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Writing in the discipline and reproducible methods: A process-oriented approach to teaching empirical undergraduate economics research

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ABSTRACT

The authors of this article describe an empirical research project as a component of an upper-level undergraduate economics writing-in-the-discipline course, thus aiming to reduce the high fixed costs associated with designing an empirical research project assignment and encourage more undergraduate economics research. This project is central to the course structure and has a dual-purpose: to teach students economics writing conventions and reproducible empirical research methods. The authors present a sequenced project design and replication documentation protocol and posit that this promotes student learning and leads to improvements in organization and coherence throughout the entire research and writing process. As an essential element of the course, students learn to do econometrics through effective writing, data management, and empirical analysis.

KEYWORDS

replication; reproducibility; teaching economics; writing in the discipline

JEL CODES

A22; B4; C8

Research, writing, and empirical skills have become increasingly important in undergraduate education. Recent surveys conducted by the Association of American Colleges and Universities (AAC&U) show that “employers want to hire college graduates who can write coherently, think creatively, and analyze quantitative data” (Selingo 2017, online). Furthermore, there is a broad consensus among economists that enabling students to understand how and when to “think like an economist” is the primary goal of an undergraduate education in economics (Allgood, Walstad, and Siegfried 2015). In addition to being a desired skill by employers, there is ample evidence that writing assignments improve student learning (Dynan and Cate 2009; Greenlaw 2003). However, most economists have no formal training in undergraduate writing instruction and 30 percent of economics departments have no formal writing requirement for the economics major (McGoldrick 2008b).¹

Economic research has become increasingly empirical, and according to the standards of the American Statistical Association (ASA), authors of research involving statistical analysis have an ethical responsibility to “promote sharing of data and methods” and “make documentation suitable for replicate analyses” available (Angrist et al. 2017; ASA 2016, online; Hamermesh 2013). Reproducibility requires documentation that allows an independent researcher to reproduce every step of the data management and analysis process and replicate the results presented in the study (Ball and Medeiros 2012). As instructors, we have the ability to set the standards and incentives that guide the work of our students, emphasizing replicability and documentation in empirical research.

Given the lack of formal training in writing and research instruction, the prospect of designing a course with a large empirical research project or augmenting an existing course with such an assignment is daunting, but could yield substantial benefits for students in terms of learning and employment opportunities. With this article, we aim to reduce these high fixed costs and encourage more undergraduate economics research and writing by outlining an empirical project that can be adapted and applied in an upper-level undergraduate empirical economics course. Importantly, this innovation improves student learning of course content, exposes students to effective research design, encourages reproducibility, and yields human capital accumulation valuable to both graduate programs and potential employers (Hoyt and McGoldrick 2017a,b).

The purpose of the empirical research project design presented in this article is to exploit complementarities in satisfying the learning objectives of a “writing-in-the-discipline” (WID) course and of reproducible empirical research. These goals are mutually beneficial: the meticulous documentation and planning required for data analysis will yield increasingly well-developed empirical research papers. The accompanying replication documentation, adapted from the Teaching Integrity in Empirical Research (TIER) protocol,² requires students to experience the cycle of data analysis—plan, collect, organize, compute, and document—which mirrors the recursive writing process in many respects—pre-writing, drafting, revising, and editing (see [appendix A](#)). When drafting and revising, authors often need to return to pre-writing and planning to develop and expand their ideas, analogous to the situation where econometricians must often revisit the collection or organization phases of data analysis. We argue that the emphasis placed on reproducibility and documentation, combined with the sequenced nature of the project, produces higher quality research papers, significantly enhances learning of the course material, and improves student writing. To this end, the purpose of the project is for students to learn how to do econometrics through effective writing, data management, and regression analysis. Greenlaw (2006, 1) suggests that “the best way to learn economics is not to hear about it, or to read about it, but to do it” and “doing economics means performing economic research.”

In the following section, we discuss the project structure and learning objectives. The two sections following it briefly describe the course history and context and develop the pedagogical rationale for the project. The article concludes with a discussion of evaluation, assessment, ongoing challenges, and suggestions for the promotion of undergraduate empirical research in economics.

Project structure and learning objectives

This project is designed to emphasize the process of empirical research, or what McGoldrick (2008a) calls the iterative research process. The objective is for students to develop an understanding of how economists conduct applied empirical research. To this end, students should demonstrate: (1) an understanding of Stata syntax, data management skills, and best coding and documentation practices for reproducibility; (2) the ability to place a research question in the context of existing scholarly discourse through an effective literature review; and (3) an understanding of the necessary components of a well-written empirical research paper and the economics discipline’s formatting and style conventions.

The project sequence and dual procedure workflow juxtaposing the writing and data management tasks is provided in [table A1](#) of the appendix. In addition, we have developed a detailed series of adaptable prompts and rubrics for each of the seven project components that are available for download.³ Partitioning the replication documentation and writing tasks into progressive assignments is an important component of student learning and process writing. As discussed in more detail in the pedagogical rationale, this sequencing, combined with the replication requirements, slows students down by facilitating intentionality and reflection.

	Replication Documentation Tasks	Writing Tasks	Hansen (2001) Proficiencies
Week 3	Preliminary Data Documentation establish folder structure	Annotated Bibliography & Research Question	Access existing knowledge; interpret existing knowledge.
Week 5		Proposal 2 pages	Access existing knowledge; display command of existing knowledge; interpret existing knowledge.
Week 8	Metadata Guide & Data Collection original, importable, and base data; processing do-file		Access existing knowledge; interpret and manipulate economic data.
Week 10		Literature Review 3 – 4 pages	Access existing knowledge; display command of existing knowledge; interpret existing knowledge.
Week 12	Data Construction & Summary analysis data; construction & summary do-files; data appendix	Data & Methods 3 – 5 pages	Interpret existing knowledge; interpret and manipulate economic data.
Week 14	Data Analysis analysis do-file	Results & Discussion 3 – 6 pages	Display command of existing knowledge; interpret existing knowledge; apply existing knowledge.
Week 16	Final Project Folder final paper (20 page maximum); ReadMe file; complete replication files.		Apply existing knowledge; create new knowledge.

Figure 1. Project structure.

This empirical research project encourages students to develop proficiencies consistent with Hansen (2001): access existing knowledge; display command of existing knowledge; interpret existing knowledge; interpret and manipulate economic data; apply existing knowledge; and, create new knowledge. These proficiencies, developed by Hansen (1986, 2001) are routinely used as a template for curriculum, course, and project design (Allgood, Walstad, and Siegfried 2015; Klein 2013; Li and Simonson 2016; McGoldrick 2008a). The project phases, workflow, descriptions, and how they align with Hansen’s (2001) proficiencies are illustrated in figure 1.

Students begin the semester by exploring research topics and creating a replication documentation folder using a file-sharing platform.⁴ This main folder includes a hierarchy of folders, discussed in more detail in the replication documentation section, that serve as a repository for writing and data management tasks during the semester. This folder structure provides a straightforward vehicle for both assignment submission, instructor feedback, and replication. By week 3, students submit an annotated bibliography and preliminary research question. It is important to note that students are asked to produce the annotated bibliography before submission of the research proposal in week 5. In a previous iteration of the project, when students were required to submit proposals prior to finding and evaluating the existing literature, the product was often underdeveloped, unoriginal, and/or unrealistic. By reading, analyzing, and thinking critically about the literature prior to submitting the proposal, students learn to engage in a scholarly discussion and produce higher-quality proposals. After receiving feedback on initial sources and research questions, students write a preliminary thesis statement in their proposal.

The most difficult and time-consuming component of the project tends to be the “Metadata Guide and Data Collection” due in week 8. This subsection requires students to combine several new component skills: finding data, processing data, and learning statistical software syntax (in our case, Stata). These opportunities for deliberate practice are crucial for student learning (Ericsson and Charness 1994; Ericsson and Lehmann 1996; Ericsson, Krampe, and Tescher-Romer 1993). At this phase, students submit their data files, data processing command files, and a metadata guide.⁵

After submitting this section, students focus their attention on a literature review, the objective of which is to motivate their research question, place it in the context of previous work, and provide a foundation for their analysis. The “Metadata Guide and Data Collection” and “Literature Review” are due in isolation because of the rigorous nature of these two project components. At this stage, we use this as a learning opportunity to differentiate between an annotated

bibliography and literature review. The annotated bibliography does not require any organization of sources, while the literature review synthesizes the related literature and uses the literature to form an argument about the relevance and importance of their research question. At this point in the semester, students are moving beyond an exploratory search of the literature to a narrow, focused mastery, which may include reading and writing about different or additional sources. Also in the literature review, students are required to update their thesis statement. Here, students have an opportunity to see the evolution of their thesis statement since the proposal phase of the project, as they have incorporated realizations based on data availability and existing literature. At this stage, students struggle with whether they need to narrow or refine focus and begin the recursive process, recognizing that a shift in thesis may require more data collection and management. Finally, students will consider whether or not the Literature Review motivates their empirical specification. This is exactly the type of intentionality and reflection promoted through this project sequencing. Writing and research become a process of discovery.

During the last month of the semester, students complete the final components of an empirical research paper, working on writing and data management tasks in tandem. At week 12, students submit their data collection and summary files and the Data and Methods section of the paper.⁶ At week 14, students submit their analysis command files and the Results and Discussion section of the paper.⁷ As mentioned previously and discussed in detail below, our focus for the empirical research paper is on the process, not necessarily on the product. To that end, while we expect that students will produce well-written and well-specified applied econometrics research, we care less about interesting and novel results and more about students' demonstrating an understanding of the research and writing process in economics. Therefore, we do not place a lot of emphasis on statistically significant results. Instead, we ask students to think critically about why their results are statistically significant or not and to provide explanations for results being consistent or inconsistent with hypotheses.

Finally, in the last week of the semester, or in lieu of a final exam, students submit their final empirical research papers, incorporating all feedback from previous submissions and a final replication documentation folder.⁸ Please see [appendix A](#) for more details on project requirements and sequencing.

Course history and context

This project has the potential for implementation in a variety of courses at the undergraduate level. Some courses are natural environments for teaching writing and research methods, the most obvious outlet being an upper-level econometrics course; ideally, this would be the second course in an econometrics sequence.⁹ However, this project also could be used in a senior seminar or capstone experience, honors thesis writing, or any empirical upper-level elective. Currently, at Dickinson College, we implement this project in a 300-level advanced econometrics course.

In developing this project, we recognize both the increasingly empirical nature of the economics discipline and the increasing popularity of econometrics in the undergraduate curriculum. In 1980, only about 6 percent of undergraduate institutions required econometrics and less than half offered at least one econometrics course (Siegfried and Wilkinson 1982). More recent estimates show that, as of 2010, 81 percent of all undergraduate economics programs offered at least one econometrics course, while 50 percent required it (Johnson, Perry, and Petkus 2012; Siegfried and Walstad 2014). Even though econometrics has become an increasingly important part of the economics major, few instructors have incorporated a research project in these courses. As of 2010, only 10 percent of national universities and 21 percent of liberal arts colleges that offered econometrics required an independent empirical research assignment (Johnson, Perry, and Petkus 2012).

In the upper-level WID advanced econometrics course at Dickinson College, the course is built around the project, which makes up 45 percent of the final course grade. The instructor teaches advanced econometric content through lectures, emphasizes application through problem sets and workshops, tests knowledge with an examination, and solidifies understanding through implementation of the course project and providing feedback. The course has an enrollment capacity of 16, with introductory econometrics and intermediate theory (microeconomic or macroeconomic) as prerequisites. Students already have experience with statistical software (Excel and Stata) from their first econometrics course. The course covers panel data, time series and forecasting, and other advanced topics such as binary dependent variables, instrumental variables, and quasi-experiments. A midterm exam (20% of the final course grade) is used to assess student understanding of the theoretical tools needed for successful project completion. Throughout the semester, students practice theoretical and applied content through five or six problem sets due every 2 or 3 weeks (totaling 30% of the final course grade). Approximately every other week throughout the semester, at least one class meeting is reserved for applied workshops.¹⁰ The final week of the course is devoted entirely to workshop time for the course project.

While an econometrics course, as described above, may be the most straightforward setting for this kind of project, another natural environment is a senior seminar or capstone experience. As of 2013, about half of economics programs required a senior seminar or capstone (Siegfried and Walstad 2014). In the same vein, this type of project could be adapted to guide honors or senior thesis writing, both of which have become more popular in recent years.¹¹ Finally, this project could be used in any upper-level economics course with a focus on data analytics and WID.¹²

We recognize that this project will not be feasible in its current form at all institutions due to class size limitations. However, below are several suggestions that would allow implementation of the project, even with a relatively sizable number of students, without a significant burden on the instructor. First, the most obvious adaptation of this assignment is to reduce grading by assigning group projects. In this case, the remainder of the project structure would be unchanged. We discuss several strategies for group project implementation in our Supporting Information, including formation of groups, techniques to help mitigate free-rider problems, and methods of evaluating individual member contributions. Second, instructors in large classes may wish to reduce the overall project workload through variations in replication documentation requirements or written assignment length. A clear adaptation of this project would be an abbreviated version of each written component with the end goal of constructing an economic note, such as those published in *Economics Letters*. If the replication documentation requirements are too demanding, instructors could modify the project to pursue partial replication, as described in more detail in the following section, which develops the pedagogical rationale for an empirical project that promotes student learning of writing and reproducible research methods in economics.

Pedagogical rationale

Siegfried et al. (1991, 211) claim that “writing clearly is the acid test of thinking like an economist.” Thus, the link between writing and knowledge in the discipline is “doing economics” (Carter 2007). Central to this pedagogy, a writing-to-learn approach is the belief that instructors must not only devote time and energy to the assessment of students’ finished papers but also to their writing processes, “the strategies and procedures followed in the act of writing” (Cohen and Spencer 1993, 219). To achieve complementarities in learning outcomes across writing in the discipline and reproducible data analysis, we utilize “process writing” (Schmeiser 2017, 256) or “iterative research” (McGoldrick 2008a, 347), a method of sequencing the project components and an adaptation of the TIER Protocol (Ball and Medeiros 2012). At the beginning of the semester, we emphasize that a successful project requires a parallel workflow between data management and the writing process. The goal is that requiring students to produce comprehensive replication

documentation leads to improvements in organization and coherence throughout the entire research and writing process. Below, we describe the pedagogical rationale for this empirical research project in two parts through a discussion of process writing and replication documentation.

Process writing

When students are learning how to write, they often focus solely on the final polished version of a paper, the *product*, and regularly dismiss the writing *process* (sequencing, drafting, and revision). This misplaced emphasis frequently leads to procrastination, inadequate drafts, and a subpar final product. Even if the assignment includes sequenced deadlines, without the appropriate ancillary materials, these are viewed only as speedbumps on the road to a final product. Development and implementation of this empirical research project, with its replication requirements, sequencing, and transparency in assessment helps to improve students' ability to treat research and writing as a recursive process, a tool of discovery.

Effective teaching of economics or design of an empirical research project can be viewed as a constrained optimization problem: maximize student learning and retention subject to cognitive load constraints and developmental barriers (Hultberg and Calonge 2017). For students to achieve mastery of any domain, they must acquire a set of component skills, practice them to the degree that they can be combined fluently with some degree of automaticity, and understand when and where to apply these skills appropriately (Ambrose et al. 2010). A sequenced empirical research paper with reproducibility documentation requires students to combine several component skills, notably: finding data, managing data, utilizing statistical software, finding and evaluating existing literature, and writing technically. Consequently, the total information processing demands imposed by the project (the cognitive load) can often exceed what students can manage without direction (Ambrose et al. 2010; Hultberg and Calonge 2017).

Naturally, experts (instructors) do not suffer as much as novices (students) when it comes to performing and combining complex tasks (Ambrose et al. 2010). As instructors, we often exercise the research and writing skills needed in economics so automatically and instinctively that we may no longer be aware of what we know. We take shortcuts that our students cannot. In general, this works for us in our own research and writing but is often an impediment in teaching research skills to our students. Novice students, on the other hand, do not know what they do not know, often leading to inflated self-assessments of their own abilities (Ambrose et al. 2010; Kruger and Dunning 1999; Sprague and Stuart 2000).

This developmental divide, with instructors unaware of what they know and students unaware of what they do not know, often this leads to an *expert blind spot*, where instructors are unaware of students' learning needs (Camerer, Loewenstein, and Weber 1989; Nathan and Petrosino 2003; Wieman 2007). This generates confusion for students and frustration for instructors in the form of, "do I really have to put that in the prompt?!"

Therefore, a key element in this project design is developing writing instructions for students that clearly articulate expectations but are not so exhaustive and detailed that it risks overwhelming them by exceeding their cognitive load.¹³ Ambiguous assignments create unnecessary misalignment of expectations and the resulting papers represent work derived from standards to which students have previously been exposed, not the sophisticated knowledge of component skills and their applications that we wish to assess. Comprehensive prompts are less time-consuming for instructors and less over-whelming for students when a complex task—like an empirical research project—is divided into several smaller tasks that are more manageable. The impact of this type of sequenced project design on student learning depends upon the clarity of expectations. Decomposing project tasks into component parts allows students to practice component skills before integration, which is essential to student learning (Ambrose et al. 2010). Self-reported

assessments of students' knowledge of and ability to complete college-level writing show that this course significantly improved both knowledge and ability.¹⁴ In addition, course evaluations suggest that the course was a successful learning experience.¹⁵

Replication documentation

In recent years, the lack of reproducibility in scientific research has received much attention (NASEM 2016). Historically, the economics discipline has done little to promote reproducibility and facilitate replication (Chang and Li 2015; Duvendack, Palmer-Jones, and Reed 2017).¹⁶ However, the discipline is increasingly moving in the direction of establishing robust incentives for transparency through more data and code archiving requirements (Anderson et al. 2008; Ball and Medeiros 2012; Duvendack, Palmer-Jones, and Reed 2017). Many top journals in economics now require authors to submit data and analysis code files as a precondition for publication (including *Econometrica*, *Journal of Political Economy*, and *Journal of Applied Econometrics*). In 2004, the submission policy for the *American Economic Review* stated that it would publish papers only “if the data used in the analysis are clearly and precisely documented and are readily available to any researcher for purposes of replication” (Bernanke 2004, 404). As instructors, we have the ability to set the standards and incentives that guide the work of our students, emphasizing replicability and documentation in empirical research. In doing so, we have the potential to create a “trickle-up” effect, as our students enter the workforce or continue their education (Ball and Medeiros 2012).

For those academic journals that do require documentation of data and code files, most require that the data and code used to produce the final empirical result be archived (e.g., *American Economic Review*), but generally do not require authors to submit the original, unprocessed data sets and code with the commands that import and transform the data. This can best be described as *partial replication* and is a laudable first step towards reproducibility. A more rigorous standard of replicability would require “authors to submit all of the programs used to transform the raw data files into the tables and figures found in the paper,” because this “leaves no ambiguity about what procedures the authors conducted to perform their analysis” (Glandon 2011, 69). The TIER protocol is based on this standard and is modeled in this project, what Ball and Medeiros (2012) call a “*soup-to-nuts*” replication. To meet this standard, the replication documentation for a project should include:

1. copies of all raw data files, in their original unmodified form;
2. documentation that provides a researcher with all information necessary to obtain and interpret the raw data file(s); and
3. easily readable command files that execute all data processing and analysis steps required to reproduce the results of the paper (Ball and Medeiros 2012).

These files should contain all commands required to import raw data files, clean, process, combine, generate new variables, and produce the final empirical estimates in the paper. For partial replication, only part (3) is necessary.

As mentioned in our discussion of the project structure, we require that students create a folder structure at the beginning of the semester as a repository for all future replication documentation. Students then submit the project components in the appropriate folder over the course of the semester—writing tasks in the Documents folder, command files in the Command Files folder, and data files in the appropriate (Original, Importable, or Analysis) Data Files folder.¹⁷

Our guiding principle in adapting the TIER protocol to this empirical project is to come as close to the soup-to-nuts replication standard as possible. If time constraints, class size, or prior

student knowledge make such a standard infeasible, instructors should pursue adaptations closer to partial replication that make implementation possible.¹⁸ Regardless of the standard pursued, emphasizing the process of reproducible research can improve student learning of expository writing and economics.

Evaluation and assessment

For proper implementation of the empirical research project described above, the project should constitute a large proportion of the students' final course grade so that they understand the significance of the assignment for their learning experience and recognize the appropriate amount of time that should be devoted to the project.¹⁹ At the same time, it is important that students are evaluated and given formative feedback at each stage, indicating that each phase is significant and continually providing opportunities for revision.²⁰ Placing a positive weight on each part of the research project helps reduce the probability that students turn in "draft" work for the initial phases, emphasizing that each phase has already been through the drafting process. However, as with any long-term project, the components of the projects will be edited again before submission of the final research paper.

In the evaluation process, the objectives outlined in the project prompts must align with the criterion for assessment. Practice activities motivated by goals and direction should be coupled with targeted feedback in order to maximize learning.²¹ These two activities, practice and feedback, can be viewed as a cycle, where practice results in observed outcomes that can be assessed, which further informs future practice. Goals and learning objectives are at the center of this cycle and guide every stage, but they must be written in a way that can be monitored and measured (Ambrose et al. 2010).

Goal-directed practice and coordinated targeted feedback through articulating expectations and identifying an appropriate level of challenge support the greatest learning gains (Ambrose et al. 2010). Frequent, timely, and accurate targeted feedback is an important part of the writing process (Ericsson, Krampe, and Tescher-Romer 1993). Feedback should be provided early (Mathan and Koedinger 2005) and often (for a review, see Hattie and Timperley 2007). Furthermore, research shows that any feedback (even minimal) is superior to no feedback (Traxler and Gerensbacher 1992). In order to apply these principles regarding the timing of feedback, the project design necessitates feedback at each stage of the writing process.

The most straightforward way to articulate expectations and align objectives and outcomes is to provide rubrics. In addition, rubrics serve as an efficiency-enhancing mechanism for instructors by lowering the marginal cost of grading. Moreover, rubrics aid instructors in recognizing strengths and weaknesses of individuals and classes, signifying areas of focus for additional learning, and encourage consistency in evaluation (Ambrose et al. 2010). Finally, rubrics and rubric sharing have been shown to increase the quality of student work, student knowledge of quality work, and academic performance (Andrade 2001; Andrade and Du 2005; Osana and Seymour 2004; Reddy and Andrade 2010; Reitmeier, Svendsen, and Vrchota 2006; Schneider 2006).

The content of feedback given to students dictates the degree to which learning occurs through the revision process. Beason (1993) shows that students respond to about 90 percent of teacher's concerns in the revision process; so, the quality and direction of instructor comments are extremely important for improving writing. Research suggests that when the opportunity for revision exists (as in the type of project outlined above), formative assessment relative to stated goals and target criteria offer the greatest opportunities for improvement (Black and Wiliam 1998; Cardelle and Corno 1981; McKendree 1990).²² By providing the opportunity for revision, we give control and ownership of the writing process to the students.

In responding to student writing, while any feedback is better than none, too much feedback can be counterproductive and overwhelm students (Lamburg 1980; Shuman 1979). Students tend

to address only those comments that are easy to change (for example, they focus on the details as opposed to the structure). In commenting, instructors must be careful to balance between global-meaning (major) and local (surface-level or minor) comments. Surface-level comments can be important for improving writing skills and facilitating communication of economic content. However, in the presence of over-commenting or only surface-level feedback, students will often ignore areas for global improvement.²³

Our article reduces the fixed-costs associated with feedback, such as rubric generation, by supplying an adaptable template for each stage of the project. In addition, rubrics also reduce variable costs for instructors by decreasing time spent on each student's paper and utilizing a standard unit of analysis.²⁴ The time cost to instructors of providing feedback will never be zero, but we argue that the marginal benefit to students is greater than the marginal cost to instructors with the materials and instructions provided here. As evidence, student course evaluations from several semesters suggest that instructor feedback was an important part of course learning.²⁵

Several techniques (in addition to rubrics) can facilitate the feedback process and further reduce time demands on instructors. First, a file-sharing platform and use of track changes in Microsoft Word can reduce the time it takes to provide comments. Second, "minimal marking" can be used to identify local errors without having to make corrections throughout the entire paper. The purpose of minimal marking is to choose one representative paragraph from the student's writing and identify all surface-level comments and areas for improvements (Haswell 1983). Students are then asked to extrapolate and apply knowledge of these errors to the remainder of the paper. From a pedagogical perspective, this technique forces students to struggle with the grammatical rules and disciplinary norms and understand mistakes. Haswell (1983) finds that by identifying only the presence of an error with a check in the margin, students are able to correct 61 percent of all semantic signaling, punctuation, spelling, and grammar errors.²⁶

The project structure, outlined in [figure 1](#), supports implementation of the pedagogical approaches to feedback described above. Approximately every 2 weeks throughout the semester, students are receiving feedback on the practice activities (project components). Please see endnote 3 for information on how to access adaptable rubrics.

Conclusions and extensions

In this article, we describe an empirical research project for use in an upper-level undergraduate economics writing-in-the-discipline course with goals of reducing the high fixed costs associated with designing this type of assignment and encouraging more undergraduate economics research. In presenting the sequenced project design and replication documentation protocol, we posit that requiring students to produce this comprehensive documentation promotes student learning and leads to improvements in organization and coherence throughout the entire research and writing process.

The adaptable nature of the project structure and resources lends itself to innovation and extension. As previously mentioned, we utilize Stata, Microsoft Word, and Microsoft OneDrive for statistical computing, word processing and providing feedback, and assignment submission and return, respectively. The TIER protocol (currently in Version 3.0), which we adapt in this project, is software neutral.²⁷ The choice of statistical software is, therefore, determined by the instructor and the availability of computing resources. The use of programs such as R Markdown can further streamline the process by seamlessly combining LaTeX and R syntax to estimate empirical results and produce a written document.²⁸ Using batch files to stitch together Stata and LaTeX code can provide similar functionality and is equally reproducible. Depending on the learning objectives of the course, these project components can be scaled up or down to meet the needs of instructors and their students.

As an additional learning experience, instructors may offer the opportunity for peer review. This can be facilitated in class, outside of class, or electronically. In the online Supporting Information, we outline an example of a peer review activity. In addition, instructors can provide an online platform for students to share project ideas, data sources, and help with coding through a blog or discussion board on a learning management system.

Finally, as more students and instructors begin to utilize such tools in the classroom, opportunities for sharing undergraduate research become available. Regional collaborations among institutions can organize symposia designed to bring undergraduate students together to share their research and bring instructors together to share the research culture among undergraduate economics students that yield learning valuable to both graduate programs and potential employers.

Exposure to the research process is a key component in teaching undergraduate students to “think like economists” (Hoyt and McGoldrick 2017b). It fosters a deep appreciation for what economists actually do. The resource-intensive nature of supervising undergraduate research, alongside the rising popularity of econometrics and increasingly empirical economics discipline, has left time-constrained economics departments and faculty unable to provide ample research opportunities for undergraduates. Almost universally, economics faculty believe that exposure to the research process is vital to the development of well-rounded economics majors and cite resource constraints as the primary reason for the inability to provide these opportunities.

In this article, we have discussed an empirical research project that can be adapted in a variety of undergraduate economics courses. The pedagogical rationale above and teaching resources provided online are designed to reduce the otherwise large fixed costs associated with such a project and promote more opportunities for undergraduate research. The highly sequenced project structure and replication documentation requirements support student learning of course content and expose students to “doing economics” as a tool of discovery.

Notes

1. Of the institutions that do have a formal writing requirement, the most common type is a “writing-in-the-discipline” (WID) course or senior capstone with a writing component. Additionally, only 15 percent of economics departments reported offering courses dedicated to the research process, while fewer still (10%) reported offering a course that was specifically designated as “research methods” (McGoldrick 2008b).
2. Project TIER developed the TIER protocol in an effort to advance the goals of research transparency and reproducibility through disseminating and teaching instructional practices. The guiding principle of this protocol is “that the documentation should allow an independent researcher to replicate every step of the data management and analysis and to generate the same results” (Ball and Medeiros 2012). For more information, please visit <http://www.projecttier.org/>.
3. These materials are highly adaptable. Password protected electronic copies of the prompts and rubrics can be downloaded here: <http://sites.google.com/site/emilycorinnmarshall/teaching-resources> and here: <http://blogs.dickinson.edu/underwood/teaching-resources>. Please email either Emily C. Marshall (marshaem@dickinson.edu) or Anthony Underwood (underwoa@dickinson.edu) from your institutional email account to obtain the password.
4. This is a highly adaptable feature of the project. In our experiences, we have utilized both email and Microsoft OneDrive. However, many other platforms could be used such as Dropbox, Google Drive, or Open Science Framework.
5. This includes: (1) original data files (in unmodified form), (2) importable data files (minimally altered in order to be read by the statistical software), (3) base data file (master data file combining data from all original sources), (4) processing command (.do) file (file including all commands used to produce the base data file), and (5) metadata guide with an entry explaining how to obtain and understand each original data file.
6. This entails the submission of (1) an analysis data (.dta) file (used to produce the final estimates in the paper), (2) a construction command (.do) file (file containing all commands used to produce the analysis data from the base data), (3) a data appendix summarizing the analysis data, and (4) a summary command (.do) file (file including all commands used to produce the data appendix). The Data and Methods document describes the conceptual or theoretical framework, data, and model specification.

7. The analysis command (.do) file contains all commands used to produce final results tables included in the paper.
8. We also ask students to include a ReadMe file explaining the contents of the replication folder and providing step-by-step replication instructions.
9. This also could be implemented in a first econometrics course, provided that, it is upper-level.
10. These workshops are designed to facilitate both the completion of problem sets and complement the project components, including topics such as finding sources, finding data, and cleaning data.
11. In 1980, one-third of institutions offered honors in economics (Siegfried and Wilkinson 1982) and only about 7 percent of major programs required a senior thesis. As of 2013, these numbers have risen to 46 and 18%, respectively.
12. According to Swarthmore College's (n.d.) *National Census of Writing*, 39 percent of the sampled 4-year colleges and universities reported having WID and 62 percent require all students to take writing-intensive courses (outside of the English or writing department).
13. As instructors, writing assignment prompts is one of the two most important forms of writing we do for our students (Gottschalk and Hjortshoj 2004). The other is written feedback from the instructor, which is discussed in the evaluation and assessment section.
14. At the end of the semester, students ranked their knowledge (1 = least knowledgeable; 5 = most knowledgeable) of college-level writing before and after taking the course. From a sample of 26 students (spring 2017) and two different instructors, students report prior knowledge of 3.5 and after knowledge of 4.3, a statistically significant increase ($t = 3.38$, $p = .002$). Students also ranked their ability (1 = least able; 5 = most able) to write at the college-level before and after taking the course. From this same sample, students report prior ability of 3.6 and after ability of 4.2, also a statistically significant increase ($t = 2.96$; $p = .005$).
15. From a sample of 55 students (spring 2017, fall 2017, and spring 2018 semesters) and two different instructors, 91 percent of students (agree or strongly agree) that after taking the course they have a better understanding of the subject matter and 96 percent (agree or strongly agree) that they now have a better understanding of the methods used in econometrics.
16. Chang and Li (2015) attempt to replicate 67 empirical papers published in 13 well-regarded economics journals; some of these journals require data and code files and others do not. They were able to replicate the key qualitative results for 49 percent of the papers (Chang and Li 2015).
17. This folder structure is an adaptation of the TIER protocol. See <https://www.projecttier.org/tier-protocol/> for more details.
18. For partial replication, the folder structure could be simplified. A suggested organization would be three main subfolders: Documents, Data, and Code. Documents would contain all written project components, data would include all data files (most likely in .dta format), and code would consist of .do files to run the data transformation and results.
19. In our course, the project is worth 225 points out of 500 total points available, or 45 percent of the final course grade. At national universities and liberal arts colleges that require a project in econometrics, the projects typically constitute 28 to 29 percent of the course grade (Johnson, Perry, and Petkus 2012).
20. Each part of the project is worth 9 to 20 percent of the project grade or 4 to 9 percent of the final course grade.
21. In this context, "practice" refers to the components of the final paper and the final paper itself. Practice is defined as any activity in which students apply their knowledge or skills.
22. For more information on written responses to student writing, see Flanigan and Menendez (1980), Flower (1979), and Sommers (1980, 1982).
23. In addition, it is tempting to spend more time on weaker student papers and less time providing feedback to strong student papers. Instructors must be careful to balance feedback between weak and strong student papers.
24. In our experience, we estimate that utilizing a rubric at each phase of the project for an individual student cuts grading time to ~20 to 30 min per paper. This, of course, can be highly variable and time per paper tends to decrease with experience but converges to a non-zero positive number.
25. From a sample of 55 students (spring 2017, fall 2017, and spring 2018 semesters) and two different instructors, 82 percent of students (agree or strongly agree) that instructor's comments were an important part of their learning in the course.
26. Note, there are many variations on minimal marking and only one is described here.
27. Originally, this protocol was developed for Stata and R. See <http://www.projecttier.org/tier-protocol/> for more details.
28. Stata 15 also now has integration capabilities with Microsoft Word. See <https://www.stata.com/new-in-stata/create-word-documents/> for information on this update.

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Appendix A

Just as good writing requires forethought and planning, so does effective data workflow and construction of replication documentation. Thus, this project can be viewed as two interrelated projects happening simultaneously: the writing process and data workflow. This workflow is designed to help keep students organized and enhance their understanding of data processing and analysis. [Table A1](#) below outlines the project timeline and workflow that is distributed to students at the beginning of the semester:

Table A1. Project timeline and data workflow.

Dates	Writing process	Data workflow
Weeks 1 to 3	Brainstorm Research Questions and Topics related to your interests. Find sources. Read them. Engage with them. How can your research contribute to this conversation?	Explore potential data sources related to these topics. Which variables do you need? Complete “Pre-Data” work. Construct a hierarchy of empty folders in Office 365 and create three blank documents: <ul style="list-style-type: none"> • A ReadMe file • A Metadata Guide • A Data Appendix
End of Week 3	Write Annotated Bibliography and Research Question. Refine the focus of your paper. Submit your Annotated Bibliography and Research Question	Find data. Explore the contents. Based on the existing literature do you have all the variables you need? If not, find them. Begin “Data Work”
Weeks 4 to 6	Evolue your thesis statement. Narrow your focus. Write your Proposal.	Each time you obtain a new file containing data you will use for your project, you should save a copy in your Original Data folder, and record some information about the data in your Metadata Guide and ReadMe file. Begin writing your “Processing.do” command file as you obtain these original data files. Save this in your Command files folder.
End of Week 6 Weeks 7 to 9	Submit your Proposal Further engage with the sources from your annotated bibliography and all other additional sources as you continue to narrow your focus. Where does your research question fit into the existing conversation? How does it contribute? Begin writing your Literature Review. Read it. Does it achieve its goal? Are you engaging with the sources critically and meaningfully or just	After receiving feedback on your proposal, verify you have all the data that you need to address your research question. Begin cleaning and processing in order to generate your base data file, which you should save in your Original Data folder. Record information about any additional data in your Metadata Guide and your ReadMe file as necessary. Be sure to document any cleaning decisions that

(continued)

Table A1. Continued.

Dates	Writing process	Data workflow
End of Week 9	summarizing? Is it beginning to inform your empirical methodology?	were made during the generation of the base data in your Metadata Guide. Submit original data files, base data file, Processing.do command file, and Metadata Guide
Weeks 10 to 11	Revisit your Literature Review. Is it consistent with your thesis? Does your thesis need to evolve? Does your focus need to be further narrowed or refined? Again revisit your Literature Review. Does it motivate your empirical methodology? How is what you are doing different from what others have done? How is it the same? You should have a clear sense of your model specification by this time. Using information already compiled in your Metadata Guide, ReadMe file, and Data Appendix, begin writing the Data section of your paper.	Begin constructing your analysis data file(s) from your base data file. Document these commands in your Construction.do command file and save it in your Command Files folder. Any new variables, transformed variables, etc. should be generated during this phase. Once you've completed data construction, save your analysis data file(s) in your Analysis Data folder and immediately begin working on your Data Appendix and compile these commands in the Summary.do command file and save in your Command files folder. Get to know your data. What stands out? Which aspects of the composition of your sample are most relevant?
End of Week 11	Submit your Literature Review	Give your documentation a "check-up." Is everything there? Have you worked on your ReadMe file?
Weeks 12 and 13	Revisit the Data section of your paper. Which details about your data does your reader need to know to understand your methodology and the meaning of your results? Develop your regression specification. Write out the equation using the equation editor in Word. What is your explanatory variable of interest? What are your expectations for your estimates? Why?	Complete your Data Appendix. Be sure that all commands necessary to generate the descriptive statistics, tables, and figures needed for the Data Appendix are included in the Summary.do file. What is most relevant in describing your data? Do your data make sense? Are the components in line with expectations? Do you have outliers? What does your reader need to know? Which tables, charts, or graphics from your Data Appendix may be helpful to the reader in understanding your data? Which type of chart is most effective in making the point?
End of Week 13	Submit Data & Methods	Submit analysis data files, Construction.do command file, Summary.do command file, and your Data Appendix
Weeks 14 to 15	After ensuring that you have estimated your model correctly and obtained results, begin interpreting your results. Are they in line with expectations? Are they statistically significant? Are there any surprises? What can you say about your research question? Provide context for your reader. How should they understand the results? Think big picture about your results. Revisit your results in the context of	Begin analyzing your data. All commands used to generate descriptive statistics, graphics, regression results, and hypothesis testing should be compiled in the Analysis.do command file. Every command that generates any of your results should be preceded by a comment that states which result the command generates. Generate tables of your results using outreg2. Include these commands in your Analysis.do command file. Finish your ReadMe file. You should already have recorded one part of the

(continued)

Table A1. Continued.

Dates	Writing process	Data workflow
Beginning of Week 15 Week 15 and Final Exam Week(s)	<p>your research question and thesis statement. Have you answered the question? Likely, you have in some ways and not in others; discuss these. What limitations do you see in your analysis? Were you limited by your data? Did you need more variables? More observations? Are you concerned about unobserved heterogeneity and omitted variable bias? Were you able to effectively deal with problems of heteroskedasticity or serial correlation?</p> <p>Submit Results & Discussion</p> <p>Begin construction of your final paper. Most empirical papers include these sections:</p> <ul style="list-style-type: none"> • Introduction • Literature Review • Data & Methods • Results/Discussion • Conclusion • References <p>For the most part, you need to simply compile the work you've already done, but do <u>not</u> simply copy/paste them into one document. Your introduction is likely new, perhaps it draws from your proposal, but it should motivate your thesis statement. You'll need to add in transitions between these sections to make the paper more readable and cohesive.</p> <p>Check your citations and reference list. Be sure that all sources cited in the paper are listed in the reference list and vice versa. Check to be sure you are consistent with your citation style (Chicago or APA).</p> <p>Read your paper. Read it again. Does it flow well? Have someone else read it. Do they agree? Revise. Revise. Revise.</p>	<p>required information, namely notes explaining any modifications you made to the original data files when you made importable versions of them and generated the base data. To finish your Read Me file, you should add: (1) an overview of all the files included in the replication documentation and the structure of the folders in which they are stored and (2) Step-by-step instructions for using the replication documentation to replicate the study.</p> <p>Submit Analysis.do command file</p> <p>Edit all of your command files to be sure they are accurate, concise, and free of clutter. Have you provided sufficient comments in your command files? Could someone else follow what each command is doing?</p> <p>Test your command files to be sure that they all run without error and that they successfully reproduce the results you report in your paper. Try following the instructions for replicating your project that you wrote in the ReadMe file to be sure that all your command files run without a hitch and produce the intended output.</p> <p>Check to be sure your replication documentation is complete. Are all the required files included in your replication documentation, and are they are stored in the correct folders? Finally, delete any extraneous files that are not required and unnecessary for replication.</p> <p>Check all documents for accuracy and readability. The ReadMe file, Metadata Guide, and Data Appendix should be well-written, proofread, and formatted.</p>
Final Exam Date	Submit Final Paper	Submit Final Replication Documentation