Exploring Microeconomics: A collaborative learning project

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Keywords: intermediate microeconomics, collaborative learning, independent learning, microeconomics, learning by teaching, economic theory

*JEL Code*s: A12, A22

Date last revised: 5/13/2018

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Abstract

This work introduces a new approach to promoting independent study and quantitative skills in undergraduate theory courses. For the Explore project, students work in groups to study new theoretical material independently, then use this expertise to teach their classmates. This pedagogical approach is grounded in research on collaborative learning, requires students to develop a deep understanding of new material, and encourages students' self-efficacy and independence by challenging them to tackle difficult topics. While this paper focuses on implementing the project in an Intermediate Microeconomics course, extensions to a wide range of courses are discussed.

In most economics departments, Intermediate Microeconomics is an undergraduate's first foray into formal economic theory. The course serves as a gateway to the field, developing the conceptual and mathematical foundations which form an essential toolkit for undergraduate research and upper-level theoretical electives such as game theory, industrial organization, and behavioral economics. The central role of this course in the economics curriculum presents the instructor with a pair of unique challenges:

•Microeconomic theory encompasses a tremendous amount of material. How does one balance course coverage across the wide spectrum of engaging, challenging, and important topics in microeconomic theory over just one semester?

•Intermediate Microeconomics introduces students to the ways in which mathematics is used to study economic theory. How does one best transition students from varied mathematical backgrounds into the quantitative language of economics?

In consideration of these concerns, I implement the **Explore project** in Intermediate Microeconomics.[1] The project tasks students with *exploring* an economic theoretic topic not previously discussed in class. Student groups are assigned carefully curated readings, work together to understand this new topic, and must teach their classmates about the topic through a combination of (1) an in-class lecture; and, (2) a mock textbook chapter written assignment. For example, in Intermediate Microeconomics, I teach income and substitution effects with only a passing mention of Giffen goods; one group is then assigned the topic of Giffen goods to explore. They must use what they have seen in class, any readings provided by me - Jensen and Miller's (2008) exploration of potential Giffen behavior in rural China in this case - and additional materials

[1] I use the Explore project in upper-level electives in theoretical areas of economics as well. This is discussed in section 3.

they find independently to learn about the inner workings of Giffen goods and determine the best way to communicate what they have learned to their peers.

This project, like any new classroom initiative, has costs of implementation to the instructor. There is upfront planning of readings for each topic, monitoring (typically in office hours or by appointment) students' independent work, and forgone class time which is allocated to group teaching presentations. Nevertheless, the approach simultaneously widens the breadth of topics covered and promotes depth of understanding in ways which strengthen students' abilities to work independently.

Section 1 gives the pedagogical motivation for the Explore project. Section 2 describes the benefits, instructor costs, and tradeoffs of the project. Section 3 provides detailed guidelines for Explore project implementation, highlighting the flexibility of the project for use at different times of the semester as well as in other courses.

1. PEDAGOGICAL MOTIVATION

The Explore project is grounded in the literature on collaborative learning,[2] which relies on encouraging students with a common grasp of fundamentals to work together in small groups and create a shared understanding of new ideas or concepts. Collaborative learning de-emphasizes the role of the instructor as a keeper of knowledge, promoting the interdependence of students in creating knowledge. Key to this idea is students working together to translate as they create, melding their shared knowledge of fundamental concepts and their diverse backgrounds to

[2] See Bruffee (1999) for a canonical review of collaborative learning. Springer, Stanne, and Donovan (1999) conduct a meta-analysis supporting the positive impacts of small group learning (including collaborative learning techniques) in STEM fields on student achievement, attitudes toward learning the material, and self-esteem.

generate a new and unique understanding. According to Bruffee (1993), particularly for "students who are inexperienced in collaboration, a series of modestly challenging tasks can, over time, give them a chance to discover the value, interest, and often in fact the excitement that they can derive from interpreting tasks on their own and inventing or adapting a language with which to negotiate the consensus that they need in order to get the work done" (p. 26).

By engaging in collaborative learning, the Explore project fosters students' independence and confidence. The approach is active: instead of waiting for the punchlines to be provided for them in lecture, the students are learning directly from their efforts independent of class. This increases students' agency in the learning process as they engage with the material, developing and answering their own questions. A student who grapples with a difficult concept, then has an "Aha!" moment *of their own making* will be more confident at the next difficult concept they encounter. If our goal as educators is to helps students become autonomous economic thinkers and problem solvers, whether in upper level courses, on a senior thesis project, or post-graduation, cultivating student confidence and independence go hand in hand.[3]

This approach is well-framed by work on the zone of proximal development, introduced by Vygotsky (1978). The zone of proximal development (or ZPD) captures those skills beyond what a student can successfully execute on her own but able to be executed with the appropriate guidance from an instructor or collaboration with more capable peers. The ZPD is often pedagogically linked with the concept of scaffolding: an instructor should provide a guiding framework to support students' efforts at tasks at a level of difficulty just above what students are able to do on their own. With the appropriate scaffolding, students expand what they are able to

[3] Albert Bandura's (1997) concept of self-efficacy - the belief in one's own abilities to achieve their goals - is particularly relevant here. This belief is developed and strengthened through what Bandura describes as enactive mastery experiences: using a skill successfully instills confidence in one's ability to successfully and independently use that skill again in the future.

understand and accomplish independently. Wass and Golding (2014) describe the impact of the ZPD approach: "[W]ith more capable peer or teacher assistance, students are able to operate at a higher level than they could on their own, and this enables them to learn to operate independently at this level" (p. 672).

The Explore project falls squarely in students' zones of proximal development. Each topic builds on Intermediate Micro material students have seen, which ensures they have the background to learn independently and successfully. Topics are sufficiently advanced and near (or possibly past) the boundary of what is taught: a challenging extension, one-off, or next step to a previously covered unit of the course. Carefully curated readings accompany each topic, chosen from advanced undergraduate textbooks, graduate textbooks, and scholarly research to scaffold the project.[45] Students tasked to work on Giffen goods are directed to the theoretical section of Jensen and Miller (2008), which provides indifference curve-budget constraint graphs but with a "twist" - the elbow-shaped indifference curves characteristic of subsistence zone consumption and Giffen behavior. While students have knowledge of core concepts - they have seen indifference curves, substitution and income effects, and the law of demand prior to the Giffen goods project - each project topic demands students synthesize in new ways and reach beyond what they have previously seen.

[4] The task of assigning topics to teams is critical for a project like this one, particularly considering the limited economics background for Intermediate Micro students. If a group takes on a project with too wide a scope, and sinks in a sea of technical readings, all will be lost. Green, Bean, and Peterson (2013) discuss what they characterize as a failed attempt to implement a research paper in Intermediate Microeconomics. The authors' project asked students to write a research paper by finding their own real-world economic issue and applying microeconomic theory learned during the class. However, students often did not correctly apply the economic theory, and the open-ended nature of the task failed to generate projects with a clearly defined thesis in some cases.

[5] Figure 1 provides a selection of Explore project topics. A more complete list, including descriptions of pedagogy and motivation for each, is provided in the Appendix.

Outcomes from the Explore project are two-fold: each group produces an oral presentation and a written exposition of the material they have explored with the express purpose of instructing their classmates. This choice relies on the learning by teaching approach,[6] wherein each group of students is (in the eyes of their classmates) expert on a particular topic and must choose how to best communicate that expertise. As many academics are fond of noting, an effective way to test if you really know something is to see how easily you can teach it to others. The translation that occurs between expert level knowledge and more generally comprehensible knowledge is a critical component to cementing that knowledge. As Grzega (2005) describes,

> LdL [Learning by teaching] encourages and demands creativity, independence, self-confidence and fundamental key qualifications (i.e. the ability to work in a team, complex thinking, the competence to seek and find information, explorative behavior, presentation skills, project competence, internet competence, generating knowledge as well as disciplinary virtues like punctuality, reliability, patience). [...] [S]tudents have to cope with the uncertainties of life and learn to make complex topics more and more linear and thus to develop quantitatively and qualitatively improved cognitive maps. (p. 2)

Communication is key to the learning by teaching approach. Importantly in the Explore project, students decide *how* the material is presented to the class. The 25-35 minute oral presentation can consist of a chalk-and-talk lecture, a lecture with slides, a Socratic approach, a video, an interactive in-class exercise, or any combination of the above. The written output is a mock textbook chapter, and could include old standards such as definitions in the margin, "real

[6] This approach, developed by Jean-Pol Martin, is often abbreviated from its original German *Lernen durch Lehren* (literally learning by teaching) as LdL. See Grzega and Schoner (2008) and Grzega (2005). In the literature on collaborative learning, this is often referred to as reciprocal teaching, as in Barkley, Major, and Cross (2014).

world" examples in boxed-off inserts, numerical examples to accompany key concepts, and

Project Topic	Sample Questions	Sample Readings	Fundamentals
Auction Theory	•What are the most common types of auctions and their properties? •How does truthful bidding arise in a second-price sealed-bid auction? •Why does auction design matter?	•Watson (2008), Ch. 27 •Klemperer (2004), Intro & Ch. 1 •Dixit, Skeath, and Reiley (2009) Ch. 17	reservation prices, willingness to pay, strategies, Nash equilibrium, subgame perfect equilibrium
Social Choice Theory	•What is a social preference? In what contexts do we need a social preference? •How does Arrow's Impossibility Theorem illustrate the challenge in constructing a social preference?	•Varian (2010), p. 632-634 •Kreps (1990), p. 174-180 •Maskin and Sen (2014)	individual preferences, completeness and transitivity of preferences
Matching Markets	•What types of real-world markets are best modeled using matching markets? •What constitutes a stable matching?	•Roth and Sotomayor (1990), Ch. 2 •Osborne (2004), Ch. 8.7	individual preferences, incentive to deviate, Nash equilibrium
Problems with Probability	•What is the distinction between objective and subjective probability? •How do individuals make errors calculating probabilities in the Monty Hall Problem?	•Azcal (2004), p. 95-103 •Angner (2012) p. 69-80 •Gilboa (2007) (selections)	basics of probability theory
Repeated Games	•In what applications would analysis of repeated games be appropriate? •How do payoffs differ in repeated games? •What is a discount rate? •How do strategies differ in repeated games?	•Watson (2008), Ch. 22	simultaneous-move games, Nash equilibrium, subgame perfect equilibrium

Figure 1: A (non-exhaustive) list of example Explore topics, including sample questions of focus, sample readings, and the common fundamentals needed for students to successfully complete the project.

end-of-chapter questions with answers. Trentin (2009) notes that the collaborative development of a written text yields "strong benefits on a cognitive and social level," and that co-writing processes "offer an excellent opportunity not only to practise reading and writing skills, but also to stimulate reflection, knowledge sharing and critical thinking." This exercise in communication choice encourages students to reflect on their own learning processes, consider their peer audience, and adapt their practices to best suit their own pedagogical objectives. The Explore project encourages the development of both direct communication skills - such as giving an effective oral presentation with slides, public speaking, and organizing and running a group activity - and big picture communication skills including actively choosing the format of both oral and written presentations.

2. COSTS AND BENEFITS OF THE EXPLORE PROJECT

I implement the Explore project in Intermediate Microeconomics, a course with a maximum of 20 enrolled students at the University of Puget Sound, a small liberal arts college. The course has a sole prerequisite of our one-semester introductory economics course, and while Intermediate Microeconomics does not require calculus as a prerequisite, I teach the material using calculus.[7] The Explore project is included on the syllabus, and several weeks into the semester, students receive a detailed guide[8] of my expectations for the project. Shortly thereafter, students form groups (typically three students per group) and topics are assigned. Pedagogically, the group nature of the project aligns with the goals of collaborative learning detailed above. Logistically, it

[7] I lead outside-of-class sessions, post self-made videos, and math review guides to introduce students to calculus tools as needed in the course. Truth be told, the role of calculus has no bearing on the Explore project, as nearly all explore project topics do not rely on calculus techniques.

[8] This guide, which includes learning objectives, a list of suggested topics, and grading expectations, is included in the Appendix.

addresses time constraints for both the instructor (outside of class meetings with 6 or 7 groups instead of 20 individual student meetings) and for class time during presentations.[9]

The project introduces a breadth of topics in Intermediate Micro while maintaining sufficient depth of understanding. Though the opportunity cost of student 25-minute oral presentations on new material is class time that I could spend teaching that very material in 25-minute mini-lectures, there is a clear positive tradeoff. Each student still gets to hear lectures on (roughly) the same material they would had I given them.[10] Moreover, each student has focused their presentation on one topic, requiring a deeper level of understanding than if I had wanted to prepare 6 sets of background readings for each of my 25-minute mini-lectures on the Explore material. This is all achieved with an approach that is more pedagogically effective, with students playing an active and independent role in the discovery and communication of the material.

Admittedly, if there is a time tradeoff, it may come at the expense of outside of class time for the instructor. I meet with each group individually, typically several times over the course of the semester, to discuss my expectations for the project, establish the scaffolding for the group's particular topic, and answer questions of comprehension they may encounter.[11] Even when scheduled to overlap with office hours as much as possible, these sessions take time. Nevertheless,

[9] With class periods of 80 minutes, student groups each get 25 minutes to present. This limits the amount of time needed for class presentations to two full class periods.

[10] I permit and even encourage students to bring original project ideas to me as well. This has been especially effective when students have suggested topics which align with their interdisciplinary interests. One group of students taking a concurrent course in artificial intelligence used the Explore project to discuss learning algorithms and machine learning in strategic AI programs, then taught the class how they work in practice by building a program in Python to play Connect 4. Another group shared interests in biology, and jumped at the chance to work on evolutionary game theory. They were introduced to an intersection of biology and economics they had never seen before, and were able to merge the literatures (using a Lotka-Volterra population model and a fitness-generating function) better than I ever could. So, it is possible that through student-led lectures, the class is exposed to a more interesting and relevant (to them) set of topics!

[11] This point is delicate. The ZPD approach is most effective when instructors provide only necessary and limited guidance on questions of comprehension. Rather than give answers away, or jump to major conclusions for them, I point students to additional resources or return their questions with questions to send them along the right path. Limiting my involvement in question answering - except when necessary - is both pedagogically sound and supports a more reasonable time commitment outside of class.

they are an essential component to students' scaffolding for the project (much as regular meetings are for any out of class project), and even provide an important "checking in" function to ensure students who are working for long stretches of time on difficult material are indeed making progress.

The Explore project is an investment in economics majors' skills throughout their careers in the department. A confident work ethic which emphasizes independence can benefit students engaging in (or stimulate student interest in) undergraduate research, working as an undergraduate teaching assistant, or writing theses.[12] The same can be said for cultivating student experience in communicating heavily mathematical concepts through presentations and written work, a task less likely to be practiced in a writing course and deceptively difficult for many economics students. A successful Explore project also helps to break down the psychological barriers which impede many economics students from venturing to look at "scary" advanced mathematics in scholarly work or advanced economic textbooks.[13]

3. EXPLORE PROJECT IMPLEMENTATION

The Explore project supports pedagogical flexibility both across the curriculum and throughout the timing of a semester. It can be effectively implemented in many courses outside of Intermediate Microeconomics, and would be best suited for courses which feature (1) a common set of fundamental ideas or skills; (2) areas of advanced understanding which are situated in students' zones of proximal development and therefore challenging yet attainable given instructor

[12] At my institution, each economics major is required to write a senior thesis. The economics department also deploys approximately a dozen juniors and seniors as teaching assistants for our introductory level courses.
[13] Explore project details in the Appendix identify the quantitative content emphasized in each project. Additionally, sample projects which exemplify quantitative work are posted on the project website.

scaffolding; (3) a sufficiently small number of students to effectively promote collaborative learning. For example, the project has been successfully implemented in an upper-division course in game theory with a list of topics adapted to better align with game theoretic material; a similar adaptation could be employed in a course on labor economics, industrial organization, environmental economics, macro theory, or even econometrics.[14]

The timing of the project can also be tailored to the needs of the course and the interest of the instructor. Since I open my Intermediate Micro course with a section on consumer theory, I have also used the Explore project over a shorter early span of the semester. With knowledge of consumer theory in hand, students are equipped to tackle topics including Giffen goods, social choice and Arrow's Impossibility Theorem, matching markets, and a range of topics in behavioral economics. Students receive topic and group assignments in week 4 (of a 15-week semester), and are asked to give presentations in week 8.[15] Compared to a project which spans the entire semester, early implementation of the Explore project trades off a bit of depth to focus on a narrower set of fundamental concepts (consumer theory) and double as midterm review.

The project can be used to incorporate collaborative learning and small group work into large classes as well. There is evidence that small group approaches – centered on cooperative or collaborative learning - effectively enhance critical thinking, promote cognitive elaboration, help students to appreciate diversity, and reduce student attrition (Cooper and Robinson 2000), though there is a robust discussion of how to best implement these approaches in classrooms which may range from 40 to 400 students.[16]

[14] While this project is geared toward improving technical preparation in areas of economic theory, a non-technical version of this project could easily be used in small introductory-level courses as well. The guidelines below would apply just as well to such an implementation.
[15] Since the project spans a shorter period of time when implemented early, page expectations and presentation times are adjusted downward.
[16] Mulryan-Kyne (2010) and MacGregor et al. (2000) effectively frame this discussion.

In the context of the Explore project, the challenges of large-class implementation include strains on instructor meeting time, the maintenance of efficient monitoring and assessment of group work, and the provision of classroom time for group presentations. Evidence from other collaborative learning projects in large classes across the university curriculum suggests that careful use of technology can effectively address these concerns. An early success story in a 200-student chemistry course (Glaser and Poole 1999) used online resources available at the time to supplement a collaborative learning project with web site creation (for groups to communicate the content they have created), progress reports via e-mail, and electronic peer review. As technology evolved, wikis have emerged as a pedagogically effective means of content creation and sharing in small group work.

A wiki is a website where contributors create and edit content directly from their browser. Importantly, wiki content is not owned by any one user; rather, all collaborators on a wiki can contribute to the content and structure of this shared document.[17] Editing is tracked as it occurs, and the content evolves as collaborators expand their understanding. Wikis can also include sub-wikis, or be embedded in larger collections of sites, to easily link related topics. In many ways, wikis perfectly embody the objectives of collaborative learning, for without a singular keeper of knowledge, users create a shared understanding of the material as it is created.

Wikis have been successfully implemented in technology (Trentin 2009), engineering (Molyneaux and Brumley 2007), language arts (Matthew, Felvegi, and Callaway 2009), and chemistry (Evans and Moore 2011) classrooms, and supporting technology for wiki use can be

[17] There are important technical advantages here. First, wiki editing does not require knowledge of coding language – such as HTML – which gives it advantages over web site creation. Moreover, since the work all lives in one space, output is truly decentralized. There is no need for one contributor to stitch together individually-created offline documents. Trentin (2009) identifies this feature as *distributed editing*, akin to the concept of distributed writing or co-writing.

found in most learning management systems (Moodle, Canvas, Blackboard) and online (Google Docs share many features of wikis). Typically, the wiki serves as the exposition of a collaborative learning project. In that role, it formalizes many pedagogical objectives, including co-writing a shared understanding of the material, peer review and distributed editing, and big picture synthesizing (Trentin 2009). Wikis can be easily shared, either as independent sites or incorporated into an existing course website, and make for a natural alternative to the textbook entry, in-class presentation, or both.

Due to their collaborative nature, wikis have built-in features for tracking, highlighting, and recording the history of edits to the site, documenting date, time, and user for each edit. This allows the instructor to use the wiki for monitoring (Was the work completed steadily over time? All at the last minute?) and free-riding prevention (Are group members contributing equitably?) functions. Importantly, the instructor can monitor progress remotely, lowering the cost of identifying and reaching out to struggling groups.

While the wiki can be incorporated as the final exposition of the Explore project in a class of any size, wikis provide particular benefits to large class implementation of the Explore project. Edit tracking features of the wiki allow for easier monitoring of group work, which can alleviate the potential pressure on the instructor to set as many face-to-face meetings with each individual group.[18] Moreover, since in-class group presentations can be prohibitive in large classes, the wiki can take the place of presentations and pedagogically support group learning by teaching.[19] Students can construct wikis with the express purpose of teaching classmates, and wikis can be

[18] While e-mail or a group discussion board are not perfect substitutes for face-to-face meetings, they can facilitate communication in larger classes where such meetings cannot reasonably be scheduled. At the expense of class time, in-class group workshop days are another alternative, where instructor can monitor progress, provide feedback, and answer questions of comprehension in a face-to-face setting.

[19] Although groups may not hone the same skills constructing a wiki as they would teaching a live lecture to a class, the wiki can still be a valuable alternative in large class settings. Explore project groups must still develop a pedagogy in conveying their expertise to classmate via the wiki, which supports the learning by teaching objective of the project.

integrated into a course website or Moodle page to present group-created content to the rest of the class.

Despite the flexibility in implementation strategies, the effectiveness of the Explore project hinges on a handful of pedagogical focal points. A reader who aims to replicate this approach should ground their work in the following guidelines:

•**Topic selection is critical**. Aim for topics which stoke student curiosity. If a certain concept grabbed your interest the first time you read about it, it is likely to do the same for students. I save some of my favorite topics for Explore projects; even though I often look forward to teaching these topics the most, assigning them to students allows them to develop their own unique understandings and forge their own connections to the material.

•**Invest in the right scaffolding**. Balance a popular press article on background or relevance with technical readings on theory. When selecting technical readings, look for textbook chapters or scholarly articles which share notation and terminology to lower barriers to entry for students. When such readings are inadequate or unavailable, I provide students with copies of my lecture notes –material I have not covered or material from other courses - or notes created specifically for the project. Using self-created material allows you to sync mathematical notation, mold the scope and depth of the material, and tailor an appropriate level of difficulty, all without relying on external (and potentially costly) resources.

•**Encourage independence and creativity**. Students often (mis)perceive theory courses as a presentation of a narrow set of problems, rather than as a flexible set of modeling tools which can be applied to many real world applications. However, when students are able to draw connections between concepts in class and the world they see, they develop a deeper understanding

of the power of economic theory.[20] Support students who apply their topic to areas across the curriculum and to situations in their own lives.[21]

•**Share pedagogy**. Group meetings provide an opportunity for frank discussion on teaching approaches with students: as the instructor, you have the chance to share how you might normally teach the topic; as students learning the material for the first time, they can share what they struggled with, as well as what concepts, examples, or supplemental articles best aided their own understanding. This can lead to a productive two-way discussion which both (a) helps students better understand your own pedagogical practices and motivations and (b) provides you as the instructor valuable insight on how students experience new and challenging material.

4. OUTCOMES AND CONCLUSION

In course evaluations, students describe the Explore project as "cool" and challenging. One student says the project "promote[s] student learning and fun," while another places its contribution to a course which "challenge[s] us and make[s] us think outside of the box with the tools he has given us." Moreover, courses in which I include the Explore project receive consistently positive responses to the questions "The instructor encouraged students' intellectual

[20] On the economics blog Worthwhile Canadian Initiative, Frances Woolley said, "In theory courses - whether in economics or in other disciplines - theory becomes an object of study. Professors teach about theory - because this is how they were taught, because this is how textbooks are organized, and because it's relatively easy to teach students how to step up and solve a series of standard models. But to teach students how to do theory? It's like riding a [bicycle] - ultimately, the only way to learn is just to push off and start peddling. Send people off to model the world and see what they come up with." Theory taught with this emphasis requires students to think creatively as they grapple with more ill-defined problems. Additional discussion can be found in Monaco (2018).

[21] Students have linked: matching theory to roommates in dorms and greek life matching for bigs and littles; repeated games to environmental policy and decision making; and social choice to problems in political science. One group memorably designed a social choice example around course grading policy, despite ultimately acknowledging the failure of the non-dictatorship condition.

self-reliance and self-motivation," and "The instructor encouraged students to take learning seriously and to think critically."

Importantly, students' constructive criticisms have also shaped the project. One common concern - that student groups would benefit from additional check-ins and can suffer lapses in focus over a semester-length project - encouraged me to be more proactive in initiating meetings with student groups, allot class time for the occasional check-in, and to explore the five-week implementation of the project as a successful alternative to the semester-length implementation. Additionally, student feedback on assessment has emphasized the importance of establishing clear expectations regarding how much of Explore material students will be asked to know on exams.[22]

As with many group projects, students express concern regarding free-riding behavior in Explore groups. The project has benefited from the use of peer review feedback forms and individual-level assessments (such as exam questions where individual students are asked a question related to their particular topic.) Moreover, the integration of wikis provides additional opportunities for detailed tracking of student contributions, which can be weighted into formal grading of the project.[23]

Courses in economic theory - particularly Intermediate Microeconomics - provide a unique opportunity to shape economics majors' evolving inquiries into economic phenomena. The Explore project harnesses this opportunity with a collaborative learning approach which can complement instruction in a wide range of undergraduate theory courses by fostering student independence and empowering students to forge their own connections with the material.

[22] Exams in my theory courses typically include a non-zero share of "extension" questions, which ask students to extend course material to a deeper understanding or to a new application. As a general rule, therefore, since Explore project topics are already one-offs and extensions of core course material, project concepts are fair game for any extension questions on exams.

[23] Trentin (2009) provides models of evaluating individual student contributions to a wiki, such as computing the number of pages and total number of characters produced by each student as one component of a student's grade.

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APPENDIX A: Explore Project Topic Details

This document can also be found online on my faculty page at https://www.pugetsound.edu/faculty-pages/amonaco/explore/.

Here, I am happy to provide details and pedagogical motivation for the topics I implement in Explore projects across the curriculum. My aim is to give sufficient background on each topic so instructors who wish to use the topic in an Explore project can do so confidently. This guide can be used as a blueprint, or as a jumping off point for new directions as readers see fit. The description in each topic can be pared down or augmented based on the time constraints (or allowances) in your particular classroom setting. For each topic, I provide a) a list of the references I use; b) a discussion of the material; and c) suggested courses in which to implement the topic. I welcome any feedback regarding iterations of this project!

1. Criticisms of expected utility

References: Kahneman and Tversky (1979), Angner (2012)

This topic covers behavioral criticisms of standard expected utility theory. Kahneman and Tversky is a centerpiece in the field of behavioral economics, and is both conceptually accessible and technically challenging for undergraduates; different selections from the comprehensive Angner book can be targeted if the instructor would like to emphasis particular criticisms. Material for this topic could include: loss aversion; Allais' Paradox; reference points; certainty effect; prospect theory; reflection effect; and weighting function. Since the material in Kahneman and Tversky is likely standard coverage in a course on behavioral economics, but is in many ways best

understood in contrast to standard expected utility, this topic is best suited for a course in Intermediate Microeconomics where the basics of expected utility are presented but criticisms are either briefly mentioned or omitted altogether.

Quantitative skills: preference notation ($\succ, \succcurlyeq$), using the notation of functions with both expected utility and (Bernoulli) utility functions, concavity and convexity of functions (risk attitudes, prospect theory value function)

2. Auction theory

References: Watson (2008) Chapter 27; Klemperer (2004) Introduction and Chapter 1; Dixit, Skeath, and Reiley (2009) Chapter 17

Auction theory encompasses a vast collection of models and applications. Klemperer, though a bit technical, offers an extensive in-words literature review, while Dixit et al. provides a more concise summary of the standard auction types: sealed-bid, first-price, second-price, and the like. Watson has several accessible models of auctions, including equilibrium bidding strategies. Mathematical models in auction theory can quickly get bogged down in technical discussions. Therefore, students assigned this topic are often encouraged to focus on exploring (1) the wide array of auction types, including both canonical auction types and special considerations such as multi-unit auctions, common-value auctions, and risk attitudes; and (2) the numerous real-world applications of the variety of types. An advanced group might be able to discuss differences in equilibrium bids across types, revenue equivalence, or winner's curse in common-value auctions.[24]

[24] Auction theory groups have often held in-class live auctions, one even endowing "bidders" in the class with Skittles the bidders used to bid on bookstore items in a variety of auction formats. In one memorable auction, bidders each had 20 Skittles to bid on a particularly noteworthy item. The auction theory group was selling that particular item via second-price sealed bid auction. The winning bidder was the sole student who bid 21 Skittles for the item, knowing if her bid was the sole winning bid, she would only have to pay a maximum price of 20 Skittles - which she could afford!

The concepts of willingness to pay, reservation price, revenue, and efficiency make auction theory an easy tie in to Intermediate Micro, and if not covered in a game theory course, this topic is a must-have.

Quantitative skills: optimization (optimal strategy choice), functions (best response functions, bid functions), subscript notation (for bidder indeces), probability theory (common value auctions)

3. Giffen goods

Reference: Jensen and Miller (2008)

Giffen goods incorporate the familiar consumer theory elements of income and substitution effects, utility maximizing bundles, and demand curves. This topic is ideal for an Intermediate Micro course where Giffen goods are not taught in the section on consumer theory. Since Giffen goods are often taught at this level, nearly all undergraduate textbooks for Intermediate Micro have sections on Giffen goods; these sections can serve as helpful stepping stones for course resources.

Quantitative skills: graphing skills, including level curves as indifference curves, utility maximization problem and (potentially) expenditure minimization problem (substitution and income effects)

4. Matching markets

References: Osborne (2004) Chapter 8.7; Roth and Sotomayor (1990) Chapter 2

The section in Osborne provides an accessible lesson in two-sided one-to-one matching (marriage markets) and the Gale-Shapley algorithm for students who have familiarity with the basics of consumer preferences. Stable matching (i.e. the core) can be well-framed in relation to

the concept of Nash equilibrium, comparing the absence of unilateral deviation (in NE) with the absence of a deviating pair in the core. Matching markets provide ample opportunities for students to explore the question "why this matters", discussing the array of applications from residency matching, labor markets, and kidney chains to roommate matching, greek life matching, and dating applications. The practical success stories of matching theory (as well as the relatively recent Roth and Shapley Nobel win) pair well with the low-barrier-to-entry theoretical material in Osborne. This topic works well in any course where individual preferences are discussed.

Quantitative skills: functional notation (such as using mu to denote a matching function), preference notation ($\succ, \succcurlyeq$), set theoretic notation (sets of individuals to be matched), use of subscript indeces to denote individuals

5. Social choice theory

References: Kreps (1990) p. 174-180; Maskin and Sen (2014); Varian (2010) p. 632-634

This topic can be one of the most challenging to motivate properly. Students often struggle addressing the question "what unique question does this approach address?" There is broad introduction in Part 1 of Maskin and Sen, though the emphasis of this book is ultimately on The Arrow Impossibility Theorem, as well as in Dixit, Skeath and Reiley's chapter on "Strategy and Voting." I tend to emphasize two broad classes of problems social choice theory helps to solve: everyday choice problems (a family deciding where to go out for dinner), and political voting problems. The most critical foundational point for this topic is that social choice is about attempting to synthesize **individual preferences** into one preference (or choice) for the entire group.

There are several points of emphasis groups can focus on here, including the variety of voting mechanisms (plurality, majority, Borda) and voting paradoxes (Condorcet paradox, Arrow). This topic is also ripe for in-class activities: student groups have often gotten the class to vote on topics in small groups or as a whole, illustrating different outcomes under different mechanisms and illustrating the challenges in preference aggregation. This topic is ideal for implementation when consumer preferences are well-understood, particularly if properties like transitivity and completeness of preferences can be tied to the paradoxes (such as Condorcet, which leads to social choice cycling and a violation of the transitivity of the social choice rule.)

Quantitative skills: preference notation ($\succ, \succcurlyeq$), set theoretic notation (sets of individuals to be matched)

6. Nudge

Reference: Sunstein and Thaler (2009)

Standard material in any behavioral economics course. Since the readings themselves are the least technical readings of any of the projects listed, I typically assign the first 100 pages of Nudge. Students are then asked to identify both the broad principles behind the nudge (libertarian paternalism, cognitive biases), and select some examples of effective nudges and the biases they address to present to the class. This topic complements rational choice theory in Intermediate Micro extremely well.

7. Problems with probability

References: Azcal (2004); Angner (2012) p. 69-80; Gilboa (2007)

Angner brings many of the behavioral criticisms of probability judgment to the forefront, including the Linda problem, while Azcal's contributions range from the Birthday Paradox (p. 70) to Bayesian updating (p. 95). I typically include copies of my own notes on Monty Hall and Ellsberg Paradox (where Gilboa complements). Many topics on behavioral criticisms and cognitive biases in decision making under risk are likely to be covered in a behavioral econ course, but are apt as Explore project potential in Intermediate Micro when risk and expected utility have been introduced.

Quantitative skills: probability theory and notation (independent draws, distribution functions), Bayes' Theorem and conditional probability, set theoretic notation (sample space)

8. Repeated games

Reference: Watson (2008)

Watson here serves as an advanced undergraduate game theory chapter on repeated games, discussing strategy choice, discount rates, and folk theorems. Since material on repeated games is standard in my Game theory course, I primarily use this project in Intermediate Micro to buttress coverage of collusion in imperfect competition and cartel behavior. The topic requires some basic game theory knowledge, such as Nash equilibrium and 2x2 games, while net present value and discounting can be valuable touchstones as well. The focus can be geared toward infinitely-repeated games or finitely-repeated games, and I often include my lecture notes on both finite repetition and probabilistic end period of repeated games.

Quantitative skills: finite and infinite geometric series (payoff streams), summation notation, ordered pairs and higher dimension vectors (n-dimensional or infinite dimensional strategies in dynamic games)

APPENDIX B: Explore Project Guide

The project guide below can also be found online on my faculty page at

https://www.pugetsound.edu/faculty-pages/amonaco/explore/.

MICROECONOMIC THEORY
ECON 301

Explore Project: 15% of final grade

The Explore Project is an opportunity for you to delve more deeply into a particular area of microeconomic theory. There are many interesting topics which we will not have the opportunity to discuss in much detail during the normal course of lectures. This is your chance to become an expert on an area or application of microeconomic theory which you find interesting *and which will be new to you and the rest of the class*.

Each student will complete the Explore Project in a small team of 2-4 members. Once teams have been formed, each team must select a topic. Either 1) the team proposes a topic related to microeconoimc theory they would like to study, and I approve the topic; or, 2) the team selects a topic related to microeconomic theory from a list of suggested topics I will provide to the class.

I will supply some foundational resources to each team, including textbook excerpts, scholarly articles, and/or articles from online sources. We will meet throughout the semester to discuss the exact expectations regarding your topic. Each Explore Project Team will complete two tasks:

-**Presentation** (7.5%): The team will present their topic to the class at the end of the semester. In essence, the team will becomes class leaders, and teach the class about what they have learned. The presentation should be approximately 20-25 minutes, and use whatever techniques best communicate the subject material. You may construct class notes to put on the board, make a video, use interactive examples, or any other means you feel will help you teach the class about your subject. Also, construct a handout (maximum of one page) detailing the specifics of your topic material (relevant examples, terms and definitions, mathematical particulars). Be creative, engage the class, and be accurate! Grade will be determined by:

-Accuracy of content
-Level of interactivity and class participation
-Clarity and organization of visual presentation
-Clarity and organization of oral presentation
-Clarity and organization of handout
-Ability to answer questions from classmates/instructor

-**Textbook Entry** (7.5%): This is the written component of the Explore Project. In lieu of a more traditional academic paper, you will work with your team to compose a written "textbook entry" describing your findings. It should read as if it came from an economics or microeconomic theory textbook, and include a) basic definitions; b) any graphs or images relevant to your topic; c) review questions and practice problems (+ solutions) as you would find at the end of a chapter. Aim for a textbook entry which you think an intermediate- or high-level economics student could read and reasonably follow along. Your entry should include:

- Definitions (like the definitions in the little boxes on the side of the page)
- Both real-world and numerical examples of your topic
- Primary results
- Any graphical representations of your topic
- At least 5 "end of the chapter" questions, ranging in difficulty (solutions included)

Explore Project Topic Suggestions
Econ 301 Microeconomic Theory

Please see me to meet and discuss any specific topics you would like to explore. I would be happy to work with you in tailoring a topic to your individual interests.

1.) Criticisms of Expected Utility
This group will examine the famous criticisms of expected utility theory presented by Daniel Kahneman and Amos Tversky (1979). Using examples, the group should discuss the certainty effect, the possibility effect, and the reflection effect.

Is the standard presentation of expected utility without flaw?
What is the certainty effect?
What is the possibility effect?
What is the reflection effect? How does this effect relate to "prospect theory"?

2.) Problems with Probability
This group will highlight how very often, individual decision makers have difficulty forming "rational" beliefs about probabilities. Such problems can be exemplified in situations like the Monty Hall problem and the Ellsberg Paradox.

What is the distinction between objective and subjective probability?
How do individuals make errors calculating probabilities in the Monty Hall Problem?
How do individuals make errors in the Linda problem?
How do individuals make errors calculating probabilities in the Ellsberg Paradox?

3.) Nudge
This group will examine the impacts of framing and context on decision making. Using many examples, the group will discuss individual cognitive biases which influence decision making, as well as when/where/how "nudges" can help individuals make better decisions?

Describe some cognitive biases (including anchoring, availability, representativeness, status quo), as well as ways in which we often attempt to address them.

What is a nudge? What is libertarian paternalism?

How can a nudge improve decision making?

Describe the role of default options in the decision making process.

4.) Auction Theory

This group will model many forms of auctions, their properties, and applications. The group will examine auctions from both the perspective of the bidder (optimal bidding strategies) and the perspective of the seller (how to design an auction to maximize the revenue generated).

Describe the many real-world applications of auction theory.

What are the most common types of auctions and their properties?

How does truthful bidding arise in a second-price sealed-bid auction?

Why does auction design matter? How does it fit more broadly into the approach of mechanism design?

5.) Repeated Games

This group will examine a particular type of dynamic game which models strategic interactions which are repeated over time. They should explain how these games differ from other dynamic games, both in strategies and in use of discounted payoffs, using an example.

In what applications would analysis of repeated games be appropriate?

How do payoffs differ in repeated games? What is a discount rate?

How do strategies differ in repeated games?

Despite the fact that in the standard application of the Prisoners' Dilemma, cooperation cannot be maintained, can it be maintained in a repeated game setting? If so, how?

6.) Social Preferences and Arrow's Impossibility Theorem

This group will explore the concept of a social preference, and the obstacles which are encountered when we try to aggregate individual preferences into a social preference. The obstacles are encapsulated in such results as Arrow's Impossibility Theorem and the Condorcet Paradox.

What is a social preference? In what contexts do we need a social preference?

How does the Condorcet Paradox illustrate the challenges in constructing a social preference?

What positive properties would we like to have in a social preference?

How does Arrow's Impossibility Theorem illustrate the challenge in constructing a social preference?

7.) Matching Markets

This group will describe the unique class of markets in which potential partners (such as buyers and sellers) are best brought together by a matching process. They will characterize these markets, properties of individual participants, as well as effective mechanisms for developing stable matchings.

What types of real-world markets are best modeled using matching markets?

What constitutes a stable matching?

Describe the deferred acceptance procedure, and its relation to stability of matchings.

How does the study of matching markets illustrate the difference between noncooperative and cooperative game theory (i.e. coalitional games)?**

8.) Giffen Goods

This group will examine the special case of the Giffen good, its place in consumer theory, and its existence (or non-existence) in the real world.

What is a Giffen good?

How could a good theoretically be Giffen? How does this relate to the concepts of income and substitution effects?

What are the implications of a good which is Giffen?

Can you give any examples of Giffen goods existing in the world? How can their existence tie in to what you have learned about consumer theory?

Learning Objectives for the Explore project:

Over the course of this project, you should:

•develop a level of mastery of a refined concept in microeconomic theory;

•make connections between this concept and its application to the world around us;

•be able to effectively teach classmates about this concept through oral and written presentation;

•learn to work collaboratively to study new ideas without direct instructor supervision;

This project encourages:

•independent learning (learning a new idea without direct instructor supervision)

•quantitative literacy

•the ability to communicate mathematical concepts

•communication skills (oral and written) more generally

•learning about a concept by considering how it would best be taught to your peers

•not being afraid to read more advanced mathematics and economic theory

•deep learning (mastery) of one focused area

•research skills

•collaborative learning (working in a group to come to a shared understanding of a new idea)

•student agency in the learning process