



## Using Google Drawings to Create Homework Exercises

We show how Google Drive's Drawings tool can be used to create homework exercises suitable for both online and face-to-face classes. This approach allows students to create graphs actively "from scratch," similar to the traditional pencil-and-paper approach, with a minimal investment of time and money. This could be a useful active-learning tool for online, blended, and traditional courses.

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## 1. Background

Although enrollments in online and blended versions of traditional courses are rising rapidly, recent research using randomized trials finds that exam scores for the control group taught in the traditional face-to-face format are higher than for the treatment group taught in the online format (Alpert 2016; Joyce 2015; Figlio 2010). Given the central role that graphs play in economics classes, one potential concern is that students don't obtain enough practice creating graphs when homework is completed online rather than by hand. Instructors who assign homework online for face-to-face classes may have a similar concern. Increased use of slides, especially when used by students in lieu of note-taking, may also mean that students are less actively engaged with graphs during lectures. Students who rely solely on the provided slides will miss the minimal, but potentially valuable, practice constructing graphs that traditional note taking allows, even if the instructor takes care to explain the process of constructing graphs step-by-step.

While computer-graded graphing exercises from services like Aplia, Sapling, and MyEconLab address this gap, they are inherently more constrained than an exercise that asks students to construct a graph "from scratch," which is especially important for learning to translate between real-world problems and a model. Creating a graph "from scratch" allows students to deviate from the model answer in more ways, uncovering gaps in their understanding that might not be apparent when choosing from a limited number of distractors. Comparing their answers to a model answer, and optionally viewing other students' answers, gives students additional opportunities to engage in active learning. Active engagement with an exercise can improve comprehension and retention (Al-Bahrani 2016; Acchiardo, 2016; Vazquez 2014).

Nor are prepackaged solutions ideally suited for use with every textbook; the terminology or sequence of topics may not match those used by the instructor's preferred text, confusing students. Commercial solutions are also less plentiful for intermediate level coursework. Last, but not least, students have budget constraints that may deter them from purchasing these commercial products.

Of course, prepackaged solutions do have an upside: little work is required to select from already-complete exercises, and the exercises are graded by a computer. But the right tool can minimize the work of creating custom exercises. Ideally, the same tool used to create the exercises could be used to create graphs for slides, exams, and ad hoc answers to student questions. Additionally, elements of one exercise could be recycled for use in another. The Google Drawings tool is a new tool for instructors to use that satisfies these criteria. Meanwhile, student self-evaluation and interaction with peers can be used not just a substitute for traditional "grading," but as integral to the learning process.

## 2. Graphing Activities in Google Drawings

Our graphing exercises use Google Drawings.<sup>1</sup> This tool, part of the Google Drive and Google Docs suites, is available free of charge. In addition, many students are already comfortable with the Google environment, and the web based component of Google Drive is consistent

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1 See <https://drawings.google.com/> or access the tool via Google Drive or Google Docs. Additional exercises, not discussed here, use the related Google Sheets spreadsheet. Note that governments in a few countries, such as the People's Republic of China, currently block access to certain Google services, and this may complicate access for students working from those countries. In online courses, it is prudent to warn students about this potential problem in the syllabus.

across all major browsers and operating systems. Because our institution uses Google Apps for Education, all our students already have a Google account that corresponds to their school email address and includes 30 GB of free storage for their documents. Although Drawings can be used from any Google account, Google Apps for Education integration does eliminate the need to create a new account for each student or use students' personal accounts; it also simplifies the process of limiting access to the exercises, if desired.

Compared to equivalent pencil and paper homework, it takes relatively little additional effort to create the exercises because the Drawings software is easy to learn; distributing and collecting assignments online takes less time than on paper. Compared to commercially packaged exercises, grading may be much more work if the instructor evaluates students' answers individually and provides written feedback, though in that case the feedback may also be more detailed and address a wider range of errors.

Our students learned to use the software quickly and with minimal support. We created short video tutorials that introduced students to the features they would need to complete the first assignment and post their answers to the learning management system. Few students required further assistance, and some of those who did were able to rely on their peers.

Although student responses to the exercises can be shared within Google Drive itself, drawings can also be exported to standard graphic file formats. This makes it straightforward for students to post their answers to our learning management system (currently, Blackboard) or another online forum (e.g. Facebook). This approach further allays privacy concerns, even if students use their personal accounts to create their answers.

We provide students with an economic issue for analysis and a template with an initial set of curves, e.g. supply and demand or cost curves. We ask them to draw the relevant economic diagram on a grid while using a text box to explain in their own words the economic analysis represented in the diagram. Students then export their entire answer to a file in a standard graphics format (e.g. PNG or JPEG) and post it to a "post first" discussion forum in the Blackboard LMS, which hides other students' posts until the student has posted their own answer. After the due date, we post a model answer for comparison.

Grading can take a variety of forms, depending on preferences and available resources. In Blackboard, the instructor or a TA can grade the discussion posts directly and provide individual feedback. Alternately, students can complete an assignment that asks them to score their own answers using a rubric. Either way, instructors and students can use the forum for further feedback and discussion. Although having the instructor provide individual feedback might seem like the best way to bring errors to the students' attention, having students score their own work may contribute to students' learning by requiring them to engage actively with the material a second time. An instructor who is concerned that students won't review their work carefully can also audit students' scores.

#### A. Creating a Google Drawings Exercise

Here is a step-by-step description of how to set up this exercise. First, create a free Google email account. Sign into your Google email account and click on "Drive" in the Google Apps menu. In "Drive," create two folders: "Instructor" and "Student." In the "Instructor" folder, copy two templates<sup>2</sup>: one with a single grid and the other with two grids side by side as shown in

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<sup>2</sup> The templates pictured below, as well as examples of exercises we have used, are linked from <http://szarka.org/econ/gdraw/> for your use.

Figure 1 – Templates for Use in Constructing Exercises

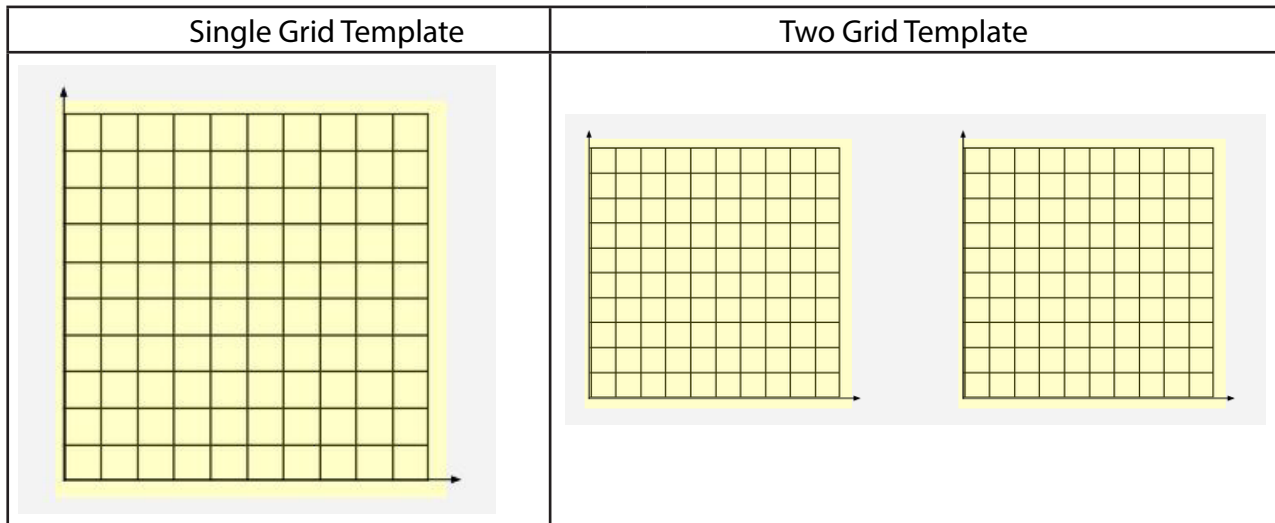


Figure 1.

As a demonstration of the graphing activity let’s use the minimum wage. Copy the single grid template by clicking “File” in the navigation bar and choosing “Make a copy.” Select the folder “Instructor” and then rename it “Minimum Wage Answer.” Double-click the file and it will open in Drawings. Using the draw tools (such as “Insert | Line” and “Insert | Text box”), draw the standard analysis of the effects of the minimum wage. As you draw, make a set of instructions (in a text editor such as Notepad or TextEdit, or in a separate Drive document) that describes to your students how to replicate the diagram.<sup>3</sup>

Once your diagram is complete, make a copy of the completed diagram, rename the copy “Minimum Wage Exercise,” and move the copy to the “Student” folder by right-clicking and choosing “Move to.” (Alternatively, with the diagram open for editing, use “File | Move to.”) Consider how much drawing you want the students to do and then open the “Minimum Wage Exercise” document for editing. Undo or delete the elements you’ve added to the diagram until you arrive at the desired starting point for your students. To make the final product accessible to your students, use “File | Share.” If, like ours, all your students have Google accounts provided by the school, the “Get a shareable link” option makes it easy to give everyone at your school permission to view the file. Alternatively, you can use the dropdown menu to make the file viewable by anyone with the link, or grant access only to specific Google accounts. Just be sure to avoid the options that make the file editable by others.

Finally, in your LMS, on a course web page, or in an email to your students, paste the instructions and the link to the “Minimum Wage Exercise” document. (You can also provide instructions within the document itself by inserting a text box and pasting the text there.) After clicking on the link, your students will need to sign into their Google accounts. They will then need to make a copy of the template you’ve provided and make changes to the copy to create

<sup>3</sup> Instructors who are concerned about possible plagiarism can insert a direction that asks students to use different numbers. For example, the instructions can state: “Start the initial equilibrium at a quantity equal to the first digit of your Student ID.”

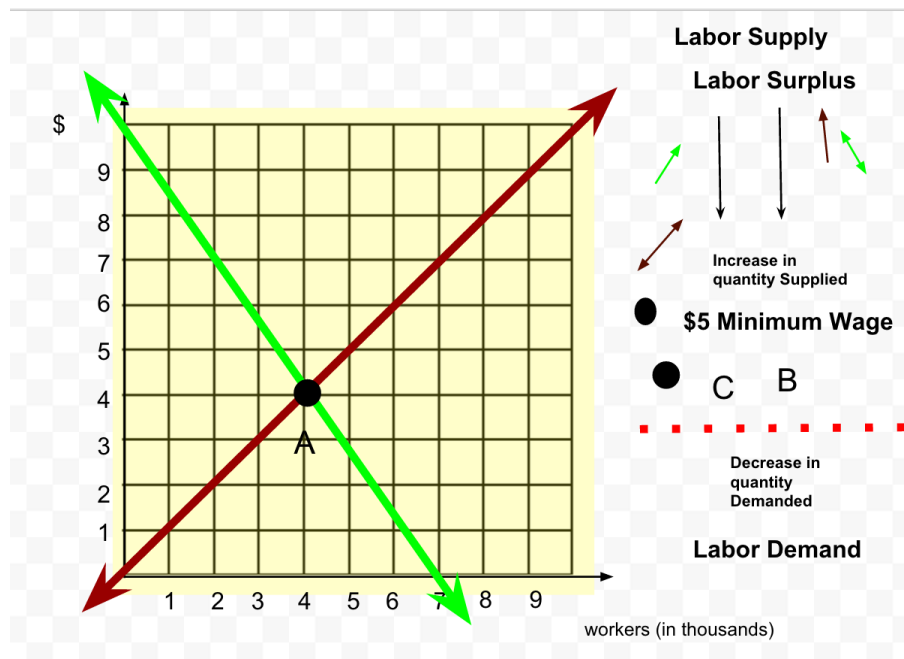
their answers to the exercise. To submit the completed diagram, you can have your students share the documents directly with you, or students can export the documents to their hard-drives in one of several standard formats using "File | Download as." We ask students to post the completed diagram to a "post-first" discussion thread within our LMS; students can view other students' submissions only after first posting their submission.

We have used this exercise format many times and have received great feedback from students. Below is a completed version of the "Minimum Wage Exercise" outlined in the above section.<sup>4</sup>

### B. The Completed Minimum Wage Exercise

Figure 2 shows the graph provided to the students for the minimum wage exercise. Diagram elements such as lines and dots are already provided for the student to drag and drop; fewer elements can be provided, leaving students to create them using the tools in Drawings, at the cost of time spent learning to use the tools.

Figure 2 –Diagram Provided to Students for Minimum Wage Exercise



4 The examples below, and others we have used, are linked from <http://szarka.org/econ/gdraw/>.

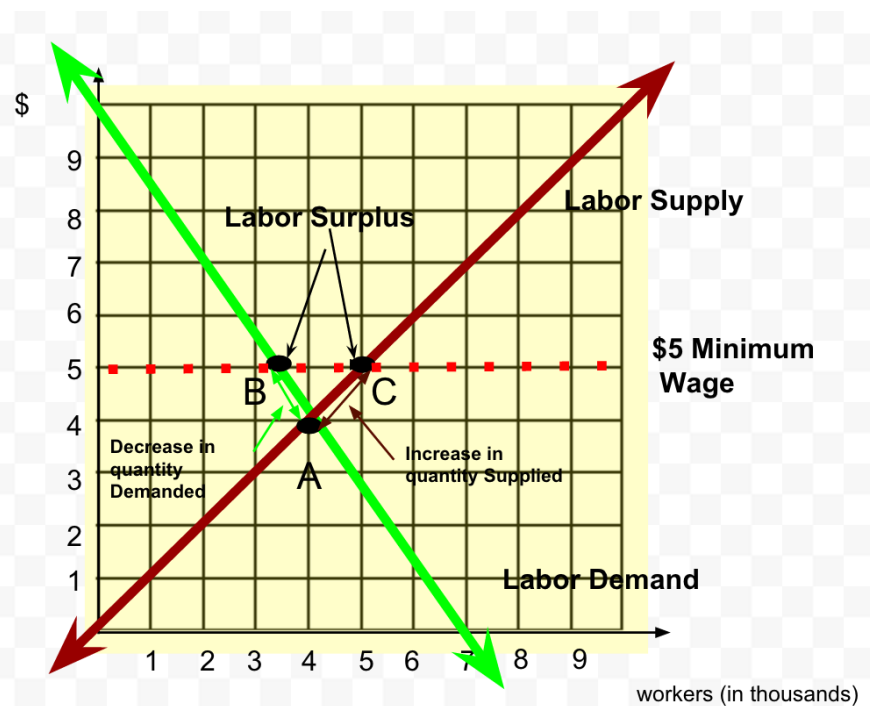
Students are given detailed instructions that guide them through the process of completing the graph. Below are an example of the instructions given to the student.

1. In the diagram, label the labor demand and labor supply curves. Label the equilibrium with a black dot and the letter A. (To address plagiarism, add the instruction: Relabel the horizontal axis so that the equilibrium quantity equals the first number in your student id.)
2. In the diagram, introduce a \$5 minimum wage. Label with a black dot the quantity demanded (label as B) and the quantity supplied (label as C).
3. In the diagram identify the resulting labor surplus.
4. EVALUATION: In the diagram, decompose the labor surplus into the portion attributable to the decrease in the quantity demanded of workers and the portion attributable to an increase in the quantity supplied of workers. Then in a paragraph explain how it is that imposition of a minimum wage results in an increase in unemployment and a surplus of workers.

The model answer is below and accompanies Figure 3:

With the imposition of the minimum wage, all other factors held constant, the quantity demanded falls as indicated by the move from point A to point B. Because employment was initially 4,000 at point A, and employment is approximately 3,500 at point B, we conclude that the imposition of the minimum wage decreased employment by 500 workers. The surplus is the amount by which the quantity supplied exceeds quantity demanded at the price control of \$5. Hence the surplus is 1,500 (5,000 – 3,500).

Figure 3 – Completed Minimum Wage Diagram



A summary of the workflow for the exercise is as follows:

1. Instructor creates exercise using Drawing tool
2. Instructor shares (view-only) exercise with students in Drive
3. Instructor posts link to exercise in assignment area of LMS
4. Students copy document in Drive
5. Students modify copy in Drive to create answer
6. Students export answer to standard graphic file
7. Students post graphic to forum in LMS
8. Students compare their answer to other students' answers
9. Students compare their answer to model answer from instructor

### C. Using Side-by-Side Diagrams: A Tax -Shifting Exercise

The example below demonstrates using side-by-side graphs. The directions to the student are:

The initial diagram has two panels. The left graph depicts a perfectly inelastic demand curve. The right graph depicts a relatively flat sloped demand curve. The initial equilibrium in each graph is labeled point A. We will impose a \$2 per unit tax in the left graph and a \$4 per unit tax in the right graph.

1. In the left graph \$2 above and parallel to the original supply curve, draw a new supply curve. Put a black dot at the new equilibrium, and label it as point B.
2. Draw a vertical arrow between the two supply curves, and label it as a \$2 Tax.
3. Shade the rectangle representing the rectangle for the tax burden on the buyer.
4. In the right graph \$4 above and parallel to the original supply curve, draw a new supply curve. Put a black dot at the new equilibrium, and label it as point B.
5. Draw a vertical arrow between the two supply curves, and label it as a \$4 Tax.
6. Shade the rectangles representing the rectangle for the tax burden on the buyer and the seller, respectively.
7. Report the amount of tax paid by buyer and seller, respectively, in each situation. Show your calculations. In a paragraph explain why it is the case that in one instance (left panel) consumers bear 100% of the tax burden while in another instance (right panel) consumers bear only 75% of the tax burden. Then offer an explanation of the type of situation each tax would be better suited for.

The graphing template should be copied to your account and then linked for the students to find.<sup>5</sup>

Figure 4 - Drawing Provided to Students for Tax-Shifting Exercise

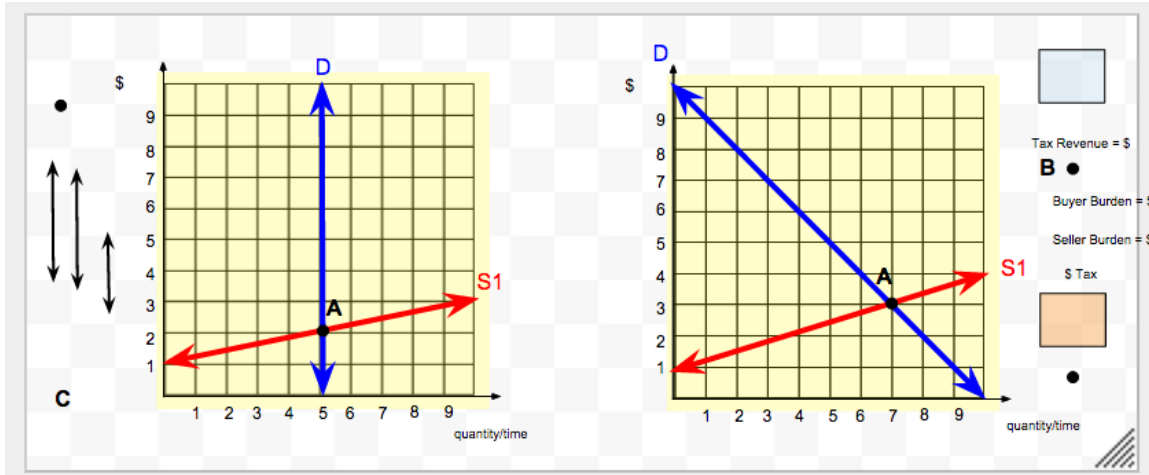
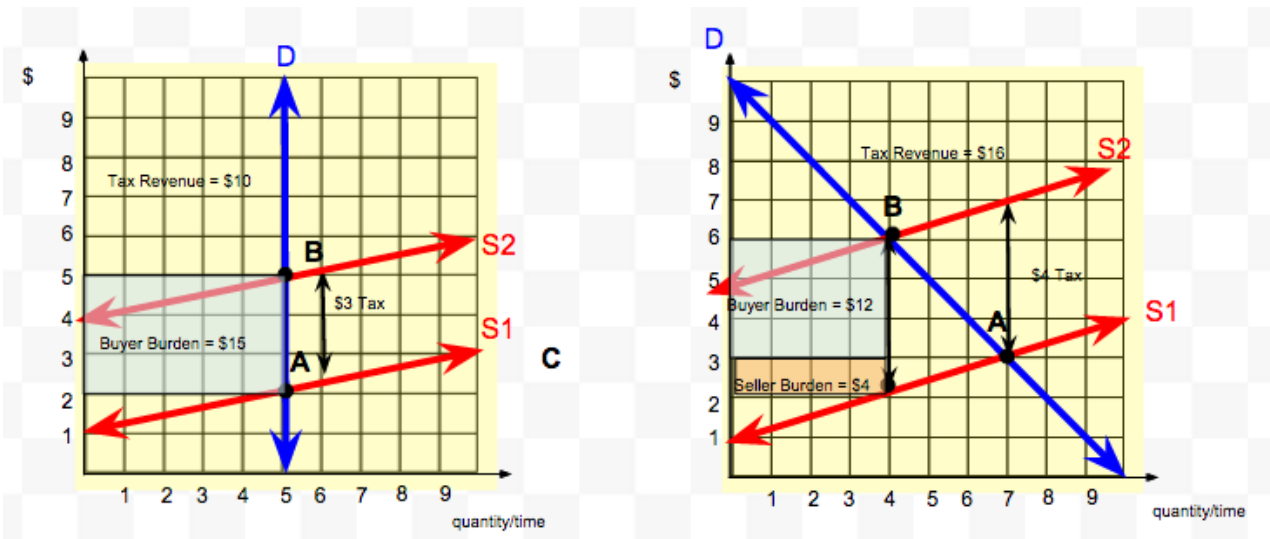


Figure 5 shows the correct answer.<sup>6</sup>

Figure 5 – Completed Tax-Shifting Diagram



<sup>5</sup> The template for this exercise can be found at <https://docs.google.com/drawings/d/1NmjU7IoNeUpChg5Vbg6OLH-0Li6-NoOHi7XdwgStGaag/edit>

<sup>6</sup> The correct diagram can be found at <https://docs.google.com/drawings/d/112zMyt4qmheU21EGeE9jip825CyRRyeb7U5ip-GF8QZA/edit>



### 3. Student Feedback

We surveyed students in the Fall 2013 iteration of our Principles of Microeconomics course. Some students pointed to the visual or hands-on aspect of the activities as the most beneficial aspect. Example student comments include:

- “Visualizing the charts helped me remember things.”
- “I am a visual learner, so that helped a lot.”
- “Being able to graph things on my own helped me more than if I had to just look at someone else’s graph.”
- “Trying to formulate the graphs on my own was definitely the most beneficial aspect. It gave me more insight than simply just viewing a graph in the textbook.”

Asked about the most difficult aspect of the activity, some students reported no difficulty at all. Other students did express frustration with the mechanics of the activity or with the activity as a whole. Clearly, making the activity concise, accessible, and useful for all students can be a challenge. Students also pointed to the required explanations as the most difficult aspect of the exercises:

- “The explanations (of the graphs) were the most difficult since they required a proper understanding of the material.”
- “Explaining what I did...”
- “The explanations.... I tried to look on the Internet for some clarity but I couldn’t find anything.”

That many students pointed to the required explanations of the graphs as the most challenging aspect of the activity suggests that the activity may have achieved our goal: getting students not only to manipulate the graphs, but to also grapple with their meaning.<sup>7</sup>

### 4. Conclusion

We have demonstrated ways to use Google Drawings to allow students to draw economic diagrams much as they would with pencil and paper. We have provided two examples that illustrate the range of diagrams that can be drawn, and we have made a full set of exercises for standard courses in principles of microeconomics and macroeconomics available online. We have shown that the exercises can be quite elementary, with step-by-step guidance, or can be delivered with only digital graph paper, leaving the student to create all of the needed objects. For each exercise, we have shown the setup diagram for the exercise as well as the solution graph.

These exercises are introduced as a complement to problem sets provided by publishers of introductory and advanced level textbooks. The tool allows the instructor to introduce exercises reflecting their customized approach and interest in economic topics. The tool’s learning

<sup>7</sup> These student comments are anecdotal and suggestive, but they are not a substitute for experimental testing of whether the tool increases student learning.

curve might be described as a bunny slope for users comfortable with the Google suite of tools and as an intermediate-level slope for those just becoming comfortable with their institution's LMS or with a textbook publisher's LMS.

## References

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