

Approaching a Mathematics Extended Essay

Step 1: Find a topic of interest to you, be curious, and write down questions that you have as you do background research

Step 2: Narrow down those questions you have to one question that you could develop into your research question and subsequently spend months learning about and 4000 words writing about

Step 3: Do research until you have answered your question in your own mind. This research will come in three forms:

- Type 1: Primary Source Research – this is you sitting down with your own brain and working to answer your question with the knowledge that you have.
- Type 2: Secondary Source Research to Inform Primary Source Research – this is you looking at the work of others to inspire your own primary source research. This is you learning about the topic and question more so that you can form your own answer to the question.
- Type 3: Secondary Source Research to verify and locate your work – this is you looking into what other mathematicians in what other places have answered the same question so that you can compare your methods, work, and answer to theirs.

Your paper will likely need all three types of research to be done.

Step 4: Decide how you will tell the story. At this point, you have answered your question in your own mind. You have done primary source research that was informed by your own investigation as well as the work of others, and you have subsequently looked and found where other mathematicians have found similar results and compared your work to theirs. Now your goal is to think about *how you will tell this epic story of learning to other people*. In practice, this means writing a table of contents and an outline for the paper. (See the back of this paper for that information.)

What do I have to do before I can Organize and Structure a Mathematics Extended Essay

What is a table of contents?

Think to yourself for a moment about what a Table of Contents is and what it's for. Seriously, think about it for a minute and answer that question in your own head. I'm waiting. Ok – my guess is that your answer was something like “It's a place you can go in a book to find out where something will be in the book. It's a little like a map.” I believe this answer is common, a little bit right, but mostly wrong. But it's ok! Thinking about this question might very well change the way you think about organizing your writing!

What a table of contents really is

You might think that a Table of Contents exists to tell you where things are in a book, but that's actually what the *index* is for. The *index* of a book is where you'd look to find something specific. The *index* of a book is not intended to ever be *read*. No one goes and *reads* the index. You'll probably *use* the index, but you won't *read* the index.

On the contrary, a Table of Contents is *intended to be read*. It's a lot like a very brief, somewhat disjointed snapshot of what the entire book is going to do. It's literally...a table...of the contents...of the book. Unlike an index, it isn't organized alphabetically. Instead, it's organized chronologically. When you read the Table of Contents, you're being given an *overview* of what the book is going to do and what order it's going to do it in.

Why does this difference matter

It matters because many students write their Table of Contents last. They write the whole paper, then they go back and add section titles, and then in a final burst of energy they scribble down a Table of Contents before passing out at 3am. I'd argue we really need to do things the other way around. We should *start* with the *idea* of our paper, develop a *roadmap* for how to tell the story of the paper, write a rough table of contents, add detail to it to turn it into an outline, THEN write the paper.

So now that we have these ideas in mind, let's answer the question: how should you structure or organize a mathematics research paper.

You can only think about this after you've answered your research question. If you haven't answered your research question (steps 1-3 on the front of this paper), then you aren't ready to organize your paper yet. So once you've researched enough to answer your research question, you can finally think about *organizing* your paper and only then can you start to write it.

How should a Math EE be structured?

When we think about how to structure a Math EE, I want you to think about it like you're going to tell a story. Imagine that something really cool happened to you, and you want to tell people the story. Often we just dive into stories, but part way through the story you realize you have to add another detail or you wanted to leave something out. If we just try to start telling a story, things might not go well. It's even worse if you try to tell a story about something that happened...that isn't done happening yet. So you need to plan that story so that you tell all the parts in the right order and the story goes smoothly.

Your Math EE is similar. You can only write your Math EE after you've finished answering your question in your mind. You have to have *had the cool thing happen to you* before you can tell the story.

In general, I recommend this flow for your paper:

Introduction:

- Consider including a brief "hook" about why the topic of your EE is of value or interest. This is not the time for a lengthy explanation of how excited you are about the topic or how you've thought it was cool since you were 7. This is an opportunity for you to explain, objectively, why this topic is worthy of consideration.
- Early in the introduction (ideally within the first 2-3 paragraphs) make your research question VERY clear to the reader. Let them know what you're going to answer. And I'd recommend, if at all possible, to briefly answer that question right then and there. Your EE is *not* the place for surprise plot twists. Spoilers are fine. Tell your reader what you want to answer and then what the answer is.
- After you've told your reader what the question and answer are, provide them a few paragraphs that will give them a map of how you're going to show them how you got that answer and what other people have said about it. These few paragraphs are a little bit like your table of contents, but they're in narrative/paragraph form which is even easier for a reader to process.

Body of your paper:

- The body of your paper should follow your Table of Contents (the map of your story) and it should follow the roadmap that you just explained in your Introduction.
- This is where you present all your research and share all you've learned in an organized, curated fashion to make it easy to understand.

Connection to the larger body of mathematical research:

- In order for a math EE to score well, it's really necessary that you connect the work you have done to the larger body of mathematical research. It is almost certain that someone somewhere has already done what you've done. Great! Tell us about what they did, when they did it, and if they found the same result as you.
- If you think that you've discovered something that no one else has (this is very unlikely as a high school student), then your job as a researcher is to *show* that you have looked into what other mathematicians have done and be sure that no one else has!
- This step is important as far as math research goes! So connecting your work to the work of others really is important!

Conclusion:

- Your conclusion is, in a lot of ways, similar to your introduction. Remind your reader of what your question was, what the answer was, and remind them of the steps you just took them on in showing it.
- A final step that can be nice is to share with your reader what other fascinating questions you stumbled upon in your research that you *could not answer* in your paper. Math research is all about generating new knowledge and encouraging curiosity and discovery. So if someone loved your paper and wants to do more with it – give them some ideas for how your work could be extended in different directions.