Boyan Kostadinov

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Teaching Philosophy

Academic and Industry Background

I have been teaching at NYC College of Technology, CUNY as an Assistant Professor of Mathematics since fall 2010. Before going to City Tech, I worked at Credit Suisse for two years, between 2007 and 2009, as a fixed income associate in the Global Modeling and Analytics Group, both in London and New York. I completed a Master in Finance from Princeton University in 2007, and in summer 2006, I was a Math Camp instructor at Princeton for the incoming Master students of Finance. In 2005-2006, I was an Adjunct Assistant Professor of Mathematics at UCLA, after obtaining my PhD in mathematics from UCLA in 2005, under the supervision of Professor V.S.Varadarajan. I have a total of seven years of teaching experience as a Teaching Assistant as well as an Assistant Professor at UCLA, covering both lower and upper division mathematics classes. I was honored to receive the prestigious Robert Sorgenfrey Distinguished Teaching Award, an evidence of my dedication to teaching. I also completed a MS in Physics from Sofia University in 1997. I was ranked top 10 nationally, in the Bulgarian Physics Olympiad, and I never lost my passion for problem solving at any level.

Computational Thinking in STEM Education

I am very excited about applications of mathematics and my main fields of interest are Computational Thinking in STEM Education, Data Analysis and Visualizations, Monte Carlo Simulations, Applied Fourier Analysis and Financial Mathematics. I am very passionate about teaching mathematics at any level and working with students on research projects, using computational software such as R, Maple, Matlab or Mathematica. I am always looking for ways to understand, present and explain advanced mathematical concepts through visualizations, animations and interactive computer simulations that build intuition and conceptual understanding. I believe that computational thinking can be understood as a fundamental skill in the 21st century that everyone can use to solve problems in any STEM field, and that the ever-increasing use of computational devices must be supported by the widespread promulgation of computational thinking and problem-solving across disciplines. We can encourage computational thinking in our students through hands-on computational activities that empower them to do mathematics and solve problems with technology. Of course, technology is not a substitute for knowledge; technology is a tool to gain insights into complex problems. Mathematics technology in the context of computational thinking can be a valuable tool to better understand difficult concepts and learn the scientific method of inquiry; it also offers students the opportunity to learn how to better communicate and present mathematics, skills of ever increasing importance, both in academia and industry.

Customized Teaching of Mathematics with Modern Technology

I customize my teaching approach as a function of my students abilities, background and interests. I greatly enjoy teaching students at all levels and different backgrounds in a way that is tailored to the students level, by paying individual attention to their needs. I have a diverse educational and cultural background, which allows me to better connect with a diverse student population. I firmly believe in education where students from all backgrounds and abilities are able to learn complex, abstract concepts at an early age; to learn how to apply them aptly, and understand their value and their limitations; to know how to integrate into a complex setting what they have learned. I strongly believe that integrative

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and inductive thinking is required today to find solutions and develop new ideas in an increasingly interdisciplinary environment. My academic and industry experience certainly supports this view. This philosophy has reflected on my work with 30 students on undergraduate research projects over the last five years at City Tech.

I like to find novel ways to motivate (sometimes abstruse) mathematical concepts by appealing to intuition based on interactive computer simulations, visualizations and animations[1], as the one shown in Figure 1, illustrating a visual approach to solving word problems at the developmental level, inspired by the internationally recognized Singapore Method for teaching mathematics, based on pictorial modeling. A new kind of intuition for calculus can be developed through creative use of computation and visualization, which can give the students the intuition they need to understand abstract mathematical ideas. For example, the concept of a derivative and the associated concept of a tangent line are difficult starting points in the study of calculus but technology can help us introduce a more intuitive visual approach that can be coded into an insightful animated zooming into the tangent line, as shown in the embedded animation in Figure 2. Another example of key importance to probability and statistics is the Central Limit Theorem, illustrated by the animation shown in Figure 3. An important topic in an upper-level course on differential equations is the Gibbs phenomenon, observed in Fourier series of discontinuous functions, illustrated by the animation shown in Figure 4. Perhaps, even more importantly, I can teach my students how to create these simulations and animations on their own, so that they can empower themselves to further develop the intuition they need to better understand abstract mathematical concepts at any level.

My long teaching experience helped me better appreciate the importance of a well-structured lecture. In addition to presenting formal mathematics, it should generate enthusiasm, excitement and genuine curiosity in the minds of the students. I sometimes appeal to the historical development, emphasizing that the ideas, with which they are struggling, did not drop out of the ether, but were sometimes hotly debated by great scientists of the past. I have realized that most students can become excited if a good idea is presented in a way that stimulates the imagination, even if they do not consider themselves to be good at mathematics. In lower-level courses, students are often mathematically under-prepared but I have found that it is possible to explain to them sophisticated mathematical ideas, if I make an effort to see things from their perspective. At this level, I avoid beginning with an abstract development of the material, for students often lose themselves in notation and find it difficult to distinguish minutiae from substantial matters. I prefer, instead, to first present important ideas in the form of concrete problems and applications, supplying detailed solutions, before introducing more abstract ideas. When I discuss a solution, I emphasize how the formulas can be derived from first principles, leading the students step by step, by asking them a plethora of questions, so that they can discover the logic behind the solution for themselves. Otherwise, they tend to memorize things without appreciating the ideas. I often give several solutions to a problem so that they can see that mathematics is rich with possibilities and that we are constrained only by our imagination.

Active Learning with Modern Technology

One of the most valuable skills I teach my students is the ability to think mathematically and further develop their problem-solving, project-writing and presentation skills by actively engaging them in a project-based learning using modern technology. The primary goals for using technology are to deepen

[1] The pdf must be viewed in Adobe Reader to enable the animations.

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student understanding of mathematical concepts, improve problem-solving, project writing and presentation skills, as well as to increase student motivation and engagement. I believe that informed and intelligent use of technology helps meet these goals.

I employ a variety of approaches to encourage active learning through technology. One successful approach, based on my classroom experience, is investigating real-world applications and working on projects using real-world data, having a computational component using a high-level computing environment, such as R. I have discovered that applications of mathematics and computing go well together, even at lower-level courses, and the most effective examples appear to be those that bear on the real world, coupled with using modern technology, such as R, especially useful for exploratory data analysis, probability and statistics. Project-based learning develops in students their analytic and computing abilities, both needed in other disciplines and valued in industry, where high degree of numeracy and a strong capacity for analytical thinking are required.

Mathematics can be difficult to grasp in its axiomatic form, and I have found the majority of students to be uninspired by mathematical abstractions they find incomprehensible. I have also found that incorporating technology is often a good way to keep students motivated and actively engaged. In fact, I would argue that the ability to compute is itself very beneficial in this technological age, and students find computing quite appealing and engaging. More importantly, technology can be presented and used through the functional programming approach, which follows the principles of mathematical thinking and problem-solving. Technology is a great tool, when properly used, for students to learn how to correctly present and implement important mathematical concepts. My classroom experience shows that students enjoy working on projects involving computing, and this experience helps them develop computational skills, better intuition and understanding of fundamental abstract and numerical mathematics, project writing and presentation skills. Students' experience using technology can help them in the workplace and in graduate school.

We see at least six ways technology can be used to enhance teaching and learning, all supported by the MAA's Committee on the Undergraduate Program in Mathematics:

1. **Exploration**: Technology can be used to explore mathematical ideas and real-world applications.
2. **Computation**: Technology can enable students to work with rich examples, realistic applications from any field, and perform data analysis on large datasets.
3. **Visualization**: Technology can be used to visually explore mathematical concepts and specific problems by adding another dimension for developing better intuition and understanding.
4. **Communication**: Technology can facilitate communication between teacher and student, and among students, inside and outside the classroom. In addition, technology can improve students' project writing and presentation skills, highly valued in academia and industry.
5. **Assessment**: Technology can give students more ways to demonstrate knowledge and understanding and improve the effectiveness of both formative and summative assessment.
6. **Motivation**: The use of technology can increase students' engagement and motivation.

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Quantitative Literacy in Today's World

In science and industry, mathematical models are the main tools for analyzing and solving complex problems. Thus, introducing mathematical modeling and statistical thinking, even at the developmental level, is essential to enhancing the quantitative literacy in today's world. Students spend a great deal of time learning the tools of mathematics - how to algebraically manipulate mathematical expressions, how to solve equations, plot graphs of functions, etc.. I believe in the idea of shifting the focus by introducing quantitative literacy through mathematical modeling, even at the high school or developmental college level, where students spend time learning the many uses of mathematics in the real world, the power of mathematics to help us understand and solve important problems from many different parts of our everyday lives and the world itself, and where students engage in collaborative learning.

There is a number of resources for introducing quantitative literacy through mathematical modeling at the developmental and lower college level. At the developmental level, there are the *Quantway* and *Statway* approaches, sponsored by the Carnegie Foundation for the Advancement of Teaching, developed in collaboration with a number of community colleges across several states. At the lower college level, there is the mathematical literacy project sponsored and developed by the Consortium for Mathematics and Its Applications (COMAP), which resulted in the textbook *For All Practical Purposes*, published by Freeman and COMAP in 2013. COMAP has also published the *Mathematical Modeling Handbook*, at the advanced high school and early college level, developed by a faculty team from Teachers College at Columbia University. COMAP also offers a number of other resources for introducing quantitative reasoning and mathematical modeling at any level.

I have developed and taught mathematical modeling courses at the upper college level and I would be very interested in getting involved with developing and implementing quantitative literacy projects and courses at any level, including developmental and lower college levels, following the mathematical modeling approach for teaching and learning.

Interaction with Students

I believe that students are most successful when they feel recognized as individuals; they feel more motivated to learn, resulting in their being more attentive in class. There are two techniques that I use to accomplish this. First, I try my best to remember as many names as possible and get an idea of their backgrounds and their goals. Secondly, I try to keep the lectures light-hearted and informal; the students feel more comfortable and so participate more actively. Students have commented positively on the latter in student evaluations. I always try to ensure, by gauging their reactions, that the students understand the material that is being discussed. I ask many questions to check that they are not lost. The relaxed atmosphere makes students feel comfortable asking questions and making comments in class. I find that students respond well when I express my genuine concern for their learning and general well-being. A friendly, yet professional demeanor, a comfortable classroom atmosphere, where questions and comments are encouraged, and individual help is offered as needed, along with appropriate recognition of student contributions tend to work well for creating a good rapport with my students that sets solid foundations for their learning. I actively encourage my students to attend office hours, where I try to maintain a friendly, informal and accessible atmosphere. I promptly respond to e-mail questions and I often use Blackboard to publish sample exams and homework solutions, lecture notes, lists of carefully selected projects, sample project reports, detailed tutorials on using modern computing technologies, such as R

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and R Markdown for computing and creating project reports and presentations, etc. My students tend to appreciate the time, thought, and energy I invest in my teaching (as evident from my student evaluations and thank you emails), which I find very rewarding.

Conclusion

I strongly believe that 21st century requires innovative teaching approaches and more inspiring and creative teaching. I have come to realize through my experiences that mathematics should be put in a more practical and unified perspective by emphasizing links with other sciences and real-world applications. I have always enjoyed teaching and dedicated a lot of time and energy to my students. I met a lot of teaching challenges in a very diverse environment, which inspired creative solutions, but most importantly, this experience taught me to be nurturing, patient and caring about my students. One of my primary goals is to help students create their own perspective and approach to learning, thus encouraging them to understand new mathematics by relating it to what they already know. It is my hope now to continue my teaching career with even greater passion than before and dedicate all my energy and enthusiasm to meeting new and exciting teaching challenges.

Supplementary Materials

A number of samples from my scholarly work, relevant pedagogical materials and documents, as well as other significant products can be found in a Dropbox folder: `https://goo.gl/sBYsyr`

Note:

The pdf must be viewed in Adobe Reader for the animations to run. The Preview on the Mac does not support javascript and the animations will not run when viewed in Preview.

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Animated Singapore Method for Solving Word Problems

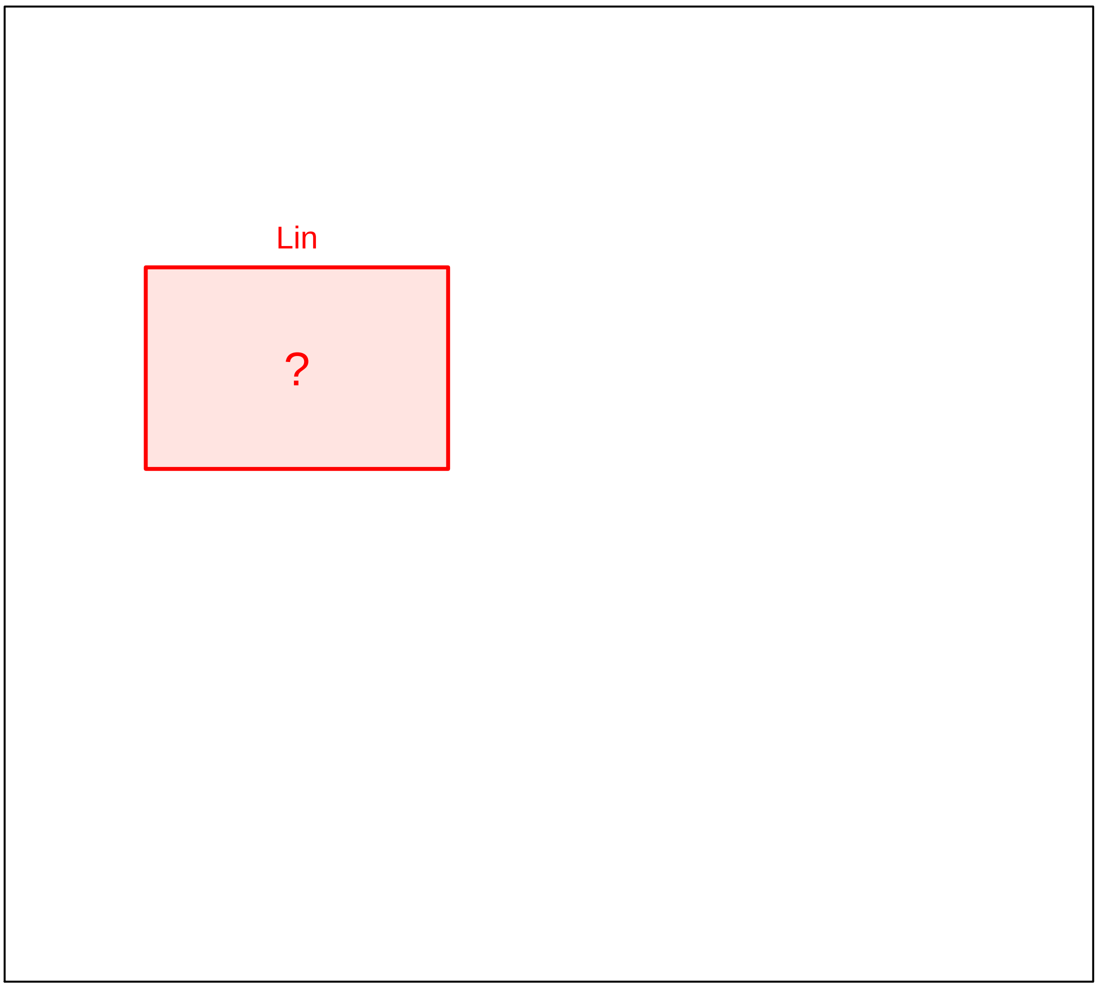

Figure 1: Animated illustration of the bar modeling approach to solving a word problem.

Animated Zooming into the Tangent Line

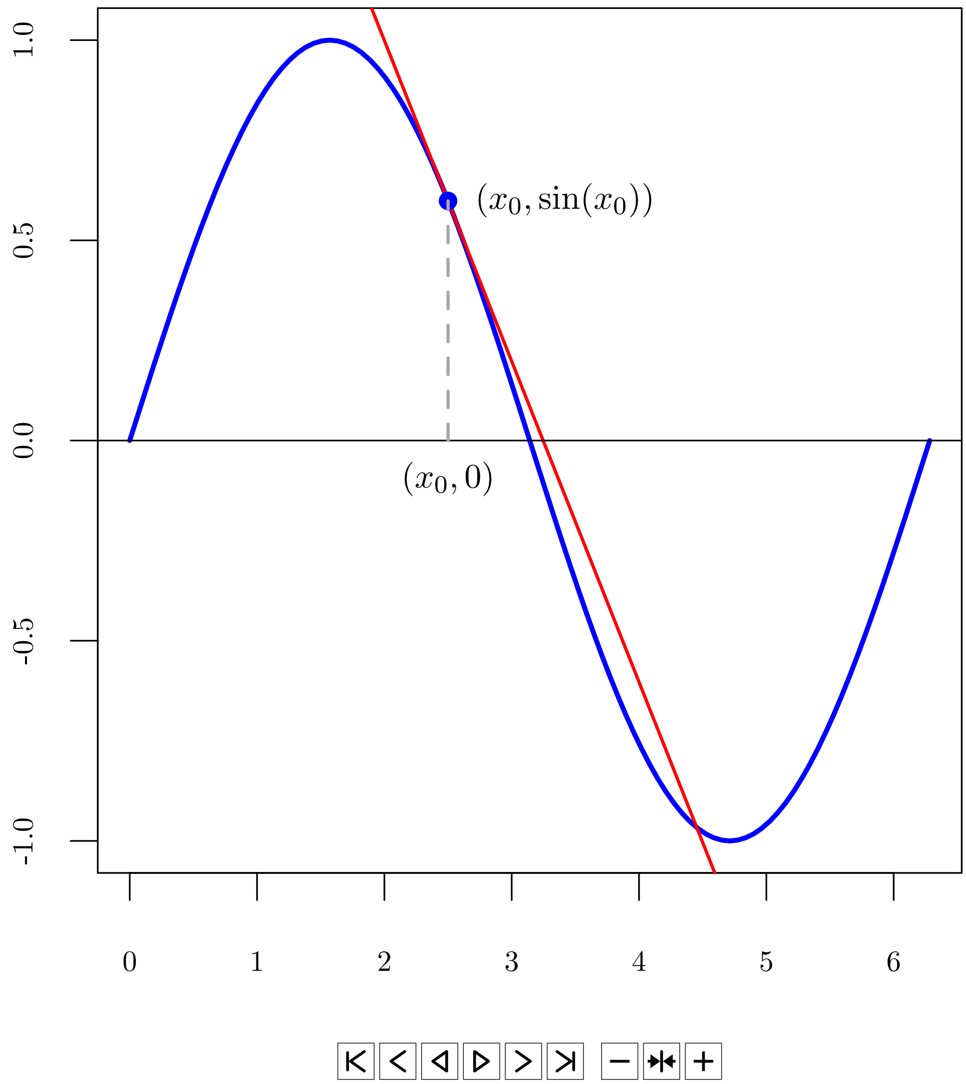

Figure 2: Animated magnification of the tangent line of $f(x) = \sin(x)$ at $(x_0, f(x_0)) = (2.5, f(2.5))$, having a slope $f'(2.5) = \cos(2.5) = -0.801144$.

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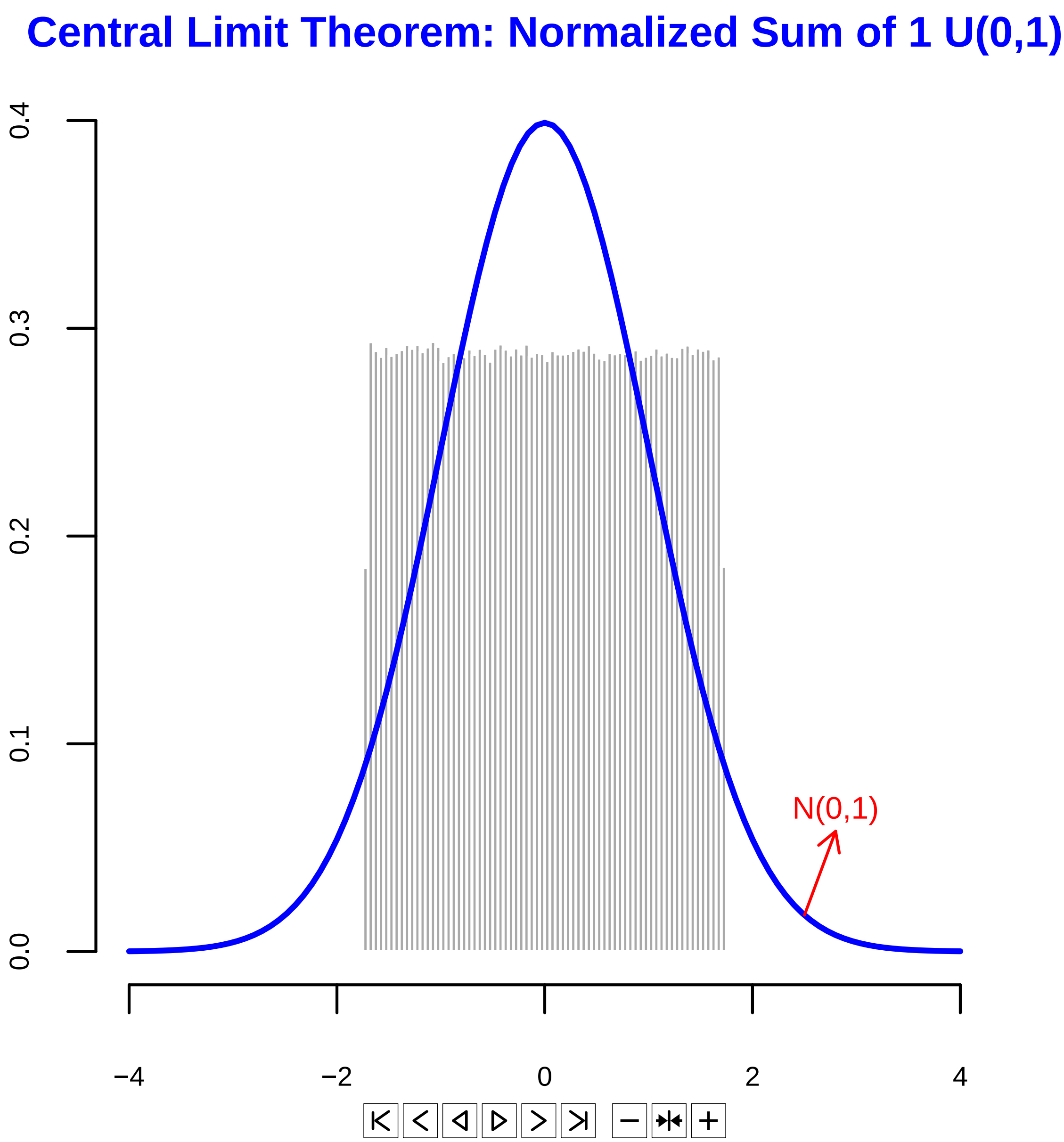

Figure 3: The CLT for the normalized sum of independent $U(0,1)$ random variables.

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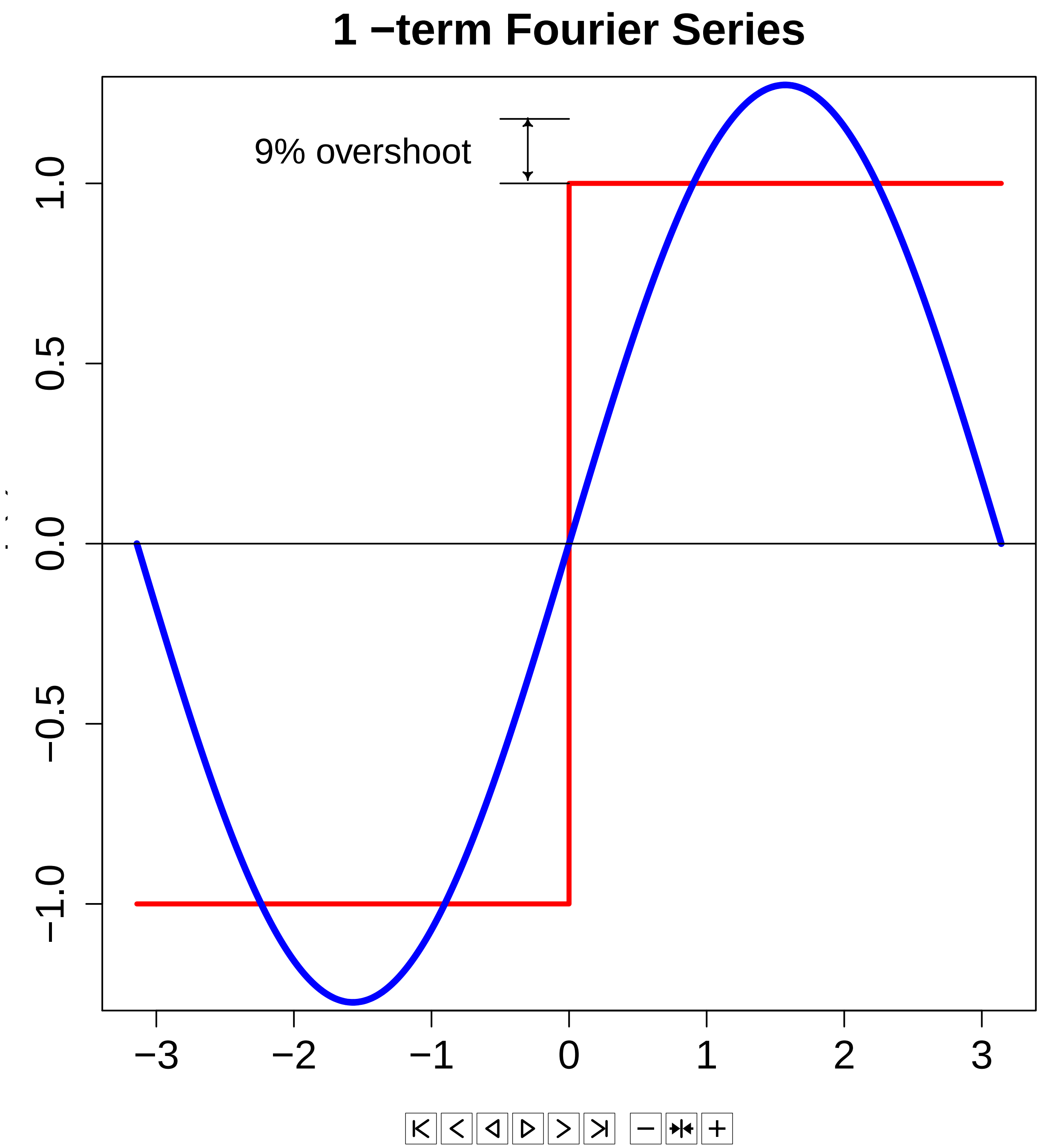

Figure 4: The Gibbs Phenomenon in Fourier series is the approximately 9% of jump size overshoot observed in the approximation of the step function (in red) by its n-term Fourier series or nth partial sum s_n (in blue): $s_n = \frac{4}{\pi}\sum_{k=1}^{n}\frac{\sin((2k-1)x)}{2k-1}$