Indiana Commission for Higher Education

Program Description—Graduate Certificate in Mathematics

To Be Offered by Indiana University as a Collaborative Program at Several Campuses

1. Characteristics of the Program

a. Campus(es) Offering Program—Joint Degree Shared by

Indiana University-East
Indiana University-Kokomo
Indiana University-Northwest
Indiana University-South Bend
Indiana University-Southeast

b. Scope of Delivery—Statewide
c. Mode of Delivery—100% Online
d. Other Delivery Aspects—None
e. Academic Unit Offering Program—Varies by campus:

IU East—College of Natural Science and Mathematics
IU Kokomo—School of Sciences
IU Northwest—College of Arts and Sciences
IU South Bend—College of Liberal Arts and Sciences
IU Southeast—School of Natural Sciences

2. Rationale for the Program

a. Institutional Rationale (Alignment with Institutional Mission and Strengths)

- Why is the institution proposing this program?

The Graduate Certificate in Mathematics will provide graduate-level instruction in mathematics to students interested in obtaining advanced skills and knowledge in this area. These may include instructors of Finite Mathematics, Calculus and other introductory college-level mathematics courses at community colleges, and high school dual-credit and international baccalaureate mathematics teachers, among others. For those students who are teaching or plan to teach introductory post-secondary mathematics, certificate courses will help them integrate new mathematical concepts and approaches into their teaching, thereby improving the quality of instruction and learning outcomes for their students.

The certificate allows instructors of introductory college-level mathematics to partially meet the faculty educational standards of many post-secondary institutions. These requirements usually include a master's degree in the discipline, or a master's degree in another field (e.g., education) plus 18 hours in the discipline. With the increased attention that the Higher Learning Commission and other accrediting bodies are giving

to the issue of faculty qualifications, current faculty are seeking ways to meet the requirement.

Finite Mathematics and Calculus are among the most highly enrolled dual-credit courses in Indiana. There are hundreds of dual-credit teachers across the state who could complete this certificate to meet HLC standards. In addition, IU expects this certificate to be popular among out-of-state teachers and others who wish to develop further their understanding of mathematics and integrate this understanding into their careers.

- How is it consistent with the mission of the institution?

This certificate answers the charge of the Indiana University Bicentennial Strategic Plan to provide an excellent education that promotes retention and completion through innovative online instruction that accommodates the work schedules and family demands of working Hoosiers.

With a focus on extending the reach of dual-credit and community college instruction in high-demand introductory level courses, the Graduate Certificate in Mathematics meets IU's charge as a public university, which the *Bicentennial Strategic Plan* as follows:

> IU is a public university in a deep sense; it exists to benefit all the people of the state, and the world beyond, and has a charge to continue its long tradition of engagement in the economic, social, environmental, and cultural life of all Hoosiers. This charge applies to all IU campuses, and it has special significance for the regional campuses. These campuses' communities and regions rely on their respective campuses for undergraduate and professional education that addresses regional needs.

As a collaborative program, the Graduate Certificate in Mathematics delivered by four IU campuses will provide efficiencies of scale building on the distinct strengths and character of the mathematics faculties of the participating campuses.

- How does this program fit into the institution's strategic and/or academic plan?
- How does this program build upon the strengths of the institution?

The December 2014, Indiana University Bicentennial Strategic Plan identified the integration of new educational technologies and collaborative platforms and the development of a robust program of online education as essential tools to ensure that the university and its faculty continue to serve the citizens of the state of Indiana.

As a part of this initiative, the university developed IU Online to serve as administrative home "coordinating and catalizing IU's efforts in this area." The plan summarizes the specific benefits as follows:

> Online and hybrid delivery allow IU through IU Online to expand its offerings across campuses in a cost-effective way, through developing systems of shared online resources. IU will complete through IU Online a university-wide framework for online education, to enhance instructional quality and support, and create scalable economies in course and program delivery for all campuses.

See Appendix 1 for Web Addresses to:

- Indiana University Bicentennial Strategic Plan
- January 2016 IU Online: A Collaborative Model for Online Education at Indiana University.

b. State Rationale

- How does this program address state priorities as reflected in the ICHE's 2016 strategic plan Reaching Higher, Delivering Value.

As a collaborative program, the Graduate Certificate in Mathematics will allow participating campuses to meet the needs of mathematics educators across the state improving mathematics instruction in dual-credit and community college courses. This collaboration answers the ICHE's call to improve College Affordability and Readiness as outlined in the 2016 publication Reaching Higher Delivering Value. Each high school in the state of Indiana is expected to deliver at least two dual-credit courses, and a significant number of schools choose to focus on mathematics teaching Finite Mathematics and Calculus.

The Graduate Certificate in Mathematics will address each one of the four goals primary goals listed in *Reaching Higher, Delivering Value*: Completion, Competency, Career, and Delivering Value, and it will benefit not only the mathematics instructors who enroll in the program, but also their students taking mathematics courses in high schools and community colleges across the state. To be specific, the certificate will meet each of the goals in the following manner:

I. Completion—As mentioned above, although the certificate may attract a wide spectrum of students, it will serve the particular needs of instructors teaching college-level mathematics courses in high school and community colleges across the state. Its online mode of delivery will provide these working professionals with a manageable option to pursue advanced disciplinary study. Individuals who may have earned prior mathematics credit in graduate programs will be able to apply some of these credits towards completion of the certificate, and it will be "stackable" with the online Master of Liberal Studies as wells as a number of other online Masters' currently in planning phase.

II. Competency—A sound foundation in mathematics is essential to success for academic success not only in STEM fields but also in coursework across the curriculum. Increasing the opportunities and improving the quality of instruction in college-level mathematics courses taught in the high schools and community colleges will provide students with the type of pre-requisite coursework essential to enter a variety of foundational and gateway courses in their first semesters of enrollment at the university; thereby reducing barriers to completion and speeding time to degree.

Employers in all sectors of the economy consistently seek employees with the quantitative and analytical skills that students develop in these mathematics courses.

III. Career—The collaborative Graduate Certificate in Mathematics will allow individuals with an interest in mathematics pedagogy and applications to meet their professional goals. Dual-credit and community college instructors will be able to meet HLC faculty qualification standards that require at least 18 credit hours of specialized graduate study, and they will have options to stack the certificate into a Master's degree program if needed.

IV. Delivering Value—While 100% online delivery mode will allow students to further their education with minimal disruption to their professional and family lives

c. Evidence of Labor Market Need

i. National, State, or Regional Need

- Is the program serving a national, state, or regional labor market need?

The collaborative online Graduate Certificate in Mathematics will allow primarily serve students in the Upper-Midwest; however, recent trends in higher education accreditation as it applies to faculty qualifications in dual-credit courses indicate that there may be a national market for a flexible online degree that teachers can pursue without interference with their regular instructional duties.

ii. Preparation for Graduate Programs or Other Benefits

- Does the program prepare students for graduate programs or provide other benefits to students besides preparation for entry into the labor market?

This degree will not prepare student for entry into Doctoral Programs in Mathematics; however, it will be stackable with a number of proposed collaborative online Master's degrees helping instructors for college-level mathematics courses to meet Higher Learning Commission standards.

iii. Summary of Indiana DWD and/or U.S. Department of Labor Data

- Summarize the evidence of labor market demand for graduates of the program as gleaned from employment projections made by the Indiana Department of Workforce Development and/or the U.S. Department of Labor?

See Appendix 2 for a Short Market Analysis and Summary of Indiana DWD and U.S. Department of Labor Data.

iv. National, State, or Regional Studies

- Summarize any national, state, or regional studies that address the labor market need for the program.

The curriculum of the Graduate Certificate in Mathematics will serve a broad range of students pursuing graduate study; however, one of the initial impetuses for prioritizing this proposal was a change in HLC accreditation practices. In an emergency presentation to the Indiana Commission for Higher Education on October 8, 2015, two representatives from the Center for Excellence in Leading and Learning, Dr. Janet Boyle, Executive Director and Tyonka M. Perkins, Interim Director of Early College presented findings about the potential impact of these HLC changes based on a credential analysis of Indiana, dual-credit instructors. Boyle and Perkins found that:

- Only 30% of current instructors hold an M.A. in their field;
- 1,193 instructors hold M.A.T.s, and other graduate degrees in the field of education, but lack the 18 graduate credit hours in the specific content area in which they teach;
- A further 600 instructors have neither a Master's degree nor the requisite content area credit hours.
- In all, more than 43,000 Indiana students currently take dual-credit courses with instructors who do not meet the HLC standards.

While many students will pursue the Graduate Certificate in Mathematics for personal and professional reasons that do not intersect with faculty qualification standards tied to accreditation, the ability to stack this degree an MLS and other collaborative Master's degrees in development should attract a significant number of accomplished teachers who wish to continue teaching college-level classes to highly motivated students.

See Appendix 2 for a Short Market Analysis and Summary of Indiana DWD and U.S. Department of Labor Data.

3. <u>Similar and Related Programs</u>

a. List of Programs and Degrees Conferred

i. Similar Programs at Other Institutions

Campuses offering (on-campus or distance education) programs that are similar:

The existing IUE Graduate Certificate in Mathematics will merge with the Collaborative IU Online Graduate Certificate in Mathematics following a set of guidelines negotiated between the VCAA at IU East and the EVPUAA.

The Graduate Certificate in Math has been designed with the expectation that it will be eligible to "stack" with a new collaborative IU Online M.A.T in Mathematics, which will be designed by a curriculum committee composed of faculty members drawn from the Schools of Education as well as from Departments of Mathematics.

- CHE staff will summarize data from the Commission's Program Review Database on headcount, FTE, and degrees conferred for similar programs in the public sector, as well as information on programs in the non-profit and proprietary sectors, to the extent possible.

  See: *CHE Appendix A: Similar Programs at Other Institutions.*

ii. Related Programs at the Proposing Institution

- CHE staff will summarize data from the Commission's Program Review Database on headcount, FTE, and degrees conferred for related programs at the proposing institution.

  See CHE Appendix B: Related Programs at the Proposing Institution,

b. List of Similar Programs Outside Indiana

- If relevant, institutions outside Indiana (in contiguous states, MHEC states, or the nation, depending upon the nature of the proposed program) offering (on-campus or distance education) programs that are similar:

  Southern New Hampshire University
  Arizona State University
  University of Michigan

c. Collaboration with Similar or Related Programs on Other Campuses

- Indicate any collaborative arrangements in place to support the program.

  The collaborative online Graduate Certificate in Mathematics will be listed on the IU Online website, and will receive marketing and recruitment support from the Office of Online Education (OOE). OOE staff and representatives will be trained to answer initial responses regarding the program and refer prospective students to the campuses for follow-up. OOE will partner with this academic program to provide marketing and recruitment campaigns that reinforce the overall recruitment message and maximize the utilization of OOE, campus, and program resources. OOE will provide effectiveness tracking of marketing campaigns and establish Return on Investment for marketing and recruitment of IU Online students.

  The Office of Collaborative Academic Programs (OCAP) will play a coordinating role for the multi-campus collaboration by providing staff support to the certificate's steering committee and serving as a clearing house for the administrative and curricular questions that may arise.

4. Quality and Other Aspects of the Program

a. Credit Hours Required/Time To Completion

Working professionals will be able to complete the 18 credit hour Graduate Certificate in Mathematics in two to three years of consecutive part-time enrollment. Students who can take more than one course at a time may complete the degree more quickly.

- Credit hours required for the program and how long a full-time student will need to complete the program

  See Appendix 6: for a two-part curriculum map.

b. Program Competencies or Learning Outcomes

- List the significant competencies or learning outcomes that students completing this program are expected to master.

  Students in the Graduate Certificate will develop graduate-level knowledge in three of these five areas of mathematics:

  1. Core applications of **Algebra** including Group Theory, Ring Theory, Field Theory, Commutative and Noncommutative Algebra, Number Theory, and other topics in Algebra.
  2. **Analysis** applications. Topics covered in this area include Real Analysis, Complex Analysis, Fourier Analysis, and other topics in Analysis.
  3. Essential concepts of **Topology/Geometry** including topics in Euclidean and non-Euclidean Geometry, Point set topology, Differential Topology, Differential Geometry and other topics in Topology/Geometry.
  4. **Differential Equations and Applications** including Numerical Methods, Mathematics of Finance, Graph Theory, Mathematical Physics, and other topics.
  5. Key concepts of **Probability/Statistics**.

c. Assessment

- Summarize how the institution intends to assess students with respect to mastery of program competencies or learning outcomes.

  The Steering Committee of the collaborative online Certificate in Graduate Mathematics will supervise the assessment process. Initial quantitative measures to evaluate the success of the program will include:

  - the number of students enrolled in the proposed certificate program,
  - the number of students who complete the program
  - student GPAs.

A full program review will be completed every five years, as part of the School's cycle of outside review. The decisions of this review will be informed by the collective of evaluation benchmarks described below.

Evaluation Benchmarks for Student Success

A. Acceptance into the Program and Entrance Survey

Candidates submit application materials (as outlined above). These materials are used to determine whether the applicant is ready for graduate study, and help identify the need for remediation. The Steering Committee will take this information into account when it assesses other curricular benchmarks and adjust the admission standards accordingly.

B. Completion of Mathematics Coursework.

1. Proof and Rigor in Mathematics This assessment will be course embedded. In appropriate courses (Analysis, Algebra, Topology), instructors will assess students' ability to understand and apply rigorous definitions, provide suitable examples and counterexamples, and give rigorous proofs of theorems. In these courses, the assessment will also investigate students' ability to judge truth of statements, and to provide a proof or a counterexample, as needed.
2. Mathematical Modeling and Applications This assessment will be course embedded. In appropriate courses (Probability, Statistics, Mathematical Modeling), instructors will assess students' ability to apply the concepts in real-world situations, select suitable solution methods and interpret the answer in the context of the given problem.
3. Assessment strategies for related courses at the graduate and undergraduate level already exist and will be adapted to meet the goals of the collaborative academic program. The programs will use the benchmarks to determine whether a student is in good standing and, if needed, will suspend students who do not meet these criteria. The program will also use the course assessment to make improvements to individual courses.

C. Exit Survey

An interview will be conducted with all graduate students upon completion of the program. Questions will be designed to evaluate outcomes of student learning along with resources, program content, program administration, and faculty. As part of the exit interview, we will administer the same survey for the students' disposition towards proof and rigor in mathematics as was given upon admission. The progression in attitude towards the principle tenets of mathematics will inform the program's decisions on course design, and possible changes in the program.

Appendix 1-Links and Web Addresses to Strategic Plan Documents

The Indiana University Bicentennial Strategic Plana can be accessed at https://strategicplan.iu.edu/plan/education.html

The IU policy paper on online collaborative programs, "January 2016 IU Online: A Collaborative Model for Online Education at Indiana University" can be viewed at https://uaa.iu.edu/academic/ooe/docs/ooe_model.pdf.

Appendix 2 Short Market Analysis and Summary of U.S. Department of Labor Data

Data Report for Market Analysis and Demand
Degree: Graduate Certificate in Mathematics
CIP Code used: 27.0101 –Mathematics, General
SOC Code(s) used: 25-1022.00 - Mathematical Science Teachers, Postsecondary;
Campus: IU Office of Online Education
Delivery: Online

OUTLOOK
Source: http://www.onetonline.org/
National Outlook: Above average
Indiana Outlook: Above average
Average Salary: National: $67,170; Indiana: $62,990
Projected growth (2014-2024):
National: +16%; Indiana: +17%
Projected annual job openings (due to growth and net replacement):
National: 2,170
Indiana: 40

COMPETITION
Source: IPEDS College Navigator 1
Other Indiana institutions offering program:1
Indiana campuses offer this degree at the "Certificate" level: IPFW (none online)
Number of institutions offering degree nationally: Certificates
: 11 (1 online)
2013-14 IPEDS
Completions data
Post-baccalaureate or Post-Master's Certificate: 60 (3 from Indiana)

Notes:
1. The College Navigator does not differentiate certificate LEVEL and may include undergraduate certificates.

Appendix 3.1 Required Credit Hours Required and Sample Two Year Completion Map

To earn the 18 credit hour Graduate Certificate in Mathematics, students must:

I. Complete at least one course in three of the following five categories (9 cr):

1. Algebra
2. Analysis
3. Topology/Geometry
4. Differential Equations and Applications
5. Probability/Statistics

II. Complete three additional elective courses chosen from among the five course categories (9 cr).

Semester by Semester Map for IU Collaborative MLS (stacked with Graduate Certificate in Literature) Part-Time Enrollment		
Fall 1	**Spring I**	**Summer I**
MATH T601 Topics in Algebra—Algebra Survey	MATH T620-Topoics in Topology/Geometry-Topology I	MATH T650 –Topics in Probability/Statistics-Theory of Probability I
Fall II	**Spring II**	**Summer II**
MATH T640 Topics in Analysis-Analysis of Numerical Methods I	MATH T640 Topics in Analysis-Analysis of Numerical Methods II	MATH T650—Topics in Probability/Statistics-Theory of Probability II

Appendix 3.2 Curriculum Map Tied to Learning Objectives.

Graduate Certificate in Mathematics: Curriculum Map

The Graduate Certificate in Mathematics is an 18 credit certificate consisting of a breadth and electives requirement.

Requirement 1) Breadth of Knowledge in Mathematical Areas of Finite Mathematics and Calculus (9 cr). Students complete at least one course in three of the following five categories: Algebra, Analysis, Topology/Geometry, Differential Equations and Applications, and Probability and Statistics; all courses are 3 credit hours.

Requirement 2) Electives in Finite Mathematics and Calculus (9 cr). Students complete three additional courses selected from among the certificate's five categories: Algebra, Analysis, Topology/Geometry, Differential Equations and Applications, and Probability and Statistics; all courses are 3 credit hours.

LO 1-Algebra: Students will develop graduate-level knowledge in core applications of Algebra including Group Theory, Ring Theory, Field Theory, Commutative and Noncommutative Algebra, Number Theory, and other topics in Algebra..

Course #	***Course Title***
MATH T601	Topics in Algebra

LO 2-Analysis: Students will develop graduate-level knowledge in Analysis applications. Topics covered in this area include Real Analysis, Complex Analysis, Fourier Analysis, and other topics in Analysis.

Course #	***Course Title***
MATH T610	Topics in Analysis

LO 3-Topology/Geometry: Students will develop graduate-level knowledge in essential concepts of Topology/Geometry including topics in Euclidean and non-Euclidean Geometry, Point set topology, Differential Topology, Differential Geometry, and other topics in Topology/Geometry.

Course #	***Course Title***
MATH T620	Topics in Topology/Geometry

LO 4-Differential Equations and Applications: Students will develop graduate-level knowledge in Differential Equations and Applications including Numerical Methods, Mathematics of Finance, Graph Theory, Mathematical Physics, and other topics.

Course #	***Course Title***
MATH T640	Topics in Differential Equations and Applications

LO 5-Probability/Statistics: Students will develop graduate-level knowledge of Key concepts of Probability/Statistics.

Course #	***Course Title***
MATH T650	Topics in Probability/Statistics