Computational and Applied Mathematical Sciences Program Proposal

I. Executive Summary

1. Design: Computational and Applied Mathematical Sciences (CAMS) is a 21st century model for technical education that takes advantage of Plymouth State University's Integrated Cluster Model. At its core, CAMS is an interdisciplinary mathematics program that emphasizes computer science, experimentation, and data collection. Mathematics provides students with methods and theory that live at the heart of problem solving and data analysis in the physical sciences, engineering, and innovative industries. Combining mathematics with computer science gives students the practical skills necessary to employ their theoretical mathematics knowledge and develop algorithms to address problems in the real world. Students in CAMS will also complete 16 to 23 credits in an enrichment option of their choice so that they have experience with experiment design and data gathering, which are often lacking in a traditional mathematics major. The enrichment option also gives students experience in a particular field where mathematics and computer science can be applied, and the background to properly implement their skills.

   The CAMS program will consist entirely of existing courses at PSU. These courses are provided by Mathematics, Computer Science, and a third discipline dependent on a student's selected enrichment option. The enrichment options in this proposal are Biology, Chemistry, Criminal Justice, Meteorology, and Psychology. We hope to add more enrichment options in the future.

2. Objectives: The goal of the CAMS program is to produce graduates that can immediately begin working in government and industry jobs or pursue a graduate degree. These graduates will be ideally suited for an analyst position in any industry, and be particularly strong candidates for positions related to their enrichment option.. Students at other institutions in similar programs have gone on to work for companies like Microsoft, Raytheon, Amazon, Disney, Apple, and Oracle along with

government agencies like the NSA and IRS. Further, the median income for students graduating with a similar degree from BYU is often above $90k, though $50k may be more consistent with nationwide statistics. [http://www.acme.byu.edu/outcomes/]

There is an ongoing shift in the necessary skills for individuals working in industry. Employees are increasingly expected to have knowledge of advanced mathematical and statistical theory as well as practice with database management and coding. Further, employers are increasingly looking for analysts and mathematicians to have practical experience with data gathering. Additionally, discussions with industry members have highlighted the usefulness and importance of high-level mathematical thinking in the success of employees. [TPSE Math Upper-Division Pathways, Worcester Polytechnic Institute, 7/11/2018-7/12/2018.]

Further, the CAMS program is, in a sense, a Cluster major, as it focuses on the intersection of the Cluster programs. Thus provides an interdisciplinary major to students with Cluster-related interests. CAMS students will be required to take common first-year courses sequences in mathematics, computer sciences, and a data-gathering discipline. Students with a major and minor in Math, CS, and/or an Enrichment option will be primed to switch into this major, should their interests shift. Thus, the CAMS major serves as a Cluster hub.

3. Student Learning Outcomes:

   (a) Demonstrate an understanding of the philosophies of mathematics, computer science, and the enrichment option.

   (b) Design and implement experiments and collect data. Analyze data and account for limitations.

   (c) Identify and employ appropriate mathematical techniques and technologies to model data.

   (d) Employ appropriate programming languages, techniques, and technologies to organize data and refine models.

   (e) Design and implement computer and numerical algorithms. Analyze correctness, time requirements, and space requirements of algorithms.

Job Title	**Median Income**	**Job Growth**
Mathematician and Statistician	$84,760	33%
Database Administrator	$87.020	11%
Software Developer	$103,560	24%
Operations Research Analyst	$81,390	27%

Table 1: Data for related fields from Bureau of Labor Statistics. A growth rate of 7% is considered average.

(f) Communicate effectively in mathematics, computer science, and the enrichment field.

4. Supporting Data: See Table 1

5. Available Resources: No new resources are required. The CAMS program will consist entirely of existing courses at PSU. Courses that teach the necessary content already exist in the PSU curriculum and have enrollments that will allow for more students without necessarily needing more sections.

6. Evaluation: The assessment and evaluation scheme being implemented by the Mathematics department in Taskstream will also be used for CAMS students.

7. Long-term Implications: It is hoped that CAMS will increase enrollment in upper-level courses in Mathematics, Computer Science courses, and the enrichment courses. Further, it is hoped that CAMS will increase retention by providing students majoring in a program in Exploration & Discovery (The Sciences) with another major option that requires courses that they've completed or by allowing students wishing to double major with a more feasible option. Additionally, it is hoped that CAMS increases recruitment to Exploration & Discovery.

II. General Information

- Institution Name: Plymouth State University
- Date of Proposal: February 8, 2019
- Degree and Program Name: Bachelor of Science in Computational and Applied Mathematical Sciences
- Name of Proposing Department: Mathematics
- 2010 CIP code and CIP title: 27.0304 Computational and Applied Mathematics
- Proposed date of program implementation: Fall 2019
- Primary Contact Person: Dr. Emma Wright, Chair, Department of Mathematics

III. Program Demand / Current Offerings

- Demand
  - Evidence of indicators of student demand, employer or community-based demand

    The TPSE Math Upper-Divisions Pathways conference held in July of 2018 focused on a potential shift in collegiate mathematics education. While degrees in Mathematics and Statistics are viable, and positions for individuals with these degrees is one of the fasting growing labor fields, they're traditionally focused on preparation for graduate programs or specific positions. There's a growing need for graduates with mathematical and programming skills, the ability to implement those skills at scale, and discipline specific knowledge that may be required to work within a specific industry.

- Detail explanation of other reasons or circumstances indicating demand

  Earning a double major at PSU in STEM fields can be difficult for many students and impossible for others. Smaller programs like Mathematics and Computer Science often run upper-level courses infrequently and in conflicting time slots. In the past 5 years, only one student has been able to make progress on a CS/Math double major, and she was only able to do so because she started her course work at an advanced level due to AP exam credit. While the CAMS program will not be a double major and will not cover as much content as a double major, it is a practical solution to the aforementioned limitations that allows students to focus on the courses and skills most associated with industry jobs.

- Comparability of the new program curriculum with other programs

  While Applied Math is becoming more popular at the graduate level, the vast majority of undergraduate math programs take a traditional route, one that prepares students for graduate work. Below are four undergraduate programs that are similar to CAMS, though some key differences are worth noting.

  - BYU ACME Program
    http://www.acme.byu.edu/
  - University of Chicago Computational and Applied Mathematics Program
    http://collegecatalog.uchicago.edu/thecollege/caam/
  - UNH Applied Mathematics Computation Option
  - Keene State College Computational Mathematics
    https://www.keene.edu/catalog/programs/detail/computer-science-bs/

  The first two programs are offered by much larger math departments at much larger universities. Thus, they require many more math courses, courses smaller universities cannot typically offer. Keene State's option is similar in name only. It is a Computer Science program with a few extra math requirements. All of these programs consist mostly of

math and computer science courses with no enrichment options. This distinguishes the CAMS program, which more evenly distributes its coursework across four fields in Exploration & Discovery (The Sciences) and the field of Criminal Justice.

IV. Program Characteristics

- Appropriateness to institution's mission and goals: The CAMS major aligns well with the universities mission and goals. The goal is to produce graduates whose skillset crosses traditional boundaries so that they are prepared to solve problems in an evolving world. Rather than adhering to a strict set of accreditation standards or preparing its students for specific jobs, CAMS imbues students with a wide range of highly applicable skills that can serve in a variety of jobs in industry and the government. Thus, CAMS graduates are prepared for evolving industries.

  CAMS is a cluster major. It strings together related coursework in several fields. Thus, students will learn a variety of skills, creating a unique skillset, and be prepared for the interdisciplinarity of "real world" jobs.

  Further, CAMS is built to take advantage of PSU's cluster structure. The CAMS major utilizes classes in several different departments while not requiring any new classes to be offered. CAMS allows for greater efficiency in these departments by filling sections of courses that are already being offered.

- Student Learning Outcomes

  1. Demonstrate an understanding of the philosophies of mathematics, computer science, and the enrichment option.

  2. Design and implement experiments and collect data. Analyze data and account for limitations.

  3. Identify and employ appropriate mathematical techniques and technologies to model data.

4. Employ appropriate programming languages, techniques, and technologies to organize data and refine models.
5. Design and implement computer and numerical algorithms. Analyze correctness, time requirements, and space requirements of algorithms.
6. Communicate effectively in mathematics, computer science, and the enrichment field.

- Description of knowledge and skills
  - Computational methods from calculus, differential equations, and linear algebra
  - Fundamentals of theoretical mathematics including sets, relations, logic, formal proof writing, and analysis theory
  - Continuous and discrete mathematical structures
  - Deterministic and stochastic modeling techniques
  - Model analysis techniques including sensitivity and robustness
  - Numerical approximation versus absolute precision
  - Fundamentals of computer programming
  - Data structures and methods of database management
  - Analysis of numerical and computer algorithms
  - A variety of experimental design and data collections methods from the students selected enrichment option
- Anticipated/planned transfer and articulation agreements: None
- Certification of licensing: None

V. Program Design

- Admission standards: Regular admission to PSU
- Interdisciplinary program collaborations: Computer Science for all options. Specific options collaborate with Biology, Chemistry, Criminal Justice, Meteorology, and Psychology. Additional enrichment options may be pursued after successful implementation of the original CAMS major.
- Degree Requirements: See attached
- Procedures and criteria for assessing student learning outcomes (beyond grading):

  Short-Term, Student-Based: Before every semester, the Mathematics Department conducts a thorough student review. All Math faculty discuss each student individually. Namely, each student's progress toward completion, performance in major classes, preparedness for future coursework, and disposition are discussed. To extend this review to non-MA coursework, the Mathematics Chair will communicate with instructors in Computer Science and the enrichment options about students' non-MA course preparedness and disposition. EAB Navigate will be used for effective dual- and triple-advising.

  Long-Term, Programatic: CAMS students will be assessed using the same assessment scheme used for Mathematics majors currently being implemented via Taskstream. An assessment scheme that incorporates the CS course and enrichment options will be developed and implemented within 2 years. Future enrichment options will be added with assessment procedures fully planned.

  Long-Term, Outcomes: One, three, and five year surveys will be sent to CAMS graduates to assess their employment, satisfaction with employment, preparedness for position, etc.

VI. Program Delivery System

- Physical locations: PSU main campus

VII. Enrollment Impact

- New student enrollment estimates for next 4 years:
  - 2019: 10
  - 2020: 10-15
  - 2021: 15-20
  - 2022: 20
- Increased FTE for the institution: The impact on FTE should be minimal unless new student enrollments is greater than expected. The bulk of the classes required in the program can hold more students without a need to offer additional sections. In a few circumstances, one additional section of courses may be required.

VIII. Institutional Resources

CAMS is constructed entirely from existing PSU courses that should have adequate room for students in CAMS without the need for additional sections.

IX. Course Syllabi

Please see the fifty-one syllabi, including lab syllabi, that are attached. (And have fun reading them all!)

X. External Review and Response

An external review has not been conducted by faculty members at an academic institution. Few programs of this nature exist, and those that do are in departments that offer advanced degrees. Since this is not a certification or accredited program, it seemed illogical to seek a formal external review.

Dr. Michael Dorff of the BYU mathematics department was informally consulted during the development of the CAMS program. He indicated that CAMS is in the same spirit as the ACME program and would provide students with many of the same skills, even if it is lacking in upper-level mathematics requirements.

Dr. Zachary Kenz, formerly of the MIT Lincoln Labs and now of DILISim, and Dr. Clay Thompson, formerly of Phizer and now of SAS, were both informally consulted. Both gave strong positive feedback and indicated that a graduate of the CAMS graduate would be immediately eligible for a low-level position within their companies. Additionally, both indicated that they would have selected the CAMS major over their traditional math degrees.