

Proposal for a
Thesis in the Field of
Mathematics for Teaching
In Partial Fulfillment of the Requirements
For a Master of Liberal Arts Degree

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1. Tentative Title: Inquiry-Based Learning in Geometry Courses in U.S. Secondary Schools

2. Abstract

Within this thesis, the history, values, and practices of inquiry-based learning in mathematics classrooms will be examined to find the ways in which inquiry-based learning can improve the educational experiences of the mathematics student in secondary schools. Example inquiry-based lessons will be created, with guidelines to help teachers write more lessons in an inquiry-based fashion.

Traditional lesson plans in U.S. secondary schools often follow a lecture-with-drill method in which students may succeed through memorization and repetition without awareness of context or ramifications, rather than through the inquisitive, creative, and critical thinking that mathematicians describe as “doing mathematics.” The author anticipates that a classroom teacher may replace some traditional lesson plans with inquiry-based learning (IBL) lesson plans in a high school geometry class, maintaining the same topical focus of the lesson (e.g., properties of special quadrilaterals) while adding to students’ cognitive demands by letting them explore, problematize, and devise questions about the topic. The author predicts that many teachers who consider IBL will desire to incorporate it in their classrooms, therefore, to aid such teachers, three or four IBL lessons will be produced in this thesis. Furthermore, the author anticipates that traditional lesson plans about other topics not named in this thesis may be transformed into inquiry-based lessons, and to that end, guidelines for transformation of

traditional lessons into IBL will be produced with attention to overcoming some obstacles that may intimidate the transition. The project will review theoretical and academic justifications for the transition to inquiry-based learning, and provide practical guidance for teachers to move toward more inquiry-based instruction in U.S. secondary school mathematics classes.

3. Thesis Project Description

A thesis is proposed which shall examine the history of inquiry-based learning as it stands apart from traditional instruction in the mathematics classrooms of U.S. secondary schools. As there are a few methods which may be classified as inquiry-based learning, the different methods will be examined for common practices, in contrast with more traditional methods of instruction. As part of such an examination, the thesis will explore the values motivating IBL and compare these values to the values in traditional math classrooms. Likewise, the thesis shall review some of the literature on the outcomes and norms of IBL versus traditional classrooms. Because it is anticipated that what IBL values is different from what traditional instruction values, the outcomes to observe will be a list that includes more than standardized test scores. It is anticipated that with the perspective on the differences of IBL versus traditional instruction, teachers in secondary school mathematics will be interested in shifting some of their lessons to IBL.

The second part of the thesis shall focus on addressing the potential challenges and difficulties of transitioning from traditional instruction to IBL. While much of the

literature about IBL is focused on undergraduate courses, the project of this thesis is about secondary school courses, and there are important barriers to entry to consider. While undergraduate education is oriented toward a major or “concentration,” and it is acceptable if some students drop a mathematics class and decide to specialize in other fields, one finds a different context in U.S. secondary schools where geometry is a graduation requirement. Moreover, teachers in grades K-12 in the U.S. teach with greater emphasis on standardized testing than do undergraduate professors in U.S. colleges and universities. How this emphasis on standardized testing affects teacher choices was summarized thus: “It takes a brave teacher... to maintain a broad focus in instruction when the fates of his or her students--and possibly those of the teacher and the school--depend on how the students will do on a narrow skills-oriented test (Schoenfeld & Kilpatrick, 2013).” U.S. secondary schools place great emphasis on educating all students and having graduation rates as close to 100% as possible, so if a secondary teacher (or administrator) has concerns that a method might lead to greater failure rates, then such a method might be dropped from consideration. For the proposed thesis to have practical value to math teachers, it must address how to move beyond the barriers to entry.

The third part of the proposed thesis shall include 3 or 4 inquiry-based lessons that a high school geometry teacher may implement, and it shall offer guiding principles on how to transition from traditional lessons and classwork to inquiry-based instruction.

4. Work Plan

Initially, research will focus on criticism of traditional math instruction. Some rather disappointing outcomes in student understanding have been observed wherein students memorize rules and then apply the rules in a manner which is not sensible. Katherine K. Merseth attributed this behavior to (among other causes) “the typical curriculum in use in our classrooms (Merseth, 1993).” By repeating rules without ever grappling with questions on a sense-making level, students may find themselves trained to accept nonsensical questions and answers (or they may be trained in such a way but never realize it). Traditional math instruction involves textbooks, which most often ask the students a question, provide an example of how to think about the question, then give students multiple exercises or problems that are only superficially different from the example. Dan Meyer’s recent article in *Mathematics Teacher* (Meyer, 2015) addresses how textbooks emphasize calculation with models but rarely offer students the opportunities to make decisions in creating models and choosing strategies to solve problems. In his 2009 book, *A Mathematician’s Lament*, Paul Lockhart asserted that traditional instruction styles of mathematics is not doing mathematics just as paint-by-numbers is not making art, and blamed traditional instruction for stunting math students’ creativity such that they hit an academic wall in math graduate courses. In dismissing traditional math instruction and promoting more inquiry, Lockhart states that “math is not about following directions--mathematics is about finding new directions.” (Lockhart, 2009) It is anticipated that an examination of the literature will present several

categories of cognitive tasks that students in a traditional classroom do not practice as much as in IBL.

In addition to researching the nature of traditional classrooms' methods and cognitive demands, the thesis will require research into the various methods which will be classified as inquiry-based. Methods to be studied shall include the Moore Method (Whyburn, 1970), and the Modified Moore Method (also known as MMM) (Chalice, 1995), the Harkness Method (Geary & Atif, 2013), the Interactive Mathematics Project (IMP) (It's About Time Interactive, 2012), and possibly more. The commonalities of such methods are expected to include similar values, which are anticipated to be different from the values of traditional instruction. Can MMM or IBL change student attitudes about mathematics? Some undergraduate MMM classes have observed gender differences in attitudes. (Bailey, Cooper, & Briggs, 2012) At least one study (Laursen, 2013) has observed not just attitude changes but changes in performance distinguishable by gender in IBL undergraduate classes. From a second study:

Our study indicates that the benefits of active learning experiences [IBL] may be lasting and significant for some student groups, with no harm done to others.

Importantly, "covering" less material in inquiry-based sections had no negative effect on students' later performance in the major. (Kogan & Laursen, 2014)

It is anticipated that research of the literature will support more teachers changing to the broader IBL over the narrower traditional instruction.

To complete the second and third parts of the proposed thesis, dealing with barriers to entry for such transitions and methods to overcome such barriers, the author plans to research the literature and to gather information from teachers of geometry at

the secondary level. The secondary teachers will be questioned on values behind IBL, the barriers to entry for switching to IBL, and the practice of IBL lessons. Such research should yield common values of inquiry-based learning, and this thesis is expected to refer to such values to be utilized to inform the inquiry lessons and the “how to” guide for teachers to convert lessons into a secondary version of the MMM. Lesson topics shall be selected such that they may be inserted into a year of Geometry with spacing between them to allow for a teacher to reflect on the outcomes and implementation of one lesson for a time before teaching the next inquiry-based lesson. The use of construction tools, such as compasses or Geogebra, may be included in lessons and the “how to” guidelines.

Inquiry-based lessons must include more than a selection of good questions. Learning is better with reflections upon differences and similarities in solutions and rich discussions. To that end, the lessons shall include information about what solutions a teacher may anticipate from students, what clues to look for when monitoring student work, what criteria should guide selecting work to present, what to consider about choosing a sequence of solutions, and what ideas might connect solutions, so that after multiple solutions have been presented, the teacher can guide conversations toward connecting the various solutions with a mathematical idea (Stein, 2008). If a lesson is to get students to move from questions to understandings, as a traveler journeys from point A to B, then it is best that the teacher have a map of the surrounding territory. Some teacher guidance may be advisable, and students might find discussions of mathematics even more valuable if the teacher can lead them to see the underlying structure of solutions that differ on the surface. Moreover, each lesson will incorporate

a block of planning to assure that the lesson leads student understanding into alignment with the vocabulary, axioms, and theorems known to mathematicians in the field of Euclidean geometry (which is the bulk of the content in secondary school geometry classes.) This planning in the lesson, the planning beyond a list of good questions, should address the barriers to entry mentioned earlier in the proposal. Furthermore, as the author of the thesis anticipates using IBL in a secondary school classroom, some of the lessons will be tried in a classroom, and information will be gathered from the teacher and students before and after the lessons to further inform the proposed thesis and future lessons.

5. Project Schedule

August 1, 2015: Final thesis proposal submitted to research advisor.

September 30, 2015: Have researched history of IBL, drafted lessons, drafted transition guidelines, drafted questions for teachers and/or students, consulted Committee on the Use of Human Subjects.

October 30, 2015: Conducted interviews with teachers and/or students regarding inquiry. Have tried one or two lessons in a class, assessed the plans and revised them.

December 15, 2015: Have one or two more lessons tried in a class, assessed the plans and revised them.

January 30, 2016: Have guidelines of transition to inquiry finished, begin revisions to whole thesis.

March 1, 2016: Final thesis to research advisor and director.

April 15, 2016: Thesis submitted.

May 2016: Final draft of thesis approved, bound copy submitted, graduation

6. References

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