AC 2009-115: WRITING TECHNIQUES FOR IMPLEMENTING PROJECT-DIRECTED MATHEMATICS

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Since Fall 2004, N. Jean Hodges has been an Assistant Professor of Writing and Writing Center Instructor at Virginia Commonwealth University Qatar (VCUQatar) in Doha, Qatar. Hodges works on writing assignments individually with VCUQatar students in all three of the university's design majors as well as in the liberal arts courses. She earned her degrees in North Carolina: a Master of Science in Technical Communication from North Carolina State University; a Bachelor of Arts in Business Administration, magna cum laude, from Queens College (now Queens University); and an Associate of Applied Science in Executive Secretarial Science from Catawba Valley Technical Institute (now Catawba Valley Community College). Her work experiences in legal, medical, executive, and academic positions and her business training have informed her understanding of writing in the workplace, and her interdisciplinary Master's program inspired the focus of her research and academic work: how we learn—the psychology of writing and creating. She has presented on this topic in professional meetings and academic venues and has published several poems and articles. Since 2005 she has been collaborating with Dr. John Schmeelk on a series of studies of MATH 131, Contemporary Mathematics, students at VCUQatar. Results from these studies have been presented in Abu Dhabi and Qatar, as well as at previous annual meetings of ASEE.

Writing Techniques for Implementing Project-Directed Mathematics

Introduction

Understanding college-level mathematics poses problems for many students, especially when those students are studying the concepts in a non-native language. Recently, the College of Humanities and Sciences at Virginia Commonwealth University in Richmond, Virginia (VCUR), designated MATH 131, “Contemporary Mathematics,” as a participating course in its new Writing Across the Curriculum (WAC) initiative. This is a General Education course required of all students attending VCUR’s branch campus in Doha, Qatar (VCUQatar), which means that the students taking MATH 131 in Qatar also became participants in the WAC program.

This study, the fourth in a series examining ways to motivate learning of contemporary mathematics among design students at VCUQatar, examines methods for incorporating writing into MATH 131 at the Qatar campus and the effects of students’ writing upon their mastery of the concepts. Because one must think clearly in order to write clearly and because writing is a unique mode of learning, the authors hypothesize that requiring students to engage with the topics in MATH 131 through writing will improve both (1) the professor’s delivery of instruction by alerting him to problems with students’ language mastery as well as their mathematical thinking and (2) the students’ mastery of the MATH 131 concepts by requiring deeper and more diverse mental engagement with them.

Background

The university and students. Virginia Commonwealth University in Qatar (VCUQatar) is the flagship school of Education City, an innovative and expanding community of United States universities invited to operate branches in Doha, Qatar. Doha is the capital city of Qatar, a peninsula of 4,400 square miles (comparable to Connecticut in size) extending into the Persian Gulf and connected by a southwest border to Saudi Arabia. Education City is the brainchild of Qatar’s Emir and his Consort, Sheikha Mozah Bint Nasser Al Missned, who chairs Qatar Foundation, the organization that manages Education City, among other projects. Initially supervised solely by Qatar Foundation, VCUQatar began in 1998 as Shaqab College of Design Art, but in 2002 the school became an official branch campus of VCUR, began to operate more fully under its direction, and was officially renamed Virginia Commonwealth University in Qatar.

Students attending VCUQatar come not only from Qatar but from all over the world. Regardless of their nationality, all are required to demonstrate mastery of English because all courses are taught in English at the request of the country’s rulers, who intend for Qatar to become a major participant in world affairs and who recognize English as the *lingua franca* of global business.

VCUQatar undergraduates may major in Fashion Design, Graphic Design, or Interior Design. As part of their curriculum, all students must meet specified General Education requirements, and MATH 131, “Contemporary Mathematics,” is the required General Education math course.¹⁰ As the mathematics professor teaching this course since 2001, Dr. X from the start has been

concerned with tailoring the course to fit the unique needs of VCUQatar's diverse students. This concern led to the series of studies preceding and including this study.

Previous studies of MATH 131. In their previous research, the authors relied upon the work of Ricki Linksman, an expert in accelerated learning who founded the National Reading Diagnostic Institute in the United States and who popularized her research on accelerated learning in *How to Learn Anything Quickly*. Basically, Linksman claims that students learn best when new material is presented in ways that appeal to their favorite learning style (visual, auditory, tactile, or kinesthetic) and brain hemispheric preference (i.e., right-brain, left-brain, mixed, or integrated preference). The combination of learning style and hemispheric preference favored by an individual is known as that person's "superlink," according to Linksman, and appealing to someone's superlink is the fastest way for that person to learn.⁷

In the first study of MATH 131, the authors *observed* the students, predicted that the majority of them would be right-brained visual or tactile learners, and suggested effective teaching strategies for these types of learners that related the course's mathematical concepts to the students' culture (prior knowledge) and to their design majors.

The second study *tested* the researchers' prediction of learner types and examined the effectiveness of incorporating projects into the course. The authors recorded students' superlinks after administering Linksman's tests for determining learning style and brain hemispheric preferences (see Appendices A and B for test copies). The tests were given shortly after introducing the course and its project-directed concept, and the results were discussed with the students, who also received handouts of Linksman's characterizations for each of the learning styles and brain hemispheric preferences to use as they studied the math concepts throughout the course. Among the conclusions of this study were that students' documented superlinks did not confirm the assumptions made in the first study, thus identifying the necessity for *testing* students' preferences; sample projects proved helpful; and more research was needed.

The third study *extended* the second study in three primary ways:

- it continued tracking the students' superlinks by adding new data,
- observed the effectiveness of using projects more extensively as both samples and assignments, and
- examined individual and group techniques for effectively motivating project-directed mathematics by engaging students in high-level thinking and mathematical problem-solving.

This study basically revealed that sample projects combined with required projects offer versatility that can appeal to all superlink types.

The problems. These three studies revealed benefits (1) in tying course material (new information) to cultural elements familiar to students (prior knowledge), (2) in allowing students to handle and examine sample projects related to each new topic in addition to creating their own math projects, and (3) in using a variety of teaching methods to address diverse superlinks. They showed the necessity for actually *testing* students' learning preferences rather than inferring appropriate teaching strategies by observing students. They also suggested that the project-directed approach is more successful than the traditional lecture and problem-solving techniques

because students are eager both to collaborate with their peers and professor and to compete against each other in developing the most creative projects. However, the third study revealed that despite students' *reporting* that they were applying knowledge of their individual superlinks to their studies, they often did not even remember what those superlinks were when tested. This finding suggested that students reported to the researchers what they thought the researchers wanted to hear rather than learned the information despite its personal relevance. Similarly, although the students were becoming more engaged with the math topics and more active during class, in-class discussions, quizzes, and tests indicated that they were not fully understanding the concepts and applying them in their everyday lives or major fields.

Consequently, three major goals for incorporating VCUR's WAC program into the MATH 131 project-directed approach became

- to develop students' metacognition about their learning and thinking processes,
- to convince students of the benefits of using knowledge of the personal superlinks in *all* of their courses, and
- to deepen their understanding of how the MATH 131 concepts apply to them personally and professionally.

The Current Study: Incorporating Writing

Writing Across the Curriculum. Writing Across the Curriculum (WAC) began to emerge with studies of writing as a learning method during the 1960s. Writing researchers James Britton² and Janet Emig were instrumental in converting the observation that writing enables the writer to capture and clarify thoughts into pedagogy during the 1970s. In 1971 Emig published *The Composing Processes of Twelfth Graders*, a landmark study of eight 12th-grade writers thinking aloud as they wrote that revealed the complex recursiveness of writing and initiated the "writing-as-process-over-product" movement. This movement gained substantial momentum with the publication of Emig's article in 1977, "Writing as a Mode of Learning,"⁴ in which she proposed that "writing is neurophysiologically integrative, connective, active, and available for immediate visual review," making it a unique and powerful learning tool (p. 58).¹

In 1975 the work of Britton, et al., identified one of three major writing functions as *expressive*, in which the writer captures his or her ideas (Vygotsky's *inner speech*¹¹) and investigates and reflects upon them. Britton and his colleagues argued that language is a powerful tool for organizing experience and substantially strengthened the idea of using cross-curricular expressive writing to enhance students' learning (pp. 57-58).¹

Throughout the 1980s and 1990s, Emig's and Britton's work became the basis for recognizing writing as a primary learning method, for examining writing in specific environments, for observing the effects of different writing assignments upon learning, and for applying writing in different disciplines (WAC). During the New Millennium researchers have begun addressing ethical issues involved with WAC programs. (For a more complete discussion of WAC history, refer to Chapter 5, "Writing to Learn," of *Reference Guide to Writing Across the Curriculum*, by Charles Bazerman, et al.¹) VCUR's WAC program emerged through the establishment of its Center for Teaching Excellence in 2001.

Classes. The current study involves students enrolled in MATH 131 courses for Fall 2008 and Spring 2009 semesters. As of this writing, the Fall Semester has been completed, and its results are reported in this document. The June 2009 presentation at the ASEE Annual Conference in Austin, Texas, will also include results from the Spring Semester.

The Fall 2008 course consisted of nine female students, none of whom were freshmen.

Method. In addition to the course syllabus and assignment schedule, students entering MATH 131 were given a handout explaining why they would be required to write journal entries in the course and how those entries would be assessed (see Appendix C). The authors discussed this handout and the writing component of the course at length, answering students' questions in class. The course introduction included an explanation of the research being conducted and the project-directed approach evolving from this research. As in the authors' previous studies, Linksman's tests for determining learning style and brain hemispheric preferences (see Appendices A and B) were given early in the term, and the results were discussed with students, who received handouts of Linksman's characterizations for each of the learning styles and brain hemispheric preferences. In addition, students received composition notebooks, individualized by name and superlink listed on the front cover, to use as their personal journals. In addition to specific journal assignments, students were encouraged to record any of their thoughts about the course in their journals and were reassured that such additional comments would be regarded as private and would not affect their grades.

Three sets of three journal assignments each were distributed during the term (see Appendix D). Each set was given at the beginning of the unit covering its topics, and students were required to complete each writing assignment in their journals. On the due date for each assignment, the authors collected the journals, reviewed the writings, recorded the students' completion of the assignments or lack thereof, and "talked to" the students through written comments in the margins of their writings. When the journals were returned at the next class, relevant issues, comments, and examples from the students' journals were discussed as a class.

In addition to the journals, "one-minute papers" were used to identify students' understandings, misunderstandings, and questions as well as to promote their metacognition. These papers consisted of a half-sheet of paper listing a writing prompt, such as "what I didn't understand in today's lesson was _____," that students wrote about for one minute. Depending upon the specific prompt, one-minute papers were completed at either the beginning or the end of a class session. Sample one-minute paper topics are shown in Appendix E.

Finally, students were asked to complete a survey at the end of the course to help assess whether they remembered and used their "superlink" information as well as their reactions to the journal assignments. A copy of the survey appears in Appendix F.

As in previous studies, during class each new topic was introduced visually by showing students past student projects submitted as partial fulfillment in the previous MATH 131 courses. Students were allowed to handle the projects and were encouraged to think about and ask questions about the comprehensive final project that they would be required to complete as part of the project-directed approach to the course. The students were quite impressed by the past

projects, asked many questions, and wanted to compete with each other to find innovative ways to illustrate mathematical principles in their own projects.

Results

Superlinks. All nine students in the Fall 2008 MATH 131 class took the learning style and brain hemispheric preference diagnostic tests. Their results appear in Table 1 below.

Learning Style	Number of Students	Percentage of Class
Visual	1.5*	16.66
Auditory	0.5*	5.56
Tactile	$4 + (2 \times 0.5) = 5.0^{\dagger}$	55.56
Kinesthetic	2.0	22.22
TOTAL	9.0	100.00
Brain Hemispheric Preference		
Right	2	22.22
Left	2	22.22
Mixed-Right	3	33.34
Mixed-Left	0	0.00
Integrated	2	22.22
TOTAL	9	100.00

Table 1. Results of MATH 131 Students' Diagnostic Preference Tests for Fall 2008

*Two students' scores were tied and their style preference distributed equally between two styles

[†]The students whose scores were tied shared a tactile preference in common

Table 1 shows that the majority of students preferred to take in information through their sense of touch (the tactile learning preference). Letting these students handle the former students' projects used to introduce new topics and having these students write in their journals were strategies that especially appealed to their learning style. Talking about these sample projects and discussing journal entries and one-minute paper responses in class addressed the auditory preference of one student. Similarly to the tactile students, the visual students' learning preferences were addressed by showing the completed projects, writing and illustrating concepts on the white board, and encouraging students to illustrate their journal entries. To facilitate the kinesthetic students' learning style, students were asked to participate in class by coming to the white board and by manipulating the sample projects.

As might be expected of artistically inclined design students, the hemispheric preferences in this class favored the right hemisphere, in which processing of sensory experiences, nonverbal communication, and global thinking occur for most people. The hemispheric preferences of this class were particularly interesting because Linksman's work, which focuses on students in the United States, suggests the mixed and integrated preferences are less common than left or right dominance. The mixed preference results when the diagnostic scores for the two hemispheres are within one or two points of each other. This means that the individual uses each hemisphere for appropriate tasks fairly regularly but slightly prefers the approach of one hemisphere over the other and occasionally uses the techniques of that hemisphere to perform tasks better suited to the opposite hemisphere. When this happens, learning is more difficult. The integrated

preference indicates a tie in the scores of left and right hemispheric preferences and suggests that the individual is using the two hemispheres most appropriately for all tasks. In other words, functions that are easily handled by the left side of the brain (such as linear, step-by-step processing of information) actually *are* handled by that hemisphere, and vice versa. Such development enables the individual to take better advantage of innate potential and to learn easily in either a right- or a left-hemispheric environment. The unexpected frequency of mixed and integrated preferences throughout the authors' research series concerning MATH 131 students suggests future work along another line of research to investigate how and why American and Gulf students are developing so differently along these lines.

Journal writing. The students seemed to really like the idea of having their own journals and immediately asked to include their homework and one-minute paper responses in them as well as their journal assignments and private musings. Throughout the semester, several students used their journals for all of their math-related work, while others reserved them solely for their written journal assignments.

Students' written responses to the journal assignments were especially revealing for three fundamental reasons. First, in responding to them, all of the students at one time or another moved beyond the basic levels of knowing and understanding to the higher cognitive domains of applying, analyzing, synthesizing, and evaluating. For example, in response to the assignment to "observe the teaching of any one of your professors during two class periods and note what he/she does that fits in with your preferred learning style and hemispheric preference," one student with mixed-right and tactile preferences wrote:

Over two class periods I have observed my Experiential Design class professor explain and teach the class about sustainable packaging. . . . I got the feeling that it was easy to soak up and understand information from this teacher. I began to ask myself why? . . . I realized that part of the reason . . . is because I am a tactile person, which means I use my sense of touch a lot, and this really relates to the 3D and 4D packaging class. I noticed I was very imaginative and thinking of what does not yet exist.

My professor was really good at using descriptive words, ones that simply made me imagine or understand what she meant. The tone of her voice and the pace she spoke in really made a positive impact on my learning. . . . I noticed the professor uses hand gestures a lot when trying to explain a matter. She was also enunciating each word clearly, which made it easier for me to grasp that knowledge. It made me have a visual memory of how the information was said and how it related to the project, how it could even relate to several other projects.

These were some of the aspects in my professor that really caught my attention . . . Although I do think that there are some things that could be added to the way of teaching in order for me and people with my same or similar hemispheric preference is to not stand too close to me with eye contact as she is explaining something because it can be uncomfortable at times. . . . maybe introducing some

more materials and bring in examples and samples to class when explaining instead of just saying it orally would make a big difference to my learning. (B. Al-M.)

Another student with a mixed-right, visual superlink not only analyzed why she liked fractals but also planned to use them in a project she was working on:

. . . I think these fractals above are very beautiful in many ways. The shape and color. The movement of these fractals are very beautiful as if it is dancing in slow motion, and very romantic feeling to it. These shapes can be very inspiring, in color schemes and shap [sic]. Personally, I love spiral shapes and the effect of wavey [sic] and spiral shapes and movement are very strong shown in my designs, and these fractals give me anew [sic] prespective [sic] meaning of spiral.

I do see a lot of possibilities in using fractals in interior design [her major]. I [sic] can be used to design wallpaper or floor design, or even an artistic furniture piece. I'm doing a retail store project for a fashion designer and I'm thinking of using fractals to design the wall behind the cashier, or a display piece for accessories. I'm still depating [sic] my ideas. Below their [sic] are some sketches for a rough ideas. (H. Al-M.)

Second, for at least one student the journal assignments helped her discover new information while wrestling with the mathematical concepts. In response to the assignment question, *how could geometric and arithmetic sequences be applied in Fashion Design, Graphic Design, or Interior Design*, she began her entry with doubts about their applicability to Fashion Design, then considered the meaning of the terms, and finally arrived at a relationship to her major:

Using these kind of sequences in fashion design might be a little unusual. I'm trying to figure out how these sequences can be used in fashion but I can't figure it out.

Arithmetic is a sequence which goes from one term to the next by always adding (or subtracting) the same value (common difference, d). Geometric is a sequence which goes from one term to the next by always multiplying (or dividing) the same value (common ratio, r).

A way to use this in fashion would be when sizing patterns, going up one size, each time adding a certain amount to a certain part of the pattern. (S. C.)

This student had a left, visual and tactile superlink, and it is easy to see her using the left hemispheric strategy of linear, step-by-step thinking to determine her answer to the question.

Finally, the responses to the journal assignments revealed information about the students' efforts in the course that the professor otherwise would have never known. Many of the students' responses revealed sudden engagement with the mathematical concepts as students discovered a

relationship to their interests and passions. Some students reported really struggling with some of the concepts and repeatedly seeking additional outside help or conducting online research.

In her discussion of symmetry, one student chose the capital letter *H* to illustrate symmetry, rotation, and glide reflections. As she concluded her answer, her enthusiasm became evident:

Overall, the letter H in Helvetica has tons of different kinds of symmetry.

A nice re-design I see for this where it would still be very symmetrical is adding equilateral triangles to the H, like this:

I think it's pretty cool. (S. C.)

Another student, a senior, revealed that her interior design professors had never mentioned geometric and arithmetic sequences:

I had not heard of these sequences before I studied them in Math 131. I can't say any of our Interior Design teachers have ever mentioned these sequences.

I found them hard to get my thoughts around but after some hours of study, I finally started appreciating the scope of these sequences in design. I found that we actually could use linear sequences in design to pull space together, that is tie in different parts of our design to make a whole. . . . Writing about it has made me think more deeply about its application in design, thus making it more meaningful. (F. G.)

Another senior commented on fractals in her journal:

No matter how much I expose myself to the world of fractals, it remains a mystery to me. This is because the beautiful patterns produced out of basic shapes or geometric equations are tremendously powerful. Regardless of its logical sequence, fractals are hard to believe. While studying this chapter I couldn't wait to generate complex geometric patterns. I couldn't surrender to my ignorance in the field and not produce complex fractals. So, I downloaded fractals software and started playing with inputs and outputs. It's a phenomenal experience.

Fractals are very tight to graphic design. Fractals give beauty to graphic design. It could be a method to achieve a design concept. This means that fractals could be more than beauty. It could adapt the function, too. (F. M.)

One-minute papers. Work with the one-minute papers was disappointing overall because the students convinced the professor to alter the plan for their use by including the responses in the students' journals. This resulted in a few responses being recorded in the journals but not reviewed by the professor until well after the class discussion, as well as in some students'

failure to complete the responses at all. This experience emphasized the necessity of immediately collecting these responses after one minute of writing.

Projects. Both sample projects and students' project assignments continue to motivate students and to facilitate their mastery of the MATH 131 concepts. Following are the results of this method as they apply to the course topics.

Sequences, Series, and Fibonacci Numbers. Arab art and architecture are strongly influenced by geometrical designs, so MATH 131 includes several chapters^{3, 5} that expand upon rotations, reflections, and translations. The course begins with mathematical formulas that describe geometric shapes, followed by an intense development of the Fibonacci sequence and several of its properties illustrating its "real-life" utility. To motivate students' interest, the instructor connects these topics with elements of Muslim culture, since most of the students are Muslims and VCUQatar exists in a Muslim country. Among these elements are those shown in Fig. 1 below concerning Muslim achievements, such as inventing Algebra; creating the notion of zero; and writing the first book on algebra⁹, Muhammad ibn Musa al-Khwarzimi's famous *Kitab al-Jabr wa al-Mugabala*.

The Fibonacci sequence is presented as the first sequence since it enjoys a rich history. The professor and students consider Fibonacci as an Italian mathematician, and the students research him on the web. The corresponding journal assignment requires students to think about Fibonacci's discovery in greater depth by discussing how his being European yet learning the Hindu-Arabic system of numbers and arithmetic contributed to his discovery of the Fibonacci sequence.

The classroom discussion of the Fibonacci sequence (1, 1, 2, 3, 5, 8, 13, 21, ...) is illustrated using past students' projects on the topic, such as the poster shown in Fig. 3. One past project is a love seat designed by an interior design student using a double Fibonacci spiral, which was used to motivate computing and working problems on the white board (see Fig. 2). During class time students draw the Fibonacci spiral. A rough draft for such a drawing is shown in Fig. 4. This spiral is drawn using a rectangular coordinate system whereby the box lengths are 1, 1, 2, 3, 8, 13, 21, ... centimeters. Two squares, each 1 cm long, are drawn side by side, and then another square, 2 cm long, is drawn above the two original squares. A fourth square 3 cm long is drawn

Fig. 2: Love Seat designed with double Fibonacci Spiral

Using their artistic talent, the students create several Fibonacci Spirals, such as the unique one displayed in Fig. 5 done in Spring Semester 2008. Taking the concept even farther that semester,

Fig. 4: Student's Draft of Fibonacci Spiral

an interior design student created a Fibonacci coffee table (Fig. 6). When students saw this project, several of them commented that “I didn’t know what these numbers mean, and now I know I understand them.”

Fig. 9: Nautilus Seashell

Fibonacci Numbers

In mathematics, the Fibonacci numbers are a sequence of numbers named after Leonardo of Pisa, known as Fibonacci. Fibonacci's 1202 book, *Liber Abaci*, introduced the sequence to Western European mathematics, although the sequence had been previously described in Indian mathematics.

The first number of the sequence is 0; the second number is 1, and each subsequent number is equal to the sum of the previous two numbers of the sequence itself. In mathematical terms, it is defined by the following recurrence relation:

$$F_n = F_{n-1} + F_{n-2} \text{ if } n \geq 1$$

Recall:

0 1 1 2 3 5 8 13 21 34 55 89 144 233 377 610 987 1597 2584 4181 6765 10946 17711 28657 46368 75025 121393 196418 317811 514229 832040 1346269 2178309 3542248 5713017 9255467 14930352 24146017 39086369 63245610 102334155 165580141 267914256 433494401 701408737 1134903170 1836311905 2971215073 4807526243 7778762530 12586864177 20365583040 32951280099 53316291173 86267571272 139583862445 225851433717 365435296162 591286729879 956722026041 1555047367540 2512354672861 4069921911651 6581355947712 10653569644013 17225775746064 27939562446076 45169150672969 73094715069034 118213640340889 191349540448863 309583646869792 500057106633081 809045724659571 1298786233917203 2099841408946184 3398531138121776 5501350630047157 8899787169166440 14406069579146657 23307779156414784 37714788115561941 61010521473692025 98765438880000000 159376221471213200 258144015166834400 417720837238357200 676093215411166080 1094607864611005300 1771149047463536000 2865712384601000000 4636831785261771300 7502531842236766000 12139302424546731000 19641835561592952000 31781107409753046000 51422934746355999000 83204046909064448000 134626967365590597000 217830901846460601000 354224809344969095000 571301776726548564000 925546726598608549000 1493035296165114689000 2414601771367383359000 3908636917224900658000 6324561088402284157000 10233415516684698896000 16558014186097018055000 26791425602781501001000 43349440118879199856000 70140873726056199856000 11349031704908640000000 18363119057480156000000 29712150732379160000000 48075262447287856000000 77787625309544512000000 125868641771713700000000 203655830400801408000000 329512800995548960000000 5331629117363403520000000 8626757127282558720000000 13958386244559747300000000 22585143371741150080000000 3654352961662480000000000 59128672987965940480000000 95672202604185580160000000 155504736754051520640000000 251235467286137000960000000 406992191165188501760000000 658135594771245503360000000 1065356964401332505600000000 1722577574606418009600000000 2793956244607653017600000000 4516915067296971027200000000 7309471506903488044800000000 11821364034088960000000000 19134954044886300000000000 30958364686979200000000000 50005710663308100000000000 80904572465957100000000000 129878623391720300000000000 209984140894618400000000000 339853113812177600000000000 550135063004715700000000000 889978716916644000000000000 1440606957914665700000000000 2330777915641478400000000000 3771478811556194100000000000 6101052147369202500000000000 9876543888000000000000000000 15937622147121320000000000000 25814401516683440000000000000 41772083723835720000000000000 67609321541116608000000000000 109460786461100530000000000000 177114904746353600000000000000 286571238460100000000000000000 463683178526177130000000000000 750253184223676600000000000000 1213930242454673100000000000000 1964183556159295200000000000000 3178110740975304600000000000000 5142293474635599900000000000000 8320404690906444800000000000000 13462696736559059700000000000000 21783090184646060100000000000000 35422480934496909500000000000000 57130177672654856400000000000000 92554672659860854900000000000000 149303529616511468900000000000000 241460177136738335900000000000000 390863691722490065800000000000000 632456108840228415700000000000000 1023341551668469889600000000000000 1655801418609701805500000000000000 2679142560278150100000000000000000 4334944011887919985600000000000000 7014087372605619985600000000000000 1134903170490864000000000000000000 1836311905748015600000000000000000 2971215073237916000000000000000000 4807526244728785600000000000000000 7778762530954451200000000000000000 12586864177171370000000000000000000 20365583040080140800000000000000000 32951280099554896000000000000000000 53316291173634035200000000000000000 86267571272825580160000000000000000 13958386244

Fig. 11: Student Painting B on Fibonacci

This section concludes with the standard arithmetic (linear) and geometric (exponential) sequences and series. We distribute the formula sheets to the class (see Appendix G). The linear and geometric sequences and series are displayed in pie and bar graphs using Matlab-6.7, which also introduces the students to this software package. We exhibit two figures illustrating the standard geometric sequence and series, $\frac{1}{2}, \frac{1}{4}, \frac{1}{8}, \frac{1}{16}, \frac{1}{32}, \dots$ (see Figs. 12 and 13).

The journal assignment for geometric and arithmetic sequences asks students to discover ways these concepts could be applied in their majors (or intended majors for undeclared students). Students are encouraged to think creatively, using their design skills to design a future application if they are unable to uncover an existing one.

Fig 12: Pie Graph
Geometric Sequence and Series

Fig 13: Bar Graph
Geometric Sequence and Series

Symmetry. Symmetry is explained using photos of Doha's mosques. Figures 14, 15, and 16 illustrate mosques that are about 75 years, 45 years, and 10 years of age, respectively. Being mostly Arab Muslims, the students can immediately identify symmetry found in the mosques. Since all the men in their families are obliged to go to the mosque five times daily, the young women are constantly exposed to mosque life and also are encouraged to attend mosque with their families and friends whenever possible. (Attendance obligations differ for men and women.)

The reference book, *Architecture of the Islamic World*⁵, is circulated among the students so they can observe architectural structures designed by Islamic architects. Its illustrations precipitate the students' understanding of Islamic architects' extensive use of structural symmetry and help motivate their understanding of the underlying symmetrical principles displayed in the mosques and other buildings in Qatar.

The relevant journal assignment gives students numerous suggestions for choosing an object to examine and discuss its symmetry (or lack thereof). They are required to write about changes in their object as the terms *rotations*, *reflections*, *translations*, *glide reflections* are applied to it. Finally, they are asked if any of these terms spark an interesting idea for redesigning the chosen object.

Fig. 14: One of the oldest Doha mosques, about 75 years old

Fig. 15: A Doha mosque, about 45 years old

Fig. 16: A modern Doha mosque showing Spanish influence (about 10 years old)

Fig. 17: A symmetrical lighting fixture inside a hotel

A lighting fixture (Fig. 17) in the Intercontinental Hotel is shown to the students (since a lighting course is required for interior design students) as the starting point to present the symmetric notions of rotations, reflections, and glide reflections. The concepts of rotations and reflections are presented in the text, implementing the notation D_n to indicate symmetry having exactly n rotations combined with exactly n reflections. The notation Z_n indicates exactly n rotations and no reflections. Notational requirements present problems to most novice math students, but MATH 131 students relate these ideas clearly and concisely when working with projects.

A carpet image is shown to the students. The rug in Fig. 18 is in the Ritz Carlton, and the medallions in it illustrate several properties of symmetry. Each student is then given a greeting card from Istanbul, and they must determine its properties of symmetry using the notations, Z_n and D_n (see Fig. 19).

Fig. 18: Rug in Ritz Carlton

Fig. 19: Greeting Card Medallion

Student projects on symmetry using these notational conventions are shown in Figs. 20-23.

Fig. 20: A student's project on symmetry

Fig. 21: A student's project on symmetry

Fig 22: Student project on symmetrical patterns and reflections

Fig. 23: A student's project illustrating symmetry in the design of kick plates on a stairway

Fractals. The journey through fractal designs begins by showing students a famous fractal selected from the web (Fig. 24). The students work with developing the basic Koch Snowflake fractal and the Sirpinski Gasket fractal by illustrating them on graph paper and developing the sequences contained within each illustration. They measure number of edges, lengths of individual edges, length of total perimeters and areas on worksheets (see Appendices H and I). This develops the various aspects of fractals in an elementary manner, which leads to completing student projects such as those shown in Figs. 25-29.

Fig. 24: A famous fractal from a web site

Fig.25: Koch Snowflake (media: 3-dimensional model)

Fig. 26: Koch Snowflakes (media: graphics)

Fig. 27: Koch Snowflake (media: pottery)

Fig. 28: Sierpinski Gasket (media: 3-dimensional model)

Fig. 29: Koch Snowflake (media: graphics)

There are two journal assignments on fractals. The first asks students to relate fractals to their major or intended major and to try mentally re-designing something in their field that is typically geometric using fractals, again calling upon their creativity and design skills while asking them to become more personally involved with the concepts. The second assignment asks students to delve more deeply into fractals by either answering questions about Benoit Mandelbrot after researching his life or by comparing at least three fractals for similarities, differences, and design inspirational value.

The Mandelbrot set (Fig. 31) is shown to the students and carefully examined, and the mathematical technique is studied implementing both real and complex numbers. This allows students to introduce artistic development by employing colors for the escaping, periodic, and attracting sequences within fractals. A short MatLab program (see Fig. 30) generates 301 by 301 seeds and iterates each seed 50 times before it is returned to the picture displaying the color. This helps the student understand the iteration of the point and the need for computer power to

Figure 30: Program

Figure 31: The Mandelbrot Set

obtain good fractal results. Work in progress involves using software to create some interesting fractals. Again, the students can introduce artistic creativity by employing hot and cool colors for the escaping, periodic, and attracting sequences.

Graph theory. The course concludes with a very brief introduction of graph theory. Several topics are developed from graph theory, such as Euler and Hamilton graphs. The maps shown in Figs. 32-33 help students visualize the famous Königsberg seven-bridge problem. We also cover the famous Kruskal's algorithm, which can select the best route on a graph to maximize profit. The algorithm is demonstrated in a student's innovative project shown in Fig. 34.

Fig. 32: Map of Königsberg illustrating its bridges

Fig. 33: Königsberg bridges highlighted

Fig 34: Student project on Euler and Hamilton graphs using a board game

Course survey. Four of the nine students completed the survey at the end of the semester. All four students recalled their brain hemispheric preference and learning style correctly with the exception of one student who forgot that her hemispheric preference was actually *mixed-right* and reported only the *right* portion of that preference. All four students agreed that (1) they did pay attention to their learning and hemispheric preferences in both math and other courses during Fall 2008 semester, and (2) superlink information should continue to be included in MATH 131. Their comments on the latter response were positive, ranging from “helps a bit” to “and I believe it should be given in freshman year so we can implement it in all other courses. Maybe it should be a separate course. This way we learn more about it.”

Three of the four students reported that the journal assignments were helpful to their understanding of topics in MATH 131. Two students reported that the first assignment regarding their superlinks was the most helpful. The fourth student, who did not find the journal assignments helpful, commented that students “need to work on it in class, too.” She also identified *four* journal assignments (although only one was requested) as being least helpful to her because “I didn’t understand it much.” (It should be noted that this student failed to submit much of her work and had poor attendance.) The remaining respondents found different journal assignments least significant, because the related math concepts were complicated or the assignment seemed irrelevant or unnecessary.

Surprisingly, all four respondents said that journal assignments should continue to be included in MATH 131 because “it gives the student a chance to analyze his/her understanding in math,” “it does help in relating math to real life and to my major,” the journal assignments “helps understand the topics a bit,” and it is “helpful and good for students to write.” These comments seemed surprising because only two of the four reported that they thought differently after taking MATH 131. One of the affirmative respondents said the course had made her think of real life applications, and the other reported thinking differently about her major after taking MATH 131. The two negative respondents gave similar personal reasons for their responses:

- (a) “I’m sorry to say this, but I never enjoyed math, and I never will.”
- (b) “I don’t really enjoy math that much, so I still feel the same though it helped me see a more creative side to it.”

Three of the four respondents found the sample projects “somewhat helpful” for giving them ideas about what the professor expected in the final project. The fourth student responded “very helpful” because “It is like history. If you read history, you avoid a lot of mistakes and you learn from other people’s experience. And it helps you also by not starting from zero point and opening a lot of possibilities for you.”

Two students found creating their own projects “somewhat helpful,” but neither commented on her answer. One student found this “not very helpful” because “we’ve got far too many deadlines already but it was fun making them [the projects].” The fourth student did not answer this question because “I cannot say because I did not finish yet.”

All four students reported elements from the course that they would be able to use in their careers and/or daily lives.

Conclusions

Incorporating writing into MATH 131 in particular helped students become aware of their learning and thinking processes and apply the MATH 131 concepts to their personal and professional lives, satisfying two of the three goals for this course. Evidence of convincing students to apply their superlink knowledge in all of their courses was less apparent, but the unanimous response to continue including journal assignments in the course suggests that the students did find the information helpful personally.

In addition, journal writing gave the professor another method for “talking” individually with each student and providing positive, reinforcing, and encouraging comments. It showed concrete evidence of students’ movements into the higher cognitive domains of Bloom’s Taxonomy of learning cognition, confirmed the use of writing as a means of discovery, and revealed information about the students’ struggles and enthusiasms that the professor otherwise would not have discovered and been able to address. Incorporating writing within a project-directed approach shows great promise as an effective strategy for teaching contemporary mathematics to design students.

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Appendix A

VCU SCHOOL OF THE ARTS IN QATAR
MATH 131, INTRO TO CONTEMPORARY MATHEMATICS

FALL, 2008

NAME: _____

The Learning Style Preference Assessment

(Source: Linksman, Ricki. *How to Learn Anything Quickly*. New York: Barnes & Noble Books, 1996. 4-9.)

Instructions: *For each question, circle the ONE response that BEST describes you. Remember, there are no “right” or “wrong” answers—you should try to match your preferences as honestly as you can and choose no more than one answer.*

1. When you meet a new person what do you FIRST notice about him or her?
 - a. what he or she looks like and how he or she dresses
 - b. how the person talks, what he or she says, or his or her voice
 - c. how you feel about the person
 - d. how the person acts or what he or she does
2. Days after you meet a new person, what do you remember the most about that person?
 - a. the person's face
 - b. the person's name
 - c. how you felt being with the person even though you may have forgotten the name or face
 - d. what you and the person did together even though you may have forgotten the name or face
3. When you enter a new room, what do you notice the most?
 - a. how the room looks
 - b. the sounds or discussion in the room
 - c. how comfortable you feel emotionally or physically in the room
 - d. what activities are going on and what you can do in the room

4. When you learn something new, which way do you need to learn it?
 - a. A teacher gives you something to read on paper or on the board and shows you books, pictures, charts, maps, graphs, or objects, but there is no talking, discussion, or writing.
 - b. The teacher explains everything by talking or lecturing and allows you to discuss the topic and ask questions, but does not give you anything to look at, read, write, or do.
 - c. The teacher lets you write or draw the information, touch hands-on materials, type on a keyboard, or make something with your hands.
 - d. The teacher allows you to get up to do projects, simulations, experiments, play games, role-play, act out real-life situations, explore, make discoveries, or do activities that allow you to move around to learn.
5. When you teach something to others, which of the following do you do?
 - a. You give them something to look at like an object, picture or chart, with little or no verbal explanation or discussion.
 - b. You explain it by talking, but do not give them any visual materials.
 - c. You draw or write it out for them or use your hands to explain.
 - d. You demonstrate by doing it and have them do it with you.
6. What type of books do you prefer to read?
 - a. books that contain descriptions to help you see what is happening
 - b. books containing factual information, history, or a lot of dialogue
 - c. books about characters' feelings and emotions, self-help books, books about emotions and relationships, or books on improving your mind or body
 - d. short books with a lot of action, or books that help you excel at a sport, hobby, or talent
7. Which of the following activities would you prefer to do in your free time?
 - a. read a book or look at a magazine
 - b. listen to an audiotaped book, a radio talk show, or listen to or perform music
 - c. write, draw, type, or make something with your hands
 - d. do sports, build something, or play a game using body movement
8. Which of the following describes how you can read or study best?
 - a. You can study with music, noise, or talking going on, because you tune it out.
 - b. You cannot study with music, noise or talking going on because you cannot tune it out.
 - c. You need to be comfortable, stretched out, and can work with or without music, but negative feelings of others distract you.
 - d. You need to be comfortable, stretched out, and can work with or without music, but activity or movement in the room distracts you.

9. When you talk with someone, which way do your eyes move? (You can ask someone to observe you to help you answer this question.)
 - a. You need to look directly at the face of the person who is talking to you, and you need that person to look at your face when you talk.
 - b. You look at the person only for a short time, and then your eyes move from side to side, left and right.
 - c. You only look at the person for a short time to see his or her expression, then you look down or away.
 - d. You seldom look at the person and mostly look down or away, but if there is movement or activity, you look in the direction of the activity.
10. Which of the following describes you best?
 - a. You notice colors, shapes, designs, and patterns wherever you go and have a good eye for color and design.
 - b. You cannot stand silence, and when it is too quiet in a place you hum, sing, talk aloud, or turn on the radio, television, audiotapes, or CD's.
 - c. You are sensitive to people's feelings, your own feelings get hurt easily, you cannot concentrate when others do not like you, and you need to feel loved and accepted in order to work.
 - d. You have a hard time sitting still in your seat and need to move a lot, and if you do have to sit you will slouch, shift around, tap your feet, or kick or wiggle your legs a lot.
11. Which of the following describes you the best?
 - a. You notice when people's clothes do not match or their hair is out of place and often want them to fix it.
 - b. You are bothered when someone does not speak well and are sensitive to the sounds of dripping faucets or equipment noise.
 - c. You cry at the sad parts of movies or books.
 - d. You are restless and uncomfortable when forced to sit still and cannot stay in one place too long.
12. What bothers you the most?
 - a. a messy, disorganized place
 - b. a place that is too quiet
 - c. a place that is not comfortable physically or emotionally
 - d. a place where there is no activity allowed or no room to move

13. What bothers you the most when someone is teaching you?
 - a. listening to a lecture without any visuals to look at
 - b. having to read silently with no verbal explanation or discussion
 - c. not being allowed to draw, doodle, touch anything with your hands, or take written notes, even if you never look at your notes again
 - d. having to look and listen without being allowed to move
14. Think back to a happy memory from your life. Take a moment to remember as much as you can about the incident. After reliving it, what memories stand out in your mind?
 - a. what you saw, such as visual descriptions of people, places, and things
 - b. what you heard, such as dialogue and conversation, what you said, and the sounds around you
 - c. sensation on your skin and body and how you felt physically and emotionally
 - d. what actions and activities you did, the movements of your body, and your performance
15. Recall a vacation or trip you took. For a few moments remember as much as you can about the experience. After reliving the incident, what memories stand out in your mind?
 - a. what you saw, such as visual descriptions of people, places, and things
 - b. what you heard, such as dialogue and conversation, what you said, and the sounds around you
 - c. sensation on your skin and body and how you felt physically and emotionally
 - d. what actions and activities you did, the movements of your body, and your performance
16. Pretend you have to spend all your time in one of the following places where different activities are going on. In which one would you feel the most comfortable?
 - a. a place where you can read; look at pictures, art work, maps, charts, and photographs; do visual puzzles such as mazes, or find the missing portion of a picture; play word games such as Scrabble or Boggle; do interior decoration, or get dressed up
 - b. a place where you can listen to audiotaped stories, music, radio or television talk shows or news; play an instrument or sing; play word games out loud, debate, or pretend to be a disc jockey; read aloud or recite speeches or parts from a play or movie, or read poetry or stories aloud
 - c. a place where you can draw, paint, sculpt, or make crafts; do creative writing or type on a computer; do activities that involve your hands, such as playing an instrument, games such as chess, checkers, or board games, or build models
 - d. a place where you can do sports, play ball or action games that involve moving your body, or act out parts in a play or show; do projects in which you can get up and move around; do experiments or explore and discover new things; build things or put together mechanical things; or participate in competitive team activities

17. If you had to remember a new word, would you remember it best by:

- a. seeing it
- b. hearing it
- c. writing it
- d. mentally or physically acting out the word

TOTAL ANSWERS MARKED A: _____

TOTAL ANSWERS MARKED B: _____

TOTAL ANSWERS MARKED C: _____

TOTAL ANSWERS MARKED D: _____

Your preferred learning style is: _____

Appendix B

VCU SCHOOL OF THE ARTS IN QATAR
MATH 131, INTRO TO CONTEMPORARY MATHEMATICS

FALL, 2008

NAME: _____

The Brain Hemispheric Preference Assessment

(Source: Linksman, Ricki. *How to Learn Anything Quickly*. New York: Barnes & Noble Books, 1996. 10-15.)

Instructions: For each question, circle the letter of the answer that **BEST** fits you most of the time. If both answers suit you equally well in this section, **CIRCLE BOTH A AND B**. If you do not understand a word or a question, please ask your instructor for help. Remember, this test is designed to help you learn your own preferences, so there are no right or wrong answers. Answering as truthfully as you can will give you a more accurate picture of your own hemispheric preference.

1. Close your eyes. See red. What do you see?
 - A. The letters *r-e-d* or nothing because you could not visualize it
 - B. The color red or a red object
2. Close your eyes. See three. What do you see?
 - A. The letters *t-h-r-e-e*, or the number 3, or nothing because you could not visualize it
 - B. Three animals, people, or objects
3. If you play music or sing:
 - A. You cannot play by ear and must read notes
 - B. You can play by ear if you need to
4. When you put something together:
 - A. You need to read and follow written directions
 - B. You can use pictures and diagrams or just jump in and do it without using directions
5. When someone is talking to you:
 - A. You pay more attention to words and tune out their nonverbal communication
 - B. You pay more attention to nonverbal communication, such as facial expressions, body language, and tones of voice
6. You are better at:
 - A. Working with letters, numbers, and words
 - B. Working with color, shapes, pictures, and objects
7. When you read fiction, do you:
 - A. Hear the words being read aloud in your head?
 - B. See the book played as a movie in your head?
8. Which hand do you write with?
 - A. Right hand
 - B. Left hand

9. When doing a math problem, which way is easiest for you?
 - A. To work it out in the form of numbers and words
 - B. To draw it out, work it out using hands-on materials, or use your fingers
10. Do you prefer to:
 - A. Talk about your ideas?
 - B. Do something with real objects?
11. How do you keep your room or your desk?
 - A. Neat and organized
 - B. Messy or disorganized to others, but you know where everything is
12. If no one is telling you what to do, which is more like you?
 - A. You do things on a schedule and stick to it
 - B. You do things at the last minute or in your own time, and/or want to keep working even when time is up
13. If no one were telling you what to do:
 - A. You would usually be on time
 - B. You would often be late
14. You like to read a book or magazine:
 - A. From front to back
 - B. From back to front or by skipping around
15. Which describes you best?
 - A. You like to tell and hear about events with all of the details told in order
 - B. You like to tell the main point of an event, and when others are telling you about an event you get restless if they do not get to the main idea quickly
16. When you do a puzzle or project, do you:
 - A. Do it well without seeing the finished product first?
 - B. Need to see the finished product before you can do it?
17. Which method of organizing notes do you like best:
 - A. Outlining or listing things in order?
 - B. Making a mind map, or web, with connected circles?
18. When you are given instructions to make something, if given the choice, would you:
 - A. Prefer to follow the instructions?
 - B. Prefer to think of new ways to do it and try it a different way?
19. When you sit at a desk, do you:
 - A. Sit up straight?
 - B. Slouch or lean over your desk, lean back in your chair to be comfortable, or stay partly out of the seat?

20. When you are writing in your native language, which describes you best?
- A. You spell words and write numbers correctly most of the time
 - B. You sometimes mix up letters or numbers or write some words, letters, or numbers in reverse order or backward
21. When you are speaking in your native language, which is more like you?
- A. You speak words correctly and in the right order
 - B. You sometimes mix up words in a sentence or say a different one than what you mean, but you know what you mean
22. You usually:
- A. Stick to a topic when talking to people
 - B. Change the topic to something else you thought of related to it
23. You like to:
- A. Make plans and stick to them
 - B. Decide things at the last minute, go with the flow, or do what you feel like at the moment
24. You like to do
- A. Art projects in which you follow directions or step-by-step instructions
 - B. Art projects that give you freedom to create what you want
25. You like:
- A. to play music or sing based on written music or what you learned from others
 - B. to create your own music, tunes, or songs
26. You like to play or to watch:
- A. Sports that have step-by-step instructions or rules
 - B. Sports that allow you to move freely without rules
27. You like to:
- A. Work step-by-step, in order, until you get to the end product
 - B. See the whole picture or end product first and then go back and work the steps
28. Which describes you the best?
- A. You think about facts and events that really happened
 - B. You think in an imaginative and inventive way about what could happen or what could be created in the future
29. You know things because:
- A. You learn from the world, other people, or reading
 - B. You know them intuitively, and you can't explain how or why you know
30. You like to:
- A. Stick to facts
 - B. Imagine what could be

31. You usually:
- A. Keep track of time
 - B. Lose track of time
32. You are:
- A. Good at reading nonverbal communication
 - B. Not good at reading nonverbal communication
33. You are:
- A. Better at directions given verbally or in writing
 - B. Better at directions given with pictures or maps
34. You are better at:
- A. Being creative with existing materials and putting them together in a new way
 - B. Inventing or producing what is new and never existed
35. You usually work on:
- A. One project at a time, in order
 - B. Many projects at the same time
36. In which of the following environments would you prefer to work?
- A. A structured environment where everything is orderly, someone is telling you what to do, a time schedule is kept, and you do one project at a time, step-by-step and in order
 - B. An unstructured environment where you have freedom of choice and movement to work on what you want, where you can be as creative and imaginative as you want, keep your belongings any way you want, and do as many projects as you wish simultaneously, without any set time schedule

TOTAL ANSWERS MARKED A ONLY: _____

TOTAL ANSWERS MARKED B ONLY: _____

TOTAL ANSWERS MARKED BOTH A AND B: _____

Your preferred hemispheric preference is: _____

SCORING INSTRUCTIONS FOR THE LEARNING STYLES PREFERENCE AND THE HEMISPHERIC PREFERENCE TESTS

Learning Styles Assessment:

Total the scores for each letter of the assessment. If you gave more than one answer for any question, include all of the choices in the total for each letter.

TOTAL A: _____ If A is highest, you are VISUAL

TOTAL B: _____ If B is highest, you are AUDITORY

TOTAL C: _____ If C is highest, you are TACTILE

TOTAL D: _____ If D is highest, you are KINESTHETIC

Also note your second, third, and least preferred learning styles. Some people have developed several or all learning styles, and two, three, or all four styles may be tied.

Brain Hemispheric Preference Assessment:

Score one point for each question you answered with only A and write the total: _____
If your highest score is A, you prefer the LEFT HEMISPHERE.

Score one point for each question you answered with only B and write the total: _____
If your highest score is B, you prefer the RIGHT HEMISPHERE.

Score one point for each question you answered with both A and B and write the total: _____
If your highest score is in both A and B (tied), you are INTEGRATED.

If you have almost the same number of checks for A and B (not including the tied A and B column), you may have a MIXED preference and are using each side of the brain for different functions.

If your scores for the single A and the single B are within 1-2 points of each other, you have a MIXED preference favoring the (A/LEFT, B/RIGHT) hemisphere.

Appendix C

VCUQ MATH 131, INTRO TO CONTEMPORARY MATHEMATICS
FALL, 2008

INCORPORATING WRITING INTO PROJECT-DIRECTED MATHEMATICS

Why write in a math course?

As you may already have learned in your English classes, writing is a way of finding out both what you already know about something and what you do not know about something.

Often, our thoughts are flitting around in our minds like butterflies that need to be captured and held in our hands for examination before we can tell what kinds of butterflies we have, what colors they are, and how many we've caught. Writing—the act of physically putting thoughts on paper—enables us to capture and examine our thoughts, as well as to re-examine them at any time in the future that we choose.

For many students, math is an especially difficult subject, and, if the math course content is well-chosen and well-designed, you will discover within it something that is new to you, even if you are already a good math student. Research about how we learn shows that successful learning requires “multi-representational and integrative re-inforcement, . . . self-provided feedback . . . [both] immediate and long-term, . . . conceptual groupings, . . . [and is] active, engaged, personal . . .” (Emig 91). Writing can be used to improve learning by accomplishing these things.

How can I write to improve my learning in a math course?

The writing method you will be using this semester is a personal journal in which you may “talk” to yourself about your math fears, questions, discoveries, etc. Periodically, you will be given a specific homework assignment to write in your journal. These assignments are **required**, but you may write anything else in your journal that you wish.

Journals will be collected at times to check that you have done this assigned thinking/writing. Entries can be “first drafts” with spelling and grammatical errors, but they must be readable and understandable by your professor as well as yourself. If your journal contains the assigned writing when it is due, you will receive a checkmark (✓) worth one homework point (1) for having done the assignment. If your entry is especially detailed and exhibits extensive thinking about the assigned topic, you may earn a check-plus (✓+) that will add two (2) homework points. Any missing or late assignments will earn a minus (-), which is a negative point (-1) from your total homework points. Points earned will be added to the possible 250 homework points (acting as extra credit); points deducted will be subtracted from the possible 250 homework points (thus reducing your homework grade).

Emig, Janet. “Writing as a Mode of Learning.” *The Writing Teacher’s Sourcebook*, 2nd ed. Gary Tate and Edward P.J. Corbett, eds. New York: Oxford University Press, 1988. 85-91.

Appendix D

FIRST THREE JOURNAL ASSIGNMENTS

DUE: SEPTEMBER 22, 2008

(Note: Identify each REQUIRED assignment in your journal with the number and topic.)

1. Learning Styles & Hemispheric Preferences (“Super Links”)

Observe the teaching of any one of your professors during two class periods and note what he/she does that fits in with your preferred learning style and hemispheric preference. Use the same professor for both class observations. In your journal,

- state your preferred style and hemisphere,
- identify what the professor did to appeal to your “Super Link” (or failed to do if that is the case), and
- discuss alternative things the professor could have done to appeal to your “Super Link.”

2. History of Fibonacci

Read the brief biography of Leonardo Fibonacci on Page 328 of your math textbook (and other sources if you wish). Note the statement, “Leonardo was not the first European to learn the Hindu-Arabic system of numbers and their arithmetic, but he was the first one to truly grasp their extraordinary potential.”

What do you think Fibonacci saw in this system that others did not? How do you think that his knowing this system influenced his discovery of the Fibonacci sequence?

3. Geometric and Arithmetic Sequences

How could geometric and arithmetic sequences be applied in Fashion Design, Graphic Design, or Interior Design? Create one example for using an arithmetic sequence and one for using a geometric sequence in your design major (or your intended major if you haven’t yet declared a major). This is an opportunity to think creatively—your application does not have to be one that now exists but could be one that you design for the future.

SECOND SET OF THREE JOURNAL ASSIGNMENTS

DUE: OCTOBER 20, 2008

*The following assignments address topics that you will cover in the next sections of MATH 131. Complete all three assignments in your journal. Remember to identify each as a **REQUIRED ASSIGNMENT** with its number and topic.*

1. Finance, Investing Money, and Sales

Are you finding the math problems involving sales, discounts, interest, etc., easy, hard, or somewhere in between? Think about your experience until now with financial matters as well as your “Super Link” and your math homework. Write in your journal about why you are reacting to this section as you are.

2. Symmetry

For this assignment, choose ONE of the following items and sketch or paste a picture of it with this assignment in your journal to help you visualize and think about the item:

- Mosque, Church, or other place of worship (your choice of ONE)
- Any statue
- A stained-glass window
- The pattern on a fabric, a rug, or wallpaper (choose ONE)
- A window display at your favorite store
- A web ad, billboard, or other advertisement (choose only ONE)
- A furnished room or an unfurnished room (choose EITHER but NOT BOTH)
- One alphabetic letter of your choice printed in Helvetica (a sans serif typeface)

Think about the symmetry of your chosen object. Write about its type of symmetry (or its lack of symmetry) and explain what happens when each one of these terms is applied to it: *rotations*, *reflections*, *translations*, *glide reflections*. If one or more of these terms cannot be applied to your object, why not? Do any of these terms give you an interesting idea for redesigning your object in some way?

3. Fractals

On Page 432 of your textbook, the conclusion to Chapter 12 says: “The study of *fractals* and their geometry . . . is a part of mathematics that combines complex and interesting theories, beautiful graphics, and extreme relevance to the real world.” How do fractals relate to your major or intended major (Fashion Design, Graphic Design, or Interior Design)? Think of something in your design field that is typically circular, square, or triangular. Using your imagination, re-design this item by using fractals instead of the circles, squares, or triangles. What would it look like? Is this even possible? Why or why not? (IF YOU LIKE, use sketches with your writing to illustrate your ideas or to help you think through this assignment.)

THIRD SET OF THREE JOURNAL ASSIGNMENTS

DUE: NOVEMBER 24, 2008

*The following assignments address topics that you will cover in the next sections of MATH 131. Complete all three assignments in your journal. Remember to identify each as a **REQUIRED ASSIGNMENT** with its number and topic.*

3-1. Fractals

Carry your knowledge of fractals one step farther by choosing ONE of the following options to write about in your journal:

- Read more about the life of Benoît Mandelbrot and discuss in your journal
 - (a) one thing that you find surprising about him,
 - (b) why you find it surprising, and
 - (c) what role, if any, you think it played in his work on fractals.
- Search the Web for designs for fractals. Select several web designs for fractals to examine (at least three) and discuss in your journal
 - (a) what features they have in common, if any;
 - (b) whether you find them aesthetically pleasing as a group or not and why; and
 - (c) how they inspire you as a designer (or not).

(You may want to paste or tape pictures of your chosen fractals in your journal—this is optional.)

3-2. Complex Numbers

In your journal, explain complex numbers as you understand them.

3-3. Graph Theory

Choose ONE of the following four options to write about in your journal:

- What does the Königsberg Bridge Problem teach interior designers about traffic flow within buildings?
- For the following three options, select your favorite type of graph and read about the person for whom it was named. How/what in that person's life influenced the development of his graph theory?
 - (a) Euler graphs and the history of Leonhard Paul Euler
 - (b) Hamilton paths and the history of William Rowan Hamilton
 - (c) Kruskal's algorithm and the history of Joseph Kruskal

Appendix E

One-minute Response Paper Ideas

- What was the muddiest point in the lesson?
- What was the most important point?
- How useful/interesting was the lesson?

- What did you not understand in the previous class?
- What was the strongest point in the previous class?
- What do you want to know more about?

Use this before the current lesson:

- What do you already know about this topic?
- How do you think [earlier course material] might tie in with this lesson?

Use this after the current lesson:

- Summarize what you learned today
- How do you feel about your understanding of this material?
- Explain how you would tell someone else about this topic
- What did you learn today that was different from what you knew before?

- If you were a [fashion designer, graphic designer, interior designer, whatever], how would you use [whatever this math topic is] to [give specific activity]?

Appendix F

MATH 131 Course Survey Fall, 2008

NAME: _____

Your answers to this questionnaire will help us identify ways to improve MATH 131. Please answer each question as honestly and as completely as possible. Your answers will in no way affect your course grade.

1. What were YOUR brain hemispheric preference type and your preferred learning style? *(If you do not remember, please state "Don't know" in each blank.)*
_____ and _____
2. Did you pay attention to your learning and hemispheric preferences as you studied MATH 131 this semester? _____YES _____NO
3. Did you pay attention to your learning and hemispheric preferences as you studied any of your other courses this semester? _____YES _____NO
4. Should the information about brain hemispheric preference and learning style continue to be included in MATH 131? _____YES _____NO

Why or why not? _____

5. Overall, were the journal assignments helpful to your understanding of topics in MATH 131?
_____YES _____NO

Why or why not? _____

6. Which journal assignment was MOST helpful to you? *(Check only one answer)*
_____ **1.1 Learning Styles & Hemispheric Preferences ("Super Links")** (observing a professor and your Super Links)
_____ **1.2 History of Fibonacci** (what Fibonacci saw that others didn't)
_____ **1.3 Geometric and Arithmetic Sequences** (thinking creatively about applications in your major field)
_____ **2.1 Finance, Investing Money, and Sales** (your reaction to this section)
_____ **2.2 Symmetry** (write about the symmetry of an item you choose)
_____ **2.3 Fractals** (how you think they relate to your major)
_____ **3-1 Fractals** (carry them one step farther)
_____ **3-2 Complex Numbers** (explain them as you understand them)
_____ **3-3 Graph Theory** (write about the Konigsberg Bridge problem or one graph theorist)

Why was this one helpful? _____

7. Which journal assignment was LEAST helpful to you? (*Check only one answer*)
- ☐ **1.1 Learning Styles & Hemispheric Preferences (“Super Links”)** (observing a professor and your Super Links)
 - ☐ **1.2 History of Fibonacci** (what Fibonacci saw that others didn’t)
 - ☐ **1.3 Geometric and Arithmetic Sequences** (thinking creatively about applications in your major field)
 - ☐ **2.1 Finance, Investing Money, and Sales** (your reaction to this section)
 - ☐ **2.2 Symmetry** (write about the symmetry of an item you choose)
 - ☐ **2.3 Fractals** (how you think they relate to your major)
 - ☐ **3-1 Fractals** (carry them one step farther)
 - ☐ **3-2 Complex Numbers** (explain them as you understand them)
 - ☐ **3-3 Graph Theory** (write about the Konigsberg Bridge problem or one graph theorist)

Why was this one not helpful (or much less helpful)? _____

8. Should journal assignments continue to be included in MATH 131? ☐ YES ☐ NO

Why or why not? _____

9. How helpful were the previous students’ projects shown as examples in class?

☐ very helpful ☐ not very helpful
☐ somewhat helpful ☐ not helpful at all

Why? _____

10. How helpful were the projects you completed for this course?

☐ very helpful ☐ not very helpful
☐ somewhat helpful ☐ not helpful at all

Why? _____

11. Do you think differently about anything after taking MATH 131 than you did before taking it?

☐ YES ☐ NO

If yes, WHAT; if no, WHY DO YOU THINK THIS IS SO? _____

12. Which of the math topics covered this semester do you remember and understand best? Why?

TOPIC: _____

WHY? _____

13. What would YOU have preferred in this math class? Lectures? Problems to solve alone in class? Problems to solve alone outside of class? Problems to solve with classmates either in or out of class? No projects to complete? More projects to view from previous classes? Something else? Please explain below:

14. Will you be able to use anything you learned from MATH 131 in your career?

___YES, I will be able to use _____

___NO, I will not be able to use anything BECAUSE _____

15. What is your major? (*Write "Undeclared" if you do not yet have a major.*)

16. Does anything you learned from MATH 131 apply to your daily life either now or in the future?

_____YES _____NO

If yes, WHAT; if no, WHY NOT? _____

Appendix G

MATH 131

FORMULAS FOR MATH 131

FORMULAS FOR MATH 131

Fibonacci Numbers (Recursive Definition)

$$\text{Seeds : } F_1 = 1$$

$$F_2 = 1$$

$$\text{Recursive rule : } F_n = F_{n-1} + F_{n-2}, \quad n \geq 3$$

Binet's Formula

$$F_n = \frac{\left(\frac{1+\sqrt{5}}{2}\right)^n - \left(\frac{1-\sqrt{5}}{2}\right)^n}{\sqrt{5}}$$

Arithmetic Sequence or the linear growth model:

$$\text{Explicit description : } a_n = a_0 + n \cdot d$$

$$\text{Sum : } a_0 + a_1 + a_2 + \dots + a_{n-1} = \frac{(a_0 + a_{n-1}) \cdot n}{2}$$

Geometric Sequence or the exponential growth model:

$$\text{Explicit description : } p_n = p_0 \cdot r^n$$

$$\text{Sum : } p_0 + p_0 r + p_0 r^2 + p_0 \cdot r^3 + \dots + p_0 \cdot r^{n-1} = \frac{p_0(r^n - 1)}{r - 1}, \quad r \neq 1$$

Compounding Formula:

$$\text{Total Amount : } P_N = P_0 \times \left(1 + \frac{i}{k}\right)^{N \times k}$$

Appendix H

MATH 131 KOCH SQUARE SNOWFLAKE WORKSHEET- INCLUDES THE SOLUTIONS

START:

Start with a solid square, perhaps 9 boxes wide and 9 boxes high, in the middle of a sheet of graph paper.

STEP 1:

Divide each side of the square into 3 equal segments (3 boxes wide). Attach to the middle segment of each side of the figure a solid square with dimensions equal to one third of that side. (That would be 3 boxes wide and 3 boxes out).

STEP 2:

Divide each side of the outside edges again (this now would be 1 box wide), and place them in the middle again.

STEP 3:

Try to do it again. This time the square will be very small since it would only be $\frac{1}{3}$ of a box wide and high.

We will continue next class with the mathematics.

KOCH SQUARE SNOWFLAKE SOLUTIONS

Number of sides START	4
Step1 Number of sides	5(4)
Step 2 Number of sides	5(5)(4)=5 ² (4)
Step 3 Number of sides	5(5 ²)(4)=5 ³ (4)
.....	
Step N Number of sides	5 ^N (4)
Also not at start we have one square At Step 1 we have 20 sides but 4 new squares. At Step 2 we have 100 sides but 20 new squares. At each step we have the number of new squares equal to the number of sides from the previous step.	
Perimeter START one side	S
START All sides	4(S)
Step 1 Length of one new side	1/3(S)
Step 1 Length of all sides	5(4)(1/3S)=4(5/3)(S)
Step 2 Length of one new side	1/3(1/3)(S)=(1/3) ² (S)
Step 2 Length of all sides	5 ² (4)(1/3) ² (S)=4(5/3) ² (S)
Step 3 Length of one new side	(1/3)(1/3) ² (S)=(1/3) ³ (S)
Step 3 Length of all sides	5 ³ (4)(1/3) ³ (S)=4(5/3) ³ (S)
.....	
Step N Length of all sides	4(5/3) ^N (S)
Also note each side gives one new square on the next step.	

Area START	A
Step 1 Area of one new square	(1/3)(1/3)A=(1/3) ² A
Step 1 Area of all new squares	4(1/3) ² A=4/9(A)
Step 1 Total Area	A+4/9A
Step 2 Area of one new square	(1/9)(1/9)A=(1/9) ² A
Step 2 Area of all new squares	(5)(4)(1/9) ² A=(5/9)(4/9)(A)
Step 2 Total Area	A+4/9A+(5/9)(4/9)(A)
Step 3 Area of one new square	(1/9)(1/9) ² A=(1/9) ³ A
Step 3 Area of all new squares	5 ² x4(1/9) ³ A=(5/9)(5/9)(4/9)(A)
Step 3 Total Area	A+4/9A+(5/9)(4/9)A+(5/9)(5/9)(4/9)(A)

$$\text{Step N Total Area} = A + (4/9)A + 4/9(5/9)A + 4/9(5/9)^2A + \dots + 4/9(5/9)^{N-1}A$$

$$= [2 - (5/9)^N]A \text{ and as we increase steps the total area goes to } = 2A$$

Appendix I

MATH 131 SIEPINSKI GASKET FRACTAL WORKSHEET

START:

Start with an equilateral triangle, perhaps using a 24-box base and 24 box lengths for the other two sides.

STEP 1:

From the middle of each side of a triangle draw another triangle. Remove this triangle.

STEP 2:

From the middle of each side of the remaining triangles draw another triangle and remove it as in the previous step.

STEP 3:

Repeat the process and fill out the mathematical worksheet attached.

**SIERPINSKI GASKET
MATHEMATICS**

Number of sides START	3	Number of triangles =1
Step1 Number of sides	3(3)	Number of triangles=
Step 2 Number of sides		Number of triangles=
Step 3 Number of sides		Number of triangles=
.....		
Step N Number of sides		Number of triangles=
Perimeter START one side	s	
START All sides	3(s)	
Step 1 Length of one new side	$\frac{1}{2}s$	
Step 1 Perimeter of one new triangle		
Step 1 Perimeter of all new triangles		
Step 2 Length of one new side		
Step 2 Perimeter of one new triangle		
Step 2 Perimeter of all new triangles		
Step 3 Length of one new side		
Step 3 Perimeter of one new triangle		
.....		
Step 3 Perimeter of all new triangles		
Step N Length of one new side		
Step N Perimeter of one new triangle		
Step N Perimeter of all new triangle		

Area START	A
Step 1 Area of one new triangle	$\frac{1}{4}A$
Step 1: Total area of all new triangles	
Step 2 Area of one new triangle	
Step 2 Total area of all new triangles	
Step 3 Area of one new triangle	
Step 3 Total area of all new triangles	
.....	
Step N Area of one new triangle	
Step N Total area of all new triangles	