Citizenship Project

Rather than having a laundry list of potential citizenship projects that would quickly become overwhelming, I have picked a single one for which I think I can make significant contributions to in the next year. I will initiate an interdisciplinary seminar in applied mathematics, coordinating with colleagues in my department to generate interest both inside and outside of BYU in interdisciplinary and applied mathematics. As part of this goal, I have the following aspects that I will focus on to ensure that the seminar will be a success both for myself and my colleagues:

1. The seminar will be held weekly.
2. I will encourage students and faculty from the math department as well as other departments on campus to attend.
3. Using departmental funds (already in place) we will bring in an outside visitor for the seminar at least 2x per month.
4. The remaining slots for the seminar will be filled by faculty from outside the department but at BYU, as well as faculty and graduate students in our department.
Faculty Development Plan

(1) Teaching
   (a) Self-Assessment: In the past year I have sought out the advice of colleagues on how to improve my teaching and determine how to better interact with students. Some of the suggestions they have given me that I have tried to implement include: midterm student assessments, better organization of my board work (drawing vertical lines to break up the chalkboard), and one-on-one meetings with students who are struggling. In addition I have made it a point to speak only when facing the students so they will definitely be able to hear me. I still feel that my teaching can use some significant improvements. Specific goals related to these different areas are outlined below.

   (b) Goals
      (i) Quality and consistency of exams: One of the valid complaints that I had from students this past year in both of my courses was that the difficulty level of the exams did not necessarily correlate with the difficulty level of the homework, or even with other exams in the same class in the same semester. I have found writing exams to be one of the most difficult aspects of my teaching responsibilities, and from the student feedback it is clearly an area that I need to improve on. To do so, I intend to work closely with colleagues who have either taught the course before, or may have insight into how the course is structured (for the ACME course in particular) so as to write the exam to be a fair assessment of the students’ learning. I also hope to implement weekly or bi-weekly quizzes that will force me to write learning assessments more frequently giving me more practice at doing so.

      (ii) In-class feedback: In line with the last point, I plan to implement more in-class feedback with the students by introducing more frequent quizzes either weekly or bi-weekly. This gives the students more immediate feedback on the learning process and also aids me in gauging the level of understanding for each individual on a more rapid time scale than one to two times a semester.

      (iii) Student participation: One of the methods that I was taught to rely on heavily as a PhD student at the University of Michigan was in-class participation of the students by having students take turns working problems at the board, or having the students work in groups during class time. I have struggled to implement these strategies since then in my courses here at BYU, but am seeking feedback from colleagues on how to increase the students’ involvement in the class room.

   (c) Course Development: This past year I taught the inaugural Differential and Integral Equations course (Volume IV) for the Applied and Computational Mathematics Emphasis (ACME). I will be teaching this course again in the coming academic year (2015-2016). Building on the course notes I have, I plan to develop a written outline that will be the foundation for the textbook that will eventually come out of the course. In addition I am teaching Math 510 in the Fall, and plan to develop this course for a mixed audience (math and engineering students).

(2) Mentoring
   (a) Self-Assessment: In this past year I mentored 6 undergraduate students, dividing them up into groups of two. Four of these students have graduated and left BYU as part of the first cohort of ACME students. The other two: Jessica Layton and Shane
McQuarrie have continued to work with me this summer and plan to do so into the coming academic year. There was mixed success with the other 4 students, for two reasons: first I only had 9 months to work with these students, and second I did not have a definitive research question in mind when they started working for me. As a result, although the students learned a significant amount, their overall contribution was rather minimal.

(b) Selection of Students: In the future I intend to be far more selective of the students who work for me. I plan to target good students from my future classes, by asking them if they are interested in working on projects I am involved with. In addition, I intend to recruit at least one graduate student, partially because a graduate student can assist in the training and development of several undergraduates, enabling a broader team of research assistants. In addition, I would prefer having larger research groups initially and allowing the students to break off into smaller groups as the research develops. I am getting feedback on this process from several colleagues including Michael Dorff, Jeff Humpherys, and Paul Jenkins.

(c) Selection of research projects: The 3 research groups I had this last year came together by chance, i.e. I was certainly not prepared for them. One of the topics has been going rather smoothly as I had a well thought out research plan, but the other two have hit significant delays and setbacks that were more a by-product of my lack of preparedness than any fault of the students. Although such experiences are quite normal in academic research, in the future I will not agree to work with students on a project that I am not prepared to mentor them in, primarily because I can see that the setbacks are causing them to lose some interest in the project.

(d) Goals:

(i) I would like to have at least two undergraduate students I am mentoring on research at all times. That being said, I will not agree to mentor a new student purely to ensure I am filling a ‘quota’.

(ii) I plan to recruit and mentor one graduate student at a time. Ideally this graduate student would also provide some intermediate mentoring to the undergraduate students.

(iii) I will reach the point that I am submitting one paper per year with a student or former student as a co-author.

(3) Scholarship

(a) Self-Assessment: My scholarship has continued to progress at a reasonable rate. I have three primary areas of research as outlined in more detail below. An area that I want to improve on is my consistency, i.e. I would like to keep my research active enough that there are few years with a dip in productivity, but instead a consistently high level.

(b) Research Areas:

(i) Convection: Much of my success to this point has come in deriving rigorous bounds on the transport of heat by a convective fluid. Although the applications of these results are physically relevant to the physical and engineering sciences, the analysis underlying the results is long and often very slow to progress. With this in mind, I will continue to work on these bounds, but also pursue some related but less rigorous numerically motivated approximate bounds. While these less rigorous bounds are not as fundamentally definitive, they do provide the avenue for more incremental progress, and will provide insight into the future
development of the more rigorous methods. In this way I will be able to continu-
ously make progress, rather than having short bursts of contributions followed
by droughts of ineffectiveness.

(ii) Asymptotics and reduced models: This is a relatively new area for me, as I have
only a single publication in it, although I have several collaborations in place that
will produce publications in the near future. The goals of this research area are
to combine the methods of infinite dimensional dynamical systems with insight
gained from geophysical fluid dynamics to understand the role that reduced as-
ymptotic models play in the long-time, chaotic dynamics of a geophysical system.
This will also involve a combination of numerical simulations and rigorous anal-
ysis. The benefit of the numerical simulations is that I can get students involved
at an early stage, and demonstrate the fundamental issues under consideration
without the students needing to completely understand all of the complicated
details.

(iii) Large scale climate and tsunami modeling: A significant portion of my previous
work has been in the numerics and verification of climate modeling. I intend to
continue working in this area with collaborations that started years ago, and I
will continue working with Ron Harris (and several students) in the Geolocial
Sciences Department at BYU on the modeling and prediction of Tsunamis in
Indonesia. For the Tsunami prediction, I will involve a graduate student in the
simulation and modification of the finite-volume based GeoClaw package. As
with my work in the climate modeling community, any research in this area will
be highly reliant on my collaborators in other fields.

(e) Large-scale Goals

(i) My primary immediate goal is to obtain an NSF Early CAREER award. This
appears rather lofty at the moment, but I plan to do everything I can to achieve
it.

(d) Yearly Goals

(i) My goal is to publish five quality academic papers per year. To do so will require
a sustainably consistent level of writing, research and collaboration. In concert
with this goal, I will have at least one paper submitted at all times so that there
isn’t a sudden drought in my publication record.

(ii) I will invite a minimum of 2-3 external visitors to come to BYU each term (Fall,
Winter, Spring/Summer) to either give a talk, work with me on a research topic,
or preferably both.

(iii) I will present my research at least 3 times each calendar year at quality venues,
but with particular emphasis on colloquiums and seminars at other academic
institutions because this is far more conducive toward further collaboration.

(iv) I will submit at least one NSF proposal per year as the PI until I am funded
continuously. In addition I intend to look for opportunities to participate in
collaborative, interdisciplinary proposals.

(e) Realistic Expectations: I plan to adjust these goals and expectations as I get more
feedback and as I continue to branch out into new avenues of research.

(4) Citizenship

(a) Self-Assessment: In the past year I have served as an advisor for undergraduate stu-
dents, and more recently as the vice-chair of the hiring committee. In addition I have
participated in the curriculum committee for the winter of 2014, and have actively
made proposals regarding the curriculum for undergraduate and graduate courses, particularly for applied mathematics students.

(b) Hiring Committee: My role in the hiring committee is to keep track of LDS mathematicians who may have an interest in applying for a faculty position at BYU. I have an updated spreadsheet that keeps track of these individuals, and have been in some form of contact with over twenty different individuals in the last six months. In this context, I try to gauge the interest of potential applicants, and their potential for fitting into the goals of the department. I very much enjoy this role on the committee and would like to stay in it so as to provide some continuity for those candidates that are coming up in the next couple of years.

(c) Additional Citizenship Goals

(i) In the future, I intend to (with the help of several others) work on revamping the graduate level applied mathematics courses. With the advent of the ACME program, there is less incentive for undergraduate applied mathematics majors to take the current graduate level courses.

(ii) I am making a special focus on initiating inter-departmental collaboration and communication at BYU. For example I was recently placed on a multi-disciplinary proposal with Ron Harris from Geological Sciences and several other professors on campus. In addition, I have successfully started working with a Mechanical Engineering PhD student Zhao Pan on particle image velocimetry (PIV) for experimental fluid dynamics. I also am actively recruiting engineering students and faculty to attend applied mathematics seminars and colloquia and recently had some success in doing so. As part of this goal, I plan to have at least one of my visitors each semester as an individual who can give an interdisciplinary seminar that those outside the mathematics department will be interested in attending. I will also seek students from engineering and the physical sciences to take my courses (particularly graduate level) even though I fully expect such a course to be much harder to teach then.
Scholarship Strategies Project

1. THEMES OF RESEARCH

My research can be categorized into 3 different sub-fields of applied mathematics and mathematical fluid dynamics in particular:

(1) Convection: Much of my success to this point has come in deriving rigorous bounds on the transport of heat by a convective fluid. Although the applications of these results are physically relevant to the physical and engineering sciences, the analysis underlying the results is long and often very slow to progress. With this in mind, I will continue to work on these bounds, but also pursue some related but less rigorous numerically motivated approximate bounds. While these less rigorous bounds are not as fundamentally definitive, they do provide the avenue for more incremental progress, and will provide insight into the future development of the more rigorous methods. In this way I will be able to continuously make progress, rather than having short bursts of contributions followed by droughts of ineffectiveness.

(2) Asymptotics and reduced models: This is a relatively new area for me, as I have only a single publication in it, although I have several collaborations in place that will produce publications in the near future. The goals of this research area are to combine the methods of infinite dimensional dynamical systems with insight gained from geophysical fluid dynamics to understand the role that reduced asymptotic models play in the long-time, chaotic dynamics of a geophysical system. This will also involve a combination of numerical simulations and rigorous analysis. The benefit of the numerical simulations is that I can get students involved at an early stage, and demonstrate the fundamental issues under consideration without the students needing to completely understand all of the complicated details.

(3) Large scale climate and tsunami modeling: A significant portion of my previous work has been in the numerics and verification of climate modeling. I intend to continue working in this area with collaborations that started years ago, and I will continue working with Ron Harris (and several students) in the Geosocial Sciences Department at BYU on the modeling and prediction of Tsunamis in Indonesia. For the Tsunami prediction, I will involve a graduate student in the simulation and modification of the finite-volume based GeoClaw package. As with my work in the climate modeling community, any research in this area will be highly reliant on my collaborators in other fields.

2. GOALS BY FEBRUARY 2016

(1) 4 new quality papers submitted.
(2) At least 2 proposals submitted to national funding agencies such as the NSF (1 proposal submitted as PI).
(3) Primary organizer for an international conference (in honor of my primary advisor’s 60th b-day in 2016).

3. STRATEGIES FOR IMPROVING PRODUCTIVITY

(1) Write/work on research the first thing when I get to work for at least 30 mins.
(2) Write notes from the very beginning of each project, particularly collaborative ones (almost everything I do is collaborative). Keep these notes in a version control system and share it with collaborators so we can continuously revise and improve the ideas and writing.
(3) Find a student who can help out with the numerical simulations/ visualization via Python scripting.

4. EVALUATION

I will keep a simple text file on my desktop that I will check each day when I spend time doing the first item, and will be able to easily evaluate the second goal. The third strategy will also be easily verifiable, dependent on whether I have trained such a student in the tasks desired.
Math 510: Numerical Linear Algebra  
Fall 2015

Instructor: Jared Whitehead, TMCB 350, whitehead@mathematics.byu.edu  
Office Hours: 11-12AM Monday, or schedule an alternative time  
Classroom and Time: 301 TMCB, MWF 1-1:50PM  
Textbook: *Numerical Linear Algebra*, by Lloyd N. Trefethen and David Bau III.

Prerequisites: Math 313 or equivalent. Working knowledge of a high level programming language (something like Matlab is sufficient). A background in mathematical proofs is highly recommended (MATH 290 is a good example).

Learning Outcomes: This course is designed so that students will be able to solve problems in linear algebra that arise in applications of the physical, biological, and engineering sciences. As such the course is a hybrid between the mathematical theory of convergence and stability of the numerical algorithms, and the practical implementation of these algorithms. In other words, the successful student will be expected to understand both the proofs that establish the veracity of an algorithm, and be able to program the algorithm and perform some numerical computations.

Some of the topics covered in this course are (certain not limited to the following however):

- Unitary matrices
- Norms (definitions and properties)
- well-conditioned and ill-conditioned problems
  - Definition of the condition number
  - Definition of stability and backward stability
- fundamental axiom of floating point arithmetic to determine stability
- Difference between stability and conditioning
- LU and PLU factorization
- Gaussian elimination and the relationship to PLU factorization
- Cholesky decomposition
- Singular Value Decomposition (SVD)
- Projections and orthogonal projections
- Gram-Schmidt and modified Gram-Schmidt
- Householder reflections
- Householder QR factorization
- Least-squares problems
  - normal equations/ pseudo-inverse
  - QR factorization
  - SVD
- eigenvalues/ eigenvectors under similarity transformations and shifts
  - spectral decompositions
  - unitary diagonalization
  - Schur decompositions
- Arnoldi algorithm
- GMRES algorithm
- Lanczos iteration
- CG algorithm
• v-cycle, multi-grid algorithm and full multi-grid algorithm
• preconditioners: block diagonal, incomplete LU, and incomplete Cholesky
• CGN and BCG as well as other Krylov space methods

**Homework:** Homework assignments will be due weekly (Fridays at 5pm in the box outside my office door). Typically the homework problems will come from the textbook, although occasionally they will also be drawn from other sources. As mentioned above, the homework will include: proofs, computations, and programming.

Homework problems that do not involve programming should be written cleanly and legibly so that any member of the class can easily follow the necessary arguments. Points may be deducted for poor explanations and/or poor presentation. Such homework assignments can be turned in, or typed via LaTex and e-mailed directly to me at (whitehead@mathematics.byu.edu).

Assignments that involve coding should be e-mailed directly to me at the address given above, or preferably, posted to learning suite. The code should be adequately commented and written cleanly enough that once again, any member of the course can easily follow what is happening. This is not a programming course, but very poor programming practices can still result in lost points on homework assignments.

Late homework is not accepted, however the lowest homework score will be dropped at the end of the semester.

Working with others on homework is acceptable and encouraged as long as it is acknowledged. Be aware however that each individual is responsible for completing the assignment on their own, and relying to heavily on another member of the course will severely harm the student's ability to perform well on the final. Copying solutions or code directly from someone is never acceptable, and will not be tolerated.

**Quizzes and reading:** Reading assignments from the textbook will be distributed at the beginning of each week. At some point throughout the week, a reading quiz will be given on the material from the assigned reading. If you have completed the reading, these quizzes will be very easy. Due to occasional absences etc., 2 quizzes will be dropped when calculating the final grade.

**Exams:** The midterm will be an open book, take home exam due on October 28th at 5pm. The midterm will be distributed in class on Wednesday October 21st, and should be around the same difficulty level as a homework assignment. The final exam will be of a similar format, and is due Friday December 11th at 5pm (midnight if e-mailed to me).

**Final Project:** The final project must be related to the course and should also be related to your personal or research interests. Proposals for the final project will be due Friday October 16th in class. The proposal is simply a one page summary that explains what the project is, and how it relates to the course and your individual interests. The project should require the same amount of effort that 3-4 homework assignments does. You are free to work in pairs or as individuals on the final project, however more will be expected from final projects that include more than one individual.

**Grading:**
30% Homework
5% Quizzes
20% Midterm
20% Final
25% Final Project
**Preventing Sexual Harassment**: Title IX of the Education Amendments of 1972 prohibits sex discrimination against any participant in an educational program or activity that receives federal funds. The act is intended to eliminate sex discrimination in education and pertains to admissions, academic and athletic programs, and university-sponsored activities. Title IX also prohibits sexual harassment of students by university employees, other students, and visitors to campus. If you encounter sexual harassment or gender-based discrimination, please talk to your professor; contact the Equal Employment Office at 801-422-5895 or 1-888-238-1062 (24-hours), or http://www.ethicspoint.com; or contact the Honor Code Office at 801-422-2847.

**Students with Disabilities**: BYU is committed to providing reasonable accommodation to qualified persons with disabilities. If you have any disability that may adversely affect your success in this course, please contact the University Accessibility Center at 422-2767. Services deemed appropriate will be coordinated with the student and instructor by that office.