Proposal to attach the QR-flag to MATH 120, “Elementary Functions”  
(submitted by Dr. Bernd Rossa for the Department of Mathematics)

Some Background
MATH120 has recently been completely revised from a pre-calculus type course to a course in Quantitative Reasoning. While I will go into more detail about the details of the revised course below, the benefit of this change is, at least, two-fold:

1. It places students into a playing field of “numbers” instead of symbolic representations (e.g. algebra), in which they have a much greater chance to be able to make sense, to explore, to ask “What-if questions”, and to engage in discussion about possible approaches. “Making sense” is not what students were asked to do in mathematics classes during their middle and high school years, where the main goal, most likely, was to get the right answers to all kinds of questions as quickly as possible through drill and memorization. Because the more investigative and exploratory approach is employed in all Mathematical Perspectives Courses we offer, this course retains its role as stepping stone into a College mathematics course, like Elements of Calculus, which is required by a number of Xavier’s programs and majors.

2. Mathematically under-prepared and/or under-performing students are introduced to logical reasoning and argumentation in the context of data, numbers, relative sizes, and so on, a facet of private and professional life that is often more vital than furthering their understanding and skills in the more abstract discipline of mathematics.

The materials we use in MATH120, and which we continually adapt for this course are called “Thinking Quantitatively”, and were written and published by the then president of the National Numeracy Network, the largest and best known organization in the U.S. whose mission is to promote that education pay attention to further students’ improvement of Quantitative Reasoning, also referred to as Quantitative Literacy, or Numeracy – not instead of, but on top of mathematics.

The Course MATH120 (outline of topics)
Rather than giving a complete run-down of the course here, I will mention the most important and defining ingredients, goals, and topics in bullet form:

- **EXCEL**
  Students learn some basic uses of Excel, such as exploring Loans with different terms and APRs (“Annual Percentage Rates”), retirement accounts, as well as producing visual displays of data like histograms and other graphs. At the same time, the cell-reference structure with which Excel works will improve students’ algebraic thinking, as the cell-references represent whatever numbers happen to be in that cell.

- **Loans and Retirement Accounts**
  We discuss and explore features which students may have been told, but which they have not experienced. A couple of examples here are that a Loan with, say, a 12% APR, will actually charge 12.8% interest over a year’s time! – or, that if students would start a retirement fund at 4.6% now will result in a balance at retirement of which more than
80% come from interest! These results are achieved by hands-on exploration, rather than by plugging certain numbers into obscure formulas, which does not lead to conclusions that they believe, or to insights that make sense to them.

• **Ratios**
  Ratios are introduced as a common way to express relative sizes of Quantities. Students learn and experience that there are many ways to express a ratio. For example, the ratio of the 2013-2014 average tuition of public in-State tuition ($8,893) to private non-profit colleges ($30,094), which is the ratio 8,893 : 30,094, can also be written as 1 : 3.4, suggesting the easy-to-understand interpretation that “private college tuition was about 3 and a half times as much as public in State tuition”. Alternatively, this ratio can be written as 29.6 : 100, which suggests the interpretation that “public in-state tuition is about 29.6% of private tuition”. Students learn how to re-write ratios using a visual aid called “ratio-tables”, a strong alternative to memorizing rules about fractions, at which most of our students have failed to succeed in their past learning experiences. Another example: Students will recognize immediately that just because there are more fatalities from car accidents in the US each year than in the UK, we cannot conclude that brits are better drivers than US Americans. They recognize that the number of fatalities must be taken relative to the population size, the number of drivers in each country, maybe the total number of vehicles, or the total number of miles driven in each country. This, of course, is accomplished using ratios, like “number of fatalities per 100,000 drivers”.

• **Proportionality of Quantities – “Proportional Reasoning”**
  The idea of “proportional reasoning” pervades a large number of everyday calculations, like currency exchange, the time-dependent value of money, maps and models of real things, calculation of drug dosages, and much more. The key idea is that the ratio of proportional quantities will be the same, no matter how large or small particular measurements of the quantities are in a particular instance. Through the discussion of many examples of pairs of quantities, students develop intuitive understanding for what proportionality means, and to decide whether two quantities are proportional, or not. Proportionality is then connected to straight-line graphical displays, and is later developed into the famous linear function idea of “y = mx + b”, for which students rarely attach any kind of real meaning.

• **Percentages**
  Percentages are introduced as ratios, where one of the quantities has been re-scaled to 100 (See above.) An important extension of this idea is the repeated addition or subtraction of a fixed percentage to (from) some amount, which students got to know earlier in segments discussing loans and saving for retirement. In every life, we often hear that some number (e.g. population, home values, HIV fatalities, ...) has “increased by 6.8% over last year”, for example. At the same time, it is clear that an increase in a year’s Revenue by, say, “$10 million” may be a lot, or not, depending on the size of the business or organization. Expressing the increase using a percentage has the advantage that it takes the size of the revenue generating organization into account. The idea of growing or declining by a fixed percentage, repeatedly, leads to the notion of exponential growth, an ill-understood and under-estimated concept, which students
have encountered only in the form of stale formulas (which they were told to memorize as “Pert”), making the idea artificial to them. However, the tension between limited space and resources and repeated growth by any fixed percentage lies at the root of many issues facing humanity, appearing in many of our academic disciplines as well as in reality, where, for example, fixed percentage growth of an economy is often advocated in the face of limited resources, which makes the idea of unlimited (and accelerating) exponential growth questionable.

- **Unit conversions and Rates**
  It is astounding, how poorly students handle unit conversions, and if they are able to perform the conversion, hey rarely understand what they are doing. Even the idea of how length-units lead to area- or volume-units seems to be lacking in many cases. This segment of the course offers a last attempt in most students' lives to fill this gap.
  Rates are introduced as ratios between quantities with different units, like "Miles driven : gallons of gas used", "number of violent crimes : 100,000 people", or "traffic fatalities : millions of miles driven by cars".
  To give a bit more flavor of what happens in this course, I have attached a small collection of problems about unit conversion and rates, which were used in the Spring of 2016. Such problems are either solved in small teams during class, or they are assigned as homework problems, sometimes in advance of more detailed discussion in class, and sometimes as follow-up problems to classroom discussions.

- **Basic concepts from Statistics and Probability**
  Basic descriptive statistics, like mean and standard deviation of a data set are introduced early. The focus here lies in their meaning, and less on the formulas used to calculate them. Later on in the course, when a better understanding of the well-known “Bell-Shaped curve” (technically speaking: “Normal Distributions”) is the goal. An expansion of this topic to understand probability as a ratio of, say, successes : trials is not currently in place, but may be desirable for a course that is more focused on the topic of Statistics (e.g. MATH116).

- **The consumption of statistics reported in the media** (optional)
  At least one of our instructors for MATH120 has introduced readings and discussions of this topic to the course. For example, after a first short reading assignment, students are asked to comment on numbers reported like these:
  (a) “The number of American children gunned down each year has doubled since 1950”, versus the statement “The number of American children gunned down has doubled each year since 1950”.
  (b) “More than four million women are battered to death by their husbands or boyfriends each year.”
  (c) “Today, in the US, some young person, age 14-26, kills herself or himself every 13 minutes.”
  Several things are to be accomplished through these readings and discussions:
  (i) The importance of careful use of language
  (ii) The importance of asking questions like “Who counted?”, and “How did they count this?”, and “Why did they count this?” about such reports, and the understanding that falsely reported numbers are often accidental. Someone made a mistake, and
no one noticed, evidence for and the result of widespread “Innumeracy” in society. At the same time, once these (bad) numbers are out there, it is often impossible to correct them.

(iii) The need for having some benchmark numbers, like, "How many people live in the US?", "How many deaths and births are there in the US (currently) per year?" An initial handout about "benchmark stats" also includes information about the racial distribution in the US population, the number of suicides, deaths from heart attacks and cancer, etc.

Narrative
The proposal guidelines require a disciplinary context in which students investigate issues or problems using Quantitative information. Of course, MATH120 does not operate in a single disciplinary context. However, every single activity and reading provides a context. There are no context-independent "drill" exercises. The great variety of contexts which appear in the problems discussed is intended to demonstrate that the topics we discuss are relevant in many (if not every) area of study and life. None of the contexts are too specialized for students to be able to engage the questions, and we hope that the lack of having a single disciplinary context throughout the course is not an obstacle to receiving the QR-flag. This course is fully, and entirely, focused on a selection of topics considered to be integral parts of "Quantitative Reasoning". Given the 15-week time frame, and given the major task of helping students transition from "applying memory based procedures when told to do so" to being guided by "what makes sense", it may not always be possible to engage all of these topics. At the same time, one might argue that other topics may be more relevant or important. But, all in all, this course provides a meaningful entry into looking at numbers in new ways, the ability to think about measurements and what they tell us, what can be concluded, what cannot be concluded, and the ability to communicate with confidence about one's own thoughts and reasoning when processing Quantitative information.

Each semester, we currently offer 6-8 sections of this course (with hopes of growing that number), which means that a number of different instructors teach the course. For all of us who teach the course, we are faced with teaching ideas we have never taught (or, in many cases, thought about). In order to help each other, and in order to create some uniformity across different sections of the course, we implemented regular meetings of these instructors, and have fostered an atmosphere in which the exchange of ideas, materials, and questions we develop or run into is commonplace. These meetings are called and led by a course coordinator determined by our Chair. These meetings, and the cooperative atmosphere among instructors have become the cornerstone for our success in delivering and improving this course over time.

Ultimately, the question about whether successful participation in this course improves our students' Quantitative Reasoning abilities is to be asked. In that regard, we only have weak indicators after the short period for which the course has been taught (we started in the Fall 2015 semester.) We have used a Quantitative Reasoning assessment tool (developed and used at Bowdoin College in Maine) twice, at the end of the Spring 2016 semester sections of this course, and again at the beginning of the Fall 2016 semester. Enrollment in both semesters was
around 150 students. Of course, it may be argued that the end-of-semester results in the Spring 2016 were skewed because the weakest students had dropped the course, or that the group in Spring 2016 was simply stronger than the Fall 2016 group. However, experience from the past indicates that MATH120 classes in the Spring semester are weaker, most likely because they contain many more students who entered Xavier mathematics courses at the lowest level of MATH105 (which does not provide core credit). The results of our assessments were as follows:

**The assessment consists of 20 questions.**

- Spring 2016 (post): average number correct was 9.1 with a standard deviation of 3.
- Fall 2016 (pre): average number correct was 7.9 with a standard deviation of 3.4

I present these numbers here not so much as an indication that this course has a positive impact in the desired way, but more to indicate that such assessment is underway. In fact, the Core Curriculum Assessment Committee has implemented the same assessment tool we used in MATH120 to be taken by one third of all entering freshmen (pre), as well as by a third of our graduating class (post). Once these numbers are available, and after a few years of collecting these results, we hope to learn more about the role and the benefit of this course.

Finally, I want to mention that this course MATH120 carries the label of "Mathematical Perspectives", the current core requirement in mathematics. The mathematics department insists that if the course will have the QR flag attached, it can **not** be used by any student to satisfy BOTH the mathematics requirement AND the quantitative reasoning requirement of the Xavier Core. The most important rationale here is the fact that students enroll in this MATH120 mostly based on weak performance during mathematics placement. It would be counter-productive to offer this 2-in-1 option, selectively, to our weakest students. It has been cleared with the registrar that Xavier's system will be able to take care of the resulting record keeping issues, and the Core Curriculum Committee has discussed and affirmed that this practice will not contradict the word or the spirit of our New Core.
Syllabus for MATH120, Sec. 03 and 04, Fall 2016

Instructor: Dr. Bernd Rossa
Office: Hinkle Hall 132 Phone: 745-3686 e-mail: rossa@xavier.edu
Office Hours: TBA (until then: whenever you find me in my office)

This course has the “Mathematical Perspectives” designation:
“Mathematics is the study of patterns. It provides a unique way of investigating and understanding the world around us, using as its primary tools exploration, conjecture, and logical argumentation. In this course, by exploring rich mathematical problems, you will further develop your abilities to reason critically; to defend the correctness and validity of your conclusions; to present your results clearly in both written and oral forms; and to experience fresh perspectives on the nature of mathematics.”

Notice: As a Mathematical Perspectives course, this course will most likely be different for you, when compared with previous mathematics classes, where, most likely, the delivery method was “Show and Tell”: The teacher shows and tells the students, who try to remember and practice what they have seen. Such traditional courses do not include exploration, discovery, and careful reasoning to be done by the students. In such a course, an authority is needed to decide what is correct and what is not. In this course, as is much more realistic, a mere “answer” is not enough. Instead, students must provide reasons and interpretations in order to support the correctness and validity of any “answer”.

This course is part of the Xavier Core Curriculum, which “aims to develop people of learning and reflection, integrity and achievement, in solidarity for and with others.” This course addresses the following Core Learning Objectives (at the introductory level):

1a: Students recognize and cogently discuss significant questions in the humanities, arts, and the natural and social sciences.

2a: Students find, evaluate, and logically convey information and ideas in written and oral form.

2b: Students evaluate problems using quantitative methods and arguments.

Course materials are online, and you can access them (only) after you register for the course with Pearson. Instructions how to do this will appear as you enter this course on Canvas. However: On the first day in class, we will go through this process together. Bring your laptop if you have one. If you don’t have a laptop, take notes about the process, so that you can go through the sign-up process on your desktop computer.

The course materials are called “Thinking Quantitatively”. What does this mean? Well, first off, it indicates what I said at the beginning: This is NOT your usual Math course, full with formulas and procedures to memorize and practice. What then is it?

Here are a few interesting (actually, disturbing) pieces of information, taken from different places in the literature about Quantitative Reasoning, also called Quantitative Literacy, or Numeracy:

“87% of U.S. adults Cannot Read or Write…”
“...with Numbers. They are Quantitatively Illiterate.”

Becoming Quantitatively Literate is as important today, as learning to read and to write was 50 or 100 years ago. Here is some data about the state of things:

What does a level of “basic” or “intermediate” Require? Read on.
**Course Objective:** To set a foundation for you NOT to belong to the large majority of US adults who cannot perform tasks like the ones listed above. As a Xavier graduate, who will seek valued and well-paid employment, it is a MUST to become quantitatively literate. Of course, this can not be accomplished in just a few weeks of watching a teacher, and then try to imitate what he/she showed you. All we can hope for is to set a few cornerstones that will help you develop into a quantitatively well-functioning adult and citizen.

The purpose of this course is to provide an overview of quantitative skills required to cope with practical demands of daily life, as well as to prepare you for further quantitative coursework, which will require a good understanding of information that is presented in mathematical terms (numbers, graphs, percentages, and the like), and the ability and confidence to draw and to support reasonable interpretations and conclusions.

“Quantitative literacy empowers people by giving them tools to think for themselves, to ask intelligent questions of experts, and to confront authority confidently. These are skills required to thrive in the modern world.” (from *Mathematics and Democracy*, [http://www.maa.org/ql/001-22.pdf](http://www.maa.org/ql/001-22.pdf))

To improve your Critical thinking, problem solving, applying quantitative skills to real world scenarios, and reasoning from quantitative evidence is the goal. These reasoning capabilities are closely linked to your ability to communicate with numbers effectively. So, all of these will be our focus.

**We will learn to use the spreadsheet Excel** to help achieve these of these goals, and, more generally, to equip you with a valuable computer skill used in so many jobs and investigations.

We will define *Quantitative Reasoning* as the **skill** to process quantitative information and the **capacity** to critique, reflect upon, and apply such information in making decisions. Also called *Numeracy*, which is a well-established and highly studied construct, Quantitative Literacy encompasses not so much mathematical ability, but the disposition to engage quantitative information in a reflective and systematic way, and to use it to support valid inferences.

Derek Bok, in his book, *Our Underachieving Colleges* (p. 68), provides a useful list of qualities of mind and habits of thought related to critical thinking that we will attempt to cultivate in this class. The ability to:

- Recognize and define problems/questions clearly.
- Ask pertinent questions.
- Identify arguments/issues on all sides.
- Gather relevant facts... appreciate their relevance.
- Perceive as many plausible solutions as possible.
- Exercise good judgment in choosing solutions.
- Use inference/analogy/logic to test the cogency of arguments.

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Classes: Class activities will vary. There will (hopefully) be a lot more discussion than lecture. These discussions will often begin in small groups, trying to solve a problem, discussing what might be an appropriate comment on an issue, things of that sort. This will sometimes be interrupted for short lecture segments, or whole class discussion, sharing ideas and questions currently on the table in the various groups. On some days we will work on Excel, on some days we will work on problems intended to deepen your understanding of what you may have read or worked on in preparation for the class. If the reading/HW was not well-understood by many students, we may just talk about the reading/videos. There may also be days on which I lecture, especially after I graded some of your work, and I find common misunderstandings. Your participation in all of these activities is crucial for the development and deepening of everyone’s understanding and of your own confidence.

HW: There will usually be different parts to the daily HW assignments:
(1) You will often be instructed to read a small portion of the e-book, which can be reached from the MyMathLab link on Canvas. It is important that you do this. It is not expected that you understand everything you read. But you are expected to notice that something you read is not clear to you, and maybe even to try to find the place where you get lost. Find something so that you can share your question(s) in class.
(2) You will usually be asked to do some online HW. These are online exercises, that are graded automatically. You can redo this HW and improve your score as many times as you want before the posted deadline.
(3) Occasionally, you may be instructed to do some other reading and/or writing, and I may collect your writing in the next class period.

HW-Instructions and deadlines will be posted as “Announcements” and “Assignments” on Canvas (after class). ALL POSTED DEADLINES ARE FIRM!! No exceptions.

Quizzes: In-class quizzes will be given about once a week, usually unannounced. They will address material from the homework and/or from our class discussions. We may add some take-home quizzes related to news articles or other reading.

Exams: Midterm + Final. Failure to show up for an exam will result in a score of 0. Make-ups will be allowed in extreme circumstances only. No Make-up Quizzes.

Graded Project and Excel Problems: There will be a Project and a number of Excel Problems assigned throughout the semester. For most (maybe all) of the six chapters, you will be asked to submit to me your solution to one or several Excel Problem. The Project will contain portions to be worked with Excel. The Project will be, by far, the most challenging and time consuming assessment of the course, and it will involve Excel. Late submissions will NOT be accepted.

Honor system: In class you will have to work with a partner or in a small team, and it is perfectly OK for you to talk to and to help each other outside of class. It is expected, however, that you will never submit the same Excel file or HW write-up as someone else. Every submission, such as Take Home Quizzes and Excel HW must be entirely your own work! (See Xavier’s Academic Honesty Statement, below.)
General Comment: Mathematics and Quantitative Reasoning is learned by doing, which makes homework the most important part of any mathematics course. **You are expected to struggle a bit and you are expected to come and see me for help, regularly!** Staying on top of the daily assignments is the best way to prepare for Classes, Quizzes, and Tests, while falling behind and letting little problems turn into huge problems is a sure recipe for disaster. See me before this happens! You are also expected to **attend all classes and to participate in our discussions.**

Grading: The grade for the course will be determined as follows:

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<tbody>
<tr>
<td>Homework</td>
<td>20%</td>
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<tr>
<td>Class Participation</td>
<td>20%</td>
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<tr>
<td>Quizzes</td>
<td>10%</td>
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<tr>
<td>Midterm and Final Exam</td>
<td>10% each (20%)</td>
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<tr>
<td>Project</td>
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<td>Excel Problems</td>
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How to succeed:
The single biggest obstacle to success in anything (not just this math class) is how willing you are to participate and persist in the endeavor. Your mere presence in the classroom, while necessary, is far from sufficient for success (the plants in my office don’t seem to have learned much over the years). You must learn to be Present with a capital P. Boredom and dislike are states of mind that can be changed! The following five states of mind (AEIOU) should be cultivated at all cost and all negative thoughts about this course and its possible outcomes should be banished 😊

1. **Be Active** in all parts of the learning process from the classroom to homework.
2. **Be Engaged** in what others are saying and in what you are doing.
3. **Be Interested,** it is so much more fun than being bored.
4. **Be Observant** and reflect on what you see, ask questions as much as possible.
5. **Be Uplifting** toward others and yourself.

In addition, the following three math faux pas\(^2\) should be avoided:

- a) Students expect and often ask to be told the procedure to solve problems.
- b) Students ask for help on problems without first making a serious effort to solve them on their own.
- c) Students are reluctant to ask questions about the motivation for the content presented and the reasoning behind their teacher’s and classmates’ assertions.

Attendance: You are expected to attend all classes. Every missed class will affect your participation grade negatively. After missing more than 3 classes, I may choose to lower your semester grade by a letter. After you missed 6 classes, I will lower your course grade by a letter, lowering your grade one more letter for every 3 classes missed after that. Please, don’t make me do it, and come to class. That’ll make both of us happy.

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XAVIER UNIVERSITY: ACADEMIC HONESTY

The pursuit of truth demands high standards of personal honesty. Academic and professional life requires a trust based upon integrity of the written and spoken word. Accordingly, violations of certain standards of ethical behavior will not be tolerated at Xavier University. These include theft, cheating, plagiarism, unauthorized assistance in assignments and tests, unauthorized copying of computer software, the falsification of results and material submitted in reports or admission and registration documents, and the falsification of any academic record including letters of recommendation.

All work submitted for academic evaluation must be the student’s own. Certainly, the activities of other scholars will influence all students. However, the direct and unattributed use of another’s efforts is prohibited as is the use of any work untruthfully submitted as one’s own.

Penalties for violations of this policy may include one or more of the following: a zero for that assignment or test, an “F” in the course, and expulsion from the University. The dean of the college in which the student is enrolled is to be informed in writing of all such incidents, though the teacher has full authority to assign the grade for the assignment, test, or course. If disputes of interpretation arise, the student, faculty member, and chair should attempt to resolve the difficulty. If this is unsatisfactory, the dean will rule in the matter. As a final appeal, the academic vice president will call a committee of tenured faculty for the purpose of making a final determination.