UNIVERSITY OF ARKANSAS

J. William Fulbright College of Arts and Sciences
Department of Mathematical Sciences

8 December 2015

Dear Superintendent Hofmeister

I am writing in support of the proposed Oklahoma State Standards for Mathematics. As a Clinical Assistant Professor at the University of Arkansas, my primary research is in geometry, particularly the study of aperiodic order. Though my work started in pure mathematics I have also studied many applications, both in and out of Academia. My work with physicists has been published in the Proceedings of the National Academy of Science and I have consulted with several companies in industry. I have also worked extensively in mathematical outreach including talking at the national Museum of Mathematics in New York and work as the Academic Director of a summer camp for mathematically gifted 7-11 year olds. Within education my interest is how mathematics can best develop strong independent thinkers as opposed to blind rule followers. Both creating the high achievers who can harness the huge power of modern technology and informed citizens who can understand and carefully critique the numerical information they are presented with and surrounded by. I believe that these standards show the potential to develop this for Oklahoma.

Any education needs to balance the discipline required for rigorous thought with the creativity to apply that thought flexibly to the world. In mathematics the discipline is generally around the ability to reliably and accurately perform calculation, the creativity lies in using those abstract systems to understand and model the world, as well as getting a feeling for how they fail to do this. The role of computers and the internet has greatly increased the power and importance of the processing of information. As a result in preparing students for the twenty-first century the importance of a subtle understanding of mathematics is more important than ever.

The proposed Oklahoma standards do an excellent job of developing the various mechanical tools for mathematical calculation, starting from computation and moving to algebraic manipulation. They provide a steady ramp of difficulty, at the same time as foreshadowing later material. For example the use of counting in twos or fives (1.N.1.4) foreshadows the later development of multiplication and the use of a variety of strategies to initially explore division (4.N.1.7) helps to begin algebraic thinking.

The goal of gaining a powerful general understanding of how to use this technical material is harder to divide into distinct individual items. These standards address this in two ways. Firstly by emphasising throughout that mathematics is a highly connected field, not a collection of distinct topics. This is most noticeable in the logo used for the standards. In addition the mathematical actions and processes at the start of the document highlight the ways students should be able to work with the material. In particular "Develop a Deep and Flexible Conceptual Understanding" and "Develop a Productive Mathematical Disposition". For the latter I particularly enjoyed the first sentence that students should "Hold the belief that mathematics is sensible, useful and worthwhile." As a university professor I see far too many students both for the math major and for general education who have missed this fundamental idea, and without it any technical mastery they might have is worthless, as they will never make use of it. In addition, the Data and Probability as well as the Geometry standards are used to attach the connected subject up to important real world uses. Overall however, I feel that the technical material is emphasised beyond the conceptual.

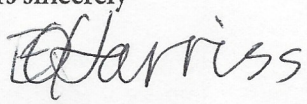
A central job of any set of standards to to provide a structure in which important learning is not just described, but can be assessed. In mathematics this leads to a particular problem. The technical material is very easy to assess and the understanding can be a lot harder to see. In many ways this is a result of the power of mathematical abstraction; the ability to convert information from one form to another with no loss. Academic standards for mathematics should, therefore, ensure that teachers have the space to help students build their ability to not just get the right answer, but understand what they did to achieve it, and how the objects they manipulate (numbers, variables, equations, functions etc) work. It is this understanding, backed by strong calculation ability, that makes mathematics one of the most valuable skills for coming generations. This is not developed by a pedagogy that focuses on the next test. While it is tempting to move towards the cheap options provided by the computer assessment of technical skills, it is essential that these are backed by robust assessments of understanding, primarily using free form written answers. This is a discussion that goes beyond the standards themselves but, if the importance of understanding beyond calculation is left out of the standards, there is no chance that it will become part of the assessment. As I have stated I believe that without this understanding the value of a mathematical education is greatly reduced. My own interaction with industry has made far greater use of the ideas I understand than my ability to calculate and, more importantly, has required partners who understand that mathematical ideas are meaningful.

Overall I feel that the standards given here are very strong and also congratulate the authors on the clear language that has been used throughout. Reading the standards was a lot more pleasurable than I expected. I am therefore happy to recommend that the standards are accepted. My primary criticism would be that the balance between assessment and protecting understanding that I describe above has swung a little too far towards assessment.

I have a couple of more minor points beyond the general discussion. Firstly these standards are generally aimed towards a preparation for Calculus. Though this is the general practice in the US, and expected by many colleges the role of Statistics as a capstone for school mathematics education should be encouraged. This develops far more of the tools needed to use mathematics in the world and can be just as rigorous as Calculus. With this in mind the Data and Probability section could be extended perhaps at the expense of some of the algebra, for example working precisely with polynomials and solving quadratic equations.

Also in the geometry section the lack of the regular polyhedra pains me as a geometer. These are fundamental objects that have been studied since the ancient Greeks began the western quest for mathematics and their beauty provides incredible motivation for mathematics (at least in my experience with outreach). From a practical point of view they are great examples of how three dimensional geometry is significantly more complicated than two dimensional, and thus give a gateway into using mathematics to understand the space we live in.

Yours sincerely



Edmund Harriss
Clinical Assistant Professor of Mathematics, University of Arkansas
email: eharriss@uark.edu