Piecing Things Together

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Host Organization: Stanford University

ETP Type: Classroom Lesson

Subject/Grade: Math/11 & 12

Abstract

In the ideal math world, we are able to write a single equation that can perfectly model a situation. However, if we collect actual data from the real world, we will almost always not be able to write one equation that will completely match the data. During my fellowship with the Gu Lab Group at Stanford, I collected and analyzed data, which will be brought back to the classroom for students to analyze through writing equations for piecewise defined functions as the data does not fit one particular group of functions. Also, each piece of the function does not perfectly fit as well, so students will use technology to apply regression methods as well.

Focal Content & Supporting Practices

- Piecewise Functions (F-IF 7a, 7b)
- Linear/Quadratic Fitting (S-ID 6a)
- CCSS SMP 4 - Model with mathematics

21st Century Skills and Applications

- Students accurately identify, break down, and analyze problems.
- Written and oral communications are clear, correct, and concise.

Measurable Objective(s)

Students will be able to

- write the equation(s) of piecewise function given the graph.
- fit data into the equation of linear and quadratic functions.

Formative Assessment(s)

- Entrance Ticket

Summative Assessment(s)

- For a project, students design a logo. Then they write the equations of piecewise functions that would result in the graph of the logo. Finally, they graph the equations on Desmos for comparison.
- Test Question(s) on Piecewise Functions (part of the functions test)

Fellowship Description

My fellowship was at the Gu Lab Research Group in Stanford University. The lab focused on the study of

the mechanical behavior of architectured nanomaterials. I worked closely with a graduate student, John Kulikowski, on a project to engineer a material design that is both strong and light-weight. The goal of the project was to gain a better understanding of the science, rather than to apply it for a commercial use.

Through the use of direct laser writing (3D printing), the nanomaterial was used to construct structures of various geometries and compositions. Strength tests were then performed on the structures to determine their mechanical properties. One such test involved using a nanoindenter to apply a force on the structure until it fractured. Data was then acquired and analyzed to calculate properties such as toughness and stiffness. The experiment was then simulated on a software program called Abaqus for comparison.

My main duties included performing the strength tests as well as collecting and analyzing the resulting data to calculate the mechanical properties of each structure. I also used Abaqus to build the structures virtually as well as perform the simulation tests. In addition, to gain a better understanding of the science behind the project, I read multiple research papers as well as literature on elementary Material Science in order to understand the research papers.

Through this work, I gained a renewed appreciation for collaboration and cooperation, as well as the experience of feeling what it's like to be a student again. Hopefully, this will guide me in my teaching practices for the upcoming school year.

Fellowship Connection to School/Classroom

During the spring semester of the 2021-2022 school year, one of my students would give me a test to take while they were taking tests. She said that I don't understand how much stress/anxiety that tests cause them because it's been a while since I was a student. As the fellowship was a research assistant position that involved me learning difficult material as well as reading dense research papers, it certainly gave me the feeling of what it's like to be a student again. This certainly will cause me to change some of my teaching practices. An idea that I have at the moment is to include more group tests/quizzes, to further encourage students to work together. More ideas will develop in time.

In terms of specific curriculum, the fellowship mainly involved me collecting and analyzing data. The scientific theory involved is well beyond the high school level. However, the analysis of the data does relate to two topics that are covered, namely piecewise defined functions and regression/fitting.

Instructional Plan

Time required: 3 days

Prior Knowledge
- Graphing Equations of Functions Using a Table
- Linear Functions
- Quadratic Functions

Day 1 (50 min class period)
Objective: Introduce the concepts of piecewise functions and continuous/discontinuous graphs.

Do Now (15 min): Students will be given two equations to graph (one linear in slope-intercept form and one quadratic in standard form) as review. Then we will go over the problems together.

Main Activity (35 min):
- Part 1 (15 min): Students will work, in groups, to work on 3 graphing problems (1 graphing in vertex form and 2 piecewise functions - one continuous and one discontinuous).
- Part 2 (20 min): Groups will be randomly chosen to present their work on the whiteboard to the

entire class. We will also review what piecewise functions are as well as introduce the idea of continuous vs. discontinuous graphs. We will also go over how to use Desmos to graph piecewise functions. (See **How to restrict domain and/or range in Desmos** to graph piecewise functions by restricting domain.)
Note that in general, I choose groups randomly to present work, not only those that are correct. I thank those who make mistakes so that it gives us a learning opportunity to go over and learn from the mistakes.

Day 2 (50 min class period)
Objective: Reinforce the concepts of piecewise functions and continuous/discontinuous graphs.

Entrance Ticket (10 min): Students will be given a problem to graph a piecewise defined function. They may use their notes as reference.

Main Activity (40 min):

- Part 1 (25 min): Students will work, in groups, to work on 4 problems in which graphs are provided and students are asked to write their equations. There will be a 5th problem involving finding the value of the parameter of one of the equations of a piecewise function so that the graph becomes continuous.
- Part 2 (15 min): Groups will be randomly chosen to present their work on the whiteboard to the entire class. Following #4 of the problems, we will go over how to use Excel (or Google Spreadsheet) to perform regression on the data. I will share with them that it is actual data obtained from the summer fellowship and that part of the analysis I did involved me performing linear regression.
  A teacher who is not comfortable with Excel/Google Spreadsheets may choose to use Desmos to perform the regression. See **How to perform regressions on Desmos** if necessary. The reason I use Excel is because students have been exposed to regression using Desmos already in their Algebra 1 class, so it would be beneficial for them to see it done on a spreadsheet.

Day 3 (1 hr 30 min class period)
Objective: Summative assessment of piecewise functions.

Do Now (10 min): Students will be asked to draw a logo (in pen) for their group. Teacher will circulate around the room to approve/reject the logo (to make sure it's not too complicated/simple for the activity as well as classroom appropriate).

Homework Check/Discussion (10-15 min): Teacher will circulate around the room to stamp homework. Students will be provided answers to the assignments. Questions that come up should be discussed with tablemates. Teacher will go over questions that cannot be resolved by any group (and possibly point out key mistakes to look out for or main ideas of the homework).

Main Activity (55-60 min)

- In groups, students will write multiple sets of equations for piecewise functions (along with domain restrictions) that will generate their logo.
- Once they are done, they must get teacher approval before moving onto the next step.
- Students will grab a Chromebook and graph their equations on Desmos. Then they will save the graphs and share with the teacher. (See How to save and share Desmos graphs if necessary.) They will also submit their hard copy work as well.
- When giving instructions, the teacher should emphasize that work must be divided relatively evenly amongst the members. He/she should also circulate around the room to monitor progress, to make sure students are collaborating.
- Note that the teacher should create a logo to model the activity to the students. Let them know that the graph on Desmos should resemble their logo but need not be perfect. Sample Logo - Bread Man Tran

Additional Supports

Tools to meet the needs of all learners (SEL, distance learning, ELL, SPED)

- Computer connected to a projector (Teacher)
- Calculators (Student)
- Chromebooks (Student)

Materials

Include links to all files within this ETP

Please note the equations are not rendered properly in Google Doc. The .doc version is included only to allow edits. The .pdf version shows how the equations should appear.

- Day 1 Questions Doc Day 1 Questions PDF
- Day 2 Questions Doc Day 2 Questions PDF
- Sample Logo - Bread Man Tran
- Summative Assessment Scoring Rubric

References

- Desmos Help Center. (n.d.). *Getting Started: Inequalities and Restrictions*. https://help.desmos.com/hc/en-us/articles/4407885334285-Getting-Started-Inequalities-and-Restrictions
- Desmos Help Center. (n.d.). *Regressions.* https://help.desmos.com/hc/en-us/articles/4406972958733-Regressions
- Desmos Help Center. (n.d.). *Saving and Managing Graphs*. https://help.desmos.com/hc/en-us/articles/4405901719309-Saving-and-Managing-Graphs

Keywords

Piecewise Functions, Continuous vs. Discontinuous Graphs