Title of Project: Riemann Lab Authentic Math Project
Subject(s): Mathematics & Language Arts
Grade Level(s): 9-12

Abstract:

Georg Friedrich Bernard Riemann was German mathematician who created the Riemann Hypothesis in 1859. His work on prime numbers led him to what is called "The Riemann Zeta Function," and the resulting Riemann Hypothesis which has never been solved. This is just one of many unsolved mathematical problems that exist today. In this project, students will investigate unsolved problems in mathematics, making conjectures, exploring examples, constructing counter-examples and trying to prove special and also general cases. They will work in groups to attempt to solve problems while honing their analytical, communication, intuitive, and creative skills in the course of their investigations. Mentors will consist of upper level students and mathematics professors at Southern Polytechnic State University or Kennesaw State University who will communicate through video chat, collaborative documents, and blogs using the ePals Collaborative Online Learning platform. Collaborative sketchpads will be shared among students and mentors as well. Problem solving is a constructivist pedagogy that encourages students to develop content knowledge while also honing their thinking strategies. Problem solving requires flexibility, collaboration, and self-regulation and a certain amount of creativity to be effective. All of these abilities are essential for higher learning to take place. Students will keep journals and contribute to a class Wiki to document their progress for other students and educators working to solve the same problems.

Learner Description/Context:

The learners will be high school juniors or seniors enrolled in mathematics classes at North Paulding High School (NPHS) located approximately 40 miles northwest of Atlanta, GA. Over 2,000 students are enrolled at NPHS. They come from different backgrounds and incomes, but the majority are middle class. Paulding County is in close proximity to two universities, Southern Polytechnic State University and Kennesaw State University. Many of our students attend these institutions upon graduation and cooperative arrangements are already in place between the 3 schools.

The NPHS School Improvement Plan identifies mathematics as an area that needs improvement. It is our belief that authentic, real-world activities in mathematics will engage students in ways that are not possible through traditional instructional strategies. In this project, students will select their own unsolved problems from a problem bank and then work with researchers outside the classroom to develop strategies to attack these problems. Students will maintain personal journals and contribute to a class blog where they can brainstorm ideas and document their discoveries. Finally, they will share their reflections on a class Wiki. Along the way they will develop deeper knowledge, better problem-solving strategies, and stronger analytical and critical thinking skills.

Time Frame: The program will span 16 weeks over the course of the school year, 8 weeks in the fall semester and 8 weeks in the spring semester. Students and mentors will meet for 60 minutes every other week and students will work another 3 hours every two weeks outside of class to problem-solve.

Standards Assessed:

Georgia CCGPS for High School:

- Number and Quantity
  - ❖ MCC9-12.N.RN.1 to MCC9-12.N.RN.3

- ❖ MCC9-12.N.Q.1 to MCC9-12.N.Q.3
- ❖ MCC9-12.N.VM.1 to MCC9-12.N.VM.12

• Algebra
- ❖ MCC9-12.A.SSE.1 to MCC9-12.A.SSE.3
- ❖ MCC9-12.A.APR.1 to MCC9-12.A.APR.7
- ❖ MCC9-12.A.CED.1 to MCC9-12.A.CED.4
- ❖ MCC9-12.A.REI.1 to MCC9-12.A.REI.12

• Functions
- ❖ MCC9-12-F.IF.1 to MCC9-12.F.IF.9
- ❖ MCC9-12-F.BF.1 to MCC9-12.F.BF.5
- ❖ MCC9-12-F.LE.1 to MCC9-12.F.LE.5
- ❖ MCC9-12-F.TF.1 to MCC9-12.F.TF.9

• Geometry
- ❖ MCC9-12-G.CO.1 to MCC9-12.G.CO.13
- ❖ MCC9-12-G.C.1 to MCC9-12.G.C.5
- ❖ MCC9-12-G.GMD.1 to MCC9-12.G.GMD.4

• Statistics and Probability
- ❖ MCC9-12-S.ID.1 to MCC9-12.S.ID.9
- ❖ MCC9-12-G.IC.1 to MCC9-12.G.IC.6
- ❖ MCC9-12-G.CP.1 to MCC9-12.G.CP.9
- ❖ MCC9-12-G.MD.1 to MCC9-12.G.MD.7

ISTE-S Standards:
- Creativity and Innovation - 1a,1c
- Communication and collaboration - 2a, 2b, 2d
- Research and information fluency – 3a, 3b, 3c, 3d
- Critical thinking, problem solving, and decision making – 4a, 4b, 4c, 4d
- Digital citizenship – 5b, 5c
- Technology operations and concepts – 6a, 6b, 6d

Learner Objectives: *Write a statement of what students are going to know and be able to do as a result of this learning experience and how it will be measured.*

- Students will understand and apply mathematical concepts
- Students will analyze problems and hypothesize solutions
- Students will experiment with strategies to solve problems
- Students will publish journals explaining their methods to solve these equations with critical and creative thinking skills

Student performance will be measured using the following rubrics found in Appendix A.

The "hook" or Introduction:
A brief description of how the learning experience will be introduced to students and why the project "should" be interesting/motivating to students.

Students need to hear from someone who works in mathematics and is passionate about their work. Professor Edward Frenkel, from the University of California, Berkeley has created a series of videos about math and has launched a campaign to me make math part of our cultural heritage in the same way as art or literature. To begin this project, students will watch his video "Reimann Hyopothesis" on

Numberphile Channel on Youtube. The video can be found at this link. Dr. Frenkel gives an understandable introduction to the hypothesis and introduces many of the vocabulary terms and concepts that will be an integral part of the project. The million dollar prize for solving the hypothesis he mentions is also a form of hook that will reinforce for students, the idea that mathematics is a valuable part of our cultural knowledge base.

Process:

The process is the way you structure the learning to engage students in the project/learning experience goals and objectives. How are they going to accomplish the task? What are the students doing? What is the teacher doing? How are you assessing the process of learning? How is the student directing the learning? A sequence of unfolding events is usually provided and a timeline is often used.

After their initial meeting with their mentors, students will conduct independent research and analysis which they will share with their groups in half hour meetings once a weeks. They will be student explorers, teacher, and producers. In their weekly meetings, they will share their findings with each other and develop new ways to attack the problem. Students are in charge not only of choosing their unsolved problem, but of conducting their own research and building their own strategies based on their prior knowledge. The teacher will serve as co-learner and facilitator. She will arrange the logistics of meetings with mentors. She will be available during her normal tutoring sessions to help students with their problems individually or in groups. During classroom meeting times, she will share with the class what she knows or has found in her research. She will move among the groups monitoring for critical thinking, assisting with brainstorming, checking calculations and journal entries, and looking for teachable moments.

Product:

What is the end-product the students will produce? Who will use/care about the product? Why will the product be meaningful to students? How is technology integrated within this product? How will you assess the product?

Students will create a class Wiki to share their discoveries and hypotheses with the rest of the world. Researchers and students of mathematics will be interested in this site as a source of inspiration for their own theories. Sharing and having their ideas validated by experts outside the classroom will give personal meaning to students as they work together to solve real problems. Technology will be integrated via internet research, chat rooms (probably *Skype*), blogs, wikis, and collaborative documents.

Technology Use: *What technologies are critical to the project and how will they be used (examples: To communicate with peers/mentors, to construct/publish original products, to analyze data, etc.) How does the proposed technology use in this learning experience support the indicators of engaged learning?*

The students will use the Internet to research mathematical concepts related to the problems. They will have access to *Geometer's Sketchpad* and *Maple 18 for Students*, mathematical modeling programs which will help them visualize their solutions. They may use *Excel* to create charts. *Skype* or an equivalent program will be used to communicate with mentors. Alternatively or in addition, an *ePals* classroom will be set up which gives students communication tools yet preserves their privacy. Students' identities will be protected by only using first names in all communication.

References

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Roblyer, M. D., & Doering, A. H. (2013). *Integrating educational technology into teaching*. Boston: Pearson/Allyn and Bacon.

Skype and/or Microsoft. (2014). Skype in the classroom. Retrieved July 9, 2014, from https://education.skype.com/

What modifications have you made since you submitted your "idea" for feedback?

I had considered *ePals* before, but upon suggestion am taking a closer look at that forum. It provides several secure methods of communication that would be very useful in working with those outside our school. I also emailed my counselors about possible contacts at KSU and SPSU, but have not heard back from them as they are on vacation.

Which indicators of Engaged Learning will be high in this lesson and why?

This project is standards based and challenging as students try to solve unsolved problems. It is multi-disciplinary in that students are required to engage in mathematics problems and write about them in blogs, journals, and a wiki. It is authentic as student engage in problem-solving at the adult level. Students are explorers, teachers, and producers. The teacher is a co-learner. It is collaborative and generative as students work with researchers and college students to brainstorm and create a website that can be shared with other students and researchers.

Which indicators would you like to strengthen?
I originally wanted to make the project more culturally responsive and to refine the assessment process. Based on feedback, I incorporated ePals which has the potential to connect with other classrooms. I also refined my assessment rubric.

What LoTI level do you think this lesson would be and why?

I think this would be a LoTI level 6. It incorporates collaboration with a research institution, highly integrated technology, and a product of interest to researchers and students of mathematics.

What help would you like to receive from us?
I have not yet reached out to KSU or SPSU. If you have connections with mathematics professors either at KSU or at SPSU who would be interested in working with us on this, please share! I have a teacher who is interested.

Appendix A

Riemann Lab Authentic Math Rubric

Student/Group Name_____

Score Levels	Hypothesis & Strategy	Understanding and Application	Evaluation and Revision	Written explanation
40	• Is well thought out and supports the solution to the challenge or question • Reflects application of critical thinking • Has clear goal that is related to the topic • Is pulled from a variety of sources • Is accurate	Is well thought out and supports the solution to the challenge or question Reflects application of critical thinking Has clear goal that is related to the topic Is pulled from a variety of sources • Is accurate	• Is well thought out and supports the solution to the challenge or question • Reflects application of critical thinking • Has clear goal that is related to the topic • Is pulled from a variety of sources • Is accurate	• Information is clearly focused in an organized and thoughtful manner • Information is constructed in a logical pattern to support the solution • Language is used to clarify and illustrate the main points • Information is very organized
30	• Is well thought out and supports the solution • Has application of critical thinking that is apparent • Has clear goal that is related to the topic • Is pulled from several sources • Is accurate	Is well thought out and supports the solution Has application of critical thinking that is apparent Has clear goal that is related to the topic Is pulled from several sources • Is accurate	• Is well thought out and supports the solution • Has application of critical thinking that is apparent • Has clear goal that is related to the topic • Is pulled from several sources • Is accurate	• Information supports the solution to the challenge or question • Language is used to illustrate the main points • Information is somewhat organized
20	• Supports the solution • Has application of critical thinking that is apparent • Has no clear goal • Is pulled from a limited number of sources • Has some factual errors or inconsistencies	Supports the solution Has application of critical thinking that is apparent Has no clear goal Is pulled from a limited number of sources • Has some factual errors or inconsistencies	• Supports the solution • Has application of critical thinking that is apparent • Has no clear goal • Is pulled from a limited number of sources • Has some factual errors or inconsistencies	• Narrative has a focus but might stray from it at times • Information appears to have a pattern, but the pattern is not consistently carried out in the project • Information loosely supports the solution
0	• Provides inconsistent information for solution • Has no apparent application of critical thinking • Has no clear goal • Is pulled from few sources • Has significant factual errors, misconceptions, or misinterpretations	Provides inconsistent information for solution Has no apparent application of critical thinking Has no clear goal Is pulled from few sources • Has significant factual errors, misconceptions, or misinterpretations	• Provides inconsistent information for solution • Has no apparent application of critical thinking • Has no clear goal • Is pulled from few sources • Has significant factual errors, misconceptions, or misinterpretations	• Content is unfocused and haphazard • Information does not support the solution to the challenge or question • Information has no apparent pattern
Comments & Score				