MAR 0 8 2012

UNIVERSITY OF WASHINGTON

CREATING AND CHANGING UNDERGRADUATE ACADEMIC PROGRAMS

OFFICE USE ONLY
Control # BIS-20120213

After college/school/campus review, send a signed original and 8 copies to the Curriculum Office/FCAS, Box 355850.

For information about when and how to use this form: http://depts.washington.edu/uwcr/1503instructions.pdf

College/Campus Bothell	**Department/Unit** Interdisciplinary Arts and Sciences	**Date** 2/13/12

New Programs

- ☐ Leading to a Bachelor of _____ in _____ degree.
- ☐ Leading to a Bachelor of _____degree with a major in _____.
- ☒ Leading to a Mathematical Thinking and Visualization Option within the existing major in Interdisciplinary Studies.
- ☐ Leading to a minor in _____

Changes to Existing Programs

- ☐ New Admission Requirements for the Major in _____ within the Bachelor of _____.
- ☐ Revised Admission Requirements for the Major in _____ within the Bachelor of _____.
- ☐ Revised Program Requirements for the Major in _____ within the Bachelor of _____.
- ☐ Revised Requirements for the Option in _____within the major in _____.
- ☐ Revised Requirements for the Minor in _____.

Other Changes

- ☐ Change name of program from _____ to _____.
- ☐ New or Revised Continuation Policy for _____.
- ☐ Eliminate program in _____.

Proposed Effective Date: **Quarter:** ☒ Autumn ☐ Winter ☐ Spring ☐ Summer **Year: 20 13**

Contact Person: Michele Libin	Phone: 425-352-5271	Email: mlibin@uwb.edu	Box: 358530

EXPLANATION OF AND RATIONALE FOR PROPOSED CHANGE

For new program, please include any relevant supporting documentation such as student learning outcomes, projected enrollments, letters of support and departmental handouts. (*Use additional pages if necessary*).

Please see attached.

OTHER DEPARTMENTS AFFECTED

List all departments/units/ or co-accredited programs affected by your new program or changes to your existing program and acquire the signature of the chair/director of each department/unit listed. Attach additional page(s) if necessary. *See online instructions.

Department/Unit:	Chair/Program Director	Date:
		2-15-12
Department/Unit:	Chair/Program Director	Date:

CATALOG COPY

Catalog Copy as currently written. Include only sections/paragraphs that would be changed if your request is approved. Please cross out or otherwise highlight any deletions.

PROPOSED CATALOG COPY

Reflecting requested changes (Include exact wording as you wish it to be shown in the printed catalog. Please underline or otherwise highlight any additions. If needed, attach a separate, expanded version of the changes that might appear in department publications). **Please note:** all copy will be edited to reflect uniform style in the General Catalog.

The option in Mathematical Thinking and Visualization in the Interdisciplinary Studies major is housed in Interdisciplinary Arts and Sciences at the University of Washington Bothell. The degree educates students in knowledge and capacities related to mathematical and quantitative reasoning and data visualization. The curriculum mixes courses that introduce and develop these topics with workshops that enable students to create their own data visualization projects.

APPROVALS

Chair/Program Director:	Date: 2-13-12
College/School/Campus Curriculum Committee:	Date: 2/29/12
Dean/Vice Chancellor:	Date: 3-8-12
Faculty Council on Academic Standards/ General Faculty Organization/Faculty Assembly Chair:	Date: 2/29/12

POST TRI-CAMPUS APPROVAL (when needed)

Faculty Council on Academic Standards/ General Faculty Organization/Faculty Assembly Chair:	Date:

UNIVERSITY of WASHINGTON | BOTHELL

Office of the General Faculty Organization

To: Faculty Council on Tri-Campus Policy

From: Pamela Joseph, Chair, Executive Council of the General Faculty Organization, University of Washington Bothell

Date: February 24, 2012

Re: Executive Council Approval of Mathematical Thinking and Visualization

The Executive Council (EC) of the General Faculty Organization of University of Washington Bothell reviewed the responses from the tri-campus review of the proposal for the Mathematical Thinking and Visualization at its February 7, 2012 meeting. The EC has determined that the proposing faculty in the Interdisciplinary Arts and Sciences Program have duly considered and responded to the comments posted by faculty from across the three campuses during the tri-campus review period. The EC furthermore voted to approve the Mathematical Thinking and Visualization proposal.

Please let me know if you need any additional information.

May 3, 2011

Proposal for an Option in Mathematical Thinking and Visualization Interdisciplinary Arts and Sciences University of Washington Bothell

Overview

A new option for Interdisciplinary Arts and Sciences (IAS) students at the University of Washington Bothell (UWB) is proposed to start in Fall 2012. The option in Mathematical Thinking and Visualization (MRV) will join existing options in the Interdisciplinary Studies major. In addition to normal graduation requirements for all Interdisciplinary Studies majors, students will complete 40 credits for the MRV option.

The proposed option responds to the UWB 21st Century Initiative's commitment to "develop new majors and graduate programs in high-demand fields and foundational studies to serve student, employer and regional needs" and to the IAS priority to "provide students with a transformative education that hones their ability to think critically and creatively, research and communicate effectively, and work and lead collaboratively." The UWB Mathematics and Quantitative Reasoning Task Force, in its final report of March 24th, 2011 discussed this proposal along with a draft proposal for a Bachelor of Science in Mathematics, which would be offered by the Science and Technology Program. It wrote that

> ...these degrees, if approved, would:
>
> - add to the already-rich variety of UWB degrees that draw on lower-level mathematics courses. This connects to recommendations for supporting teaching in the CUSP mathematics courses.
> - potentially share some upper-level courses, such as game theory or graph theory. We recommend that faculty curricular decisions be informed by cross-program consultation, and that the campus adopt as a goal the greatest possible sharing of courses.
> - facilitate the offering of courses useful to non-majors.
> - help to build a campus culture in which mathematics is prominently visible, and richly linked to other areas of study. [1]

That document further "encourage[s] continued cross-campus coordination of upper-level mathematics and quantitative reasoning." The current Washington State Higher Education Coordinating Board Strategic Master Plan identifies education in mathematics among its priorities, and urges an expansion of degree opportunities in that area.

[1] MQRTF Task Force Report, page 8.

Background

Mathematics has been part of the IAS curriculum from the beginning and has formed an important part of the campus-level curriculum shared with other programs. Instruction has addressed the applied needs of IAS and other students, especially in statistics, but has also treated mathematics as a subject in its own right, via courses on mathematical aspects of art, game theory, number theory, and other subjects.

In Spring 2006, IAS Senior Lecturer John Rasmussen interviewed 15 regional leaders from for- and non-profit organizations. One of his questions asked "What math/quantitative skills and abilities do you value in entry-level college graduates?" Among the five abilities identified by more than half of the respondents, three

(1) translate real world problems into numbers and formulas
(2) use of statistics
(3) analyze data and present it visually.

inform the currently-proposed degree. Current IAS math courses have also incorporated these ideas into their learning goals, and BIS232: "Visualizing and Interpreting Data," was developed as a result of this work.

There are currently three mathematicians on the IAS faculty, and a much larger number of faculty have graduate-level mathematical, statistical, and/or quantitative reasoning. Several faculty have training as practitioners and scholars visual arts. During the 2009-10 academic year IAS made two hires in Geographic Analysis and Visualization, both of whom bring expertise in mathematical modeling, and interpretation of data, as well as experience in communicating the results of geographical work to local communities. IAS students in a number of degrees have reported that their abilities in communicating data and concepts visually have made a difference in getting employment in such areas as environmental consulting.

As the UWB Mathematics and Quantitative Reasoning Task Force report notes, the MRV degree can complement a more traditional mathematics degree of the kind contemplated by the Science and Technology program, because courses can be cross-listed, faculty can teach across both degrees, and faculty development and student support can be provided for both. This degree provides options for students in the Education program who are seeking to fulfill requirements for a Mathematics Endorsement, particularly for primary and middle school; at least seven of the IAS courses listed below would meet requirements for a secondary school endorsement in the State of Washington.[2] The proposed degree would support innovative efforts by the CSS program to offer courses of interest to non-CSS-majors.

As IAS grows, we look forward to supporting the growth of mathematics and quantitative reasoning across the campus and contributing to cross-program initiatives, as well as increasing the opportunities of IAS students to learn mathematics and have their work recognized in the

[2] For a complete listing of the Secondary Education Mathematical Endorsement requirements, see: http://www.uwb.edu/secondarycertmed/mathendorsement

form of degrees. In both its subject matter and opportunities for course cross-listing, this degree option can act as a bridge between our degrees and degrees across campus.

Rationale

An Bachelor's degree with an option in Mathematical Thinking and Visualization will address State needs and student interests in communicating data and concepts. It will build on IAS strengths in quantitative reasoning, logical and critical thinking, data visualization, and geographic visualization. It will support, and develop links to, teaching in Environmental Studies, Environmental Science, Community Psychology, Media and Communication, Policy Studies, Global Studies, Cultural Studies, and Interdisciplinary Arts.

"Mathematical reasoning" refers to abilities to

- Recognize mathematical forms in real-world phenomena: this may include simple pattern-recognition, the identification of functional forms, and the ability to see common types of model in multiple guises.
- Identify and describe key features of a *problem* mathematically, and use that mathematical description to analyze the problem.
- Construct appropriate models (from a range of choices).
- Generate frameworks of concepts that can be filled with data.
- Gather and interpret data, with attention to units, measurement, and sources of error.
- Use a range of techniques, including diagrams, graphs, tables, formulas, simulations, to understand data, problems, and data-based claims.

As the term is used here, "mathematical thinking" is broader than the view that mathematics "is about developing rigorous logical proofs about formally defined abstract structures, starting with a set of precisely formulated specific axioms;" like Keith Devlin we seek a wider range of ways to "do math."[3] The list above draws on Alan Schoenfeld's argument for a more inductive, problem-focused education in mathematics.[4] The inductive focus of this degree also represents a division of labor within UWB: the B.S. in Mathematics currently being developed in the Science and Technology program would proceed along more traditional deductive lines, prioritizing formal proof.

Students trained in mathematical thinking are not compelled to take at face value the models, formulations, or data-derived arguments they encounter. That is, a student with this background should not merely be competent in quantitative reasoning, but able to think critically about the concepts and choices that underlie the frameworks for the data and mathematical models used to address a question. Students should also be able to bring together quantitative and non-quantitative data to address a question.

---

[3] Keith Devlin, "What does "doing math' mean?" Mathematical Association of America, April 2005.

[4] Alan H, Schoenfeld, . (1992). Learning to think mathematically: Problem solving, metacognition, and sense-making in mathematics. In D. Grouws (Ed.), Handbook for Research on Mathematics Teaching and Learning (pp. 334-370). New York: MacMillan. Note that aside from the emphasis on the nature of proof, the proposed degree closely tracks the recommendations from the MAA's Committee on the Undergraduate Program in Mathematics (CUPM) can be found at http://www.maa.org/cupm/

"Visualization" refers both to ways that we make questions, phenomena, and arguments clear to ourselves, and to the ways we communicate them to others. While this degree draws on powerful visual traditions and techniques, it does not preclude sound, narrative, or other technologies of communication. This is a rich area, in which work in natural sciences (in particular biology), mapping, social sciences, and arts converge. Some courses of this kind, for example in the Visual Arts in Biology and the mathematics of aesthetics, have already been taught in IAS.

There is already a substantial base of students in several IAS degrees who are taking a required introductory statistics course[5]; a focus in this concentration would let them deepen those skills through advanced courses, explore their theoretical underpinnings, and gain more experience doing research projects that use quantitative methods and communicate their results. Courses in logic, mathematical modeling, and visualization, most of which are already being taught regularly in IAS, would round out this option.

There is also a large base of students who are taking required courses in geographic information science (GISc). At both introductory and advanced levels, students are learning a complete new set of quantitative skills within the fields of spatial analysis and geo-visualization. One of the main skills gained through these courses is the ability to translate geographic problems into mathematical and logical formulations that can be used to model, analyze, and quantify the relationships between geographic features and the environment. In addition, the outcomes of these spatial analyses are represented and visualized as a form of map. Students learn how to create, understand, and interpret geo-visualization where 'numbers' and spatial analyses are embedded in its production.

As IAS increases emphasis on writing and communication, and on completing substantial projects, we are seeing more student research drawing on social and environmental data. In many cases, students collect their own data. The demonstrated capacity to interpret and communicate concepts and information, whether to immediate colleagues or the public at large, will be a compelling skill for a range of employers. IAS students, in particular, have the opportunity to gain experience with a wide range of modes of (interactive) presentation, including photo essays, websites, research papers, and live facilitation. This degree will give students with a strong interest in understanding and communicating complex ideas and dense information an opportunity to develop and showcase those capacities.

At least a dozen full-time IAS faculty members are potential contributors to a course of study of this kind. Advanced courses in quantitative reasoning would also be attractive to business and science students as well as students in other IAS degrees such as community psychology and policy studies. There are numerous undergraduate and graduate degrees and research centers in quantitative methods and information visualization that we might look to as models.[6] IAS

---

[5] For example, the following concentrations require BIS315 (Intro Statistics) for graduation: CP, STS, Env. Science, and SEB. Others, e.g. AMS and ES, also have considerable quantitative tracts.

[6] For example, see Columbia's MA in Quantitative Methods for the Social Sciences (http://www.columbia.edu/cu/gsas/departments/quantitative-methods-social-sciences/bulletin.html), or the University of New Hampshire's Data Visualization Lab (http://ccom.unh.edu/vislab/index.html)

faculty could also contribute significantly to students thinking about knowledge production about and with data, including the ways in which data is created and used.

Developing the above degree would also help IAS meet the growing need for our graduates to achieve competency in quantitative literacy. AAC&U has listed QL has one of its essential learning goals, and there is growing national work that IAS could learn from and contribute to in this area. Throughout IAS, and across the campus, we need to build a culture that sees mathematical methods not as a barrier, or even a hoop to jump through, but a means to insight and better communication. This degree's emphasis on these qualities will serve both its majors and the campus at large.

IAS' annual assessment evaluates student portfolios against criteria for these four goals; those criteria have been revised in 2011 to include mathematical and quantitative skills. This annual assessment encompasses all IAS degrees, but also provides a process that can easily be adapted so that individual degrees can gather evidence about their students' learning.

Learning Objectives

The learning objectives for the Mathematical Thinking and Visualization degree are aligned with and support the four course IAS learn objectives (critical thinking; interdisciplinary research; writing and presentation; shared leadership and collaboration). Students receiving this degree will:

1. Acquire critical competence in different ways to address real-world problems in mathematical forms (CT).

2. Learn to apply statistical tools and critique their applications, including building and critiquing arguments based on quantitative data. Generate reliable data and evaluate which methods to apply to a given data set (CT; IR).

3. Gain experience creating visual representations of problems and data, and communicate these ideas, results, and analyses in multiple formats (WP).

4. Learn to use mathematical tools across varied disciplinary areas (IR).

5. Learn to work in interdisciplinary teams to communicate and to understand a range of problems that have mathematical underpinnings (IR; SLC; WP).

Curriculum

The curriculum of a new Mathematical Thinking and Visualization degree option will be structured with courses falling into four categories:

1. Prerequisites: Students will be asked to complete

- one quarter of calculus
- one quarter of linear algebra

Students can complete these regularly taught courses at UWB or at another institution. These courses provide underpinnings of the quantitative models and essential mathematical ideas.

2. Required Core Courses: In addition to BIS300 (Introduction to Interdisciplinary Inquiry), which is required of all IAS students, students in this degree would complete

BIS209: Engaging Visual Arts: This course will introduce students to visual form – to the range of possibilities for visual communication, and some part of the history of visual conventions. Viewers encounter visual phenomena having already learned to see and interpret them in particular ways. Arts both draw on those learned ways and, sometimes, change them. The course in visual arts, therefore, provides students a richer understanding of the possibilities in visual communication, and a more sophisticated grasp of visual form as a means to communicate to an audience. It is useful for purposes of this degree to approach visual form and communication *outside* the context of mathematics, in order to isolate the question of visualization.

BIS232: Visualizing Quantitative Data: This course introduces students to the scholarship of data visualization. Through multiple case studies, students learn how numbers become proxies for ideas and what information quantitative modeling can and cannot provide for important decision making. Students learn how to locate public data sets and create both a technical and creative presentation from these data sets. (We may change its name to Introduction to Data Visualization.)

BIS315: Understanding Statistics: This course is central to this degree not only for the study of statistical inference, but also because it addresses the fundamental understanding of how data is constructed, and how a given question in the world might be addressed in different ways – different choices of model, different foundational assumptions.

3) Students must take 25 credits in the two categories listed below, with a minimum of 10 credits in each category.

Mathematical Thinking: Students will choose at least two courses that will help them develop the mathematical tools gained in their prerequisite and core courses. This list will evolve as curricula across UWB change; courses in this category explicitly study mathematical principles. That emphasis is manifest in their readings, assignments, and evaluation. This criterion does not exclude courses with substantial application, but a student finishing a course in this category should be able to reflect critically on the mathematical principles learned, in a way that aids their thoughtful application elsewhere.

Visualization Practice and Methods: Students will choose at least two courses that extend their capacities in visualization and communication. "Visualization" may include modeling and tools for examining data sets. It includes interactive and informal modes of presentation and communication, along with polished presentations to specific audiences. Courses in this category develop means of representing, and critically examining data and arguments.

4) Like all IAS students, MRV students will take BIS 499: Portfolio Capstone. If it is approved, they will also need to satisfy the IAS "Interdisciplinary Practice and Reflection" requirement. The latter can be satisfied by courses listed as "mathematical thinking" or "visualization practice." Students can also take an additional course (on top of the 25 credits) to satisfy this requirement.

Category	Credits	Courses
IAS Core	5	Interdisciplinary Inquiry
Degree Core	15	BIS 209 Engaging Visual Arts BIS 232 Using, Understanding, and Visualizing Quantitative Data BIS 315 Understanding Statistics
Mathematical Thinking	10-15	BCUSP 125/126 Calculus II and III BIS230 Mathematical Thinking for the Liberal Arts BIS302 Issues in Mathematics Across Cultures BIS 329 Topics in Mathematics Across the Curriculum (Topics have included game theory, knot theory, mathematical modeling, symmetry, and cryptography; up to 10 credits) BIS 350 The Concept of Number BISMRV 3xx Logic BISMRV 3xx Graph Theory and Social Decision Making BISMRV 3xx Cryptography BISMRV 4xx Mathematical Systems BISMRV 4xx Combinatorics and Discrete Probability STMATH 300 Foundations of Modern Mathematics STMATH 3xx Mathematical Theory of Games CSS 342 Mathematical Principles of Computing Additional CSS courses *Selected courses from an upcoming formal math degree in S&T may also be available in this option.*
Visualization Practice and Methods	10-15	BIS 2XX: Visual Communication BIS 342: Geographic Information Systems BIS 4XX: Advanced Geographic Information Systems BIS 4XX Geographic Visualization BIS 382 The Visual Art of Biology BIS 434 Psychology and the Visual Arts BIS 447 Topics in Quantitative Inquiry BISMRV 4xx Data Visualization Workshop *Suggestions of other IAS and UWB courses are welcome.*

Additional IAS Coursework	22	This category may including 10 IAS credits in each of the UW areas of knowledge, if not already satisfied.
Portfolio Capstone	3	BIS 499 Portfolio Capstone
General Electives	20	

Note: Within the 90 credits, students must complete 10 credits each in Individual and Society (I&S), Natural World (NW), and Visual, Literary, and Performing Arts (VLPA).

Faculty and Staff

Alex Barchechat: Mathematics

Cinnamon Hillyard: Undergraduate Mathematics Education, Numerical Methods for Partial Differential Equations, Ethnomathematics

Jin-Kyu Jung: Geographic Information Science, Urban Geography

Santiago López: Geography and the Environment

John Rasmussen: Interdisciplinary Mathematics, Finance, Computer Modeling

Additional Faculty

Our ability to staff courses, develop curriculum, and work with students would be greatly enhanced by the addition of colleagues in two areas:

Statistics and Modeling: A social or natural scientist with experience designing and applying a range of models and statistical techniques

Data Visualization: A scholar with training in both mathematics and visual arts

While not essential to begin the degree, a colleague who could teach logic would help expand options to students in the degree.

Administration and Advising

The MRV option will be housed and administered in IAS under the leadership of the IAS Director and a Curricular Area Working Group charged to oversee MRV. Advising will be done principally by IAS advisors.

Effect on Curriculum

The most significant positive effect of a new MRV option on the rest of the IAS curriculum, apart from the increase in enrollments and economies of scale within IAS and UWB, will be to provide an increased level of proficiency in mathematical thinking, quantitative literacy, data visualization and communication across the program and campus. We anticipate that this

increased quantitative literacy among students will strengthen courses throughout the program and across the campus.

The most significant negative effect will be to draw faculty teaching away from other options in which those faculty members currently teach. This concern is addressed in part by the request for faculty to both develop new courses within the MRV option and to help cover existing courses in other options for which existing faculty will no longer be available.

At the moment, the prerequisites for this degree are being taught on a regular basis, as are BIS 315 and BIS 209. BIS 232 (Visualizing Quantitative Data) is not taught frequently, and would assume a key role in this degree (we may also want to promote it to the 300 level), so that we will at a minimum need to free up faculty time to develop and teach this course. Among the upper-level electives, we offer enough at the moment that a student could fulfill requirements, but choices would not be large. A particular need would be for a regularly-offered logic course.

The equivalent of two additional full-time faculty members will be needed to offer this degree well; at least one of those needs to be a tenure-track hire.

Budgetary Impact

While the degree could be started without additional resources, it will, especially if it is successful in attracting a flow of students, make claims on GIS software and computing, on the Quantitative Skills Center, and on library databases.