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# Improved Reasoning in Undergraduate Writing through Structured Workshops

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# ECONOMIC INSTRUCTION

## Improved Reasoning in Undergraduate Writing through Structured Workshops

Jason E. Dowd, Michelle P. Connolly, Robert J. Thompson, Jr., and Julie A. Reynolds

The Department of Economics at Duke University has endeavored to increase participation in undergraduate honors thesis research while ensuring a high-quality learning experience. Given the faculty-to-student ratio in the department (approximately 1:16), increasing research participation required the creation of a stable, replicable framework for mentoring students through research. The department aimed to make the research experience more consistent and interactive so that students also learned from each other in a group setting. Here, the authors assess the relationship between changes in mentoring support of honors research and students' scientific reasoning and writing skills reflected in their undergraduate theses. They find that students who participated in structured courses designed to support and enhance their research exhibited the strongest learning outcomes, as measured by systematic writing assessment.

***Keywords*** *economic education, undergraduate instruction, undergraduate research, writing*

***JEL codes*** *A20, A22*

Over the last 25 years, there has been a concerted effort to apply our increasing understanding of how students learn to inform higher education pedagogical and curriculum practices. This has led to the development and adoption of practices that promote active student learning. A number of high impact practices have been identified, including writing-to-learn, experiential learning, and particularly participation in undergraduate research (Kuh and Geary Schneider 2008). A focus on experiential learning has been a mainstay of science education through the laboratory component of the curriculum for physical and life science disciplines with the goal being to go beyond "learning about" science to "doing science." Evidence is accumulating that participating in research experiences improves undergraduate science students' skills with regard

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to critical thinking, problem-solving, and applying knowledge (Lopatto 2004; Seymour et al. 2004). Direct participation in research engenders a more sophisticated understanding of the nature and construction of knowledge, confidence and empowerment to make a contribution, and a sense of responsibility for the process and the outcome (Seymour et al. 2004; Lopatto 2004).

The Department of Economics at Duke University has endeavored to more fully engage students in the practice of economics through increased participation in research and completion of undergraduate theses. Traditionally, undergraduates who wrote honors theses in the economics department worked one-on-one with faculty mentors. As participation rates increased, however, the department needed to create a stable and replicable framework for mentoring them through the research experience so that the quality of the learning experience would remain high. The department adapted to both the increasing number of students participating in research and the need for enhanced quality control through the implementation of changes in pedagogy, peer interaction among students, and mentoring. Here, we evaluate student learning outcomes when students participate in an honors economics research workshop using writing assessment tools adapted from tools previously developed in the Department of Biology. These workshops support students' completion of an undergraduate economics honors thesis by scaffolding and facilitating the thesis-writing process while efficiently expanding faculty resources for undergraduate research. In this analysis, we pose the question: How do changes in the support of undergraduate thesis writing relate to students' critical reasoning and writing skills? To address this question, we analyzed student theses completed between 2001 and 2011 in the Department of Economics at Duke University as major changes occurred in the curriculum and research workshops.



## LITERATURE REVIEW

In 1990, Bartlett and King argued that the teaching of economics was less than it could be because of a lack of understanding of how students learn and the reluctance to teach economics as a science. Furthermore, they argued that faculty do not teach with an awareness of the developmental progression in the sophistication of students' thinking, but they try to reach the highest levels without guiding students through the prerequisite stages of understanding. They contrast the pedagogy of economics with the pedagogy of the physical and life sciences that involves teaching students not only what is known but also how scientists go about discovering this knowledge. Bartlett and King (1990, 186) not only recommended the development of a laboratory component to the economics curriculum but also urged economists to "rethink and reorganize their courses in order to bring the pedagogy of undergraduate economics courses into line with the practices of the discipline." About the same time, in their report regarding the economics curriculum, Siegfried and colleagues (1991, 217–18) recommended the inclusion of "capstone experiences such as special seminars or traditional opportunities for senior theses, honors research projects, and independent studies."

To determine the extent to which writing activities (individual papers and designated courses) and research experiences (honors, capstones, and theses) have been incorporated into undergraduate economics education, McGoldrick (2008b) sent a survey to 814 chairs of economics departments in the United States in the fall of 2004. The final sample of 254 departments comprised approximately one-third each of national universities, master's universities, and liberal arts institutions. Results indicated that honors programs were offered in approximately 37 percent of

departments, and 60 percent of departments offered a capstone/senior experience. Such experiences took the form of a capstone course (49 percent), a senior thesis (17 percent), or some kind of comprehensive exam (27 percent). Many of the capstone experiences were content-specific seminars, but some were designed to facilitate students' research and enhance their ability to do economics research (McGoldrick 2008a). The results of McGoldrick's survey indicated that opportunities to participate in undergraduate research exist and that students are writing more than they did 15 years prior to the survey, but these opportunities occur most often at smaller institutions than at larger, research-oriented institutions (McGoldrick 2008b). Providing students with the opportunity to "do economics" remains an important challenge that larger institutions must overcome (McGoldrick 2008b).

Establishing an honors program is one way in which post-secondary institutions (national universities, in particular) have endeavored to foster engagement in undergraduate economics research (McGoldrick 2008b). Completing an independent research project is central to most undergraduate honors programs (Siegfried 2001). In addition, some honors programs include a sequence of courses to support students' early initiation and continuous engagement with the research and thesis-writing process. For example, Siegfried (2001) described a three-course sequence at Vanderbilt University that began with a one-credit independent studies course in the spring of the junior year to support the students' formulation of their research question and proposal. The one-credit honors seminars in both the fall and spring semesters of the senior year focused on what it means to "think like an economist" and provided opportunities for students to make presentations to their peers, initially about their proposal and subsequently about what they have done, while completing the initial draft and revisions of their theses.

One challenge that universities face in encouraging more students with more widely varying backgrounds to participate in undergraduate research experiences is to ensure that the quality of the experiences does not decline. High-quality research experiences involve not only the application of sophisticated concepts and approaches, but foster deep learning of those concepts and methods. These experiences also develop students' epistemological beliefs, intrinsic motivation, and metacognitive skills. To this end, structure and support during learning promote the cognitive processes of selecting, organizing, and integrating knowledge (Kirschner, Sweller, and Clark 2006; Mayer 2004). Moreover, the value of sequencing assignments and designing them to promote deep learning and transfer of knowledge has been identified in students' end-of-course writing activities (Green, Bean, and Peterson 2013). Therefore, efforts to expand participation require not only efficient use of departmental resources but also effective pedagogical approaches and mentorship.

We focused on student learning outcomes in the Department of Economics when students participate in a one- or two-semester honors research workshop that scaffolds and facilitates the thesis-writing process. The workshop increases faculty support for and involvement in undergraduate research, while at the same time conserving total faculty resources.

## CONTEXT

At Duke University, approximately 200–300 students graduate with a major in economics each year, more than any other discipline. From year to year, an increasing fraction of these students complete an undergraduate thesis (figure 1). These students can choose whether to work

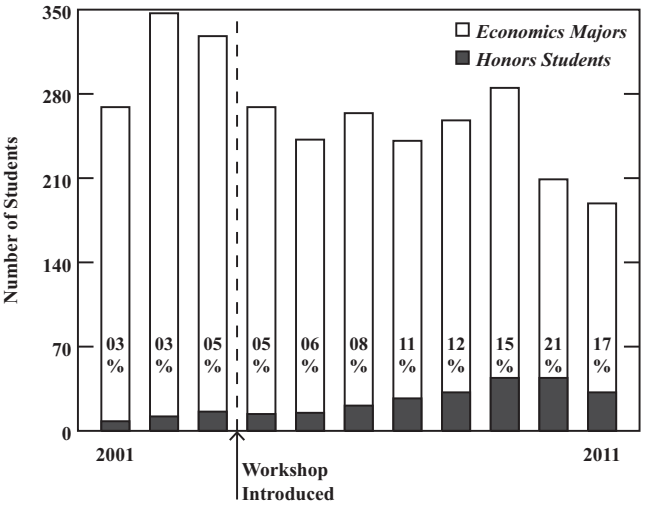


FIGURE 1 Economics majors choosing to write honors theses. The number and the fraction (displayed within each column) of graduates completing honors theses generally increase over this time period, despite the overall decrease in number of economics majors.

independently with a research advisor (if they can find a faculty member willing to do an independent study with the student) or participate in a research workshop. The instructor teaching the workshop automatically becomes one of two advisors for those students in the workshop. The instructor oversees oral presentations of the students' research and provides feedback on evolving drafts of the theses.

Unlike students in other disciplines, who necessarily work within a lab or research group and therefore have a *de facto* advisor and general research topic, economics students on the workshop path are allowed to select their own research topics. Only when a student has picked a topic (with guidance from the workshop instructor) does she/he then find a second faculty advisor who specializes in the topic chosen by the student. This has two advantages over the traditional independent study path for writing honors theses that pairs one student to one professor. First, the student ends up receiving guidance and help from two advisors, as well as all of her/his classmates in the workshop. Second, because the workshop focuses on content, mechanics of writing, and reasoning in writing, the second advisor's time is more flexible, and he/she can more easily advise students on the content. This system has allowed for an increase of well over 100 percent in the number of economics students who have been able to conduct high-quality research, in spite of assigning two advisors to each student's project; a few faculty members focus on the broader aspects of thesis writing so that the demands on additional faculty members for content-related advice are greatly reduced. In other words, greater specialization among the faculty allows for disproportionate gains in student output from faculty input.

The purpose of the first semester of the research workshop is to help second-semester juniors or first-semester seniors begin their research project. Students learn what constitutes novel research, how research papers are created and written, and what writing resources, software, tutoring, and faculty support are available. Moreover, this course establishes, at the undergraduate level,

the tradition of presenting and discussing one's research to colleagues, just as one does in graduate school and academia. The final product is a clear research proposal, so students are well positioned to complete their research project and submit their honors thesis after the second-semester workshop.

In both semesters of the research workshop, student presentations occupy most class meetings. The earliest meetings are devoted to introducing the course goals and bibliographic resources, followed by one-on-one meetings between the instructor and each student to discuss potential research. The first assignment is for students to choose a previous honors thesis and review it. This task provides students with the opportunity to familiarize themselves with what an undergraduate honors thesis entails and begin to contextualize what they would like to study. Based on the individual student meetings with the instructor, students try to narrow down their topic of interest and identify one or two academic journal articles that are most related to their topic of interest. In their first class presentations, students present the article or articles most similar to the research that they are hoping to undertake. The article may demonstrate a similar topic or a similar technique that may be applied in a novel context. Once the first round of presentations is complete, the cycle immediately begins again with introductions to students' projects, then proposed theoretical frameworks, and in the case of empirical papers, descriptions of the empirical specifications, data, and results. Rather than a summative evaluation of the presenting student's progress, the presentation is entirely focused on brainstorming and improving the quality of the research project. Because the first presentations introduce the topic and relevant literature to the entire class, students gradually build a shared knowledge base as everyone's research evolves. This is done in stages as students present fledgling research plans, help others with their plans, share literature with the group, collect data, and eventually write up and present research proposals for the subsequent workshop.

Although the research workshops are designed as a two-semester sequence, some students who submit an honors thesis ultimately take only one of the two courses in the research workshop sequence (figure 2). This happens for a variety of reasons. Sometimes, a student begins in the first semester workshop and then decides (often for scheduling reasons) to finish the second semester as an independent study with their field-specific advisor. Alternatively, a student may have already taken a course (or an independent study) that required some research, so he/she decides to join in the second semester of the research workshop to help finish the thesis.

Multiple instructors run different research workshop sections each semester, and each instructor has the flexibility to run the section however she/he chooses. Some instructors are very structured and ask that students regularly read and review each other's written work. Other instructors take on the role of facilitator in class and encourage broad discussions among the students without requiring them to read each other's work before class. Despite differences in instructional styles across sections, the students are consistently highly motivated and display genuine interest in the research and a willingness to critically engage others.

The honors research workshops have changed over the 11 years that are the focus of this study. The very first honors research course was introduced in 2004 and was structured as a general workshop for honors students writing theses. After 2004, the department decided to create subject-specific workshops in such topics as finance, microeconomic theory, and applied microeconomics. The hope was to create greater overlap among student topics and to better match the expertise of faculty teaching the workshop with the honors thesis topics. It also was hoped that this matching of interests might obviate the need for a secondary advisor. Some of these

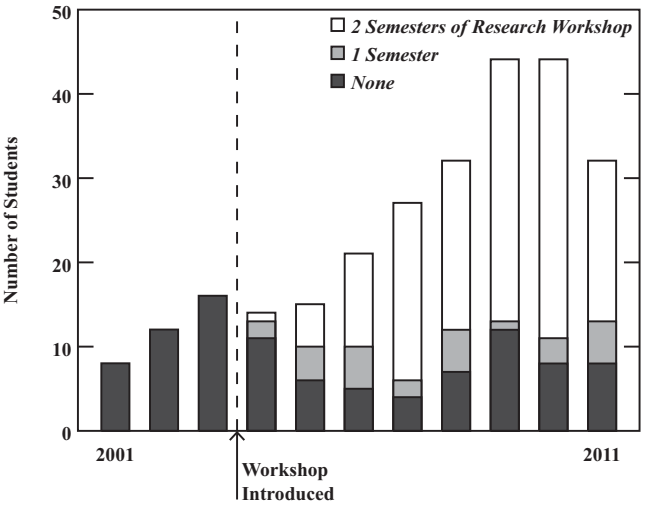


FIGURE 2 Research workshops taken by thesis writers. Students may choose to participate in none, one, or two of the courses in the research workshop sequence.



subject-specific workshops were greatly successful, but the faculty involved found the effort of being the sole advisor of up to nine students overwhelming and requested to no longer teach the workshop. In other cases, enrollment was inconsistent. The popularity of the topics or professors may have played a role. A key factor, however, seems to be that many students are reluctant to commit to a particular subject-specific workshop because, at the time of enrollment, they do not know what topic they will choose for their thesis. When both generalized and specialized workshops were offered concurrently, enrollment in the generalized workshops was consistently greater than in the specialized workshops. Gradually, the department abandoned most of the specialized workshops in favor of providing more sections of the generalized research workshop each semester. This also provides greater flexibility for the students because the workshop sections are offered at different times; although many students keep the same instructor through both semesters, they may switch. After all of these changes, the current format closely resembles the original workshop created in 2004.

## METHODS

### Study Design

Because of the nature of this academic intervention, the study design must be appropriate for the evaluation of program effectiveness and assessment of impact, in contrast to formal experimental research (Rossi, Lipsey, and Freeman 2003; Upcraft and Schuh 2002). That is, our aim was not to conduct an experimentally controlled research study that would require random assignment of students to different specific pedagogical approaches or curriculum components and control of prior experience levels. Rather, our aim was to evaluate the impact/effectiveness of honors

TABLE 1
Evolution of Average Student Background Traits over Time

| | Correlation with year |
|---|---|
| SAT math | 0.72* |
| SAT verbal | 0.84** |
| Research-oriented courses | 0.69* |
| Writing-intensive courses | 0.78** |

*Note:* Pairwise correlations between students' background characteristics and time. Each of the background characteristics was averaged by year, resulting in 11 mean and standard deviation values (2001–11).
*$p < .05$; **$p < .01$.



workshops within the context of the decade-long changes in the economics honors program in pedagogical approaches and mentoring support. The learning outcome of interest was students' scientific reasoning and writing skills as reflected in their thesis writing. The measure adopted was the Economics Thesis Assessment Protocol (EconTAP). The basic aim of impact assessment is to produce an estimate of the "net effects" of the intervention (Rossi, Lipsey, and Freeman 2003). In this case, we were interested in evaluating the role of the honors workshop sequence beyond the influence of other processes and events that could affect scientific reasoning and writing skills. The study design was quasi-experimental by necessity, in that students' curricular and course choices were uncontrolled and students varied on multiple dimensions of prior and current experiences. Furthermore, the intervention being addressed was implemented in varying ways. Therefore, we identified the effects of increased structure provided by the research workshops through systematically exploring salient contrasts and employing statistical control for potentially contributing variables.

## Study Sample

From 2001 to 2011, 249 undergraduate honors theses submitted by 264 students to the economics department merited graduation with distinction (17 theses were co-authored by two students, and two students each wrote two theses). The number of undergraduates who completed honors theses generally increased over the years (as reflected by a Pearson correlation coefficient of $r = 0.91$, $p = .001$), despite an overall decrease in students majoring in economics ($r = -0.72$, $p = .01$; figure 1).

Over the years, students' backgrounds and classroom experiences changed. The average SAT math and verbal scores increased over time ($r = 0.72$, $p = .01$, and $r = 0.84$, $p = .001$, respectively; table 1), as well as the average numbers of both research-oriented and writing-intensive courses completed by students ($r = 0.69$, $p = .02$, and $r = 0.78$, $p = .005$, respectively; table 1).

These changes in classroom experiences reflect a broader university-wide effort to enhance students' abilities to work independently, engage in research, and exhibit scientific reasoning in writing. The research workshops continue along that same trajectory. The average numbers of research-oriented and writing-intensive courses completed by economics thesis writers were significantly greater during years in which students had the option of participating in the workshops than during prior years ($p < .0001$ in both comparisons), according to Student's *t*-tests.

To control for individual differences in skills and experiences prior to writing a thesis, we obtained the following background information (when available) for students through the university registrar, as approved by our Institutional Review Board: GPA at graduation ($n = 264$), SAT math ($n = 246$) and verbal ($n = 247$), grade in the first-year writing course ($n = 257$), number of independent study courses taken ($n = 264$), number of research-based courses taken ($n = 264$), number of writing-intensive courses taken ($n = 264$), total number of courses taken ($n = 264$), and gender ($n = 264$). For each of our analyses, we treated each combination of student and thesis as a distinct observation. If two students co-authored a thesis, the shared thesis assessment score was paired with each student's background information. If one student submitted two theses, the background characteristics of that student were paired with each of the independent thesis assessments. This resulted in 266 distinct observations.

To address the question of the relationship between changes in the support of undergraduate thesis writing and students' scientific reasoning and writing skills, we assessed 244 of the 249 honors theses. To determine if the five theses that were not available for assessment reflect a distinct subset of the total population, we compared the background characteristics of assessed versus unassessed students to see if they were significantly different. We found that none of the characteristics for which we have data was statistically significantly different at the level of $p = .05$. To determine if the subset of 242 students for whom we have theses, SAT scores, and other registrar data reflect a distinct subset of the total population, we compared the background characteristics and found that only total number of research courses ($\mu_{\text{complete}} = 5.47$, $\mu_{\text{incomplete}} = 6.5$, $p = .028$) differed at the level of $p = .05$.



## EconTAP

EconTAP is a document that guides and supports students and instructors through the thesis-writing process, just like the biology thesis assessment protocol (Reynolds et al. 2009) and the chemistry thesis assessment protocol (Dowd et al. 2014). The document describes 13 distinct dimensions assessing students' writing skills, scientific reasoning, and accuracy and appropriateness of research. Reynolds and colleagues (2009) provided detailed descriptions of these dimensions. Because we do not have the expertise to evaluate the accuracy and appropriateness of research that spans so many subfields and topics within economics, we focused exclusively on the nine dimensions related to writing and reasoning. Specifically, we assessed theses in terms of appropriateness for target audience, argument for significance of research, articulation of goals, interpretation of results, implications of findings, organization, absence of writing errors, consistent and professional citations, and effective use of tables and figures.

The procedure for rating students' theses was identical to that used in prior studies (Reynolds et al. 2009; Dowd et al. 2014). Each dimension was rated on a scale of 1 to 5. A rating of 1 indicates that the dimension under consideration is either missing, incomplete, or below the minimum acceptable standards. A rating of 3 indicates that the dimension is adequate, but the work does not exhibit mastery. A rating of 5 indicates that the dimension is excellent, and the work exhibits mastery. As different parts of the thesis might fall into different categories, intermediate ratings of 2 and 4 may be appropriate.

Theses were assessed by a group of graduate students and postdoctoral associates, trained and supervised by Julie Reynolds. For all assessments, each rater completed training in the

TABLE 2
Factor Loadings of the Nine Assessed Dimensions of Students' Theses

| Variable | Factor loadings |
|---|---|
| Identifying audience | 0.6897 |
| Structuring argument | 0.7451 |
| Stating goals | 0.7485 |
| Interpretation of results | 0.7970 |
| Implications of results | 0.7015 |
| Organization | 0.8008 |
| Minimizing writing errors | 0.8309 |
| Appropriate citation | 0.4888 |
| Effective tables and figures | 0.6276 |



use of the EconTAP rubric, which included examination of samples of students' writings that illustrated inadequate, adequate, and masterful levels of all nine dimensions being assessed. Raters then assessed sample theses that were not part of the data set, discussed them, and established consensus scores as a means of calibrating.

Each thesis in our sample was read by two raters who assessed the theses independently, subsequently discussed discrepancies in their ratings, and finally established a consensus score (the same method employed by Reynolds and Thompson [2011] and Dowd and colleagues [2014]). The consensus score is not the simple average of the scores given by the two raters. Rather, it is a discussion-based final score agreed upon by both raters. The Pearson correlation coefficient between raters' independent scores is 0.94 for total thesis scores and range from 0.64 to 0.96 for the nine distinct dimensions. Consensus scores were used in all analyses.

Formally, the nine dimensions assessed using the EconTAP rubric are independent of one another. The total score conflates dimensions as disparate as mastery in argument and mastery in employing figures and tables, and there is no *a priori* reason to collapse them. Therefore, the total score is not necessarily meaningful. However, exploratory factor analysis (also employed in Dowd and colleagues [2014]) indicates that there is a latent underlying factor representing the exhibition of these students' scientific reasoning in thesis writing. Factor loadings reveal that three of the nine dimensions (i.e., minimizing writing errors, organization, and the ability to interpret results) load most strongly onto the factor, although all dimensions except the ability to appropriately use citations load quite strongly (table 2). We consider this factor, composed of all nine dimensions, to be the primary characteristic of students' exhibition of writing skills and scientific reasoning in economics thesis writing, and therefore use this factor as the outcome variable in subsequent regression models.

We investigated the relationship between this thesis assessment factor and students' participation in two semesters, one semester, or no semesters of the thesis-writing workshop. We controlled for numerous covariates that could relate to thesis assessment. These covariates are GPA at graduation, SAT scores, grade in the first-year writing course, number of independent study courses taken, number of research-based courses taken, number of writing-intensive courses taken, total number of courses taken, and gender. We use ordinary least squares (OLS) to explore potential relationships among these covariates and the thesis assessment factor; such relationships

TABLE 3
Honors Thesis Assessment ($n = 242$)

| Variable | Model 1 | Model 2 | Model 3 | Model 4 |
|---|---|---|---|---|
| Number of research workshops | 0.527*** | 0.284*** | 0.284*** | 0.372*** |
| Year of submission (fixed effect) | | — | — | — |
| GPA | | | 0.129* | 0.115* |
| SAT math | | | 0.043 | 0.035 |
| SAT verbal | | | −0.103 | −0.082 |
| Independent study courses | | | | 0.122* |
| Research-oriented courses | | | | −0.067 |
| Writing-intensive courses | | | | −0.071 |
| Male | | | −0.089 | −0.095 |
| Adjusted $R^2$ | 0.274 | 0.395 | 0.419 | 0.430 |

*$p < .05$; ***$p < .001$.

could indicate whether some students exhibit stronger scientific reasoning and writing skills than others.

## RESULTS

Both the number of thesis-writing workshops that a student has taken and the year in which the thesis was submitted are strongly related to thesis assessment measures (table 3). In model 1, the amount of participation in the thesis-writing workshop is associated with statistically significant positive changes in thesis assessment. In models 2 through 4, even when we controlled for the numerous additional covariates, the positive relationship between thesis-writing workshop participation and thesis assessment persists (for simplicity, table 3 does not display models incorporating total courses taken and grade in the first-year writing course). The thesis submission year is treated as a fixed effect in models shown in table 3; we also consider models in which submission year is treated as a linear and quadratic covariate, and find no difference in the relationship of interest.

Students who participated in the thesis-writing workshop exhibited stronger scientific reasoning and writing skills in their thesis writing (figure 3). To make sure that these results are not driven by self-selection bias, we compared students who wrote theses during the years 2004 to 2011 (after the research workshop was introduced) and decided to participate in at least one semester of the workshop sequence to those who did not in that same time period. There are no significant differences in any of the background characteristics between these two groups *except* for the total number of independent study and writing-intensive courses completed, which we address in the discussion section.

In addition to exploring relationships between thesis assessment and the number of research workshops taken, we also investigated the relationship between thesis assessment and participation in at least one semester of the research workshop. We find that the positive relationship between thesis assessment and workshop participation persists, even when multiple covariates are included in regression.

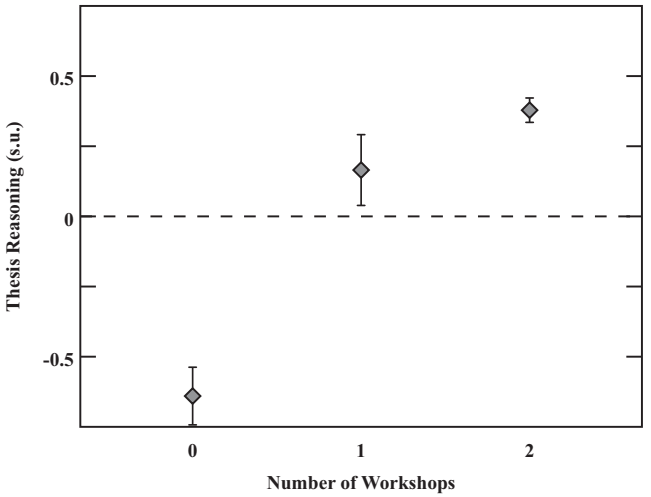


FIGURE 3 Students' scientific reasoning and writing skills in theses. Students who participate in the research workshops perform better than students who do not.

## DISCUSSION

The Department of Economics responded to both the increasing number of students participating in research and the need for enhanced quality control through the implementation of changes in pedagogy, peer interaction among students, and mentoring. To determine if these changes correspond to improved scientific reasoning and writing skills, which are an important outcome of participating in undergraduate research, we assessed students' exhibition of these skills in their thesis writing. We observed a statistically significant increase in students' scientific reasoning and writing skills in their thesis writing when they participated in the thesis-writing workshop (table 3; figure 3). Although we cannot claim that the workshop is causally related to increased reasoning, this finding, in the context of our other studies of the effects of increased course structure, is encouraging.

Students who do not participate in the workshop differ in the number of independent study and writing-intensive courses that they have taken, but this difference is largely explained by the fact that (1) the workshop tends to count as a writing-intensive class, and (2) the alternative to the workshop is often one or two semesters of independent study. Therefore, the differences in total numbers of these designated courses are entirely anticipated. Unfortunately, we cannot remove this link by subtracting from students' course totals because of individual differences among students; some students may have petitioned for independent study to count as writing-intensive, others may have participated in the workshop without receiving writing-intensive credit. While these student-by-student differences frustrate our efforts to entirely isolate the workshop from other variables, they provide sufficient variation that the correlations among these variables are not too large and the assumptions of OLS regression are not violated. We note that the number of research-oriented courses (a designation shared by both independent study and workshops) taken by students is consistent across groups. Therefore, to the extent that we are able to determine,

there are no significant differences in background among students who participate or do not participate in workshop courses.

Higher-performing students, as measured by GPA, tend to exhibit stronger thesis assessment than relatively lower-performing students (table 3). We observe, however, that even students with the lowest GPA who participate in two semesters of the thesis-writing workshop are predicted to exhibit stronger thesis assessment than the highest-performing students who do not participate (according to model 4 in table 3). Of course, as all of these students are writing honors theses, the range from low to high performance is, in absolute terms, fairly localized at the high end of the scale.

The analysis presented here is not direct evidence of a causal relationship between the workshop and improved scientific reasoning in thesis writing, but we hypothesize that participation in the thesis-writing workshop provided students with critical, highly-structured scaffolding to promote metacognition and improve learning outcomes. Our results not only closely parallel those found in the biology department's thesis writing course (Reynolds and Thompson 2011; Reynolds et al. 2009) and the chemistry department's thesis writing course (Dowd et al. 2014), but they are also similar to broader findings in STEM disciplines from other institutions and other contexts (Deiner, Newsome, and Samaroo 2012; Van Bramer and Bastin 2013; Etkina et al. 2010; Haak et al. 2011). These findings parallel findings in economics, where scaffolded writing activities are associated with improved learning outcomes (Simpson and Carroll 1999; Palmini 1996; Cohen and Spencer 1993; Hansen 1993; Davidson and Gumnior 1993; Crowe and Youga 1986). Even when the introduction of a writing activity alone was ineffective (as was the case in one intermediate macroeconomics course), additional scaffolding in the form of questions that required economic argument and evidence was related to enhanced real-world reasoning and transfer of knowledge (Green, Bean, and Peterson 2013). All of these examples involve very different student populations, but they all demonstrate (1) increased scaffolding for metacognitive engagement and (2) improved student learning. Moreover, by creating a network of peers and an environment in which research may be shared and discussed, the thesis-writing workshop brings important social aspects of research groups in STEM disciplines to the otherwise independent undergraduates in economics. In subsequent studies, we are testing the hypothesis that this increased structure directly promotes metacognition, which in turn enhances student learning (i.e., scientific reasoning).

One might wonder, with such positive learning outcomes, why the economics department does not require students to participate in the thesis-writing workshop. Although the measurable characteristics analyzed here do not indicate that any specific subset of the population is choosing to participate in the workshops, there are numerous affective and motivational factors that could play a role in a student's choice to participate and corresponding success. The independent path to the honors thesis may be effective for some, and preventing students from following this path may be counterproductive. Ultimately, instructors are motivated to invest time and attention to the workshops when the students are motivated, and student motivation is likely strongest when the workshop is optional.

EconTAP can act as a pedagogical resource in the workshop, as students in the research workshops may access the rubrics and content online. Additionally, we have discussed EconTAP as an assessment tool for discipline-based education research; indeed, it is the basis of virtually all the results presented here. An important extension of EconTAP as an assessment tool, however, actually leads back to pedagogy. The ability to quantitatively evaluate student learning outcomes

has allowed instructors in the economics department to learn from past decisions and make informed choices in future instruction. Such instructional reflection may further contribute to the improvement in scientific reasoning and writing skills observed over time. In other words, EconTAP provides the basis not only of the summative assessment of our analysis but also of the formative assessment used by instructors and departments for improved pedagogy.

## LIMITATIONS

Although we found that participation in the workshops was significantly related to scientific reasoning in thesis writing when controlling for a multitude of potentially conflating factors, our ability to control for students' incoming ability is limited by the factors to which we have access. It is possible that unmeasured differences between students who chose to participate in the workshops and those who did not played a role. A truly randomized study is not feasible, as it would create logistic and ethical challenges in the active-learning setting. Nonetheless, the thesis-writing workshops seem to be a positive intervention in the capstone research and thesis-writing experience in economics, in that they accommodate more students while simultaneously seeming to enhance scientific reasoning and writing skills.

## CONCLUSION

We find that the different pathways that students may undertake in conducting undergraduate research and writing their theses are indeed related to the assessment of students' scientific reasoning and writing skills reflected in their written theses. Students who engage with peers and share and discuss research in a structured workshop seem to exhibit the strongest learning outcomes. Even with increasing participation in undergraduate honors thesis research over the years, learning outcomes improve. The Department of Economics is successfully engaging students and improving the pedagogical resources available to them. Although this is an analysis of only a single institutional and departmental context, the connections that we have highlighted with other efforts in discipline-based education research suggest that this workshop, an intervention specifically designed to engage students' metacognitive skills, is a positive step for efficiently improving participation in honors research and enhancing students' experiences more broadly.



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