QED Student Overview

What is the QED Process? How do I do QED?

You are about to embark on an independent math research project! This is a great opportunity for you to learn more about a new problem, or revisit some topics in math you have previously studied and create a new question to pursue. There are many topics you can explore, and your project doesn't have to involve pure math questions: many great projects have involved modeling sports tournaments, using computer science to model optimal strategies for playing video games, or using mathematics to explore and solve societal problems. This document will give you an overview of the timeline and guidelines for making this research process fun and successful.

Key Dates for QED 2025

- October 1 — Registration Opens
- December 1 — Senior (9th-12th) Paper Due Date
- December 5 — Junior (5th/6th) & Intermediate (7th/8th) Paper Due
- December 13 — QED Symposium!

Project Requirements

Full project requirements are specified in this guideline document. It includes project rubrics, paper guidelines, and other practical information.

Sample Projects

Here is a directory of Sample QED projects that students have completed in all three divisions.

Register for QED

QED participants are **students in grades 5-12.** All students must register for QED through the Math Circles of Chicago registration system. You will use the same account that you use for signing up for Math Circles, or create an account if you haven't before.

Project Planning Overview

Generating an original piece of research over two months is challenging. To help you achieve your research project goals, we have divided the student experience of QED into five phases. All QED students have access to an advisor - often a current undergraduate or graduate student in mathematics - who can help you out in any of these five phases.

	Phase 1: Project Discovery & Research	**Phase 2:** What is my Question?	**Phase 3:** Generating Results	**Phase 4:** Write Paper	**Phase 5:** Presenting
What I am doing	Find a problem or area of mathematics you'd like to research.	Narrow in on your research. Specifically define the question or questions your project will solve.	Solve new problems and prove / generalize your results.	Write a research paper that combines background research, poses your question, and offers solutions.	Create a poster and manipulatives for your presentation, and practice your oral presentation to a judge.
What a QED Advisor can help me with	Help brainstorm areas of interest based on problems you've already seen	Refine and make a manageable question that can be answered by doing math.	Help check for errors in solutions and proofs, ask refining questions, and wonder "what if…"	Review the paper and project guidelines with respect to the scoring rubric.	Listen to practice presentation and give feedback on visuals and manipulatives

Phase 1: Project Discovery and Research

Finding a good research problem can be as easy as extending a problem from your personal interests, a math circle, or a math contest.

- What are topics outside of math that I am already interested in? Take something you already love and know something about and see what connections it has to math or modeling.
- If your favorite math circle lesson was about a game, how could you change the rules of that game? At your next math circle, look for extensions and wonderings about the math you did. If you did a one-dimensional problem, what would the same problem look like in 2D or 3D?
- Is there a challenging math contest problem that points in a direction of math I've not studied before? Or math that I want to learn more about?

Here are some research resources and links you could use in Phase 1:

- Games and Puzzles from the Julia Robinson Math Festival

- COMAP's problem bank at mathmodels.org
- GoGeometry's list of open (unsolved) problems
- Old math contest questions from AMC, AIME and IMO questions
- Peter Kagey's open problems
- MC2 Research Tasks
- Know of another? Email qed@mathcirclesofchicago.org and we'll add it to the list!

Phase 2: What is My Question? Refining and Specifying

Now that you have some topics of interest, problems, or data to process, it's important to take the time to refine your general interest into a set of achievable goals. Let's look at some examples from previous student papers.

- Junior Division: Magic Triangles by Kushi Pusnur (2019)
  Successful papers don't need to come up with complete generalizations: you can have a successful project just by exploring a few cases. In this paper, Kushi explores triangle perimeter number puzzles of order 3 and order 4. This is an appropriate scope for the junior division - perhaps intermediate students might look at orders 5 and greater, and senior division students would look at triangles of order *n*.

- Intermediate Division: Frogs on a Log by Miles Jung and Aadi Kalra (2019)
  This paper highlights another strategy for refining a research question at the intermediate level, which is to explore multiple variants of a classic math circle problem. This paper explores the solution to the "core" 1D frogs and toads puzzle, and then proposes and finds a general solution to three variations: changing the space between the frogs and toads, making an imbalance between the number of frogs and toads on each side of the puzzle, and doing both of these variations at once.

- Senior Division: Add, Divide, Repeat by Rileigh Luczak (2013)
  This senior division paper starts with proving some general results on continued fractions and square roots, and seeks to discover a pattern in the period length. While the paper doesn't come to a definitive conclusion, it does prove some smaller results about the form the irrational number takes and the period of such a number. In the process of seeking out a particular result, you may wind up with only partial success.

Phase 3: Generating Results

Now's the fun part: you have read and researched some background information on your topic. It's time to generate some results before you write them up into your paper! The simple question I want to ask is…what is a result of math research? Here are some examples from previous QEDs.

Results might be…

- Diagrams or visual aids that illustrate your mathematical idea. Check out 3D Sudoku by Julia Kim and Si-Eun Rhee
- A modeling of a real-world situation, with an explanation of your assumptions and calculations such as Ella Bakker's Drive My Car
- Equations, formulas, graphs and tables that illustrate both the patterns observed. A great example of this is in *Mastermind* by Axel Hinz and Phoebe Koehler.
- Code or code diagrams for a computer science project, like in this Sudoku Solver by Maansey Rishi
- Formal proofs and logical deductions with some explanatory text, in this project by Delia Lerugan exploring Lucas' Theorem.

Have other kinds of results your project might generate? Let us know at qed@mathcirclesofchicago.org and we'll add them to this list!

Phase 4: Writing Your Paper

Writing a successful math paper has many of the same qualities of writing an essay: make an outline, draft according to the outline, and revise for clarity and accuracy.

Junior Division:	Grades 5-6	3-5 Pages	Due	Dec 5, 2025
Intermediate Division:	Grades 7-8	5-7 Pages	Due	Dec 5, 2025
Senior Division:	Grades 9-12	10+ Pages	Due	Dec 1, 2025

1. Make an Outline

   Begin by consulting the thorough project guidelines document. Every project should have:
   - Abstract
   - Introduction
   - Body
   - Conclusion
   - Bibliography

2. Draft your Paper

   Take the elements of the outline above and start drafting your paper to meet total length requirements above. Some great notes on writing math papers from Dr. Kevin Lee are available here. While written for a college audience, many of you are doing college-level math research! Here are some checklist items from his article:

- ☐ Is your paper neatly typed?
- ☐ Has the paper been proofread?
- ☐ Is there an introduction?
- ☐ Did you state all of your assumptions?

- ☐ Are the grammar, spelling, and punctuation correct? Is the writing clear and easy to understand?
- ☐ Are all of the variables defined and described adequately?
- ☐ Are the mathematical symbols used correctly?
- ☐ Are the words used correctly and precisely?
- ☐ Are the diagrams, tables, graphs, and any other pictures you include clearly labeled?
- ☐ Is the mathematics correct?
- ☐ Did you solve the problem?

3. Revise for Clarity and Accuracy

   Perhaps consult with your MC2 Advisor or your math teacher for feedback!

4. Submit Your Paper!

   Before submitting your paper, confirm you have registered for QED online. Papers should be converted to .pdfs and emailed to: qed@mathcirclesofchicago.org. The file name of the submitted paper should contain the first and last name of the participant, partners (if applicable) and the division. For example:

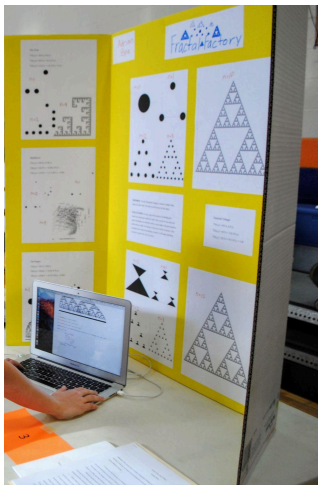
   - Haynes, Euphemia, My Amazing Project, Junior
   - Cheng, Eugenia and Wiles, Andrew, Our Amazing Project, Intermediate

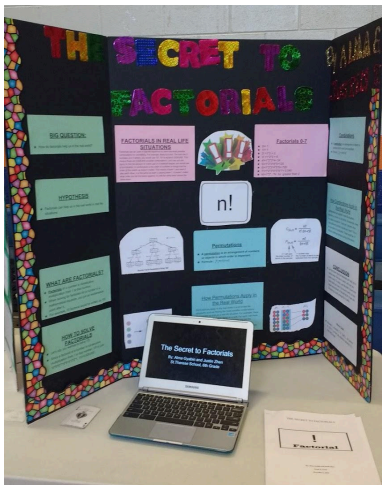
Phase 5: Your Presentation

The requirements for the papers and presentations are summarized in these two documents depending on the category of project you are submitting. **Please remember to bring three printed copies of your paper with you to the Symposium** in addition to your presentation board and other materials.

- Math and Applied Math Projects
- Computer Science Projects

Presentation Board Guidelines
Here are some archive photos from past QEDs that have great presentation boards!





Notice that in these examples, the priority is on **visualization** of mathematics over **replication of text** from the body of your paper. Students also brought along appropriate **manipulatives**, whether in the form of cards / pieces to play a math game, or a computer to demonstrate the **code** or other **digital representations** of the mathematics. These are best practices - including a presentation board is required in our rubric, but **your project will not be assessed on the visual quality of your presentation board.**

Oral Presentation Guidelines

From our rubrics, student oral presentations are assessed on a 5 point scale, with the top marks reflecting:

> *"The student is fluent about related mathematics. Presenter is engaging, articulate, and gives effective responses to questions."*

- Try rehearsing your presentation - can you give an overview of your paper orally in five to ten minutes?
- Have you thought about responding to questions on related mathematics? Or proposed some extensions to your main problem? Your judges will likely ask you about these as they formally evaluate your presentation.
- Read this blog post on some general guidelines on clarity for writing (and oral presentations) from Terry Tao

Good luck! Have fun!