Tues (15); Wed (15); Thur (15); Fri (25); Sat (15); Sun (10).
4. Create a graph of last week's range of temperatures (F): Mon (5, 15); Tues (10, 20); Wed (-5,10); Thur (10, 20); Fri (10, 30); Sat (5, 20); Sun (5,15).
5. Create a graph that shows Company ABC's profits (in millions) from 2007-2010. 2007 (5); 2008 (2.5); 2009 (-2); 2010 (3)

6. Create a graph that compares Company XYX's profits (in millions) with Company ABC's profits from 2007-2010. Company XYZ Profits from 2007-2010 2007 (2.5); 2008 (5); 2009 (1); 2010 (5).

Kathryn.Weinstein@qc.cuny.edu