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ORIGINAL ARTICLE

Online Interactive Pedagogical Tools for the Principles of Microeconomics Curriculum

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Abstract

We discuss over one hundred interactive learning tools that we created and piloted in introductory open-education (OER) microeconomics classes. These interactive tools cover a wide range of microeconomics topics. They are highly randomized so that the presented scenario and correct answers are different on each usage of a tool, which not only provides students with unlimited practice attempts, but also significantly reduces the possibility of cheating by sharing answers. These tools can be uploaded into most learning management systems, and scores are automatically recorded. Student feedback is positive. The tools are available to others at no monetary cost at http://econreimagined.gsu.edu.

Keywords Open-education (OER) · Online · Microeconomics · Pedagogy · Interactive

JEL Classification A2 · Economic education and teaching of economics

Introduction

A need exists for open education resources (OER) in economics education that assesses the student's understanding of the course material without relying on the professor's technological efficacy (Martin and Kimmons 2019; Petrides et al. 2011). Pursuant to this need, we have created a set of over one hundred OER formative (low-stakes) and summative (higher-stakes) assessments for the introductory

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microeconomics curriculum. The low-stakes formative assessments help increase the student's participation levels by giving them the opportunity to practice and solidify their understanding of the course material (Ontong 2021; Stowell 2022; Brooks 2018, Curtis 2011). In addition, empirical evidence shows that low-stakes formative assessments increase performance on the students' future summative assessments (Ontong 2021; Swerdzewski et al. 2009; Dunn and Mulvenon 2009). This advantage is especially true in our case as the formative assessments are tied directly to interactive summative assessment tools.

These tools have been used in eleven introductory microeconomics courses beginning in the fall of 2021 and were developed as part of a larger initiative to create a new open education resources (OER) principles of microeconomics course (Eremionkhale et al. 2022). The tools can be fully integrated into a learning management system (LMS) so that grades are automatically recorded into an LMS gradebook. The breadth of coverage and high quality of the tools allows for a substantive replacement of publisher-provided interactive platforms, and the associated cost savings can be passed onto students. Overall student feedback has been extremely positive.

Two of the authors currently use these assessment tools within the context of a newly designed college-level microeconomics OER course; however, the tools can be selectively adopted independently from the structure of the course. Economics educators from the high school to collegiate level can explore, evaluate, and adopt the course or specific tools into their own courses at no monetary cost at http://econreimagined.gsu.edu.

Overview of the Interactive Tools

This suite of self-guided interactive learning tools was created in direct alignment with microeconomics learning outcomes. This alignment provides students with highly effective opportunities to learn, practice, and master topics. The tools are scaffolded in single and multiple pages and are comprised of fillable calculation tables, multiple choice and select questions, and manipulatives. As students interact with and answer questions, their responses are automatically assessed. A given tool presents a different, but comparable, problem each time the tool is used. The latter was accomplished by randomizing all relevant parameters that define every problem as it is presented to a student. For example, depending on the nature of the problem, any of the following are randomized: prices, quantities, and any other numbers; names of people, goods, and services; the slopes, intercepts, and shifts of graphs; the types and ordering of questions.

The high level of randomization built into each tool provides students with a unique learning experience every time they engage. For example, consider the "identifying points on a demand graph" tool. Each time this tool displays a question set to a student, it randomly creates a discrete demand schedule containing between 7 and 11 points, with linear price increments taking 1 of 20 possible values, linear quantity increments taking 1 of 10 possible values, and the lowest price in the schedule taking 1 of 20 possible values. These factors combine for a total of 20,000

possible demand schedules that the tool may display. Further, the questions posed to a student on each iteration of the tool pertain to randomly selected points on the randomly created demand schedule, resulting in even further randomization of the questions and associated answers for this tool. It is reasonable to assume that this tool will present every student in a course with unique problems.

For another illustration of the degree of randomization built into the tools, consider the "movements along versus shifts of demand curves" tool. Each time the student interacts with the tool, a random set of ten questions is presented. The student is exposed to some questions which are changes in quantity demanded (movements along the demand curve) and some which are changes in demand (shifts of the demand curve), and the direction of those changes is randomized. In the case of the demand curve shifting, they will see different reasons for the shift (for example, changes in prices of related goods, changes in income, changes in expectations, etc.). Some questions might be based on price changes in substitute goods, others on complementary goods, and the names of those goods and the direction of the price change could differ on each iteration of the tool. Shifts based on changes in income will sometimes present with normal goods and other times with inferior goods, and the direction of the income change could differ on each iteration of the tool. A question showing a change in quantity demanded could be due to an increase or a decrease price. Even within a similar type of question, the actual goods listed are different (for example, if the question is about complementary goods, the student might see "shoes and socks" or "milk and cereal" or "pancakes and syrup," etc.). This degree of randomization is much more extensive than a simple set of questions chosen at random from an LMS's question library.

Additionally, the level of complexity coded into the tools is greater than what is found in most LMS-native quizzing features. For example, consider the level of complexity and randomization involved in the tool for determining comparative and absolute advantage with open-ended questions asking students what the opportunity costs are for each good (names of goods are random each time) for each person (whose names are randomized each time), based on production possibilities (with randomized numbers each time). In the D2L/Brightspace LMS[1], one might use an algorithmic question to present a randomized set of numbers (and perhaps randomized names of goods and people) to students in a single question. However, the algorithmic questions native to D2L/Brightspace will only allow a single question with a closed-form numerical solution to be posed to the student. It is not possible to ask for the opportunity cost for each good for each person (essentially four specific questions based on the same set of random production possibilities) within that algorithmic question.

Conversely, the interactive learning tool handles this scenario, along with additional scaffolding questions to help students figure out the opportunity costs, followed by additional questions based on that same set of data. Questions such as "Who has the lower opportunity cost in the production of each good?", "Who has

[1] The D2L/Brightspace LMS is the system used at our home institution, so this is the system with which we have direct experience.

the comparative advantage in the production of each good?", "Who has the absolute advantage in the production of each good?", and "Who should specialize in each good?" can be based on the same set of underlying data. Furthermore, in the tool for determining comparative and absolute advantage, sometimes the data are presented in a tabular format and other times in prose. In the practice version, students are exposed to four different variations. Two variations present the tradeoffs in terms of outputs, and the other two present it in terms of inputs (requiring students to transform the given inputs to outputs). Within each of those variations, one will have each person with an absolute advantage in only one good (which makes the comparative advantage questions more obvious, even if students do not properly "do the math" on the opportunity costs), and the other will have one person with an absolute advantage in both goods, but a comparative advantage in only one good. This level of complexity encourages students to think deeply about how all concepts fit together in a wholistic manner, and it simply is not possible to do this with standard LMS quizzing features.

The benefits of such significant randomization are twofold: First, when students practice their skills by repeating a tool many times, they face a seemingly new problem every time and are more likely to stay engaged and improve their higher-order learning; second, the costs of cheating are higher because the answer is different every time, which should lower the likelihood of students trying to cheat (for example, copying others' work, copying answers from other sources, sharing answers, etc.).

These tools cover a wide range of microeconomics topics, including opportunity costs, comparative and absolute advantage, basic supply and demand concepts, market equilibrium and disequilibrium, market efficiency, elasticity, market imperfections, excise taxes, price and quantity controls, calculating costs, revenues, and profit, and identifying optimal quantities. Students interact with the tools through links in the course that open web pages. The tools require no special software and render within any modern browser. The display of the tools is responsive to device screen size, which means that the software will run on a phone, tablet, or computer.

The tools, once uploaded into a course, integrate with LMS gradebooks.[2] As soon as a student completes the activity contained within a tool, an overall score is reported on-screen to the student and is automatically recorded in the LMS gradebook. This linkage with the LMS is critical for student assessment purposes. Each tool has two versions: one for learning and practice and one for quizzing with due dates. Table 1 summarizes the differences between the two versions. Both versions are comparable in the difficulty level. The aim is for students to use the practice version to learn and be more successful during the quiz version.

The practice versions are intended as formative assessments. The practice tools offer unlimited attempts and low stakes (grading them on completion only)

[2] The interactive tools were created as SCORM packages, which can be integrated with most modern LMS systems.

Table 1 Two versions of each interactive tool

Practice	Quiz
Used for formative assessment	Used for summative assessment
Unlimited attempts	Only one attempt (the first attempt counts towards grade)
Instant feedback/hints are provided upon submission of answers	NO feedback/hints provided upon submission of answers
Multiple scenarios are presented to ensure exposure to key differences in various examples	Sometimes fewer scenarios are presented to create more random quizzes, but they are comparable in difficulty
Graded on completion	Graded on accuracy

as incentives for students to work on them until they are proficient.[3] Students may repeat the practice version of the tools as often as they want, whether during the same learning session or on a subsequent visit until due dates[4] to keep students on track. Students can check their answers as they proceed through the tools. Substantive feedback and hints are provided when students answer incorrectly to help them learn from their mistakes. An overall score is reported on the last page of the tool. The practice tools are carefully designed to give students exposure to all the key variations which might occur in each microeconomic concept covered.

The quiz versions are intended as summative assessments. Here students are graded on accuracy[5] and with only one attempt recorded in the LMS gradebook[6]. Students can check their answers as they proceed through the tools and learn if they answered correctly, but in this version, feedback on incorrect answers is not provided. As with the practice versions, an overall score is reported on the last page of the tool and is automatically recorded in the LMS gradebook upon submission. Sometimes, fewer variations are presented in a quiz version of a tool. (For example, a practice version might cover all possible variants of the problem, but the quiz version presents only a single randomly selected variant.) Figures 1 and 2 show screenshots of the difference between a practice version (with feedback on incorrectly answered questions) and the quiz version of the same tool.

Over 100 uniquely titled tools were created, some of which are "revisits" of earlier tools. There are 52 practice versions and 52 quiz versions. These 52 core tools were created to assess the fundamental application-level learning objectives of

[3] Grading practice versions based on completion is a feature within the SCORM packages and cannot be edited by instructors.

[4] Availability deadlines were set in our LMS, not a feature within the SCORM packages, so other instructors might set that up differently.

[5] Grading quiz versions based on accuracy is a feature within the SCORM packages and cannot be edited by instructors.

[6] Within D2L/Brightspace, instructors have a choice of settings for the grades when loading the SCORM packages into the LMS: first attempt, last attempt, highest attempt, etc. We used the first attempt.

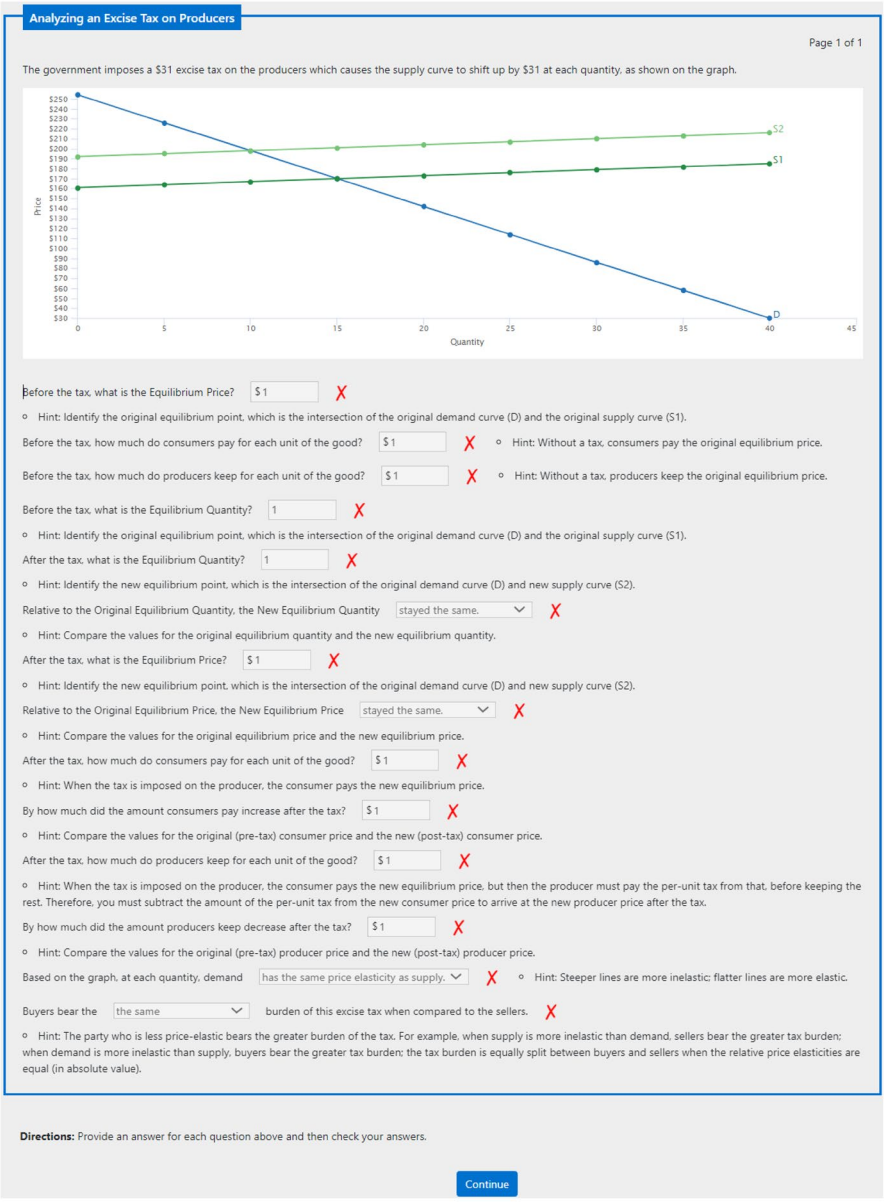

Fig. 1 Screenshot of analyzing an excise tax on producers on a graph tool (practice version)

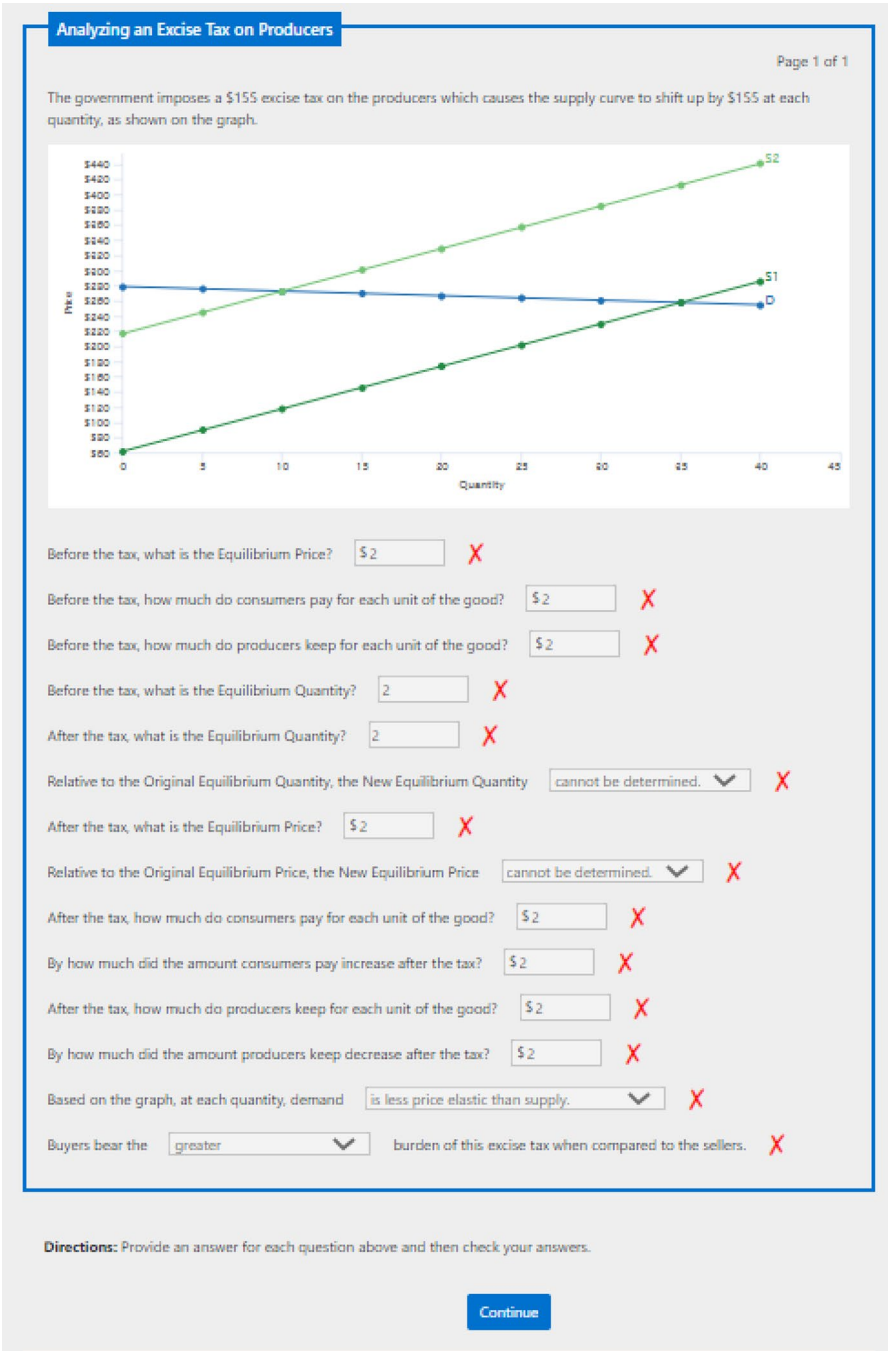

Fig. 2 Screenshot of analyzing an excise tax on producers on a graph tool (quiz version)

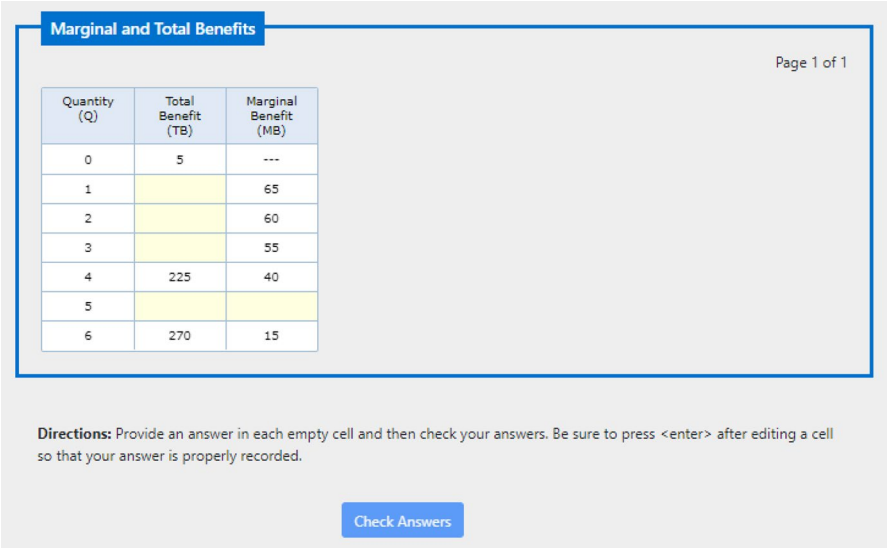

Fig. 3 Screenshot of calculating marginal and total benefits in a table tool

microeconomics. A full list of the tools created in order they appear in the course is found in appendix. There are several types of engaging interactive tools:

- Tables with fillable cells that present values to students with some randomly selected cells that they must fill in to answer a question (for example, calculating total and marginal benefits—see Fig. 3).
- Open-ended and multiple-select questions based on data presented in static tables and graphs (for example, identifying the equilibrium price and quantity from a table or graph).
- Point and click problems where students select rows from a static table (for example, calculating consumer surplus from a table).
- Manipulatives which require students to answer questions by manipulating graphs through dragging and dropping visual elements of graphs (for example, shifts of vs. movements along demand or supply graphs[7]).

Research on learning shows that students must acquire component skills and practice integrating them to develop mastery (Ambrose et al. 2010). To support this pedagogical goal, scaffolding was intentionally built into individual tools, across all the tools, and in the order students are presented the tool to help them build component skills to complete more complex tasks. An example of one of these building-block tools is the "Identifying Points on a Demand Graph" interactive tool shown in Fig. 4. This tool presents a demand curve from which the

[7] Inspired by interactive practice exercises by Marginal Revolution University at https://mru.org/

Fig. 4 Screenshot of identifying points on a demand graph interactive tool

students must identify the price associated with a particular quantity demanded value and vice versa. The numbers on the graph are randomized on each iteration, and the points seen each time this tool is loaded are selected randomly from the graph. The "Identifying Points on a Demand Graph" tool helps students understand this foundational skill, which is applied later in the course in the relatively more complex combined supply and demand model.

Another example of scaffolding is seen in the "Analyzing Price Controls on a Graph" tool. In this tool, students are first asked to identify the market equilibrium from the graph and then are explicitly asked whether the price control illustrated on the graph is binding. The skills the students master in the "Analyzing Price Controls on a Graph" tool help them perform the analysis in the next tool, "Analyzing Price Controls on a Table," which is less visual and can be more difficult for students to approach. It is tempting for students to skip the key step of using their critical thinking skills to determine whether the price control is binding, especially when a graph is not provided for them. See Figs. 5 and 6 for screenshots of these tools.

We also purposely created "revisits" of some of the tools to provide multiple opportunities for students to practice with some of these building-block tools. We strategically placed the "revisit" tools in our course to help the students see how concepts they had studied previously relate to new material. For example, some of the "demand" tools from the supply and demand module show up again in the module on consumer theory, while some of the "supply" tools show up again in the module when we first introduce the theory of the firm.

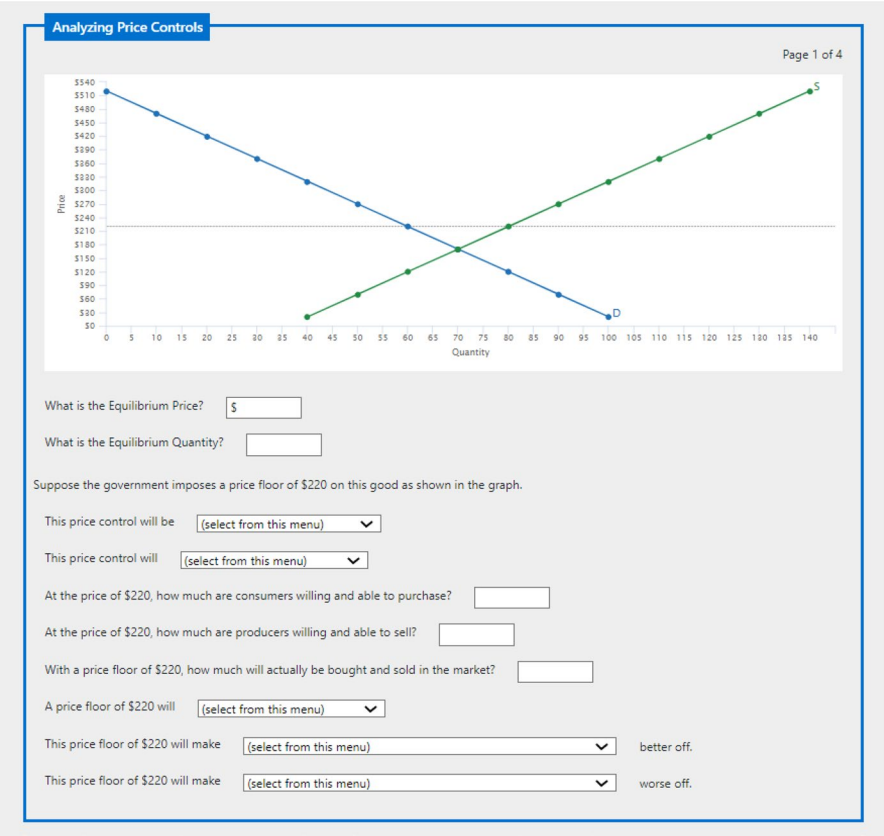

Fig. 5 Screenshot of analyzing price controls on a graph interactive tool

In addition to the repeated practice they provide, there are other significant benefits from having multiple assessment opportunities (tools) per learning objective instead of only a few summative assessments (for example, one midterm and one final assessment). This method allows students to have a more thorough learning experience and reduces their performance stress as each assessment is a balanced portion of their overall course grade. Ideally the reduction of performance stress along with significant randomization in the tools, ease of use, and best practices in course design also mitigates all forms of cheating (Rettinger 2017; Norris 2019).

The method of multiple assessment opportunities also allows the instructor to easily monitor progress and address issues before a student gets too far off track and is at high risk of failure in the course.

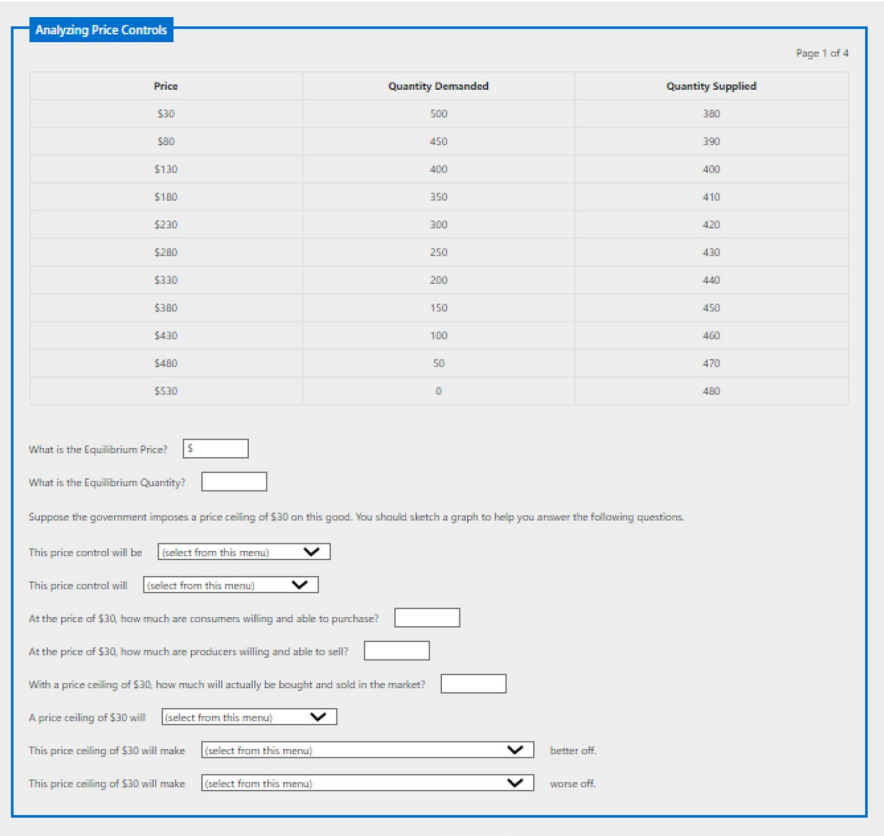

Fig. 6 Screenshot of analyzing price controls on a table interactive tool

Discussion

We have found these interactive learning tools to be beneficial to students in our own courses, and we believe that other instructors may find value in these innovations. The ability to offer students on-demand unlimited practice with rich feedback on their performance through an online assessment tool on a particular concept, knowing that each time the student engages with the tool they will experience a different set of problems, is particularly appealing. Further, these tools have eliminated our dependence on publisher software that was costing each student $75 each semester, resulting in a cost savings for students of almost $70,000 in the twelve months since we began using these tools in our courses.[8]

[8] These tools have been used by 923 students in 11 sections over the last three semesters. Each of these students did not spend $75 on the publisher software used in other sections of introductory microeconomics taught at our institution, resulting in an aggregate savings for students of 923 * $75 = $69,225. Of course, this realized aggregate savings for students will increase as these tools continue to be used in subsequent semesters.

Although the sections in which we piloted these tools were delivered in an asynchronous online format, we held optional synchronous "remote study sessions," and having these tools at our disposal to illustrate examples of the concepts was extremely helpful. Whether students were seeing the tool for the first time or if they had already worked through it some on their own, it provided an excellent starting point for discussion as we worked through the problems together. The randomization inherent in the tools means that we were not "stealing homework problems" from the students – there were still plenty available for them to practice with on their own after the live online session. This approach could also be used for in-person class sessions.

Instructors who would like to learn more about these tools can do so at http://econreimagined.gsu.edu. The tools can be launched from this website in "stand alone" mode with no LMS integration, allowing for demonstration and review of the tools without the need to first upload the tools into an LMS. Of course, no scores are recorded into an LMS gradebook when the tools are launched in "stand alone" mode, so this is not an ideal manner for students to access the tools. Instructors who would like to integrate these interactive tools into their own LMS courses may download the individual tool SCORM packages from this website and import into their own LMS courses. The site offers additional resources associated with the learning tools and the OER Principles of Microeconomics we have created. All materials on this site are provided at no monetary costs to instructors or students.

Adopting freely available online educational resources can be a risky proposition for instructors, given that so many such resources do not remain available over time. This is a general concern for which there is no simple solution. However, we are confident that these tools will remain viable over the foreseeable future for the following reasons. First, once an instructor downloads any of the tools, the instructor may use them within their own LMS in perpetuity with no subsequent interaction with any other server. Each tool is an independent self-contained SCORM package[9] which only ever interacts with the LMS into which it is loaded. Second, we are the creators of this content, including the source code, and we have not relied on others to create or maintain this material. This allows us to directly address and resolve issues as they arise. Third, we are currently working with IT professionals within our university to expand the capabilities of these tools and ensure greater institutional support in the future. Fourth, two of us actively use these tools in courses each semester and have a vested interest in maintaining these tools. Fifth, one of us was a co-PI on an NSF grant 20 years ago to develop a digital library, so we know what it takes to develop and maintain online educational resources (Cox and Swarthout 2006). Of course, no future is guaranteed, but for the reasons outlined above, these tools should remain in the public domain for quite some time.

We continue to work on improving and extending these tools. Of course, the extent to which we can do so will be determined, at least in part, by the resources we can secure. We continue to seek funding and other avenues to support this project

[9] A SCORM package is essentially a ZIP file that adheres to a specific format.

and always welcome feedback and suggestions. Additionally, we welcome motivated collaborators who wish to engage with us more closely on this project.

Appendix–List of the online interactive tools

(Ordered as they appear in our Principles of Microeconomics course.)

Thinking like an economist		
Calculating opportunity costs	Practice	Quiz
Determining absolute and comparative advantage	Practice	Quiz
Calculating marginal and total benefits in a table	Practice	Quiz
Calculating marginal and total costs in a table	Practice	Quiz
Identifying optimal quantity from a table	Practice	Quiz
How do markets work? (supply, demand, and equilibrium)		
Identifying points on a demand table	Practice	Quiz
Identifying points on a demand graph	Practice	Quiz
Demand shifts vs. movements	Practice	Quiz
Identifying points on a supply table	Practice	Quiz
Identifying points on a supply graph	Practice	Quiz
Supply shifts vs. movements	Practice	Quiz
Identifying market equilibrium on a table	Practice	Quiz
Identifying market equilibrium on a graph	Practice	Quiz
Identifying market disequilibrium on a table	Practice	Quiz
Identifying market disequilibrium on a graph	Practice	Quiz
New market equilibrium from a table	Practice	Quiz
New market equilibrium from a graph	Practice	Quiz
Consumers (demand and elasticity)		
(Revisit)–identifying points on a demand table	Practice	Quiz
(Revisit)–identifying points on a demand graph	Practice	Quiz
(Revisit)–show demand versus quantity demanded	Practice	Quiz
Determine market demand	Practice	Quiz
Calculating consumer surplus from a table	Practice	Quiz
Price changes–calculating changes in consumer surplus from a table	Practice	Quiz
Interacting with price elasticity of demand–calculations and degrees of elasticity	Practice	Quiz
Examining price elasticity demand and total revenue or total expenditures	Practice	Quiz
Interacting with other demand elasticities	Practice	Quiz
Producers (perfectly competitive supply)		
(Revisit)–identifying points on a supply table	Practice	Quiz
(Revisit)–identifying points on a supply graph	Practice	Quiz
(Revisit)–show supply versus quantity supplied	Practice	Quiz
Calculating producer surplus from a table	Practice	Quiz
Price changes–calculating changes in producer surplus from a table	Practice	Quiz
Calculating costs from a table	Practice	Quiz
Calculating revenues and costs and profits from a table (perfect competition)	Practice	Quiz

Identifying profit-maximizing quantity of output from a table (perfect competition)	Practice	Quiz
Interacting with price elasticity of supply – calculations and degrees of elasticity	Practice	Quiz
Market efficiency and types of market failure		
Calculating total economic surplus from a table	Practice	Quiz
Calculating accounting and economic profit	Practice	Quiz
Imperfectly competitive markets part 1: monopoly		
Calculating revenues and costs and profits from a table (monopoly)	Practice	Quiz
Identifying profit-maximizing quantity of output from a table (monopoly)	Practice	Quiz
Imperfectly competitive markets part 2: monopolistic competition, oligopoly, and strategic behavior		
Identifying profit-maximizing quantity of output from a table (monopolistic competition)	Practice	Quiz
Market imperfections (externalities and property rights)		
Comparing private and socially optimal outcomes with externalities in a table	Practice	Quiz
Calculating costs or benefits with externalities in a table	Practice	Quiz
Comparing private and socially optimal outcomes with externalities in a graph	Practice	Quiz
Identifying positive and negative externalities from a graph	Practice	Quiz
Why do governments intervene in the market? (taxes, subsidies, price controls, and quantity controls)		
Analyzing an excise tax on producers on a graph	Practice	Quiz
Analyzing price controls on a graph	Practice	Quiz
Analyzing price controls on a table	Practice	Quiz
Analyzing quotas on a graph	Practice	Quiz
Gains from voluntary trade		
(Revisit)–calculating opportunity costs	Practice	Quiz
(Revisit)–determining absolute and comparative advantage	Practice	Quiz
Determining gains from trade	Practice	Quiz
Calculating mutually beneficial terms of trade	Practice	Quiz

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