Indiana University of Pennsylvania
WAC
Writing Across the Curriculum

Department of Mathematical and Computer Sciences

Mathematics Writing Plan

Compiled by
Dr. Edel Reilly
Dr. Gary Stoudt
in consultation with Dr. Bryna Siegel Finer, Director, Writing Across the Curriculum

Submitted to:
Dr. Francisco Alarcón, Department Chairperson
The Faculty of the Department of Mathematical and Computer Science
Dr. Steven Hovan, Interim Dean, Kopchick College of Natural Sciences and Mathematics
Dr. Karen Rose Cercone, Provost's Associate
Dr. Edel Reilly, Director of Liberal Studies
Dr. Lara Luetkehans, Provost

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Summary

Pre-merger of the Mathematics and Computer Science Departments, in February of 2014, Dr. Edel Reilly and Dr. Gary Stoudt of the Department of Mathematics decided to try to complete a writing plan for the department. After some brainstorming to start responding to some of the prompts in the writing plan template, we decided that a reasonable goal was to try to get the department on the same page – to agree that writing should occur in some way in most courses.

In creating their writing-enriched curriculum, Drs. Reilly and Stoudt served as liaisons between WAC and the department. They used a template borrowed from the University of Minnesota[1] and adapted by Siegel Finer to thoroughly investigate where and how writing was already being taught in the Mathematica curriculum, and where and how writing could be added to the curriculum, in order to draft the Department Writing Plan (DWP) for their department instructors.

At the end of February 2014, we looked more closely at the writing plan template and discussed where and how we could move forward with the plan. We wished to make some progress on the plan first, before bringing it to their department. For the next meeting, we will:

- Start looking at course outcomes chart and section 1
- Informally survey alumni about writing they do in their jobs
- Approve news release with dept and chair
- Invite me to a department meeting (for the fall) to talk about how to teach writing efficiently
- Delegate some of the course outcomes chart to other faculty in the department

The Mathematics Department endorsed the idea of a department writing plan by including in its Five-Year Review of April, 2014 the creation of a DWP (Action Item 5.1).

In October 2014 a writing and communication survey was sent to alumni, containing questions about the importance of various forms of writing and communication and how well IUP prepared them for these types of writing. These results were compiled in December of 2014.

At the same time a survey was sent to Mathematics Department faculty concerning types of writing in mathematics, outcomes for graduates, and how they incorporated writing in their classes. These results were also compiled in December of 2014 and informed our responses to the first two sections of our final writing plan.

During the Spring 2015 Dr. Dan Radelet joined Dr. Reilly and Stoudt in performing a literature search for writing in mathematics courses. During the 2014 – 2015 academic year faculty attended a Writing Workshop at IUP facilitated by Dr. Julie Reynolds. In

[1] University of Minnesota Writing Enriched Curriculum. 2013. http://wec.umn.edu/Writingplans.html

August of 2015 the department received a report from the external reviewer (James Sellers, Penn State University). While the report did not directly address the creation of a writing plan, it did provide encouragement and suggestions for venues for our students to hone their writing and communication skills.

During the Spring 2016 semester Dr. Reilly served as Interim Chairperson and Dr. Stoudt was on sabbatical, so no progress was made on the writing plan. In Fall of 2017 we made sure to include Mathematics Education in the writing plan, and it was determined that much of the writing teachers do, aside from lesson plans (which are well represented in our curriculum), could fall under the heading of professional writing, one of our categories of writing.

During the Summer of 2018, the Department of Mathematics was merged with the Department of Computer Science to form the Department of Mathematical and Computer Sciences. Much of the Academic Year 2018 – 2019 was spent in ironing out the details that come with such a merger, and with completing another Mathematics Department review. One of the issues we have encountered is that many faculty members did not have a clear understanding of the types of writing assignments that can be included. To help with this we did have several faculty attend the Spring Liberal Studies Writing Workshops. The department continued its commitment to the writing plan.

Drs. Reilly and Stoudt did have informal meetings about proceeding with the writing plan. During this time, we matched writing assignments to MATH courses and department Student Learning Outcomes (SLOs). In Academic Year 2019-20 the demands of crafting responses to the Provost's INSPIRE initiative put a hold on the Writing Plan, although a new draft was constructed in early Spring 2020. COVID-19 and retrenchment came next, and we all struggled to stay afloat.

In summer 2021 Dr. Bryna Siegel Finer ran a WAC Workshop on DWPs and this jump-started the process. Drs. Reilly and Stoudt both participated, and with the Computer Science faculty's blessing, Dr. Reilly agreed to work on a Computer Science Writing Plan so that the entire department would be included in writing and communication as a department goal.

They also developed a statement of "Department Commitment to Writing" to include on all syllabi for courses that will be a part of the writing-enriched curriculum.

At a meeting on April 28, 2022 of the Mathematical and Computer Sciences Department, faculty voted to support the Department Writing Plan as described below in addition to the WAC Director's recommendations for continuing program facilitation on page 25 of this document.

Mathematical and Computer Sciences Department
Mathematics Writing Plan
Rollout Fall, 2022

Professional and Academic Genres in Mathematics

Professionals in Mathematics must not only be able to communicate the results of their research to their peers, but also communicate these results to non-specialists. Some examples of the latter are analyzing mathematical models in the sciences, engineering, and social sciences and professional writing in a business setting.

We have separated writing in Mathematics to three main types: writing in pure mathematics, writing in applied mathematics, and professional writing.

Generally speaking, the writing should motivate and solve a problem, anticipate the reader's questions, and explain/teach the reader a new idea or reinforce an old idea. The writing should make use of proper mathematical typesetting. Writing in mathematics is characterized by logical arguments and deductions. In formal academic writing, we have proofs and logical arguments with their own form. However, even in informal communication the emphasis is on careful, internally consistent, deductive reasoning.

The demands of mathematical writing are substantial. Good mathematical writing is characterized by clarity and precision of explanation and the use of valid and sound logical arguments to establish results. Mathematics relies on rigorous definitions of its terms, so these definitions (and associated notation) must be clear and unambiguous. Arguments are often illustrated by well-chosen examples and counterexamples.

Stylistically, good mathematical writing is often concise, well-organized, and follows a focused and sequential development of the argument (without unnecessary detours or descriptions). Arguments should be well-motivated, often with explicit justifications.

The writing is tailored to its audience, acknowledging the wealth of different backgrounds in the subject. At its heart, a proof is a logical argument designed to convince the reader of the truth of a claim. As such, it must clearly convey an idea, not merely move symbols about. Finally, as with all writing in English, mathematical writing must employ correct grammar and sentence structures. [Portions of the above summary of mathematical writing is taken from the Mathematics Writing Plan at the University of Minnesota.]

Writing in **pure mathematics** should include:

- Explanatory background material
- Precise statements of definitions and theorems
    - The terms are well-defined

    - The assumptions are clearly stated
- Concise proofs
- Clear examples and counterexamples demonstrating the results
- Consistent notation
- A logical ordering of the topics.

Writing in **applied mathematics** should include:

- A clear research question
- An introduction to the problem
- The modeling methodology
- A set of assumptions
- Mathematical results
- The relationship to the model and question
- A conclusion

Professional writing should include:

- An executive summary
- A focus on "takeaways"
- Little on analytics and methodology
- An avoidance of terminology

As you can see, the maxim "know your audience" compounds the difficulties of mathematical writing by turning the dictates of mathematical writing around to avoid the very rigor we demand when writing for a non-academic audience.

The IUP Department of Mathematical and Computer Sciences is committed to helping mathematics students in improving their writing skills toward the goal of being able to communicate as professionals in the field are required to do.

Student Writing Skills and Abilities

Students in Mathematics need a variety of writing skills and abilities upon completion of their degree in order to write in the above genres. Students should be able to:

- Assess whether an argument is complete and correct
- Produce logical and organized work
- Write mathematics that is free from errors
- Appropriately use both mathematical symbols and English grammar
- Cite appropriate source material
- Integrate sources into the writing
- Choose an appropriate model and justify the choice of model
- Select illustrative examples and visualizations to clarify the argument being made

- Communicate mathematics to a non-mathematical audience: make effective choices about level of detail based on the audience.
- Use presentation tools, typesetting packages, and mathematical software.

The IUP Department of Mathematical and Computer Sciences is committed to introducing, emphasizing, and reinforcing these skills and abilities throughout the Mathematics curricula, and does so through the purposeful mapping of writing assignments and activities that follows at the end of this document.

Integration of Writing into Undergraduate Curriculum

Department faculty have participated in professional development training in writing-to-learn pedagogy[2] through writing workshops with the WAC director, participation in the end-of-year Liberal Studies writing workshop, and in full department faculty meetings that the WAC director has visited.

Writing instruction in Mathematics is integrated in these two ways: writing-to-learn (WTL) and writing-to-communicate (WTC, i.e., professional writing).

Writing-to-learn activities allow students to build skillsets and gain proficiency through the writing process. It builds critical thinking and requires analysis, application, and other higher level thinking skills. In mathematics classes, students participate in writing-to-learn activities in order to:

- Employ mathematical ideas and knowledge
- Think through and express complicated concepts
- Increase their comfort with and success in understanding complex material
- Practice self-expression
- Demonstrate critical thinking
- Respond to reading content, analyze published sources, and make connections between texts
- Develop note taking skills
- Pose discussion questions relevant to a theme

Students majoring in mathematics or mathematics education will not be required to take ENGL 202 Composition II. Instead, students in the Mathematics BS will meet the objectives of ENGL 202 through their written assignments in MATH 271 and 272, two courses all mathematics majors are required to take. In the upper-level math courses students in the mathematics track will continue to meet the objectives of ENGL 202 in MATH 480 or MATH 493. Students in the Actuarial Science and Statistics track will have writing emphasized in

[2] "What is Writing to Learn?" *Writing Across the Curriculum Clearinghouse*. Colorado State University. 2015. http://wac.colostate.edu/intro/pop2d.cfm

MATH 450. The BSED majors will meet the objectives of ENGL 202 in their required mathematics pedagogy courses (MATH 317, 456, 461, and 471) as well as the math methods course, MATH 413. These courses include some writing to-learn, but the required writing is primarily writing-to-communicate, focusing on the following areas: 1) critique field-related journal articles and write review-style summaries; 2) examine and present research related to the area of math being studied; 3) complete related academic work in the form of progress reports, final report, and oral presentation (MATH 450, 480, and 493) or design and write lesson plans that implement a concrete and abstract approach to teaching mathematics (MATH 413). In all cases writing in the accepted style will be stressed, and students will have the opportunity to receive feedback from the instructor and revise their written reports.

Communicating Writing Expectations to Students

Communicating effectively is one of the central learning outcomes for its students. Communicating about mathematics in both spoken and written words involves a balance between the logical precision required to create new mathematical facts and the recognition of the informal language that reflects how we think about and assimilate new mathematics.

The Student Learning Outcomes (SLOs) for all Mathematics tracks contain writing and communication goals. SLO #2 in all mathematics tracks is "write mathematical proofs;" SLO #4 is "apply mathematics to analyze, model, and solve mathematical problems;" and SLO#5 is "effectively communicate mathematics." The SLOs for Mathematics Education include SLO #1 "**demonstrate and apply** knowledge of major mathematics concepts, algorithms, procedures, connections, and applications within and among mathematical content domains;" SLO #2 is "solve problems, represent mathematical ideas, reason, **prove, use mathematical models**, attend to precision, identify elements of structure, generalize, **engage in mathematical communication**, and make connections as essential mathematical practices;" and SLO #6 includes "continuously reflect on their practice."

The importance of writing skills to mathematics is communicated both in and out of the classroom. Writing activities and assignments are described on syllabi for classes in each track/program. In addition to WTL activities in class, instructors utilize peer review of writing projects and the writing process. Instructors provide individual feedback to students on their writing assignments and often require revised drafts of major writing activities. Instructors frequently refer students to the Writing Center.

Outside of class, numerous departmental activities such as department colloquia, alumni career panels, internship presentations, the COMAP Modeling Contest, and the department's Student Presentation Day all focus on the importance of writing and communication as central to the professional skills that students develop in the majors.

Syllabus Statement

The Department of Mathematical and Computer Sciences is committed to developing student writing throughout the curriculum. In this class, you will complete writing assignments and activities designed to improve your communication skills.

Implementation and Assessment of Department Writing Plan

The WAC Director recommends the following action items for continuing program facilitation:

- Elect at least one faculty member in Mathematics and one in Computer Science to continue to be the liaison with WAC (this should count as department Service)
- Provide all newly hired faculty a copy of the DWP, and recommend attendance at at least two WAC workshops or the May 2-day writing workshop for Liberal Studies faculty
- All faculty should add "Department Commitment to Writing" statement to syllabus as appropriate
- Department should continue to collect samples of senior writing every two years and analyze results with WAC Director
- Through faculty development seminars with WAC director, workshop attendance, and writing-enriched curriculum, attempt to move assessment results to target 75% and maintain results in other areas
- Add areas for the teaching and assessment of writing as goals on department and faculty five-year review documents
- Continue to update the writing outcomes curriculum map as courses are added, removed, and revised in the curricula (and communicate these changes to the WAC Director)

Writing Outcomes Curriculum Map

The Writing Outcomes Curriculum Map demonstrates:

- Conscious effort on the part of department faculty at placing core disciplinary genres at appropriate levels of the curriculum, scaffolding and reinforcing the writing skills necessary for students to succeed in writing those genres,
- Thoughtful integration of writing-to-learn activities in most courses in the curriculum,
- Balanced measures for assessing writing as process and product, that is, writing is graded for demonstrating mastery of course content as well as improvement of writing skills over time.
- 35 out of 41 courses use WTL and/or WTC = 85% of courses are writing-enriched

Efforts to develop students' skills in mathematical communication are complicated by the fact that the courses in our lower-division curriculum: MATH 121, 125, 126, 225 (Calculus), MATH 171 (Introduction to Linear Algebra), and MATH 341 (Differential Equations) emphasize computational tasks and assess these skills in a way that does not place equal emphasis on the communication of those ideas. These service courses are also taken by majors outside of the department. However, we have included these courses in our plan because we feel that by introducing WTL activities in these classes we can benefit all departments and help facilitate their own writing plans.

In 100 level courses, students are primarily focused on WTL activities, with a secondary goal of demonstrating that writing *does occur* in mathematics courses. The first course, MATH 111 (First Year Seminar), focuses on reflective writing to help students transition to college, explore our programs, and explore career options.

Also in these 100 level courses, students learn to write coherent statements and correct, detailed solutions of problems, using the proper language of mathematics. This occurs in MATH 111, 125, 126, and 171 with writing assigned to describe a process and analyze mathematical language in their textbooks. This will be emphasized in upper-level courses, as students move from analyzing arguments to creating their own arguments in theoretical courses. Students may also be assigned small projects which ask them to solve a problem or investigate material not covered in class. These assignments not only include writing but also a short presentation. Students will greatly expand upon this in the applied program, where such projects are a major part of most of the courses.

In 200-300 level courses, students learn to use mathematical typesetting software, write their own mathematical proofs, and expand upon their mathematical modeling projects. For example, MATH 341 is typically the first place the students work with the complete modeling process (see "writing in applied mathematics" above). Students first encounter WTC activities through the writing of correct mathematical proofs.

The 400 level courses all involve extensive mathematical writing of logical arguments and WTL activities that have students grapple with unfamiliar material. In addition, WTC in a professional setting is emphasized as applied courses have written and oral projects geared towards professional writing and using mathematical modeling to solve real problems.

Course Outcomes and Activities Chart

C = Math Core, CE = Math Ed Core, A = Applied Track, Ac = Actuarial Track, D = Data Science Track, E = Secondary Ed Track, M = Math Track, unlabeled = open to multiple tracks)

Course number and title	**Expected Writing Skills** Writing outcomes may be implicit –writing skills or genre knowledge you want students to leave class with but don't state as outcomes on your syllabus; or explicitly listed as course objectives (usually the mastery of a disciplinary or professional genre)	**Writing Activities- Writing to Learn (WTL) Writing to Communicate (WTC)** These are activities in and out of class that are meant to help students explore and experiment with course content through writing. Students are not expected to demonstrate mastery of course content in this type of writing. WTL is not usually graded, or it may be graded simply for completeness.	**Introduced, Reinforced, or Emphasized**
MATH 111 First-year Seminar (C, CE)	Clearly written solutions to problems. Use of Polya solution plan	Reflection papers on the week's readings (WTL); "Strong Response" on readings (WTC Bean, p. 109); exploratory writing (WTL); written homework problems (WTC); math autobiography (WTC); study plan (WTL); 4-year course plan (WTL), Career exploration plan (WTL)	Introduced
MATH 121	Clearly written solutions to problems; interpret	Process Essay (Describe a process): e.g., How to find a	Introduced,

Calculus I (CE)	derivatives as instantaneous rates of change; formulate mathematical models in order to determine solutions of applied problems	tangent line (WTL)	Reinforced
MATH 125 Calculus I (C, CE)	Clearly written solutions to problems; describe functions verbally, numerically, graphically, and algebraically; calculate and interpret derivatives; convert written applied problems into mathematical models	Process Essay (Describe a process): e.g., How to find a tangent line; What is the Mean Value Theorem saying?; How to define the area under a curve (WTL)	Introduced (for non-majors), Reinforced (for majors)
MATH 126 Calculus II (C, E)	Clearly written solutions to problems; calculate and interpret integrals; convert written applied problems into mathematical models; demonstrate understanding of the concepts of sequences and series	Process Essay (Describe a process): e.g., How are sequences and series related? How are Taylor series a generalization of tangent lines? (WTL); Reflection papers on a reading (LS articles-Reber) (WTL); Semester Project: Presentation of Research (talk, poster session) (WTC)	Reinforced Introduced
MATH 171 Introduction to Linear Algebra (C, E)	Define and analyze problems; assign an interpretation to each possible solution	Process Essay (Describe a process): How is the range of A related to solutions of Ax=b? (WTL)	Introduced (MATH 171 has no prerequisites)
MATH 216 Probability and Statistics for Natural Science (C, E)	Correctly state, analyze, and summarize a test of hypothesis; use confidence intervals and tests of hypotheses for making decisions about populations based on sample data	Not only perform, but write the conclusion of hypothesis tests (WTC); choosing the best model for a data set (WTL)	Introduced
MATH 225 Calculus III (C, E)	Formulate mathematical models for applied problems and analyze these using methods of multivariable calculus	Semester Project: Presentation of Research (talk, poster session) (WTL)	Reinforced
MATH 271 Introduction to	Assess whether an argument, whether	Find a journal article to reproduce with filled in details	Introduced

Mathematical Proof I (C, E)	logical or mathematical, is complete and correct; Know and follow conventions for mathematical exposition, including standard patterns of proof; introduction to LaTeX	and a discussion of proof style (Students' first look at this); (WTL) correctly write proofs (WTC)	
MATH 272 Introduction to Mathematical Proof II (C, E)	Assess whether an argument, whether logical or mathematical, is complete and correct; Know and follow conventions for mathematical exposition, including standard patterns of proof; employ LaTeX	Find a journal article to reproduce with filled in details and a discussion of proof style (WTL); Correctly written proofs (WTC); Proof Portfolio in LaTeX (WTC)	Reinforced Introduced
MATH 316 Data Science Fundamentals (D)	Formulate project requirements and alternative solutions appropriate to the data science problems and to implement computing solutions	Analysis of raw data (WTL); Course Project (WTC)	Introduced
MATH 317 Probability and Statistics for Mathematics Instruction (CE)	Examine and investigate probability and statistics concepts, standards, resources, and activities for diverse learners in elementary and middle schools Examine and present research related to common misconceptions and errors in Statistics and Probability	Data Analysis Project and Presentation (WTC); Open-ended questions on quizzes and exams (WTC); Middle level data analysis or probability inquiry-based lesson plan (WTC); Statistics and Probability Standards explorations (WTL)	Reinforced
MATH 341 Differential Equations (C)	Apply mathematics to analyze, model, and solve mathematical problems	Project report on a mathematical problem (WTC)	Introduced
MATH 342 Advanced Mathematics for Applications	Apply mathematics to analyze, model, and solve mathematical problems	Explaining mathematics as if to a supervisor (WTC); Project report on a mathematical problem (WTL)	Introduced Reinforced

MATH/COSC 343 Introduction to Numerical Methods	Explain the role of and the limitations of the computer in solving mathematical and engineering problems; Discuss selected numerical algorithms; Be able to explain how error accumulates and discuss the errors inherent in using standard floating point numbers.	Students choose an application they are interested in and adopt appropriate numerical methods to solve or model: proposal, oral presentation, and final report. (WTC)	Reinforced
MATH 350 History of Mathematics	Discuss the origin and development of a mathematical topic	Well-written solutions (WTC); Project proposal, annotated bibliography, Term paper (WTC)	Reinforced
MATH 353 Number Theory			
MATH 363 Mathematical Statistics I			
MATH 364 Mathematical Statistics I			
MATH 371 Linear Algebra	Assess whether an argument, whether logical or mathematical, is complete and correct; Know and follow conventions for mathematical exposition, including standard patterns of proof; employ LaTeX	Read a mathematical article and fill in gaps in a professionally written proof (WTL); Correctly written proofs; Proof Portfolio in LaTeX (WTC)	Reinforced
MATH 411 Univariate Data Analysis (D)	Choose the best model to fit a data set and predict the response variable.	Weekly data analysis projects with a focus on interpretation (WTL); Written exam/project on large data set with the aims to correctly analyze the data and present the results professionally (WTC).	Reinforced
MATH 412 Multivariate Analysis	Choose the best model to fit a data set and predict	Weekly data analysis projects with a focus on interpretation	Emphasized

(D)	the response variable.	(WTL); Written exam/project on large data set with the aims to correctly analyze the data and present the results professionally (WTC).	
EDUC 242 Pre-Student Teaching Clinical I (CE)	Design and write lesson plans that implement a concrete and abstract approach to teaching mathematics; Examine the role of equity in mathematics classrooms	Lesson plans; summary paper on experience in the K-12 classrooms; summary paper on two diversity workshops that teacher candidates attend.	Introduced
EDUC 342 Pre-Student Teaching Clinical II (CE)	Design and write lesson plans that implement a concrete and abstract approach to teaching mathematics; Examine the role of equity in mathematics classrooms	Lesson plans; summary paper on experience in the classroom; summary paper on two diversity workshops that teacher candidates attend; written responses to open-ended questions regarding activities in the K-12 classrooms	Emphasized
MATH 413 Methods for Teaching Mathematics (EC)	Design and write lesson plans that implement a concrete and abstract approach to teaching mathematics; Examine assessment issues, options, and tools; Examine the role of equity in mathematics classrooms	Open-ended written in-class activities (WTL); Unit Plan with rationale, lesson plans, discussion of unit assessment (WTC); Open-ended questions on quizzes and exams (WTC); Written discussions of various strategies for teaching mathematics (WTL)	Emphasized
EDUC 441 Student Teaching (CE)	Design and write lesson plans that implement a concrete and abstract approach to teaching mathematics; Examine assessment issues, options, and tools; Examine the role of equity in mathematics classrooms	Work sample with rationale, lesson plans, discussion of unit assessment (WTC); written discussions of various strategies for teaching mathematics (WTL); written discussion of assessment data from K-12 students; written discussion that summarizes growth and professional development during student teaching.	Emphasized
MATH 416 Time Series Analysis			

(Ac)			
MATH 418 Data Science Theory and Applications (D)	Appropriately use tools and big data software packages	Project Report (WTC)	Emphasized
MATH 421 Advanced Calculus I	Assess whether an argument, whether logical or mathematical, is complete and correct; Know and follow conventions for mathematical exposition, including standard patterns of proof; employ LaTeX	Explore a topic not in the course (WTL); read a mathematical article and fill in gaps in a professionally written proof (WTCL); correctly written proofs (WTC); Proof Portfolio in LaTeX (WTC); written report and professional presentation (WTC)	Emphasized
MATH 422 Advanced Calculus II (M)	Assess whether an argument, whether logical or mathematical, is complete and correct; Know and follow conventions for mathematical exposition, including standard patterns of proof; employ LaTeX	Explore a topic not in the course (WTL); read a mathematical article and fill in gaps in a professionally written proof (WTCL); correctly written proofs (WTC); Proof Portfolio in LaTeX (WTC); written report and professional presentation (WTC)	Emphasized
MATH 423 Complex Variables			
MATH 427 Introduction to Topology	Assess whether an argument, whether logical or mathematical, is complete and correct; Know and follow conventions for mathematical exposition, including standard patterns of proof; employ LaTeX	Explore a topic not in the course WTL); read a mathematical article and fill in gaps in a professionally written proof (WTL); correctly written proofs (WTC); Proof Portfolio in LaTeX (WTC)	Emphasized
MATH 445 Deterministic Models in Operations Research	Professional writing; Formulate a mathematical model of a problem, solve the mathematical model, verify the model, and present the results of the	O. R. Software analysis and report (oral and written) (WTC); Capstone project (proposal, preliminary report, final report, oral report (WTC)	Emphasized

	analysis.		
MATH 446 Probability Models in Operations Research	Professional writing; Formulate a mathematical model of a problem, solve the mathematical model, verify the model, and present the results of the analysis.	Game analysis (game theory project, written and oral) (WTL); Capstone project (proposal, preliminary report, final report, oral report) (WTC)	Emphasized
MATH 447 Modeling and Simulation	Professional writing; apply various mathematical tools to analyze mathematical models; understand and develop simple computer simulations.	Capstone project (proposal, preliminary report, final report, oral report) (WTL)	Emphasized
MATH 450 Topics in Applied Computational Mathematics	Analyze advanced numerical methods and write the outcomes of computer simulations and experimentations as formal reports; critique field-related journal articles and write review-style summaries utilizing and incorporating feedback from rough drafts; utilize specialized typesetting packages for equations and diagrams to write technical professional reports; prepare and present cumulative oral reports on computational mathematics topics and submit detailed written outlines	Homework assignments includes formula derivation, short proofs, and open-ended questions that require numerical experiments and visualization of results all typeset in LaTeX (WTL); critique field-related journal articles (WTL); capstone project (proposal, preliminary report, final report, oral report) (WTC)	Emphasized
MATH 456 Geometry for Mathematics Instruction (CE)	Summarize knowledge of geometric representations through reasoning, problem solving, and communication; Investigate the nature of	Paper/Presentation on finding errors in proofs (WTL); middle level geometry inquiry-based lesson plan (WTC); open-ended questions on quizzes and exams (WTC); Geometry and Measurement	Reinforced

	geometry taught in mathematics classrooms; Analyze development levels of geometric thought	Standards explorations (WTL); Written discussions of various strategies for teaching geometry (WTL)	
MATH 457 Number Theory for Mathematics Instruction (CE)	Summarize knowledge of number theory concepts through reasoning, problem solving, and communication; Investigate the nature of number theory taught in mathematics classrooms	Activity Assignment (WTL); written activities relating to "number theory" (WTL); presentations and submissions model informal lesson plans (WTC)	Reinforced
MATH 460 Technology in Mathematics Instruction (CE)			
MATH 461 Discrete Mathematics for Mathematics Instruction (CE)	Summarize knowledge of discrete math through reasoning, problem solving, and communication; Construct practical applications of the discrete math topics	Final Project (WTC); create activities similar in style to the ones found in the document, "Math Trails." (WTC) Design fun, engaging activities that classroom students typically do not learn since Discrete Mathematics is not part of the Common Core State Standards. Packets could be something that the classroom students complete on a lengthy break. (WTC)	Reinforced
MATH 471 Algebra for Mathematics Instruction (CE)	Summarize knowledge of discrete math through reasoning, problem solving, and communication Construct practical applications of the discrete math topics	Compare and contrast activities (WTL); graphic organizers (WTL); exit tickets (WTC); project on researching, designing, and presenting an algebra lesson (WTC)	Reinforced
MATH 476 Abstract Algebra I	Explain algebraic topics taught in school mathematics Develop and implement a lesson in algebra	Explore a topic not in the course, Read a mathematical article and fill in gaps in a professionally written proof; Correctly written proofs; Proof Portfolio in LaTeX	Emphasized

MATH 477 Abstract Algebra II (M)	Assess whether an argument, whether logical or mathematical, is complete and correct; Know and follow conventions for mathematical exposition, including standard patterns of proof; employ LaTeX	Explore a topic not in the course, Read a mathematical article and fill in gaps in a professionally written proof; Correctly written proofs; Proof Portfolio in LaTeX	Emphasized
MATH 480 Seminar in Mathematics (C)	Resume, cover letter, interview reflection, research paper	WTC	Emphasized
MATH 493 Internship in Mathematics	Provides on-the-job experience with private and government employers. Complete related academic work in the form of progress reports, final report, and oral presentation.	Daily Logs (WTL) Resume (WTC) Project logs (WTC) Company write up (WTC) Internship Report (WTC)	Emphasized

Appendix A – Senior Writing Samples Assessment

Protocol

Describe the process of collecting samples and rating them. Provide ethics statement for syllabi for classes in which samples are collected.

Insert the assignment sheet students respond to.

Students in all affected courses, including MATH 480 or MATH 413 (for Mathematics Education majors), are notified that their work is evaluated for programmatic assessment. A statement is included on the syllabus each time the course is taught indicating that students' writing might be randomly selected for anonymous programmatic assessment that will not affect their course grade in any way. These courses will give us writing samples from each student.

The course professors will give the materials to the WAC liaison who will remove identifying information and add a code to serve as an identifier.

For more discipline specific writing, we will also take samples from other courses. Because the last theoretical course a student in the Pure Mathematics Specialization takes varies, we will do the same in MATH 421, MATH 427, and MATH 476. For students in the Applied and Data Science Specializations, we will do the same in MATH 447, which is required of all students in both. For students in the Actuarial Science Program, we will use MATH 450.

For the Pure Mathematics Specialization we will use the proof portfolio, for Actuarial, Applied, and Data Science we will use the capstone project in MATH 447 or MATH 450.

In the Mathematics education program our focus will be on the culminating Unit Plan. In the applied programs, the focus will be in the capstone project. In pure mathematics, the focus will be in the proof portfolios. For each student, the focus will be on their ability to **communicate mathematics**, whether it be in the form of collection of theorems and proofs or modeling a real-world situation

Rubric

Grammar: Writing should demonstrate standard patterns of written mathematical and English grammar and usage

Language, clarity, flow: The writing should take into consideration the intended audience. "Flow" includes writing that has a logical progression of the argument, and "clarity" includes the use of good examples to clarify the argument.

Mathematical Correctness:
Applied mathematics writing should include motivating examples and a justification of the models/methods being used
Pure mathematics writing must show a consistent use of notation and a correct mathematical logic.
Mathematics Education writing must show a consistent use of notation and a correct mathematical logic. It must also be very clear with definitions and terminology so as to not confuse secondary students.

Criterion	**Below Expectations = 1**	**Emerging = 2**	**Meets Expectations = 3**	**Exceeds Expectations = 4**
Language, clarity, flow	Paper lacks logical flow; Plan is unmotivated	Some paragraphs have clear topics and logical flow others do not; some tangential information is included; perfunctory examples are given	Most paragraphs have a logical flow from one to the next; examples are relative to the topic	Paragraphs have a clear Logical flow and are organized to flow from one to the next; language is clear and concise; motivating examples are presented.
Mathematical Correctness	Serious logical flaws and lacks adequate justification. Misuse of notation; Few complete	Some gaps in reasoning, Argument does not form a coherent whole, Many flaws of	Hypothesis and assumptions are clearly identified and are differentiated from the	The argument is correct and flows logically, Uses correct mathematical grammar and uses notation

	sentences; Computations significantly flawed.	mathematical grammar, The individual statements are not connected, or presented out of logical sequence, Computations are flawed, No concluding statement.	conclusion. The logic through which the latter is obtained from the former is explained and is correct. In a mathematical model, appropriate assumptions are made and consequences are correctly identified.	correctly. The details are easy to follow, Links are made to appropriate definitions and previously known theorems. There is a clear conclusion.
Grammar	Serious grammatical errors are common; proofreading is not evident	Some serious grammatical errors are present; some level of proof-reading is evident	Paper is mostly free of serious grammatical errors and has clearly been proof-read	Paper is free of serious grammatical errors
The following will be added based on recommendations from the WAC Director, Dr. Bryna Siegel Finer				
Holistic Score	**Needs Improvement = 1**	**Developing = 2**	**Sufficient = 4**	**Above Average = 4**

Needs Improvement: The audience cannot clearly or easily identify the central ideas or purpose of the student work. Information is presented in a disorganized fashion causing the audience to have difficulty following the author's ideas. There are many misspellings and/or mechanical errors that negatively affect the audience's ability to read the work.

Developing: The audience can identify the central purpose of the student work without little difficulty and supporting ideas are present and clear. The information is presented in an orderly fashion that can be followed with little difficulty. There are some misspellings and/or mechanical errors, but they do not seriously distract from the work.

Sufficient: The audience is easily able to identify the focus of the student work which is supported by relevant ideas and supporting details. Information is presented in a logical manner that is easily followed. There is minimal interruption to the work due to misspellings and/or mechanical errors.

Above Average: The audience is able to easily identify the focus of the work and is engaged by its clear focus and relevant details. Information is presented logically and naturally. There are no more than two mechanical errors or misspelled words to distract the reader.

[DePaul University, https://resources.depaul.edu/teaching-commons/teaching-guides/feedback-grading/rubrics/Pages/types-of-rubrics.aspx]

Appendix B –Writing Assessment Results, 2020-21

These are considered "baseline" survey results. We have writing samples from MATH 450 (Chrispell), MATH 476 (Lattanzio), MATH 422 (Radelet), and MATH 413 (Walker).

Summary

Criterion: Grammar

year(s)	exceeds/meets	emerging/below
2020-21 *n* = 20	**85% 17 (8/9)**	**15% 3 (3/0)**

Criterion: Language, Clarity, Flow

year(s)	exceeds/meets	emerging/below
2020-21 *n* = 20	**90% 18 (8/10)**	**10% 2 (2/0)**

Criterion: Mathematical Correctness

year(s)	exceeds/meets	emerging/below
2020-21 *n* = 20	**70% 14 (9/5)**	**30% 8 (6/2)**

Areas in which student writing is ABOVE expectations: 77+

Criterion: Grammar

year(s)	exceeds/meets	emerging/below
2020-21 *n* = 20	**85% 17 (8/9)**	**15% 3 (3/0)**

Criterion: Language, Clarity, Flow

year(s)	exceeds/meets	emerging/below
2020-21 *n* = 20	**90% 18 (8/10)**	**10% 2 (2/0)**

Areas in which student writing is MEETING expectations: 68-77

Criterion: Mathematical Correctness

year(s)	exceeds/meets	emerging/below
2020-21 *n* = 20	**70% 14 (9/5)**	**30% 8 (6/2)**

Areas in which student writing is BELOW expectations below 67 and below

None

Recommendations from the WAC Director based on Assessment Results

Students are meeting or exceeding expectations in all but one criterion (mathematical correctness). The student success in writing is most likely due to the amount of writing students are expected to do throughout this major, as evidenced in curriculum map shown above; the program should be applauded for its commitment to ensuring student success in writing.

I would also suggest adding a true holistic score as another criterion on the rubric. A true holistic score (a score based on an overall impression of the full piece of writing) can allow for comparisons to individual criterion and often allows for a more reliable picture of students' strengths and struggles. It also allows for department faculty to identify their values more specifically (for instance, when high holistic scores align strongly with certain criteria, it is usually because those criteria signal stronger writing).