Maciejewski, W. (2012). A College-Level Foundational Mathematics Course: Evaluation, Challenges, and Future Directions. *Adults Learning Mathematics: An International Journal, 7*(1), 20-31.

A College-Level Foundational Mathematics Course: Evaluation, Challenges, and Future Directions

Wes Maciejewski

Queen's University
Canada
< wes@mast.queensu.ca>

Abstract

Recently in Ontario, Canada, the College Math Project brought to light startling data on the achievement of students in Ontario's College of Applied Arts and Technology System related to their performance in first-year mathematics courses: one-third of the students had failed their first-year mathematics course or were at risk of not completing their program because of their performance in such a course. Here I present the results of an attempt to address the findings of the College Math Project. A foundational mathematics course, based on the JUMP Math program, was designed and implemented at a college in Toronto, Ontario. Although the students who took this program made appreciable gains in their achievement, it is difficult to assert its effectiveness over other programs because of the absence of studies profiling college math education practices either in Canada or internationally. The intention of this article is to help establish a datum for research into specific college math education programs.

Key words: college mathematics education.

Introduction

In 2007 a group of colleges in Ontario, Canada (Centennial, Humber, George Brown, Georgian, Seneca, and Sheridan) sponsored the College Mathematics Project (CMP), designed to gain insight into the mathematics achievement of first-year college students in Ontario. The CMP analyzed the records of over 10,000 students who had enrolled in a first-semester mathematics course at one of the participating colleges. The results of the project were startling: 34% of students received a grade of D or F in their first-semester mathematics courses, jeopardizing their progress (Assiri, Byers, Orpwood, Schollen, & Sinclair, 2008). The study was replicated in 2008 and 2009 including data from all Ontario colleges, with similar results (Assiri, Orpwood, Schollen, & Sinclair, 2009; Orpwood, Schollen, Marinelli-Henriques, & Assiri, 2010).

To conclude the 2007 CMP, the participating colleges came to a consensus on two points: that student achievement in first-semester mathematics courses in Ontario colleges needs to be significantly improved, and that the attainment of this goal requires concrete action by all stakeholders (Assiri et al., 2008). To address these points, the CMP colleges proposed a list of suggestions for action. The CMP recommends that "colleges and college faculty strengthen their commitment to student retention and success by adopting initiatives found effective in other colleges", and that "the Government of Ontario adopt a 'K-16' vision of student success and continue to support research into the interface between levels". The conclusions of the CMP 2008 and 2009 are of the same spirit as these (Assiri et al., 2009; Orpwood et. al., 2010).

At this point, it is important to clarify what a college is in the Canadian context. The community college systems in Canada are quite diverse and vary from province to province (Gallagher & Dennison, 1995). Throughout the present article I take 'college' to mean an Ontario College of Applied Arts and Technology.

The purpose of the present study is to report on an implementation of a college-level foundational mathematics course designed to address the recommendations of the CMP. The course is based on the materials and methods of the JUMP Math program (Mighton, 2003; Mighton, 2008). JUMP Math, a charitable organization dedicated to increasing general numeracy, is in a unique position to answer the call of the CMP. Since its incorporation in 2001, JUMP Math has produced course materials for grades 1 to 8 which cover the entire Ontario mathematics curriculum and has developed a corresponding method of delivery and instruction. The JUMP Math approach has produced favourable anecdotal results in Vancouver, Canada, and London, England ("JUMP Math-Brock University Pilot Study", 2005; "Lambeth Pilot Programme", 2006). A more recent controlled-group study comprising 272 students from 29 classrooms across 18 schools in a rural Canadian school board found that the mathematics knowledge of those students assigned to the JUMP Math classes grew twice as much as those in the control group (Solomon, Martinussen, Dupuis, Gervan, Chaban, Tannock, & Ferguson, 2011). The school boards that have adopted JUMP Math methods indicate a significant improvement in their students' academic performance, a significant decrease in math anxiety, and an overall increase in the positive attitudes among students toward mathematics (Hughes, 2004; "Jump for Joy!", 2004). As I will discuss, these latter factors can greatly affect a student's performance in mathematics.

In 2009, I was involved in implementing a JUMP Math curriculum in three separate courses at a college in Ontario. Initially, the study was designed to compare student gains over the term to historical data. This approach was abandoned, however, once the complexities of the college environment emerged. It is the goal of the current article to discuss these complexities so that future research may benefit.

Background

The College Learning Environment

Adapting a program intended for primary school students to the college learner is a challenging endeavour, in large part due to the overall insufficient understanding of the latter demographic (Coban, 2006; de Brouker & Myers, 2006). As will be discussed at the conclusion of this study, very little research has been preformed on college math learners, especially in the Canadian context. There is, however, a solid body of research on affects of the adult learner which we will take as relevant to this study. Among these, attitudes toward mathematics, specifically mathematics anxiety, appears to be a vital indicator of student success (Hembree, 1990; Ma, 1999; Tobias, 1978). Students with high math anxiety perform significantly lower on any evaluation of math ability than those comfortable with math. Ashcraft and Krause (2007) argued that math anxiety occupies the working memory leaving less devoted to the mathematical task. As the difficulty of a math problem increases, requiring more working memory, those with high anxiety perform increasingly worse than those with low or no anxiety. Clute (1984) recognized the significance of anxiety in student learning and studied the effects of two different instructional approaches on college math learners. Those students with high math anxiety benefited, in terms of higher achievement on a standardized test, from an approach based on explicit instruction, heavily reliant on tightly scaffolded lessons.

A correlation does not, however, appear to exist between math anxiety and ability in elementary mathematics. Ashcraft and Krause (2007) found essentially no difference between the scores of a group of highly math anxious undergraduate students and a group of low anxiety students on the elementary arithmetic questions on a standardized test. A difference did emerge as the questions became more difficult; the high-anxiety group answered fewer questions accurately than those with low anxiety. This characteristic impedes objective assessment of a learner's mathematical ability and may stem the progress of students who are capable, but who do not conform to certain assessment practices.

Other factors have been shown to affect demonstrable mathematical ability. Among these are self-concept, value, enjoyment, and motivation (Aiken, 1976; Bandalos, Yates, & Thordike-Christ, 1995; Csikszentmihalyi & Schiefele, 1995). Language ability has also been indicated as a predictor of success in math (Abedi & Lord, 2001) and may be an especially important variable in the college environment as many college students have low language ability.

The three courses involved in this study are 'foundational' or 'remedial'. That is, the students have, at some point in their prior education, been exposed to the course material. The students in these courses may have been classified as 'at risk' (AR) prior to enrolling in the college. Indeed, many of the students involved in the current research were classified as learning disabled (LD). There is a growing body of research on effective instruction for AR and LD adolescents which may be relevant to the current study. One method of instruction that has consistently provided strong results is explicit instruction (Kroesbergen & van Luit, 2003; Kroesbergen, van Luit, & Maas, 2004; Swanson, Carson, & Sachse-Lee, 1996; Swanson & Hoskin, 1998; Swanson & Hoskin, 2001) where a task is decomposed into small sub-tasks and extensive guidance and individual practice is offered.

In terms of course content, there is a tendency in college, and adult, education to present the students with 'real world' problems, even though these may not draw on the student's real-world experiences (Oughton, 2009). Emerging research, however, indicates that students may learn concepts more deeply and have a greater transference of the concept to novel situations if they learn from abstract instantiations of the concept. Kaminski, Sloutsky, and Heckler (2008) presented groups of undergraduate students with an abstract mathematical concept. One group received instruction via an abstract instantiation of the concept while other groups received instruction through concrete examples. The abstract group significantly outperformed the concrete groups in transferring the concept to a novel situation. In a further experiment, one group learned through the abstract representation and then were provided with a concrete example of the concept while another group were exposed to only the abstract representation. Again, the purely abstract group outperformed the abstract-concrete group. This suggests that students may benefit from an instructional approach that de-emphasizes concrete examples. This may be particularly relevant to the college environment since not only do language barriers appear to play a role in student success in mathematics (Abedi & Lord, 2001), such examples are situated with language that often may be colloquial or unfamiliar.

The JUMP Math program was specifically designed around all of the factors above. It is for this reason that JUMP Math was deemed appropriate for the college learner.

A Primer on JUMP Math

JUMP Math was founded in the 1990's by John Mighton, mathematician and playwright, as a tutoring system for children (Mighton, 2003; Mighton, 2007). Since that time the organization has grown significantly and currently produces workbooks that correspond to the K-8 curricula across Canada. The JUMP Math method is geared toward reducing students' anxiety toward mathematics. This is accomplished by guiding the students through a series of problems, all relating to one topic and predominately abstract in nature, that become only slightly more difficult from one to the next. As Mighton (2007) writes, “Children become very excited when they succeed in meeting a series of graduated challenges, and this excitement allows them to focus and take risks in their work.” For an example of a graduated challenge, Mighton (2007) recounts his experience with Matthew, an autistic child with high levels of math anxiety:

> ...'Matthew, you're very smart. Could you add these fractions?' and I wrote: 1/17 + 1/17. When he had written the answer, 2/17, I said, “You're amazing! Could you add these?” [and I wrote] 1/39 + 1/39. When he had answered that question, I said, “You're in big trouble now. I'll have to give you these.” [writing] 1/73 + 1/73. As I continued to increase the size of the denominators, Matthew became more and more excited. After he had successfully added a pair of fractions with denominators in the hundreds, he was beside himself. (Mighton, 2007, p. 16)

Although Matthew was a learner with exceptionalities, this lesson exemplifies the JUMP Math method. The questions provided to Matthew are all identical in terms of their mathematical content, but they do differ in difficulty from Matthew's perspective. Students relate difficulty of an arithmetic question with the size of the numbers (Ashcraft & Krause, 2007). By increasing the size of the numbers without altering the question, the tutor was able assist Matthew in overcoming his fear of numbers through helping him realize that number size does not affect the operation.

The primary component of the JUMP Math course is the printed workbooks, a main feature of which is their pared-down style. Lessons are presented succinctly, using few words and extraneous pictures. The light-on-language approach should assist the college learner with lower language ability (Abedi & Lord, 2001; Ciancone, 1996). Also, there is evidence that excessive diagrams and pictures in textbooks can serve as a distractor to students (DeLoache, 2005).

JUMP Math appears to be a good fit with what the literature identifies as effective instruction for AR and LD students, which comprises the majority of the student demographic included in this study. The JUMP Math method of instruction may be classified as explicit instruction following (Swanson and Hoskin, 2001). The incremental steps in the lessons, coupled with copious feedback and extensive practice, are intended to reduce anxiety and increase self-concept in and enjoyment of mathematics. It is for these reasons that JUMP Math was chosen for the college setting. Previous studies on JUMP Math have provided favourable results (Hughes, 2004; “Jump for Joy!”, 2004; “JUMP Math-Brock University Pilot Study”, 2005; “Lambeth Pilot Programme”, 2006) which lends support to the use of JUMP Math. In addition, the material covered in the college foundational courses corresponds to the Ontario grade 8 curriculum, which is covered entirely by the corresponding JUMP Math material.

A Description of the Courses

Three classes were included in this study, one first-year foundational course in a General Arts and Science program (GAS), one in the traditional College Vocational program (CV+), and one in the College Vocational program from lower-achieving students (CV). The GAS course is for students enrolled in a liberal arts program. Students who receive a grade of less than 50% on a computer-based placement exam are required to enrol in the GAS course. Students are also able to place themselves into the course if they feel unprepared for college study. The CV and CV+ courses are a part of a program designed to prepare for meaningful employment students who are not typically considered for college admission.

All three courses cover basic number facts and operations—addition, subtraction, multiplication, and division—with rational numbers, including positive and negative integers and fractions; linear algebraic equations; the order of operations—brackets, exponents, division, multiplication, addition, and subtraction; ratio, proportion, and percent; basic graphical techniques; and, basic manipulation of equations containing variables. The level of difficulty of the GAS course is comparable to that of the Ontario grade eight curriculum while the CV and CV+ course are at a grade six level.

Instructors volunteered for the course and underwent a three-day training prior to the start of the course with a refresher training mid-term. The training session consisted of two main components: a description of the student affects of which an instructor should be cognisant, and the pragmatic implementation of a JUMP Math lesson. In addition, instructors received teacher resources from JUMP Math, including a teacher's guide comprising detailed lesson plans.

Methodology

As outlined above, a list of factors was employed to evaluate the course: change in student's technical math ability; change in student's attitudes toward math; student's enjoyment of, and general comments about, the course; the instructor's perceptions of how well the students performed, in terms of their engagement and mastery of concepts, relative to previous years; and instructor's feelings and general comments about the course. The first two are quantitative in nature and were measured with two tests, one on basic math concepts and operations covered in the course, and one designed to measure the student's attitudes toward mathematics, both offered once at the start and once at the conclusion of the course. The math test was the Canadian Adult Achievement Test, a standardized test. The second was the Mathematics Attitude Inventory (MAI) (Sandman, 1980).

The MAI was administered to gauge the student's attitudes toward math. The test is designed to measure six constructs of attitudes toward mathematics: (a) Perception of the mathematics teacher; (b) anxiety toward mathematics; (c) value of mathematics in society; (d) self-concept in mathematics; (e) enjoyment of mathematics; and, (f) motivation in mathematics (Sandman, 1980). The first construct was worded to refer to prior instructors for the start of the term and for the current instructor at the end. As outlined in the introduction, all these factors may influence a student's performance in mathematics.

Before the conclusion of the course, an anonymous survey was distributed to the students to record their thoughts about the course. The students were asked to respond to the questions: Compare this course to other math courses you have taken. (Was it too easy/difficult? Did you have enough time for practice?) What was the best thing about this course? What did you not like? What did you like about the JUMP Math workbooks? What did you not like about the JUMP Math workbooks? What helped you learn the most in this class? How could this course be improved? How long has it been since you were in school last? What was the highest level of math you studied before coming to [the college]? Before taking this class, how would you rate your math ability (option to circle 'Advanced', 'Average', or 'Low')? After taking the class, how would you rate your math ability (option to circle 'Advanced', 'Average', or 'Low')? The first several questions are designed to gain insight on what improvements should be made in future offerings of the course. The remaining questions attempted to elaborate on who the students are.

After the conclusion of the course the instructors shared their experiences and thoughts on the courses.

Results

The results of the project are mixed. The CV+ students exhibited the most marked improvements while the CV had more modest gains. Most interestingly the GAS instructor decided to discontinue the exclusive use of the JUMP Math materials and methods in their course. An analysis of this decision is present in the discussion section.

I begin with the results of the MAI. Three factors, perception of the mathematics teacher, self-concept in mathematics, and motivation in mathematics, showed appreciable increases; one, anxiety toward mathematics, a slight increase; one, enjoyment of mathematics, remained effectively unchanged in the CV+ course and decreased in the CV course; and one, value of mathematics in society, decreased (Table 1). This is the first time the MAI was used in this setting and no previous data are available which makes interpretation difficult. At most we can observe change but say nothing about the degree of change. An increase in the values for factors 1, 3, 4, 5, and 6, and a decrease in the factor 2 value, is favourable. This is not what was observed. Anxiety toward mathematics appears to have increased over the duration of the course. However, it is not known exactly when the follow-up MAI was taken; it may have been offered after the instructor mentioned an anxiety-inducing event (e.g., a test). The enjoyment of mathematics factor may be heavily correlated with the individual instructor teaching style and the value of mathematics in society factor may correspond to the nature of the course curriculum. Expanded use of the MAI will provide benchmark data that can be used to evaluate any one course.

	Start			End		
Factors	GAS	CV+	CV	GAS	CV+	CV
1. Perception of the Mathematics Teacher	19,32	20,02	22,97	N/A	27,29	23,90
2. Anxiety toward Mathematics	8,39	8,15	9,21	N/A	8,64	9,72
3. Value of Mathematics in Society	20,57	22,76	22,05	N/A	21,47	20,65
4. Self-concept in Mathematics	13,90	13,83	16,63	N/A	16,03	17,14
5. Enjoyment of Mathematics	21,00	22,04	23,34	N/A	21,99	21,65
6. Motivation in Mathematics	7,97	8,96	9,49	N/A	9,82	10,53

Table 1. Mathematics Attitudes Inventory results.

The results of the CAAT tests are in Table 2. The numbers are average primary/secondary school grade level equivalents and the 'PS' stands for 'post-secondary'. Both CV and CV+ courses demonstrate gains in student achievement. Again, historical data are not available and the values can only be taken to indicate change. The GAS students tested, on average, at a post-secondary level of mathematical ability at the start of the term, well beyond the intended level of the course. This is certainly a factor that influenced the GAS instructor's decision to discontinue the exclusive use of the JUMP Math approach.

	Beginning	End	Change
CV+	6,47	7,46	0,99
CV	5,22	5,68	0,46
GAS	PS	N/A	N/A

Table 2. Average CAAT grade level equivalency scores for the CV and GAS courses.

Survey Responses for CV and CV+

The survey results are quite promising. First, consider the CV+ course. The question what did you like about the JUMP Math workbooks? largely received positive comments. Responses to the follow-up what did you not like about the JUMP Math workbooks? were even more positive: two-thirds were 'N/A' or 'nothing'. Other positive support for JUMP Math includes 'more JUMP math books' in response to how can this course be improved? Responses to the question what did you not like [about the course]? were largely about math in general and nothing specific about the course.

For the CV course, responses to all of the survey questions are mixed. For example, what is the best thing about this course? received 'there was nothing I liked about this math course it was the same math work I did in high school' and 'I think this course is very good'.

And the follow-up question what did you not like? received 'everything was to [sic] easy and boring and we kept on doing the same work for half the semester' and 'I pretty much liked everything'.

A peculiarity emerges when contrasting the responses in the two CV courses. Many of the CV+ students indicate that the course was difficult, while many CV students stress that it was easy. This is difficult to interpret since both courses used the same workbooks, yet the CV students at the start of the course performed at more than a grade level lower than those in CV+ and gained only half a grade level on average by the conclusion of the semester.

Despite the generally positive outcomes observed in the two CV implementations, there are issues that need to be addressed. As we will see, class heterogeneity was a major issue in the GAS implementation of JUMP Math materials. It is an issue here, too, but to a lesser extent. Although a few students with higher ability may not be a concern in the CV+ course, it may be in the CV program, since the students self selected for enrolment. Based on the CAAT scores, there appears to be at least one student who is well beyond the material being presented. This is most apparent in the responses to the survey questions. Some are quite articulate while others are marked with miss-spelling, letter reversal, and low quality penmanship. This may indicate that there are some fundamental literacy and cognitive issues that must be addressed before, or concurrent with, math instruction.

Survey Responses for GAS

In stark contrast to the success of JUMP Math in the CV program, the response to the JUMP Math General Arts and Science (GAS) implementation was mixed, tending to a rejection of JUMP Math. The instructor of the GAS course felt that the methods and materials were not entirely appropriate and decided to abandon JUMP Math mid-semester. Despite this, the results should not be viewed as negative. Much was learned from this experience that will be able to guide the GAS Foundational Math program much more effectively, I believe, than if positive effects were observed. An analysis is called for.

In consultation with the GAS instructor, three factors were identified as contributing to the halting of the JUMP Math implementation: heterogeneity of the student body, the inappropriateness of the JUMP Math materials and methods, and attendance. I consider each of these in turn.

The first is the biggest factor. Severely mathematically deficient students were grouped into the GAS class alongside those deemed only slightly deficient, if deficient at all. The diversity of ability became apparent in the student's attitudes toward the class. The instructor conducted an informal survey mid-semester. The responses are as follows, grouped according to perceived ability of the student:

Intermediate to Advanced Students:

I like the instructor’s step-by-step explanations. Now I remember it. Let’s move on.

When am I going to learn something new? What about algebra and graphing? Not blaming instructor, just course content.

This stuff is too easy!

I got 80s in math in high school. Why are we covering such basic material?

I feel like I’m in Grade 6.

Weaker Students:

I like the JUMP math exercises in the workbooks, especially the fractions unit.

I’m understanding math better than before.

I’m glad I’m taking this level; it provides a good review of material I already know but forgot because I was away from math for a long time.

Heterogeneity is implicated in student survey responses as well. Throughout the survey, 'move quicker' and 'advance more' responses indicate that the entire class is not able to progress as a unit.

The second factor encompasses two concerns. First, the JUMP Math workbooks were found to be excessive. This resonates with some of the students: 'very repetitive' and 'I didn't like the repeating of the questions' were common survey responses. However, one student indicated that 'there was nothing I did not like' about the JUMP Math workbooks and, in response to “how can this course be improved?”, wrote 'do more work in the JUMP workbooks'. Second, the workbooks did not align entirely with the course syllabus. As will be discussed, there is often a tension between the course outcomes and what an instructor can deliver effectively.

Attendance was low and marked with tardy arrivals into class—a rampant problem across the college campus. This, however, may be attributed to the early class time, 8:00 A.M.—a factor mentioned in the student surveys.

The course offering was not entirely unsuccessful, as is indicated in the year-end surveys. Some of the responses are worth analysing. Consider the question “what did you like about the JUMP Math workbooks?” Although one student responded with 'I didn't really like them, they made me feel like I was in grade 2', others wrote 'they were helpful' and 'useful', and that they 'laid everything out well'. I interpret these mixed responses as indicating that the materials are not far off base and that refining them may make materials appropriate for this type of course.

Discussion

This study was designed to evaluate the effectiveness of a JUMP Math-based college-level foundational mathematics course. During the study, however, more was learned about the college math environment than about the program itself.

Despite potential limitations, this study represents a step toward addressing the recommendations of the College Mathematics Project. Indeed, this study could be viewed as more than pragmatic; it is attempting to break ground by addressing a demographic of students in Canada that have been neglected and allowed to fall by the wayside. Very little research, if any at all, has been preformed on the college math learner in Canada. A cursory search through the major channels for education research in Canada (ERIC, College Quarterly, Canadian Journal of Education, Google Scholar, Canadian Journal of Higher Education) reveals only few articles on the Canadian college demographic. Much more research has been conducted in the United States. Also, there has been increasing activity recently in the field of Adult Numeracy (Condelli, 2006), a domain that has significant overlap with college math education. A few international organizations exist that promote research in adult numeracy and mathematics education; of note, Adults Learning Mathematics (ALM) has emerged as a preeminent research forum on the issues of adult numeracy—the group publishes a bi-annual journal and hosts an annual conference. Despite the interest in, and the appearance of, a well-established body of research on adult numeracy, very little focus has been placed on pedagogical practices (Tout & Schmidt, 2002). A report by the National Research and Development Centre for Adult Literacy and Numeracy in the United Kingdom sought to address the questions “what is known from research about effective pedagogy?” and “what factors in teaching cause adult learners to make progress in adult literacy and numeracy?” The report analysed over 4,500 publications and concluded that “there were very few studies that provided quantitative evidence to answer these questions,” (Brooks et al., 2004). Adult numeracy, however, seems too broad a term and may encompass too diverse a demographic for the purposes of this study or future studies in this vein. It is evident that further research is needed not only in the field of college math education, but on the connections of this field to adult numeracy.

It is not clear how well the research that has been performed on the college math learner outside of Canada transfers to the Canadian context. For example, the term "college" has a very different meaning in the United States than in Canada, and within Canada "college" varies from province to province (Gallagher and Dennison, 1995). Initial research should be performed to explore the Canadian college mathematics environment—Who are the students? What are their backgrounds, abilities, and aspirations? What mathematical abilities do employers expect of college graduates? Who are the instructors? —and how this relates to those in other countries.

Data was gathered during the course of this study for both the Mathematics Attitudes Inventory and the Canadian Adult Achievement Test. Without more data from a larger set of students, the numbers present in the data have no meaning; at most a change in the values can be observed. I suggest gathering data on a larger scale so that instructional practices can be gauged against a benchmark. Adopting such an approach can help college educators evaluate what gains are being made. It may also help evaluate the some of the claims made in the CMP 2010, specifically, "Most students learn best when mathematics is embedded in the context of a practical field of interest to them," (Orpwood et al., 2010).

Perhaps the largest confounding variable in the GAS course offering of JUMP Math was the skill heterogeneity present in the class. Many capable students where present in the class alongside those that need extensive foundational work. Although some students opted to enrol in this course, most were placed by a computer-based skills assessment. Recognizing that all assessments have inherent limitations, this type of assessment may be particularly inappropriate since it may unintentionally use the affects of the examinees against them. As van Groenestijn (2001) states, "Criteria for placement tests on math skills of adult basic education students are needed to develop tests that are not too 'school-like' because the ABE students are often blocked by math anxiety due to past negative school experiences, students may encounter language problems that affect their math skills, simple math problems do not measure practical problem-solving skills, and a placement test having only right and wrong answers does not provide insight into mathematical procedures of adults." Use of the computer-based assessment should be re-evaluated considering the majority of the students in the GAS course—a course intended to correspond to the first years of the provincial high-school curriculum—were independent determined to be at a post-secondary level in their mathematics ability by CAAT. This heterogeneity creates tension for the instructor who must simultaneously satisfy the college-mandated curriculum and maintain the students' interest.

The GAS course was offered twice a week at 8:00 A.M. The instructor indicated that student attendance was highly variable but often low. He mentioned that this is understandable, considering who the students were as individuals. Many had great responsibilities outside of college, with families and jobs, say, and a foundational math course, however necessary the college viewed it, was not at the top of their priorities. The instructor felt that the foundational students often have failed or have a poor record of achievement in math and that a foundational course only serves to remind them of their failures. Being sensitive to who the students are appears to be a major point to consider when offering a foundational math course (Miller, Pope, & Steinmann, 2004).

Even if this study established the JUMP Math college course as an effective system of instruction, it would remain to show how effective it is relative to common instructional practices. I feel, however, that such research is not ready to be performed. No commonalities exist within college math curriculum, instructional and assessment practices, textbook choice, and course workload. In addition, other factors can vary wildly from instructor to instructor. An evaluation of what constitutes common practice in college math education is in order. It is also time to take stock of college remedial courses. There is no consensus in the literature as to the efficacy of remedial course work. Horn, McCoy, Campbell, and Brock (2009) found that placement in a foundational-level English course negatively impacted a student's future success, while Waycaster (2001) found that a significant proportion of students who successfully graduate from community college have taken a developmental or remedial mathematics course.

Perhaps the largest issue that this study raises is that of the dearth of research in this domain. Throughout the study, it was necessary to draw on research from other demographics or domains that may turn out to be tenuously relevant to the demographic studied. Concrete, foundational research must be performed if we are ever to introduce research-based practice into our college math classrooms.

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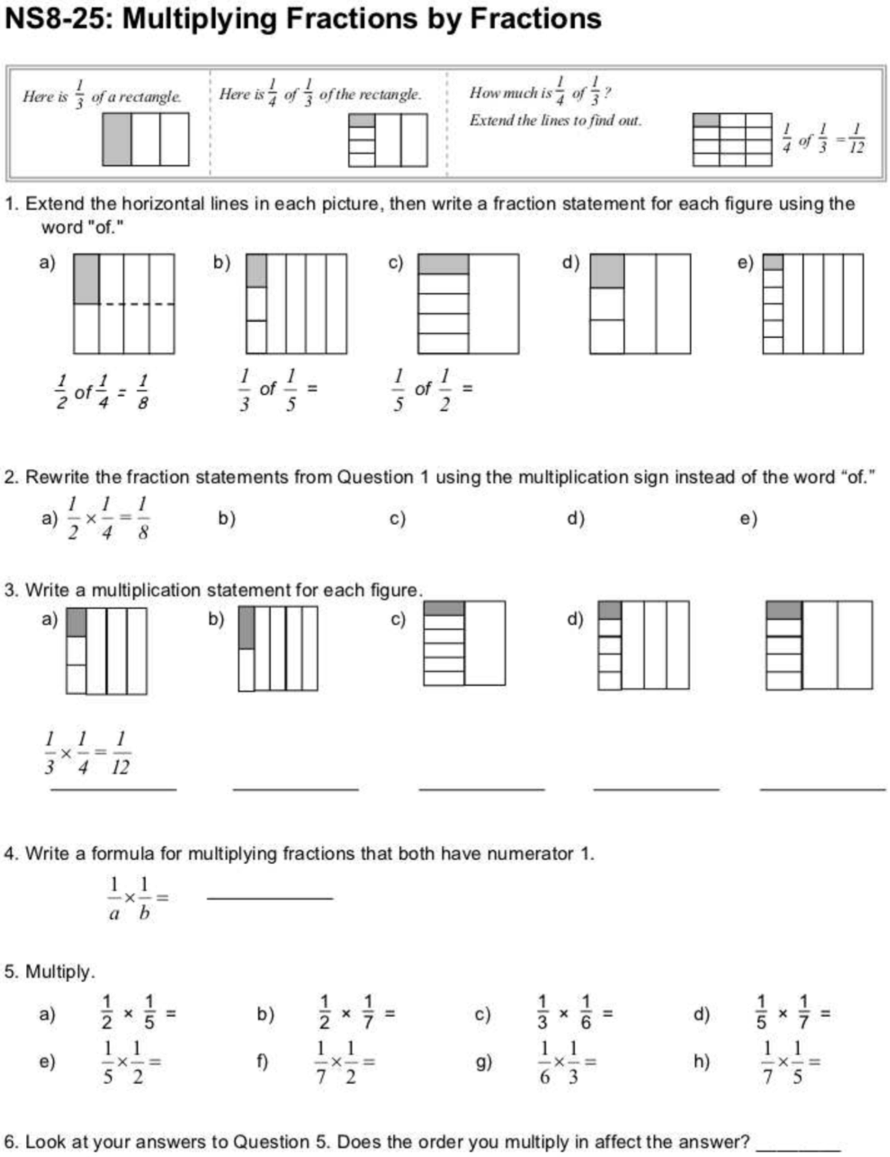
APPENDIX: A SAMPLE JUMP MATH LESSON



NS8-25: Multiplying Fractions by Fractions

Here is $\frac{1}{3}$ of a rectangle. | *Here is $\frac{1}{4}$ of $\frac{1}{3}$ of the rectangle.* | *How much is $\frac{1}{4}$ of $\frac{1}{3}$? Extend the lines to find out.* $\frac{1}{4}$ of $\frac{1}{3}$ = $\frac{1}{12}$

1. Extend the horizontal lines in each picture, then write a fraction statement for each figure using the word "of."

a) $\frac{1}{2}$ of $\frac{1}{4}$ = $\frac{1}{8}$ b) $\frac{1}{3}$ of $\frac{1}{5}$ = c) $\frac{1}{5}$ of $\frac{1}{2}$ = d) e)

2. Rewrite the fraction statements from Question 1 using the multiplication sign instead of the word "of."

a) $\frac{1}{2}\times\frac{1}{4}=\frac{1}{8}$ b) c) d) e)

3. Write a multiplication statement for each figure.

a) $\frac{1}{3}\times\frac{1}{4}=\frac{1}{12}$ b) c) d)

4. Write a formula for multiplying fractions that both have numerator 1.

$\frac{1}{a}\times\frac{1}{b}=$ ____________

5. Multiply.

a) $\frac{1}{2}\times\frac{1}{5}=$ b) $\frac{1}{2}\times\frac{1}{7}=$ c) $\frac{1}{3}\times\frac{1}{6}=$ d) $\frac{1}{5}\times\frac{1}{7}=$

e) $\frac{1}{5}\times\frac{1}{2}=$ f) $\frac{1}{7}\times\frac{1}{2}=$ g) $\frac{1}{6}\times\frac{1}{3}=$ h) $\frac{1}{7}\times\frac{1}{5}=$

6. Look at your answers to Question 5. Does the order you multiply in affect the answer? ________

Figure 1. A sample JUMP Math lesson.

Figure 1 presents a sample of the JUMP Math material used in the college foundational courses. This lesson is part of a series on learning basic operations with fractions. A key feature of this lesson is worth highlighting. The lesson focuses on only one concept with very gradual incremental progress in difficulty. This is a hallmark of the JUMP math approach; even the most seemingly "obvious" steps are not assumed by the instructor to be assimilated by the student. This fine-grained approach allows the instructor to assess where any difficulties reside.