Teaching and Educational Methods

Teaching by the Case Method to Enhance Graduate Students' Understanding and Assessment of Wicked-Type Problems: An Application Involving the Bears Ears National Monument

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Abstract
This paper presents the results of a teaching project designed to enhance graduate-level agricultural and applied economics students' understanding of wicked-type problems, and the limitations of benefit-cost analysis (BCA) as an evaluation criterion for such problems. We employed the case method, a participatory, student-centered approach to teaching, wherein students work in groups to evaluate a case. The case used for this study focused on a wicked-type problem at the time that this study was being implemented, namely determining "What is the 'socially optimal' or preferred size of the Bears Ears National Monument?" The effectiveness of the case method in achieving expected student learning outcomes was assessed through the application of a sign test and a Wilcoxon signed rank test to students' responses on a pre- and post-survey. Student learning outcomes were further assessed using the grades received by students on an individual and group assignment. Overall, results suggested the case method is an effective tool for advancing students' understanding of wicked-type problems, but not necessarily for teaching students about the limitations of BCA as an evaluation criterion for such problems. It appeared students may have already been familiar with the limitations of BCA, prior to participating in the study.

1 Introduction

Graduates of agricultural and applied economics programs should be equipped with the skills and knowledge necessary to address real world problems. One way to achieve this is to implement a curriculum that makes use of interactive, student-centered approaches to teaching and learning economic concepts and analysis techniques (Becker 2000). Academia has made progress in this area, noted by efforts to shift away from traditional chalk and talk instructional methods toward more active and interactive approaches to teaching and learning (e.g., games, labs, classroom discussions, and experiments; Watts and Becker 2008). However, there remains a need to educate students on how to go about analyzing and providing solutions to wicked-type problems (Batie 2008).

Wicked-type problems are characterized as being complex, ill-structured problems often too difficult to approach using standard reductionist analytical tools and techniques (Rittel and Webber 1973; Klamer 2007; Batie 2008). Wicked-type problems emerge almost daily in the field and sub-fields of agricultural and applied economics. Examples include complex problems related to public lands management, food security and poverty, climate change, and federal farm bill policies that affect agribusiness operations and many other sectors of the economy. As of 2008, however, the skills necessary to undertake and properly examine such problems were sparsely being included as part of the applied economics curriculum (Batie 2008). Students at the time were found to be thoughtlessly applying

models, not examining possible alternative criteria with which to evaluate complex problems, or reflecting on the nature of the science when assessing complex problems (Klamer 2007; Batie 2008).

Our independent review of the literature revealed several recent attempts to get agricultural and applied economics students to think critically, carefully, and "outside the box" when applying economic concepts and conducting economic analysis to solve complex problems; for example, see Hertel (2020), Riley (2020), Simmons (2020), and Lacy et al. (2020).[1] However, the same literature review did not reveal any formal attempts to teach (or procedures for teaching) students how to undertake and examine complex problems deemed to be wicked in nature from the perspective of an applied economist (i.e., using their economics "toolkits").

Recently, Morreale and Shostya (2021) provided an organizational framework for teaching students enrolled in an undergraduate capstone course how to manage the complexities presented by social policy problems. In another recent study, Hoffman et al. (2021) examined how reflective engagement approaches to learning contribute to students' understanding of wicked-type problems. While the Hoffman et al. (2021) study does address methods for teaching students about wicked-type problems, the study focused on the use of reflective engagement as a teaching strategy and does not focus on teaching practices specific to applied economics (Hoffman et al. 2021).

We contribute to the literature on teaching methods applied to wicked-type problems, by first describing and presenting the components of a teaching project designed to enhance graduate-level agricultural and applied economics students' understanding of: (1) wicked-type problems including their characteristics; and (2) the limitations of using standard reductionist analytical techniques, namely benefit-cost analysis (BCA) as an evaluation criterion for such problems (see Section 3). Second, we present the results of an analysis conducted to assess the effectiveness of the case method approach to teaching in meeting the teaching project's main objectives as they relate to a set of expected student learning outcomes (see Sections 4 and 5).

The case method is a participatory, student-centered, problem-based, approach to teaching and learning, wherein students are presented with a case and asked to provide recommendations as to potential solutions (Carlson and Schodt 1995; Carlson 1999; University of Illinois Board of Trustees et al. 2020). For this teaching project, the case presented to students was focused on the complex nature of the decision to designate and subsequent actions taken to resize the Bears Ears National Monument (BENM).[2] Role playing as members of private consulting firms, students were tasked with examining the case and providing recommendations for a wicked-type problem needing to be addressed, namely determining "What is the 'socially optimal'[3] or preferred size of the BENM?" Choices as to what size of the BENM should be considered "socially optimal" or preferred were confined by the size designations of the BENM established by the time that the teaching project had begun (Spring 2018): ~1.35 million (M) acres or ~0.2 M acres.

While not without criticism (e.g., see Shugan 2006; Foster and Carboni 2009), the case method approach to teaching has been shown to promote more effective learning and enhance long-term retention of the subject matter (Bruner 1991; Christensen, Garvin, and Sweet 1991). By allowing students to develop the framework used to provide a solution to the case presented, the case method approach to teaching builds a capacity for critical thinking (Bruner 1991) and improves student engagement inside of the classroom (Nkhoma, Sriratanaviriyakul, and Quang 2017). Following the case method, students who

[1] This list of recent research by no means represents an exhaustive list of attempts to get students to think outside the box in applying the science of applied economics. It does, however, point to progress made in the field and sub-fields of agricultural and applied economics, noted by recent publications in Applied Economics Teaching Resources (AETR).

[2] For more background information on the Bears Ears National monument, see Section 2.

[3] We put "socially optimal" in quotes as we are not necessarily referring to the strict definition of a "social optimum" from economic theory such as a Pareto Efficient solution or the solution to a constrained social welfare maximization problem as in the classic article by Bator (1957).

participated in this teaching project took an active role in evaluating the case. The instructor and teaching assistant acted only as the facilitators, providing students with some background information on the case, developing assignments, and answering questions as needed (Bruner 1991).

The effectiveness of the case method was assessed in terms of students having gained an understanding of wicked-type problems and the limitations of using BCA to assess and provide solutions to such problems, following the criteria outlined by the expected student learning outcomes using the results of a sign test and a Wilcoxin signed rank test. Both tests were applied to responses received by students on a pre- and post-survey administrated as part of the study conducted for this teaching project and described in more detail later in this paper.[4] Responses from students are considered collectively and individually, by each semester that the study conducted for this teaching project was implemented. The effectiveness of the case method in terms of meeting expected student learning outcomes was also assessed using grades received on an individual take-home assignment, as well as grades received on, and recommendations provided by students during final oral presentations.

Overall, our results suggest teaching by the case method positively impacted students' understanding of wicked-type problems in terms of meeting four of the five expected student learning outcomes. The case method, as it was applied for this study, however, did not have a significant effect on students' understanding of the limitations of using BCA to assess and provide solutions to wicked-type problems. The result is perhaps due to students already being familiar with BCA limitations prior to participating in the study conducted for this teaching project.

2 Wicked Nature of Assessing the "Socially Optimal" or Preferred Size of the BENM

The BENM is located in San Juan County, Utah. It was established via presidential proclamation in December 2016. Originally, the BENM encompassed approximately 1.35 M acres of federally managed land. In December 2017, however, a decision by the administration at the time resulted in the BENM being resized to include just over 0.2 M acres (Turkewitz and Friedman 2017). Four years later the question of what size the BENM should be was once again up for debate, as a new administration has established plans and is actively pursuing a review of the 2017 decision to resize the BENM (Gessner 2021; Maffly and Podmore 2021; McCombs and Whittle 2021).[5]

The original decision to designate and the subsequent decision to re-size the BENM were both based on the results of formal reports prepared by Secretaries of the Department of the Interior (DOI) at the time, Jewell (2013 to 2017) and Zinke (2017 to 2019), respectively. Reports prepared included assessments of the environmental and economic impacts resulting from the decision to establish and then reduce the size of the BENM (Jewell and Vilsack 2016; Zinke 2017). To provide a proper assessment, consideration had to be given to the interest of multiple stakeholder groups including: (1) local Native American tribes who frequent the area to collect traditional herbs and visit sacred sites; (2) local ranchers, miners, and timber harvesters who rely on the area for economic productive purposes; and (3) industries including recreation and tourism who derive economic benefits from increased visitation to the BENM (Jewell and Vilsack 2016; Zinke 2017).

As would be expected with any wicked-type problem, the views, values, opinions, and beliefs of what BENM size or footprint should be considered "socially optimal" or preferred varied by stakeholder

[4] Supporting literature for questions included on the pre- and post-survey included but were not limited to Batie (2008) and Rittel and Webber (1973).

[5] On inauguration day, the current president ordered the current Secretary of the Interior, "to in consultation with the Attorney General, the Secretaries of Agriculture and Commerce, the Chair of the Council on Environmental Quality, and Tribal governments, to conduct a review of the monument boundaries and conditions that were established by each previous presidential proclamation and determine whether restoration of the monument boundaries and conditions that existed as of January 20, 2017, would be appropriate" (Biden 2021).

group (Horn and Weber 2007; Batie 2008). For example, the decision to designate the Bears Ears area as a national monument in 2016 was supported by members of the inter-tribal coalition, given the monument status provided an additional layer of protection to cultural and historical artifacts in the area (Larsen 2016). While local lawmakers agreed that cultural and historical artifacts contained within the Bears Ears area deserve protection, they disagreed with the 2016 decision to designate the area as a national monument, stating "local officials were better suited to care for, preserve, and manage sacred artifacts within the site than the federal government" (Larsen 2016).

Under the original 2016 designation, the U.S. Forest Service (USFS) was not permitted to issue any new permits or leases for livestock grazing, timber harvesting, or mining which left many local ranchers and miners concerned over how the national monument status might end up compromising the land uses they had already built their businesses around (Buhay 2017). Furthermore, while designed to offer an additional layer of protection to the area, land use restrictions brought on by the national monument status raised concerns from many Utah residents. Of primary concern for the Utah residents was that the designation would cause long-term economic harm by not allowing for extraction of economically valuable and feasible resources, such as uranium, which could provide revenue to the state (Buhay 2017; Quinlan 2017).

Last, while the original designation of the BENM in 2016 still permitted recreational activities, many people felt the seasonal, service-industry jobs supported by the recreation and tourism industry would not compare to year-round opportunities for employment that could be possible in the absence of the national monument designation (Buhay 2017). Others suggested increased recreation and tourism visits to the area brought about by the 2016 national monument designation could yield positive economic benefits for the area, but noted that as a national monument, the federal government would be responsible for providing resources to the area to support increased recreation and tourism (Zinke 2017).

The discussion above highlights the need for an interdisciplinary, cross collaborative approach to assessing and providing recommendations as to which size of the BENM should be considered "socially optimal" or preferred. Thus far, attempts to determine a solution as to the "socially optimal" or preferred size of the BENM have only resulted in other problems and issues. For example, following the 2016 decision to designate the Bears Ears as a national monument, Utah Attorney General, Sean Reyes announced plans to partner with the Utah Governor's office, the federal and state legislators, and San Juan County, to file a lawsuit challenging the 2016 designation decision (Kaufman 2016). Following the 2017 decision to reduce the size of the BENM, five members of the inter-tribal coalition filed a lawsuit against members of the administration at the time, citing an "unlawful attempt to revoke and replace a national monument of major historic and scientific importance in violation of the United States Constitution and the Antiquities Act of 1906" (Campbell 2017).

Determining the "socially optimal" or preferred size of the BENM represents a wicked-type problem for multiple reasons. First, increasing or decreasing the size of the BENM has complex and mixed effects on the various stakeholder groups involved. Second, as with any wicked-type problem, the consequences of BENM management actions are not able to be fully realized until after a designation and the rules governing that designation are in place. For example, there is considerable risk (e.g., the potential for looting and vandalism) and uncertainty involved in allowing or preventing economic activities to occur within and around the BENM. Third, there are no easy solutions for the BENM sizing problem as there is literally no "one size fits all" solution, and each candidate for a "socially optimal" or preferred size may generate additional problems including legal, ethical, and political problems.

Thus, when assessing and providing recommendations as to the "socially optimal" or preferred BENM size, students need to carefully consider the wicked nature of the problem being presented. Although it would be convenient to determine which size of the national monument should be considered "socially optimal" or preferred following a simple BCA decision rule, such as "approve the original size of national monument (1.35 M acres) over the current size (0.2 M acres) if the net present value (NPV) is

greater than zero," a decision rule such as this on its own might not be satisfactory. However, as suggested by Klamer (2007) and Batie (2008), the methods underlying BCA represent an analytical framework that most students are familiar and comfortable with applying. Moreover, what students may lack is a deeper understanding of the role of the economist in addressing and identifying alternative criteria with which to assess problems that are wicked. Using the case method as a pedagogical means for teaching, we introduce students to the wicked nature of such a problem as determining the "socially optimal" or preferred size of the BENM, and the limitations of only using BCA to assess and provide recommended solutions for such a problem.

3 Implementing the Case Method Approach and Expected Student Learning Outcomes

To implement the case method, at the start of the semester, students were randomly divided into groups, referred to for the purpose of the teaching project, as hypothetical "private consulting firms." In their role, playing as members of their respective private consulting firms, students were presented with their "scope of work," which included a description of the case and informed them that their firm had been selected to assess the change in the size of the BENM on different resource areas using alternative quantitative and qualitative assessment methods (more detail provided below).

Students were instructed that at the end of the semester they would, together with the other members of their group (i.e., the other colleagues at their firm), present the results of an assessment and provide recommendations as to the "socially optimal" or preferred size of the BENM to an interagency BENM task force. The course professor (instructor) and teaching assistant role played as members of the interagency BENM task force. The reason for specifying an interagency task force as the "client" in this case is that the BENM is jointly managed by the Bureau of Land Management under the U.S. DOI, and the USFS under the U.S. Department of Agriculture.

Before starting on their group (consulting firm) work, students received verbal instructions on the policy/decision-making process wherein the role of a professional economist is to provide information and professional advice to the people who have the authority to make policy and management decisions, such as public land managers, the United States Congress, and the President of the United States (POTUS). The role of the professional economist as an objective analyst and purveyor of information to facilitate the policy and management process, as described by Bergstrom and Randall (2016, Chapters 4 and 22), was emphasized to students throughout the semester. In this role, professional economists are aware of politics and political pressure and influence but are not political and do not apply political pressure or influence themselves.

It was made clear to students that economic analysis is only one input into public policy decisions, such as setting the size of the BENM, and that such decisions typically consider the "triple bottom-line" of economic, environmental, and ethical/social effects. It was also made clear to students that the ultimate decision as to the "socially optimal" or preferred size of the BENM would be made by the POTUS under the authority granted to them via the United States Antiquities Act.[6]

Table 1 includes a list of the case method teaching materials used for this project.[7] The materials are designed to walk students through how to assess a wicked-type problem from the perspective of an applied economist. Together the materials provide an outline of how to conduct an economic assessment of a policy or management problem or issue, such as determining the "socially optimal" or preferred size of the BENM. Pre- and post-surveys were used to assess students' understanding of wicked-type problems and the limitations of using BCA to assess and provide solutions to such problems, both before

[6] Recently, President Biden appointed a multistakeholder type of "task force" to review the designation of the BENM with different sizes under the Obama and Trump Administrations to ultimately provide him with input and advise on his ultimate decision of what size he will keep or change for the monument.

[7] To access copies of the course materials, see the Teaching Note.

and after participating in the study.

Table 1. List of Case Method Teaching Materials Used for Wicked-Type Problems Teaching Project[a]

Case Method Teaching Materials	Description of Case Method Teaching Materials
1. Consent Form and Pre-Survey	The consent form provided important information about the study being conducted and requested for the students' agreement to participate and have their data collected. The pre-survey provided a list of declarative statements about wicked-type problems, the limitations in using benefit-cost analysis to assess and provide solutions to such problems, as well as students' preparedness in assessing such problems. The pre-survey was used to assess students' understanding prior to participating in the study.
2. Virtual Information Packets	Virtual information packets included research studies and general information related to the Bear's Ears National Monument including the controversy surrounding the decisions to designate and then resize the national monument, as well as general information on wicked-type problems.
3. Four Case Method Exercise Worksheets	The four case method exercise worksheets introduced key concepts related to conducting an economic assessment including: (1) identifying goods and services supported by an area of interest; (2) the "with" and "without" principle; (3) theoretically appropriate welfare measures for changes in market and nonmarket goods and services; and (4) market and nonmarket empirical valuation techniques, decision-making criteria, and potential quantitative and qualitative analysis tools available to applied economists.
4. Individual Take-Home Assignment	The individual take-home assignment was an assignment wherein students were tasked with conducting a benefit transfer application to assign values to the changes in goods or services supported by the area of interest (i.e., the Bears Ears National Monument [BENM]) between the two competing sizes of the BENM being evaluated. Results were used to inform final oral presentations.
5. Mid-Semester Check-in Progress Report Memo	The mid-semester check-in progress report was an assignment wherein students were asked to report progress on their final oral presentations including providing a list of the changes in ecosystem goods and services identified by their group, the theoretically appropriate welfare measures for assessing changes in the goods and services identified by their group, and their associated willingness-to-pay or willingness-to-accept compensation measures.
6. Final Oral Presentation Assignment	The final oral presentation assignment provided instructions for completing and presenting the final oral presentations including the form of the presentation, required presentation outline, the number of changes in goods and services needing to be identified by each group, and the time limit for the presentations.
7. Individual Peer Evaluation Form	The individual peer evaluation forms were filled out by each student for each member of their group. They provided an assessment of students' progress and performance by other students, specifically members of their group.

8. Post-Survey	The post-survey was identical to the pre-survey and used to assess students' understanding after participating in the study.

[a] Copies of all items and more information can be found in the Teaching Note.

Virtual information packets were provided to students via the course website and made available following the class period wherein the pre-surveys were completed by the students. The information included in each virtual information packet provided was identical. Case method exercise worksheets were completed by students with other members of their group (private consulting firm) on predesignated case method exercise days.[8] The case method exercise worksheets also provided a medium with which students could collect the data and other information necessary to complete their final oral presentations.

For their final oral presentations, members of each private consulting firm were required to evaluate the difference between the "with" and "without" net economic value of eight separate changes in ecosystem goods and services supported by the BENM area, considering two separate states-of-the-world (e.g., two separate policy scenarios):

> *State-of-the-world A*: The "without" policy scenario state-of-the-world, which we define as the current (e.g., year 2020) size of the BENM equal to ~0.2 M acres;
>
> *State-of-the-world B*: The "with" policy scenario state-of-the-world, which we define as the subsequent size of the BENM equal to ~1.35 M acres,[9]

and determining which state-of-the-world represented the "socially optimal" or preferred size of the BENM. Students were in charge of researching and identifying the types of goods and services supported by the BENM on their own and then choosing eight changes to analyze. The only stipulation on the eight changes in ecosystem goods and services chosen to be analyzed was that at least one change had to be identified for each of the six categories outlined in the case method exercise worksheets: (1) Recreation; (2) Wilderness; (3) Timber or Minerals; (4) Grasslands; (5) Waterways; and (6) Ceremonial/Historical/Cultural.

Given the time and budget constraints of this project, to complete their individual take-home assignments, students relied on secondary data from the 2016 Updated Recreation Use Values Database (RUVD) from Oregon State University, the Environmental Valuation Reference Inventory (EVRI), and other sources obtained via their own literature reviews. Results from the benefit transfer applications were used to inform a BCA to be conducted by each group (private consulting firm) assessing a change in the size of the BENM going from State-of-the-world A to State-of-the-world B. The results of the BCA were to be presented during the group's final oral presentations. Presentations were to be prepared and presented as a formal policy brief to members of the BENM interagency task force at the end of the semester.

A review of the BENM characteristics presented in Section 2 provides support for the potential difficulty in using only one analysis technique, such as BCA, to determine whether State-of-the-world A or State-of-the-world B should be considered "socially optimal" or preferred. To meet the suggestions of Klamer (2007) and Batie (2008), students were tasked with identifying and applying at least two other quantitative or qualitative analysis techniques, in addition to BCA, to assess which state-of-the-world

[8] Case method exercise days were determined by the instructor and teaching assistant prior to the start of the semester. Students were informed at least one week in advance of the date.

[9] We purposely chose the generic "State-of-the-world A" and "State-of-the-world B" terms to help students objectively assess the problem at hand of determining the "socially optimal" or preferred size of the BENM, rather than (hopefully) being distracted one way or the other by political feelings and allegiances.

should be considered "socially optimal" or preferred. Following the case method, the students had full autonomy over deciding which additional analysis techniques would be used by their groups. The only stipulation was that at least one of the techniques had to be quantitative and at least one had to be qualitative (e.g., social justice analysis).[10]

Analysis techniques chosen were to be discussed during each group's final presentation (formal policy brief) in terms of how the techniques were used, including caveats and limitations, to recommend the "socially optimal" or preferred size of the BENM. To assist students in understanding that "socially optimal" or preferred size can mean different things to different people, especially non-economists, over the course of the semester students were introduced to different types of decision-making criteria typically taught in an applied welfare economics course including Pareto Efficiency, Pareto Improvement, Maximum Value of Social Welfare (Well-Being), and Potential Pareto Improvement.

To track the progress of each group in completing the requirements for their final oral presentation, the mid-semester check-in progress report was assigned. To motivate students to participate in their groups and discourage the free-rider problem, following the final oral presentations students completed individual peer evaluations for each member of their groups prior to presenting with their groups. The results from the individual peer evaluations were factored into each student's individual final oral presentation assignment grade. Individual peer evaluations focused on student effort, participation, cooperativeness, and most importantly communication.

All of the teaching materials described above and listed in Table 1 are available to instructors of agricultural and applied economics (or one of its sub-fields) who are interested in teaching students how to address wicked-type problems using the case method. Instructors who adapt this teaching project for their courses can change the terminology if so desired to better suit their course structure and preferences. For example, perhaps using the term "socially preferred" may help avoid confusion with the strict meaning of "socially optimal" from economic theory. Interested instructors could also modify the case being used, by adopting a different wicked-type or complex problem to be addressed by students.

Expected student learning outcomes from participation in the study included a gained understanding of:

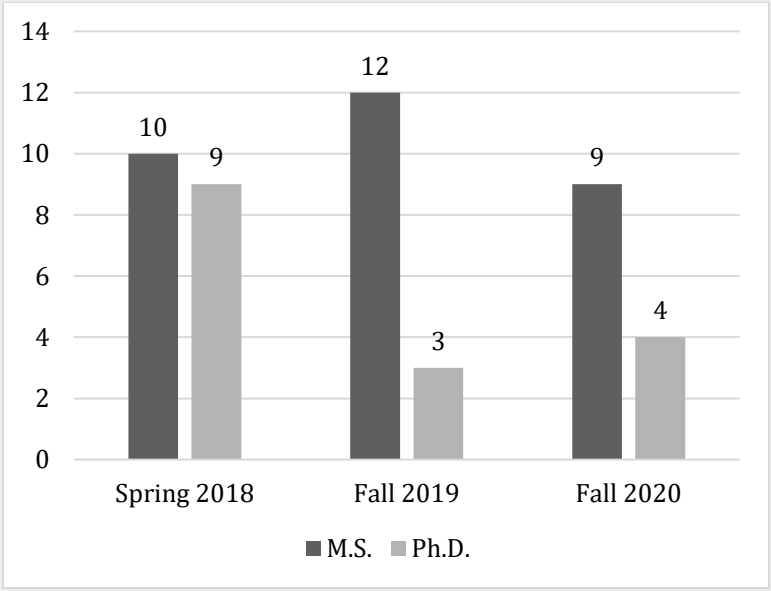
> **L1**: the general complexity presented by wicked problems and the characteristics common among problems considered to be wicked in nature;
>
> **L2**: how proposed solutions to a wicked problem may differ based on the viewpoints of the different stakeholder groups being considered, and how when tasked with addressing a wicked problem, it is important to manage and consider the viewpoints of the multiple stakeholder groups and where those stakeholder groups assign value;
>
> **L3**: an improved ability to assess wicked problems including how the application of economic principles can and cannot be used to inform decision making regarding wicked problems;
>
> **L4**: recognizing the limitations of traditional economic assessment methods, namely as BCA and identifying alternative assessment methods; and

[10] Our goal with respect to allowing them to choose the criteria is two-fold. First, as graduate-level economists in training, it is imperative that they can adequately choose from a set of evaluation criteria. Second, by presenting the results from two or more criteria, students should be able to see how the criteria chosen can influence results and policy recommendations.

L5: how to undertake applications that involve the integration of both quantitative and qualitative analysis techniques during the decision-making process for a wicked-type problem.

4 Study Design, Data Collection, and Empirical Approach

The study conducted as part of this teaching project was implemented three times (during three separate semesters: Spring 2018, Fall 2019, and Fall 2020) in a graduate-level applied economics course taught in the Department of Agricultural and Applied Economics at the University of Georgia.[11] Study participants included 47 graduate students. Nineteen students participated in Spring 2018, 15 students participated in Fall 2019, and 13 students participated in Fall 2020. Figure 1 provides a count of the number of M.S.



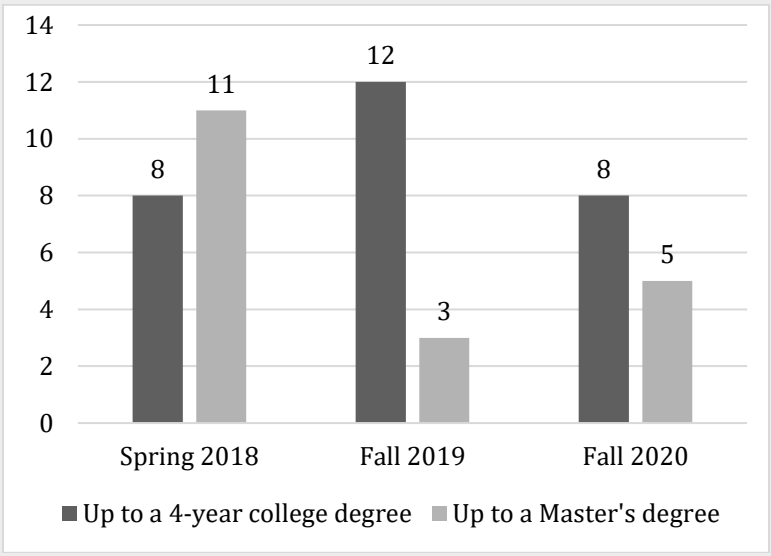


Figure 1. Number of M.S. and Ph.D. Students Participating in the Teaching Project by Semester and Number of Students Having Completed up to a 4-Year College Degree or Master's Degree by Semester

[11] The course is designed to introduce students to economic valuation theory and techniques with applications primarily to natural resource and environmental policy and management issues and problems. The course is open to graduate students both inside and outside of the department. Having passed a graduate-level microeconomic theory course is a prerequisite to enroll.

and Ph.D. students who participated in the study during each semester, as well as the highest degree completed by students who participated in each semester.[12]

In Spring 2018 and Fall 2019, in-person classes were held and hard copies of all case method teaching project materials (see Table 1), excluding the virtual information packets, were provided to students. In Fall 2020, in accordance with the university's COVID-19 guidelines, classes were held virtually via the Zoom online conferencing platform, and all classroom materials were provided to students electronically.[13] On the first day of each semester, during which this teaching project was being implemented, students were informed of the study and asked, following university human subjects research protocol, whether they agreed to participate in the study. All students enrolled in the course consented to participate in the study.[14, 15]

Students were then asked to complete a pre-survey. The pre-survey provided students with the following definition of wicked problems: "A wicked policy problem is a problem that is difficult or impossible to solve due to incomplete or contradictory knowledge and the number of stakeholders involved (e.g., people with opposing value, beliefs, and opinions). Wicked policy problems are often interconnected with other problems." Students were then asked to state whether they "strongly agreed," "agreed," "neither agreed nor disagreed," "disagreed," or "strongly disagreed" with a series of true statements related to wicked problems.

The pre-survey also provided students with the following definition of BCA: "Benefit-Cost Analysis (BCA) is an organizational framework used to identify, quantify, and compare the costs and benefits of a proposed policy or project. The final decision 'rule' is informed by a comparison of the total costs and benefits of the particular policy or project of interest." Students were then asked to state whether they "strongly agreed," "agreed," "neither agreed nor disagreed," "disagreed," or "strongly disagreed" with a series of false statements about the ability of BCA in addressing and providing a solution to a wicked problem.

The pre-survey also included a series of questions related to whether the responding student was familiar with wicked-type problems prior to participating in the study, and whether they had previously received formal training on how to assess wicked-type problems or utilize BCA in a previous course. A series of sociodemographic questions were also included in the survey. Over the course of the semester students were presented with the case method teaching materials outlined in Table 1. Following the completion of their final oral presentations, each student was provided with a copy of the post-survey. The post-survey was identical to the pre-survey. Table 2 provides a complete list of all questions included on the pre- and post-survey.

[12] While we could potentially use these responses to determine the number of M.S. students who are in the process of competing their second M.S. degree or the number of Ph.D. students who had previously completed or not completed an M.S. degree, university human subjects research protocol prevents us from matching student responses to personally identifiable information not already included in the survey. For future iterations of this study, we suggest including an additional question that asks students to reveal if they are an M.S. or Ph.D. student.

[13] The teaching note provides information on how the course and case method teaching materials were delivered in person vs. online across the three semesters.

[14] While all students consented to participate in the study, during the first semester (Spring 2018) one student who consented to participate dropped the course. Data for this student are not included in the study.

[15] Approval to conduct the study was obtained from the University of Georgia Institutional Review Board. Following university human subjects research protocol, students were not required to consent to having their data collected as part of the course. However, all students enrolled in the course were required to complete all the assignments associated with the study (see Table 1) since assignments were part of the graded requirements for the course.

Table 2. List of Questions Included on the Pre-Survey and Post-Survey Used to Assess Students' Understanding of Wicked-Type Problems, the Limitations of Benefit-Cost Analysis in Assessing and Providing Solutions to Such Problems, and Students' General Familiarity with Wicked-Type Problems Prior to and after Participating in the Teaching Project

Question #	Label	Statement
		Questions Related to Wicked-Type Problems
1	Recognize	The term "wicked problems" is not well recognized or discussed in the field of applied economics.
2	Simple	The solutions to wicked policy problems can be boiled down to a simple calculation (e.g., net present value calculation).
3	Disciplines	Wicked policy problems often span multiple disciplines.
4	BetterWorse	Solutions to wicked problems are not true-or-false, but better or worse.
5	Exhaustive	Wicked problems do not have an exhaustive set of potential solutions, nor is there a well-described set of permissible operations that may be considered when reaching a solution.
6	Assumption	It is important to consider what assumptions realistically hold when solutions to wicked problems are determined.
7	Present	The solution to a wicked policy problem could be influenced by how the problem is presented.
8	Imperative	It is imperative the graduate students studying applied economics receive formal training on how to deal with, account for, and solve wicked policy problems.
9	Training	Prior to this study, you received formal training on how to solve wicked policy problems in either an economics, applied economics, or other course taught here at the university.
10	Familiar	Prior to this study, you were familiar with wicked policy problems.
		Questions Related to Benefit-Cost Analysis
11	Appropriate	Benefit-cost analysis is an appropriate and effective tool that can be used to reach a conclusion regarding whether or not to pursue an economic policy or project involving a wicked problem.
12	Rely	No matter the context of the problem at hand, an economist can and should always rely on the results of benefit-cost analysis to support their policy recommendations.
13	Only	As a graduate student in applied economics, you should plan to analyze any economic policy or project using only benefit-cost analysis.
14	Leading	The results of a benefit-cost analysis exercise should always be the leading factor in the decision of whether or not to approve an economic policy or project involving a wicked policy problem.
15	Identify	When a conducting benefit-cost analysis, it can be difficult to identify and measure all relevant commensurable benefits and costs that can be monetarized.
16	Sufficient	You have received sufficient training on how to solve policy problems using benefit-cost analysis in either an economics or applied economics course here at the University of Georgia.

Table 2 continued.

Question #	Label	Statement
		Sociodemographic Questions—Response Options in Parentheses
17	Gender	Which most accurately describes your gender? (Male =1; Female = 0)
18	Age	What is your age?
19	Schooling	What is the highest level of schooling you have completed? (2-year college degree = 1; 4-year college degree = 2; Master's degree = 3)
20	Career	Which career path most accurately represents your plans after graduation? (Private Sector = 1; Academia = 2; Federal Government = 3; Other = 4)
21	Hours	How many hours a week on average do you spend studying outside of school? (1–5 hours = 1; 6–10 hours = 2; 10–15 hours = 3; 15–20 hours = 4; More than 20 hours = 5)
22	Professional	Are you a member of a professional economics organization? (Yes = 1; No = 0)
23	Environmental	Are you a member of an environmental group or organization? (Yes = 1; No = 0)

A sign test and a Wilcoxon signed rank (WSR) test were applied to student responses on the pre- and post-surveys to assess whether the case method, as it was applied, was an effective tool for enhancing students' understanding of wicked-type problems in terms of meeting the expected student learning outcomes outlined above, including a gained understanding of the limitations of using BCA to assess and provide solutions to such problems. Both the sign test and Wilcoxon signed rank test are used frequently to analyze paired observation data (i.e., observations from the same individual at two different points in time; Wilcoxon 1945; Snedecor and Cochran 1989; Rosner, Glynn, and Lee 2006).

To implement both tests, responses by each student i to each question j in Table 2 were coded as follows: "strongly disagree" = 1; "disagree" = 2; "neither agree or disagree" = 3; "strongly agree" = 4; and "disagree" = 5.[16] The term d_{ij} was defined as the difference between any matched pair of responses, x from student i, to question j such that,

$$d_{ji} = \left(x_{preji} - x_{postji}\right). \tag{1}$$

The sign of the difference for any matched pair of responses by each student i was estimated following (2)

$$sgn\left(d_{ji}\right) = \begin{cases} - & if\ \left(x_{preji} - x_{postji}\right) < 0 \\ 0 & if\ \left(x_{preji} - x_{postji}\right) = 0 \\ + & if\ \left(x_{preji} - x_{postji}\right) > 0 \end{cases}. \tag{2}$$

The sign test examines the equality of matched pairs by observation to a series of questions (Snedecor and Cochran 1989). Making no further assumptions regarding the distribution of individual responses,

[16] See Figures 1a through 16a in the appendix for an overview of the frequency of responses of "strongly disagree," "disagree," "neither agree or disagree," "strongly agree," and "disagree" on the pre- and post-survey together, when the class was taught in person (Spring 2018 and Fall 2019), when the class was taught online (Fall 2020), and when responses across all three semesters (Spring 2018, Fall 2019, and Fall 2020) are considered together.

the sign test can be used to investigate whether differences in responses to an individual question between the pre- and post-survey can be observed.

Following the sign test, the null hypothesis that the median of differences in responses between the pre- and post-survey to a single question is zero, can be tested against the one-sided alternative hypothesis that the median of differences in responses is positive (i.e., H_0: median of $(x_{preji} - x_{postji}) = 0$ vs. H_A median of $(x_{preji} - x_{postji}) > 0$); the median of differences in responses is negative (i.e., H_0: median of $(x_{preji} - x_{postji}) = 0$ vs. H_A median of $(x_{preji} - x_{postji}) < 0$); or tested against the two-sided alternative hypothesis that the median of differences in responses is different from zero (i.e., H_0: median of $(x_{preji} - x_{postji}) = 0$ vs. H_A median of $(x_{preji} - x_{postji}) \neq 0$). Results of the sign test are presented in terms of the number of times (frequency) in which a response on the pre-survey exceeded a response on the post-survey (i.e., $\sum_{i=1}^{n} sgn(d_{ji}) > 0$); a response on the pre-survey did not exceed a response on the post-survey (i.e., $\sum_{i=1}^{n} sgn(d_{ji}) < 0$); or a response on the pre-survey did not differ from a response on the post-survey (i.e., $\sum_{i=1}^{n} sgn(d_{ji}) = 0$).

On the pre- and post-survey, questions 1 through 7 represent true statements about wicked-type problems. Following the sign test, more negative differences in responses to each question 1 through 7 between the pre- and post-survey lead to a rejection of our first null hypothesis (H_{01}) in favor of our first alternative hypothesis (H_{A1}) that the case method is an effective tool for enhancing students' understanding of wicked-type problems. The first null hypothesis (H_{01}) we tested is related to expected student learning outcomes L1, L3, and L4.[17]

Questions 11 through 14 represent false statements about the applicability of BCA in assessing and providing solutions to wicked problems. Following the sign test, more positive differences in responses to each question 11 through 14 between the pre- and post-survey led to a rejection of our second null hypothesis (H_{02}) in favor of our second alternative hypothesis (H_{A2}) that the case method is an effective tool for teaching students about the limitations of BCA in assessing and providing solutions to wicked-type problems. The second null hypothesis we tested is related to the expected student learning outcome L2.

For the WSR test, we considered the absolute value of the signs of d_{ji} from (2) and let r_i represent the signed rank as follows:

$$r_i = sgn(d_{ji}) * rank(|d_{ji}|) . \quad (3)$$

The WSR test statistic, W was then calculated as,

$$W = \sum_{i=1}^{n} r_i \quad (4)$$

for each question. Following the WSR test, if the absolute value of W exceeded the critical value at the pre-designated 0.05 level of confidence, we failed to reject our null hypotheses in favor of our alternative hypotheses, supporting the case method as an effective tool for enhancing students' understanding of wicked-type problems including a gained understanding of the limitations of BCA in assessing and providing solutions to such problems.[18]

During their final presentations, each group was asked to state why determining the "socially optimal" or preferred size of the BENM may represent a wicked-type problem. As such, responses to this question and the grades received on the final oral presentations were used to further assess whether

[17] Based on the way student responses are coded, a negative difference in a response between the pre- and post-survey, implied that the student's response was closer to "agree" or "strongly agree" on the post-survey than it was on the pre-survey.
[18] Responses to questions 8, 9, 10, 15, and 16 were not evaluated using a sign test or a WSR test because these questions refer to student's perceived familiarity with wicked problems and BCA and preparedness in applying and utilizing BCA.

students gained an understanding of wicked-type problems through participation in the study and whether expected student learning outcomes L1 through L4 were met. Moreover, during their final oral presentations, students were asked to discuss the advantages and limitations of each additional criteria chosen by their group to evaluate the problem, including an explanation as to why additional criteria were chosen based on the wicked nature of the problem being addressed. Expected student learning outcome L5 was assessed using responses to the above questions, as well as grades received by the students on their final oral presentations.

5 Analysis Results and Discussion

Table 3 presents the summary statistics for responses by students to questions on the pre- and post-survey. Overall, approximately 62 percent of the students who participated in the study identified as being male, while 38 percent identified as being female. Across the three semesters, the age of student participants ranged from 21 years old to 36 years old, and students spent an average of 11 to 15 hours a week studying outside of school. Compared to when the course was taught in-person (Spring 2018 and Fall 2019), more students who participated in the online version of the course (Fall 2020) were members of an environmental or professional economics organization. Overall, most students planned to pursue a career in academia upon graduation.

Review of the pooled responses on the pre-survey indicated prior to participating in the study, 33 (~70 percent) of the students agreed or strongly agreed with the statement in question 8 that "It is imperative the graduate students studying applied economics receive formal training on how to deal with, account for, and solve wicked policy problems." Of the 33 students who agreed, 18 had completed up to a four-year college degree, and 15 had completed up to a master's degree. After participating, 40 (~85 percent) of the students agreed or strongly agreed with the statement in question 8. Only 2 of the 33 students who agreed or strongly agreed with the statement in question 8, prior to participating in the study, did not agree or strongly agree with the same statement after participating.[19]

Across the pooled responses, 39 (~80 percent) of the students disagreed, strongly disagreed, or neither agreed nor disagreed with the statement in question 10 that "Prior to this study, they were familiar with wicked policy problems." Of these 39 students, 27 (~69 percent) indicated they also had not yet received sufficient training on how to solve policy problems using BCA, as observed by their responses to question 16. Across the pooled responses, only 13 (28 percent) students indicated prior to this study, they had received formal training on how to solve wicked policy problems in either an economics, applied economics, or other course taught at the university, as observed by their responses to the statement included in question 9. Of these 13 students, 3 (23 percent) indicated they were a member of a professional economics organization; 1 (8 percent) indicated they were a member of environmental organization; and 9 (69 percent) indicated they were neither a member of a professional economics or an environment organization.

Table 4 provides the results of sign test applied to student responses on the pre- and post-survey for all semesters (pooled), for semesters when the course was taught in-person (Spring 2018 and Fall 2019), and for semesters when the course was taught online via Zoom (Fall 2020). Results of the sign test (see columns labeled as M1 in Table 4) applied to questions 1 through 7 suggest when responses by all students are considered (i.e., pooled responses) more negative differences than positive differences in responses are observed for all but one question—question 1, which stated: "The term 'wicked problems'

[19] The two students who did not agree or strongly agree with the statement in question 8 after participating in the study but did agree or strongly agree with the statement in question 8 prior to participating in the study changed their response to "neither agree nor disagree" after participating.

Table 3. Summary Statistics for Responses by Students to Questions on the Teaching Project Pre- and Post-Surveys[a]

Question Label	Pre-Survey Response Means				Post-Survey Response Means				Question Label	Sociodemographic Means			
	Pooled	Spring 2018	Fall 2019	Fall 2020	Pooled	Spring 2018	Fall 2019	Fall 2020		Pooled	Spring 2018	Fall 2019	Fall 2020
Recognize	3.30	3.53	3.20	3.08	2.83	2.68	3.13	2.69	Gender	0.63	0.63	0.73	0.59
	(1.08)	(1.02)	(1.21)	(1.04)	(1.01)	(0.89)	(1.13)	(1.03)		(0.49)	(0.50)	(0.46)	(0.52)
Simple	2.89	2.37	4.33	2.00	2.83	3.79	1.87	2.54	Age	25.43	26.26	24.73	25.00
	(1.37)	(1.07)	(0.82)	(0.91)	(1.40)	(1.18)	(1.06)	(1.20)		(3.02)	(4.09)	(2.15)	(1.58)
Disciplines	3.66	2.53	4.47	4.38	4.47	4.42	4.53	4.46	Schooling	2.40	2.58	2.20	2.38
	(1.26)	(1.12)	(0.64)	(0.51)	(0.58)	(0.61)	(0.64)	(0.52)		(0.50)	(0.51)	(0.41)	(0.51)
Better Worse	3.53	2.68	4.20	4.00	4.15	4.32	4.07	4.00	Career	2.19	2.21	2.13	2.23
	(1.20)	(1.29)	(0.77)	(0.58)	(0.75)	(0.67)	(0.96)	(0.58)		(0.85)	(0.79)	(0.99)	(0.83)
Exhaustive	3.38	3.11	3.73	3.38	3.60	3.63	4.07	3.00	Hours	3.17	3.68	2.73	2.92
	(1.03)	(1.24)	(0.70)	(0.96)	(1.01)	(1.01)	(0.70)	(1.08)		(1.17)	(1.25)	(0.88)	(1.12)
Assumption	3.55	2.63	4.33	4.00	4.49	4.47	4.47	4.54	Professional	0.43	0.21	0.40	0.77
	(1.21)	(1.30)	(0.49)	(0.71)	(0.59)	(0.70)	(0.52)	(0.52)		(0.50)	(0.42)	(0.51)	(0.44)
Imperative	4.02	4.16	4.00	3.85	4.30	4.26	4.13	4.54	Environmental	0.30	0.05	0.07	0.92
	(0.90)	(0.83)	(1.07)	(0.80)	(0.72)	(0.73)	(0.74)	(0.66)		(0.46)	(0.23)	(0.26)	(0.28)
Present	3.45	2.53	4.27	3.85	4.30	4.26	4.20	4.46					
	(1.33)	(1.26)	(0.88)	(1.07)	(0.69)	(0.65)	(0.86)	(0.52)					
Training	2.34	2.05	2.40	2.69	2.55	2.37	2.33	3.08					
	(1.22)	(1.13)	(1.40)	(1.11)	(1.12)	(1.16)	(1.23)	(0.76)					
Familiar	2.66	2.58	2.67	2.77	2.91	2.74	2.73	3.38					
	(1.26)	(1.12)	(1.50)	(1.24)	(1.19)	(1.15)	(1.28)	(1.12)					
Appropriate	3.74	3.89	3.67	3.62	4.00	4.11	3.73	4.15					
	(0.82)	(0.88)	(0.90)	(0.65)	(0.63)	(0.57)	(0.70)	(0.55)					
Rely	2.45	2.58	2.20	2.54	2.32	2.26	2.27	2.46					
	(0.88)	(0.96)	(0.77)	(0.88)	(0.96)	(0.99)	(0.80)	(1.13)					
Only	2.09	1.79	1.93	2.69	2.00	1.95	2.20	1.85					
	(1.00)	(0.79)	(1.03)	(1.03)	(1.12)	(1.03)	(1.37)	(0.99)					
Leading	2.66	2.74	2.33	2.92	2.79	2.79	2.80	2.77					
	(0.81)	(0.81)	(0.62)	(0.95)	(0.88)	(0.85)	(0.94)	(0.93)					
Identify	4.26	4.26	4.27	4.23	4.28	4.16	4.40	4.31					
	(0.57)	(0.56)	(0.59)	(0.60)	(0.77)	(0.90)	(0.83)	(0.48)					

Table 3 continued.

Question Label	Pre-Survey Response Means				Post-Survey Response Means			
	Pooled	Spring 2018	Fall 2019	Fall 2020	Pooled	Spring 2018	Fall 2019	Fall 2020
Sufficient	2.83	2.53	2.80	3.31	3.98	4.00	3.73	4.23
	(1.17)	(1.02)	(1.32)	(1.11)	(0.71)	(0.75)	(0.70)	(0.60)
N	47	19	15	13				

[a] Pre- and post-survey question responses recorded on a Likert scale. Summary statistics for sociodemographic indicators are only provided for pre-survey responses. Standard errors in parentheses. Pooled responses are for Spring 2018, Fall 2019, and Fall 2020 aggregated.

Table 4. Results for the Sign Test Applied to Student Responses on the Teaching Project Pre- and Post Surveys[a]

Question #	Label	Count $sgn(d_{ji}) > 0$		$p-value$		Count $sgn(d_{ji}) < 0$		$p-value$		Count $sgn(d_{ji}) = 0$		$p-value$	
Pooled Responses (N = 47)		**M1**	**M2**	**M1**	**M2**	**M1**	**M2**	**M1**	**M2**	**M1**	**M2**	**M1**	**M2**
1	Recognize	19	16	0.04	0.01	9	5	0.98	1.00	19	26	0.09	0.03
2	Simple	18	13	0.63	0.71	19	15	0.50	0.43	10	19	1.00	0.85
3	Disciplines	4	2	1.00	1.00	20	16	0.00	0.00	23	29	0.00	0.00
4	Better Worse	7	1	0.99	1.00	18	13	0.02	0.00	22	33	0.04	0.00
5	Exhaustive	8	6	0.98	0.85	17	9	0.05	0.30	22	32	0.11	0.61
6	Assumption	3	0	1.00	1.00	24	15	0.00	0.00	20	32	0.00	0.00
7	Present	7	3	1.00	1.00	22	19	0.00	0.00	18	25	0.01	0.00
11	Appropriate	4	11	0.99	0.03	13	3	0.02	0.99	30	33	0.05	0.06
12	Rely	12	5	0.50	0.62	11	5	0.66	0.62	24	37	1.00	1.00
13	Only	13	5	0.26	0.36	9	3	0.86	0.86	25	39	0.52	0.73
14	Leading	8	9	0.95	0.21	15	5	0.11	0.91	24	33	0.21	0.42
2018–2019 (In-Person) (N = 34)		**M1**	**M2**	**M1**	**M2**	**M1**	**M2**	**M1**	**M2**	**M1**	**M2**	**M1**	**M2**
1	Recognize	14	13	0.06	0.02	6	4	0.98	0.99	14	17	0.12	0.05
2	Simple	15	13	0.43	0.50	13	12	0.71	0.66	6	9	0.85	1.00
3	Disciplines	3	2	1.00	1.00	18	16	0.00	0.00	13	16	0.00	0.00
4	Better Worse	5	0	1.00	1.00	16	12	0.01	0.00	13	22	0.03	0.00
5	Exhaustive	2	1	1.00	1.00	13	8	0.00	0.02	19	25	0.01	0.04
6	Assumption	2	0	1.00	1.00	18	12	0.00	0.00	14	22	0.00	0.00
7	Present	7	3	0.99	1.00	17	16	0.03	0.00	10	15	0.06	0.00
11	Appropriate	4	6	0.83	0.25	6	3	0.38	0.91	24	25	0.75	0.51
12	Rely	8	2	0.40	0.81	6	3	0.79	0.50	20	29	0.79	1.00
13	Only	5	4	0.87	0.06	8	0	0.29	1.00	21	30	0.58	0.13
14	Leading	4	7	0.99	0.09	12	2	0.04	0.98	18	25	0.08	0.18

Table 4 continued.

Question #	Label	Count $sgn(d_{ji}) > 0$		$p-value$		Count $sgn(d_{ji}) < 0$		$p-value$		Count $sgn(d_{ji}) = 0$		$p-value$	
2020 (Online) (*N* = 13)		**M1**	**M2**	**M1**	**M2**	**M1**	**M2**	**M1**	**M2**	**M1**	**M2**	**M1**	**M2**
1	Recognize	5	3	0.36	0.31	3	1	0.86	0.94	5	9	0.73	0.63
2	Simple	3	0	0.91	1.00	6	3	0.25	0.13	4	10	0.51	0.25
3	Disciplines	1	0	0.88	1.00	2	0	0.50	1.00	10	13	1.00	1.00
4	Better Worse	2	1	0.69	0.75	2	1	0.69	0.75	9	11	1.00	1.00
5	Exhaustive	6	5	0.38	0.11	4	1	0.83	0.98	3	7	0.75	0.22
6	Assumption	1	0	0.99	1.00	6	3	0.06	0.13	6	10	0.13	0.25
7	Present	0	0	1.00	1.00	5	3	0.03	0.13	8	10	0.06	0.25
11	Appropriate	0	5	1.00	0.03	7	0	0.01	1.00	6	8	0.02	0.06
12	Rely	4	3	0.75	0.50	5	2	0.50	0.81	4	8	1.00	1.00
13	Only	8	1	0.02	0.94	1	3	1.00	0.31	4	9	0.04	0.63
14	Leading	4	2	0.50	0.81	3	3	0.77	0.50	6	8	1.00	1.00

[a] Columns labeled as M1 include results of the sign test when responses by students are coded as follows: "strongly disagree" = 1; "disagree" = 2; "neither agree or disagree" = 3; "strongly agree" = 4; and "disagree" = 5. Columns labeled as M2 include the results of the sign test when responses by students to question 1 through 7 of "strongly agree" or "agree" were assigned a value of 1 and responses of "strongly disagree," "disagree," or "neither agree nor disagree" were assigned a value of 0; responses of "strongly agree" or "agree" to questions 11 through 14 were assigned a value of 0 and responses of "strongly disagree," "disagree," or "neither agree nor disagree" were assigned a value of 1.

is not well recognized or discussed in the field of applied economics." Results were robust across different coding strategies used for responses.[20]

The number of students whose responses on the post-survey exceeded responses on the pre-survey to questions 3, 4, 5, 6, and 7 by highest degree completed at the start of the study is outlined in Figure 2. The number of students whose responses on the post-survey exceeded responses on the pre-survey to questions 3, 4, 5, 6, and 7, who indicated they were members of a professional economics organization, or an environmental organization are presented in Figure 3. When the course was taught in-person (Spring 2018 and Fall 2019), the same results hold with the exception that more negative differences than positive differences in responses were not observed for question 2, which stated: "The solutions to wicked policy problems can be boiled down to a simple calculation." When the course was taught online (Fall 2020), more negative differences than positive differences in responses were observed, but results did not hold across the different response coding strategies used. Following the results of the sign test applied to pooled responses to questions 1 through 7, we rejected of our first null hypothesis (H_{01}) in favor of our first alternative hypothesis (H_{A1}) that the case method is an effective tool for enhancing students' understanding of wicked problems meeting expected student learning outcomes L1, L3, and L4.

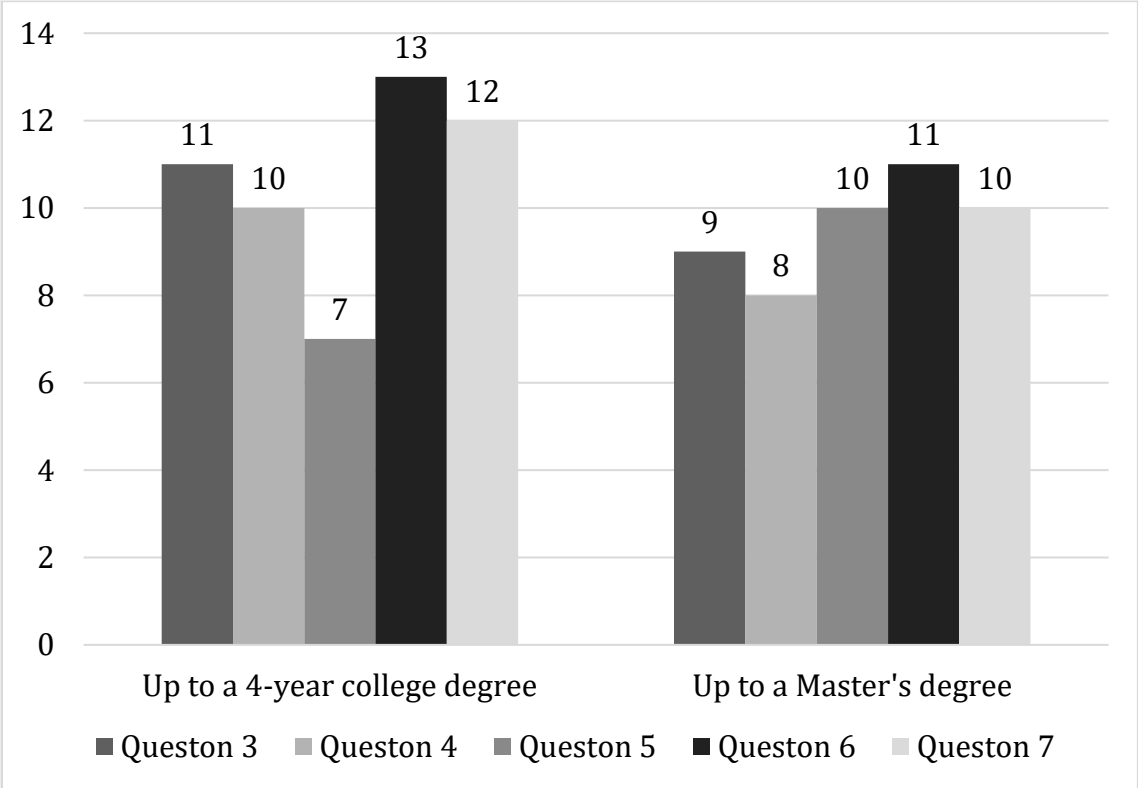


Figure 2. Number of Students Participating in the Teaching Project Whose Responses on the Post-Survey Exceeded Responses on the Pre-Survey to Questions 3, 4, 5, 6, and 7 by Highest Degree Completed

[20] As a robustness check, a second sign test was applied to student responses to questions 1 through 7. For the second sign test, responses of "strongly agree" or "agree" to questions 1 through 7 were assigned a value of 1 and responses of "strongly disagree," isagree," or "neither agree nor disagree" were assigned a value of 0. Results of the robustness check are in the columns of Table 4 labeled as M2.

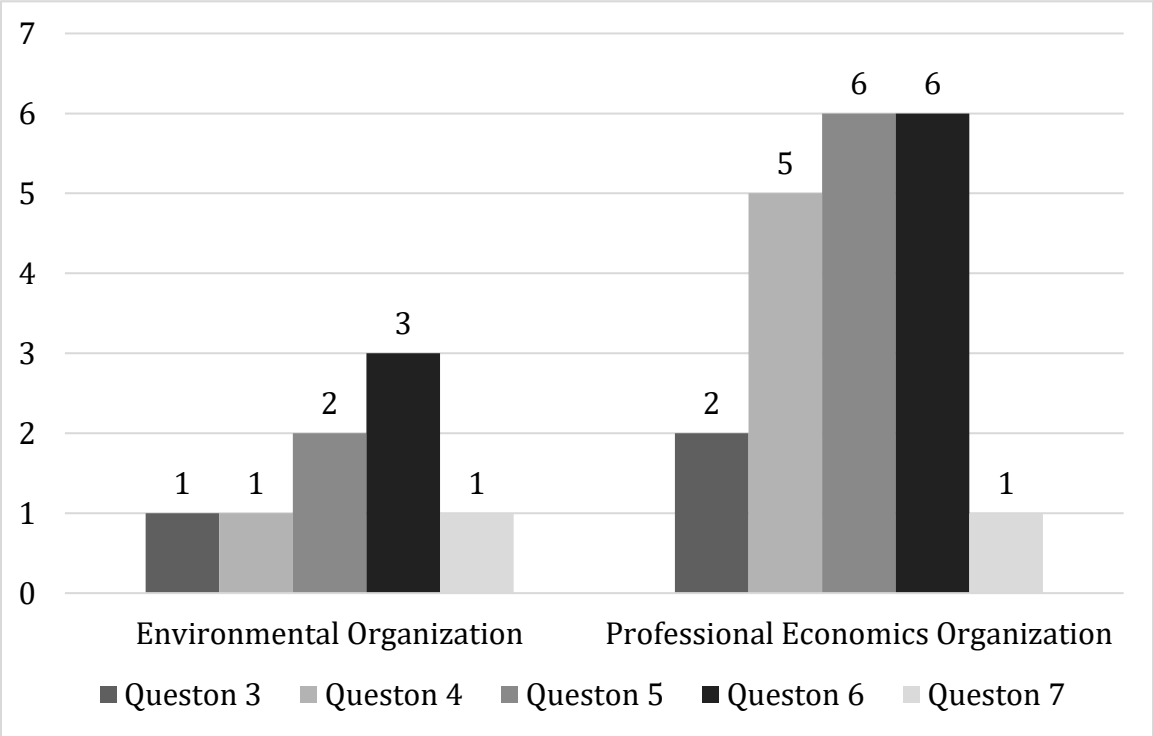


Figure 3. Number of Students Participating in the Teaching Project Whose Responses on the Post-Survey Exceeded Responses on the Pre-Survey to Questions 3, 4, 5, 6, and 7 Who Indicated Being Members of a Professional Economics Organization or an Environmental Organization

Results of the sign test applied to questions 11 through 14 (see Columns labeled as M1 in Table 4) indicate when student responses were considered together, more positive differences than negative differences in responses were observed for only two questions—question 12, which stated: "No matter the context of the problem at hand, an economist can and should always rely on the results of benefit-cost analysis to support their policy recommendations" and question 13, which stated: "As a graduate student in applied economics, you should plan to analyze any economic policy or project using only benefit-cost analysis," but results are not robust across different coding strategies used.[21] When only the in-person responses (Spring 2018 and Fall 2019) were considered, more positive differences than negative differences in responses were observed for Question 12. The same result held true when the class was taught online (Fall 2020).

Thus, we failed to reject our second hypothesis (H_{02}) in favor of our second alternative hypothesis (H_{A2}) that the case method, as it was applied for this study, is an effective tool for enhancing students' understanding of the limitations of BCA for assessing wicked problems and conclude expected student learning outcome L2 was not met. Further examination of the responses to questions 11 through 14 on the pre-survey indicate that most students were familiar with the limitations of BCA in assessing and providing solutions to wicked problems prior to participating in the study. Had students not been familiar with BCA limitations before participating in the case study, we speculate that perhaps participation in the case may have significantly increased students' understanding of BCA limitations.

The results of the WSR test applied to student responses on the pre- and post-survey are included

[21] As a robustness check, a second sign test was also applied to student responses to questions 11 through 14. For the second sign test, responses of "strongly agree" or "agree" to questions 11 through 14 were assigned a value of 0 and responses of "strongly disagree," "disagree," or "neither agree nor disagree" were assigned a value of 1. For the second sign test, positive differences in responses to questions 11 through 14 led to a rejection of our second null hypothesis in favor of our second alternative hypothesis.

in Table 5. Results from the WSR test indicate teaching by the case method positively impacted students' understanding of wicked problems as measured by their responses to questions two through seven. More specifically, based on these results, we can again reject the first null hypothesis (H_{01}) at the 0.05 level of significance in favor of the first alternative hypothesis (H_{A1}). However, the results from our WSR test again reveal that the case method may not be an effective tool for teaching students about the limitations of BCA in assessing and providing solutions to wicked problems. Thus, we again failed to reject our second null hypothesis (H_{02}) in favor of our second alternative hypothesis (HA2).

Table 6 provides an overview of average student performance on the individual take-home assignment, individual peer evaluation form, and the final oral presentations. Student performance, on the individual take-home assignment, as measured by the grades received, ranged from a D minus (62 percent) to a perfect score (100 percent). When all three semesters are considered together the average grade received was 92 percent. Grades on the individual take-home assignment were significantly higher when the course was taught in-person compared to online. Individual peer evaluation grades received followed a similar pattern. Overall, final oral presentation grades received ranged from 84 percent to 100 percent. When the course was taught online, all students received a grade above 95 percent. During final oral presentations when asked why the BENM may represent a wicked-type problem, themes common across team responses included "it is a complex scenario," "there is no clear-cut solution as to what the socially optimal size is," and "it involves the interests of many diverse stakeholders." Team responses indicate after participating in the study, students were familiar with the types of characteristics common among wicked problems.

Alternative quantitative and qualitative analysis techniques chosen by students and presented during their final oral presentations included but were not limited to ethical stewardship, voting to reach a collective decision, cost-effective analysis, multicriteria analysis, maximum social well-being, social product maximization, and ranked choice. Based on the identified alternative criteria chosen to evaluate the wicked problem and discussions during the final oral presentations, it was determined that through participation in the study, students learned how to undertake applications involving the integration of both quantitative and qualitative analysis techniques, as suggested by the identified alternative criteria chosen to evaluate the wicked problem and discussions during the final oral presentations.

Table 5. Summary of Results for the Wilcoxon Signed Rank Test Applied to Student Responses on the Teaching Project Pre- and Post-Surveys[a]

Question #	Label	Count of Positive Ranks		Count of Negative Ranks		Ties		*Z* Statistic		$p = value$	
Pooled Responses (N = 47)		**M1**	**M2**	**M1**	**M2**	**M1**	**M2**	**M1**	**M2**	**M1**	**M2**
1	Recognize	19	16	9	5	19	26	2.23	2.40	0.0256*	0.0164*
2	Simple	18	13	19	15	10	19	0.08	-0.38	0.9404	0.7055
3	Disciplines	4	2	20	16	23	29	-3.51	-3.30	0.0005*	0.0010*
4	Better Worse	7	1	18	13	22	33	-2.60	-6.14	0.0094*	<0.001*
5	Exhaustive	8	6	17	9	22	32	-1.55	-0.78	0.1218	0.4386
6	Assumption	3	0	24	15	20	32	-4.20	-3.87	<0.001*	<0.001*
7	Present	7	3	22	19	18	25	-3.25	-3.41	<0.001*	<0.001*
11	Appropriate	4	11	13	3	30	33	-2.50	2.14	0.0245*	0.0325*
12	Rely	12	5	11	5	24	37	0.41	0.00	0.6805	1.0000
13	Only	13	5	9	3	25	39	0.71	0.71	0.4769	0.4795
14	Leading	8	9	15	5	24	33	-1.26	1.07	0.2080	0.2850
2018–2019 (In-Person) (N = 34)		**M1**	**M2**	**M1**	**M2**	**M1**	**M2**	**M1**	**M2**	**M1**	**M2**
1	Recognize	14	13	6	4	14	17	1.98	2.18	0.0477*	0.0290
2	Simple	15	13	13	12	6	9	0.66	0.20	0.5126	0.8415
3	Disciplines	3	2	18	16	13	16	-3.53	-3.30	<0.001*	<0.001*
4	Better Worse	5	0	16	34	13	0	-2.82	-5.17	0.0047*	<0.001*
5	Exhaustive	2	1	13	8	19	25	-2.78	-2.33	0.0055*	0.0196*
6	Assumption	2	0	18	12	14	22	-3.73	-3.65	<0.001*	<0.001*
7	Present	7	3	17	16	10	15	-2.74	-2.98	0.0062*	0.0029*
11	Appropriate	4	6	6	3	24	25	-0.79	1.00	0.4480	0.3173
12	Rely	8	2	6	3	20	29	0.71	-0.45	0.4804	0.6547
13	Only	5	4	8	0	21	30	-0.98	2.00	0.3291	0.0455
14	Leading	4	7	12	2	18	25	-1.84	1.67	0.0657	0.0956

Table 5 continued.

Question #	Label	Count of Positive Ranks		Count of Negative Ranks		Ties		Z Statistic		$p = value$	
2020 (Online) (N = 13)		**M1**	**M2**	**M1**	**M2**	**M1**	**M2**	**M1**	**M2**	**M1**	**M2**
1	Recognize	5	3	3	1	5	9	1.02	1.00	0.3072	0.3173
2	Simple	3	0	6	3	4	10	-1.22	-1.73	0.2232	0.0833
3	Disciplines	1	0	2	0	10	13	-0.58	-	0.5637	-
4	Better Worse	2	0	2	0	9	13	0.00	-3.42	1.0000	<0.001*
5	Exhaustive	6	5	4	1	3	7	0.96	1.63	0.3352	0.1025
6	Assumption	1	0	6	3	6	10	-1.94	-1.73	0.0522	0.0833
7	Present	0	0	5	3	8	10	-2.22	-1.73	0.0263*	0.0833
11	Appropriate	0	5	7	0	6	8	-2.65	2.24	0.0082*	0.0253*
12	Rely	4	3	5	2	4	8	0.00	0.45	1.0000	0.6547
13	Only	8	1	1	3	4	9	2.12	-1.00	0.0343*	0.3173
14	Leading	4	2	3	3	6	8	0.41	-0.45	0.6824	0.6547

[a] (1) Columns labeled as M1 include results of the Wilcoxon Signed Rank Test when responses of "strongly disagree" = 1; "disagree" = 2; "neither agree or disagree" = 3; "strongly agree" = 4; and "disagree" = 5 are used. Columns labeled as M2 include the results of the Wilcoxon Signed Rank Test when responses of "strongly agree" or "agree" to questions 1 through 7 were assigned a value of 1 and responses of "strongly disagree," "disagree," or "neither agree nor disagree" were assigned a value of 0 and responses of "strongly agree" or "agree" to questions 11 through 14 were assigned a value of 0 and responses of "strongly disagree," "disagree," or "neither agree nor disagree" were assigned a value of 1. (2) *Statistically significant = 0.05.

Table 6. Summary of Student Performance by Measures Used to Further Assess Students' Understanding of Wicked-Type Problems and the Limitations of Traditional Valuation Techniques, Namely Benefit-Cost Analysis in Assessing Such Problems (N = 47)

Item		Pooled	Spring 2018 n =19	Fall 2019 n = 15	Fall 2020 n = 13
Individual Take Home Assignment	Minimum	62	80	80	62
	Maximum	100	100	100	100
	Median	94	90	98	92
	Average	92	91	96	88
Individual Peer Evaluation	Minimum	3.9	4.8	5	3.9
	Maximum	5	5	5	5
	Median	5.0	5	5	5
	Average	4.9	5	5	4.7
Final Oral Presentation Assignment	Minimum	84	84	100	98
	Maximum	100	100	100	100
	Median	100	96	100	100
	Average	98	95	100	99

6 Concluding Remarks

Using the case method, we presented students in a graduate-level applied economics course with the wicked-type problem or question, namely "What is the 'socially optimal' or preferred size of the BENM?" Throughout each semester, during which the teaching project for this study was being implemented, students were presented with a suite of classroom materials consisting of four in-class case method exercises, an individual take-home assignment, a mid-semester check-in progress report memo, and instructions for a final oral presentation. The classroom materials were designed to guide students through the process of conducting an economic assessment of a policy or management problem or issue including how to (1) identify the policy or management issue(s) of interest; (2) identify changes in goods and services related to the policy or management issue(s); (3) define theoretically appropriate welfare change measures associated with the identified changes; and (4) identify and implement economic valuation techniques for quantifying welfare change measures identified.

Following a traditional approach to teaching economic analysis, students were divided into groups and presented with two policy scenarios (i.e., two separate states-of-the-world reflecting the size and management of the BENM) and asked to provide recommendations as to which state-of-the-world should be considered "socially optimal" or preferred following the decision criteria of BCA and the decision criteria of two alternative analysis techniques as chosen by their group, at least one of which needed to be qualitative in nature. Their assessments and recommendations were to be presented at the end of the semester in the form of a final oral presentation (final policy brief), which included a discussion of the wicked nature of the problem.

Expected student learning outcomes (L1 through L5) were assessed using responses on a pre- and post-survey, and the grades received by students on an individual take-home assignment and final oral presentation. Our quantitative analysis results showed that the case method had a positive impact on students' understanding of wicked-type problems, but not necessarily on their appreciation of the limitations of BCA in assessing and providing solutions to such problems. It appeared that students were mostly already aware of the limitations of BCA for assessing policy and management decisions, perhaps from previous undergraduate and graduate economics courses.

While quantitative analysis results support the hypothesis that the case method is an effective means for enhancing students' understanding of wicked-type problems, it is important to note that there are multiple observable and unobservable factors that may be contributing to these results, which we are unable to fully account for given the limitations of the data. For example, it could be the case that students were enrolled in another course (or multiple courses) during the same semester that introduced them to wicked problems (e.g., an environmental economics or policy course). It is also possible that students were exposed to wicked problems through news outlets (e.g., Members in the News Announcements from the Agricultural and Applied Economics Association) or other sources (e.g., seminars or presentations at the university and elsewhere).

As a result, the conclusions should be considered in light of the case method having a positive, but not necessarily causal effect on students' understanding of wicked-type problems. Nevertheless, through exposure to the case method, students gained the practical experience necessary to work individually and as part of a group to assess and offer solutions to complex, multidimensional problems. Such experience and skills are imperative given that graduates in economics face a world where career opportunities are contingent upon being able to interact with a diverse group of stakeholders including lobbyists, politicians, and other practitioners of science (Bergstrom and Randall 2016; Karunaratne, Breyer, and Wood 2016).

Another limitation of our data analysis is that the sample size was relatively small and composed of a unique, specialized group of students. Thus, self-selection bias could have occurred since to be eligible to participate in our study, students first had to register and take the particular graduate course in which the study conducted as part of this teaching project occurred. Instructors who plan to make use of these course materials should consider the impacts of range restriction and survivor bias in cases where students do not agree to participate or choose to withdraw from participation during the study. Throughout the three semesters of our study, however, we had only one student withdraw from the course and study.

If an instructor is interested in using responses on the pre- and post-survey to draw conclusions about the effectiveness of the case method in enhancing students' understanding and assessment of wicked-type problems and/or the limitations of BCA to assess and provide solutions to such problems, then special consideration should be given to the size of the sample and student access to outside materials when completing the pre-survey before drawing casual conclusions. Last, questions designed to measures students' potential gained understanding of additional quantitative analysis techniques and other economics methods were not built into the pre- and post-survey. If this is of interest to instructors who make use of the course materials, we suggest including additional questions related to analysis techniques and other methods discussed throughout the semester.

In response to the COVID-19 pandemic, many universities were forced to transition to online instruction. This increase in online instruction training and experience could result in an increase in online instruction in the future even when the pandemic is over. Most colleges and universities have been expanding online learning anyway, regardless of the pandemic. Thus, there will be a need for instruction that can be adapted to both in-class and online delivery formats that engage students with the course material while simultaneously preparing them for careers in their field. The classroom materials developed for this teaching project can easily be adapted for online instruction including online breakout group meetings.

As Batie (2008) and Stephenson (2003) point out, addressing wicked problems does not equate with abandoning the science. Many of the same tools and concepts used by applied economists to address tame problems can be used to address wicked problems. Specifically, applied economists can apply traditional economic analysis methods to assess potential trade-offs associated with one policy alternative over another for a wicked problem. The value of such analysis, however, is likely to be enhanced if consideration is given to the values underlying the dispute, and if the implications and limitations of such an analysis effort are identified. Our study makes an effort to get students to do just

that.

As wicked problems continue to proliferate in the field and sub-fields of agricultural and applied economics, it is critical that graduates of these programs are aware of them, understand the limitations of traditional economic assessment methods such as BCA in assessing such problems, and gain new insight on the process and skills necessary to effectively assess and provide solutions to complex problems facing society using a variety of quantitative and qualitative techniques more effectively. Our experience in conducting the teaching project described in this paper suggests that applied economics students are not generally familiar with wicked-type problems and are interested in learning more about these problems and how to deal with them. Based on our overall positive teaching project experience, we recommend the case method as a means for providing students with the hard and soft skills needed to effectively assess and provide potential solutions to wicked-type problems and issues. These skills include effectively working individually and in groups, identifying affected stakeholders and how they are affected by a problem, quantifying benefits and costs, and integrating quantitative and qualitative assessment tools to offer more holistic policy and management recommendations.

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Appendix

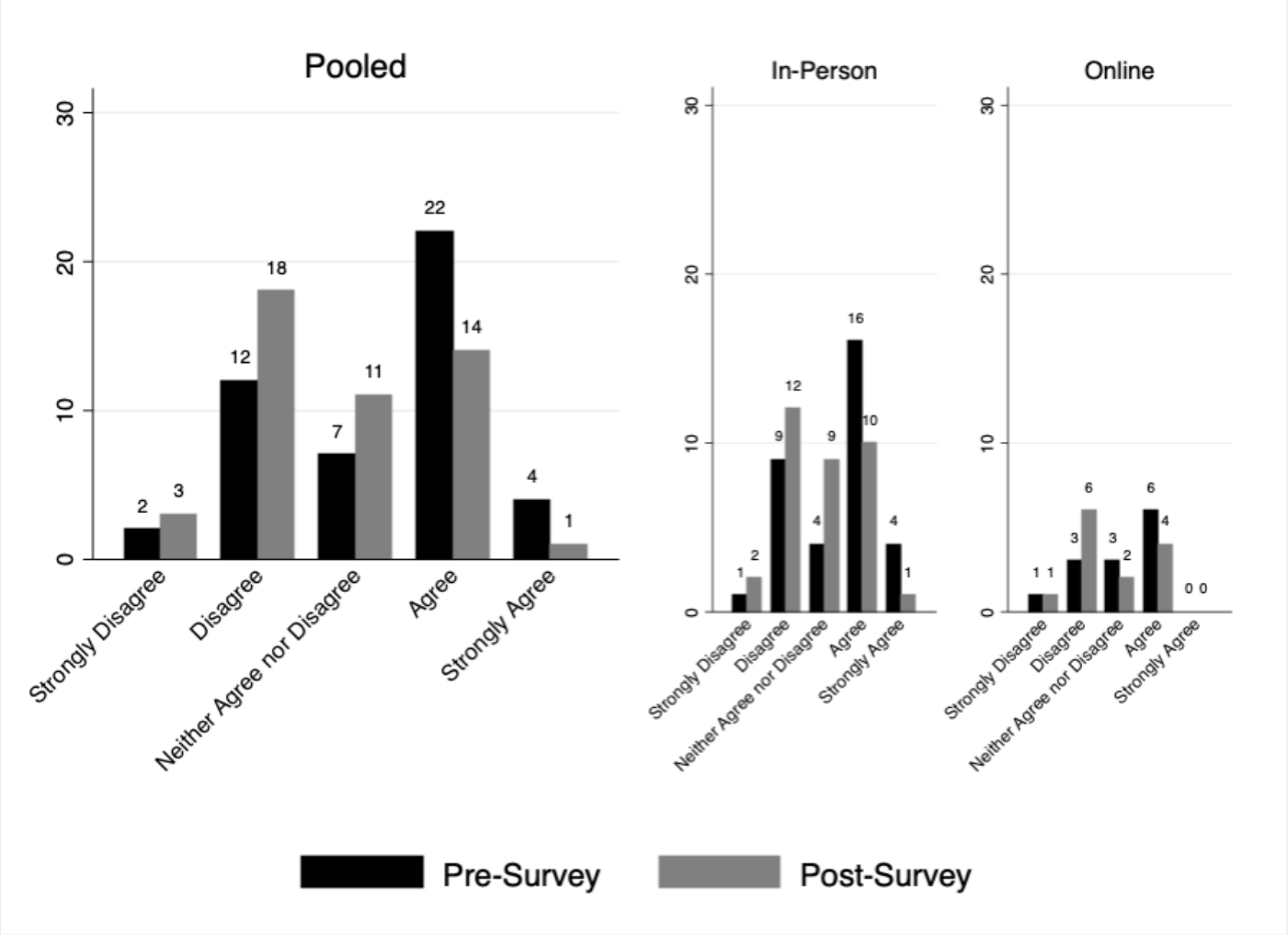

Figure 1A. Frequency of pooled (Spring 2018, Fall 2019, and Fall 2020), in-person (Spring 2018 and Fall 2019), and online (Fall 2020) responses by students to question 1, which stated: "The term 'wicked problems' is not well recognized or discussed in the field of applied economics."

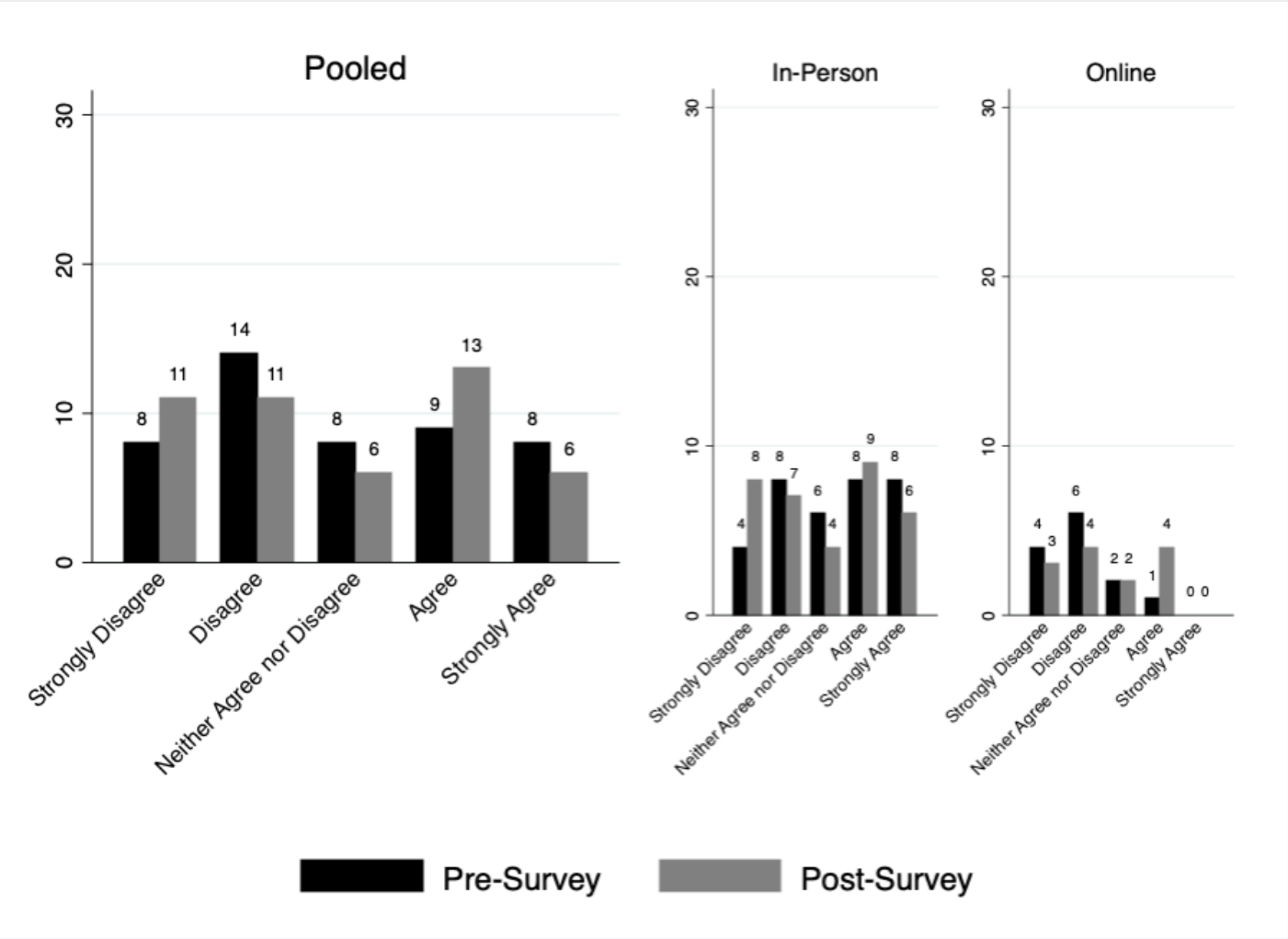

Figure 2A. Frequency of pooled (Spring 2018, Fall 2019, and Fall 2020), in-person (Spring 2018 and Fall 2019), and online (Fall 2020) responses by students to question 2, which stated: "The solutions to wicked policy problems can be boiled down to a simple calculation (e.g., net present value calculation)."

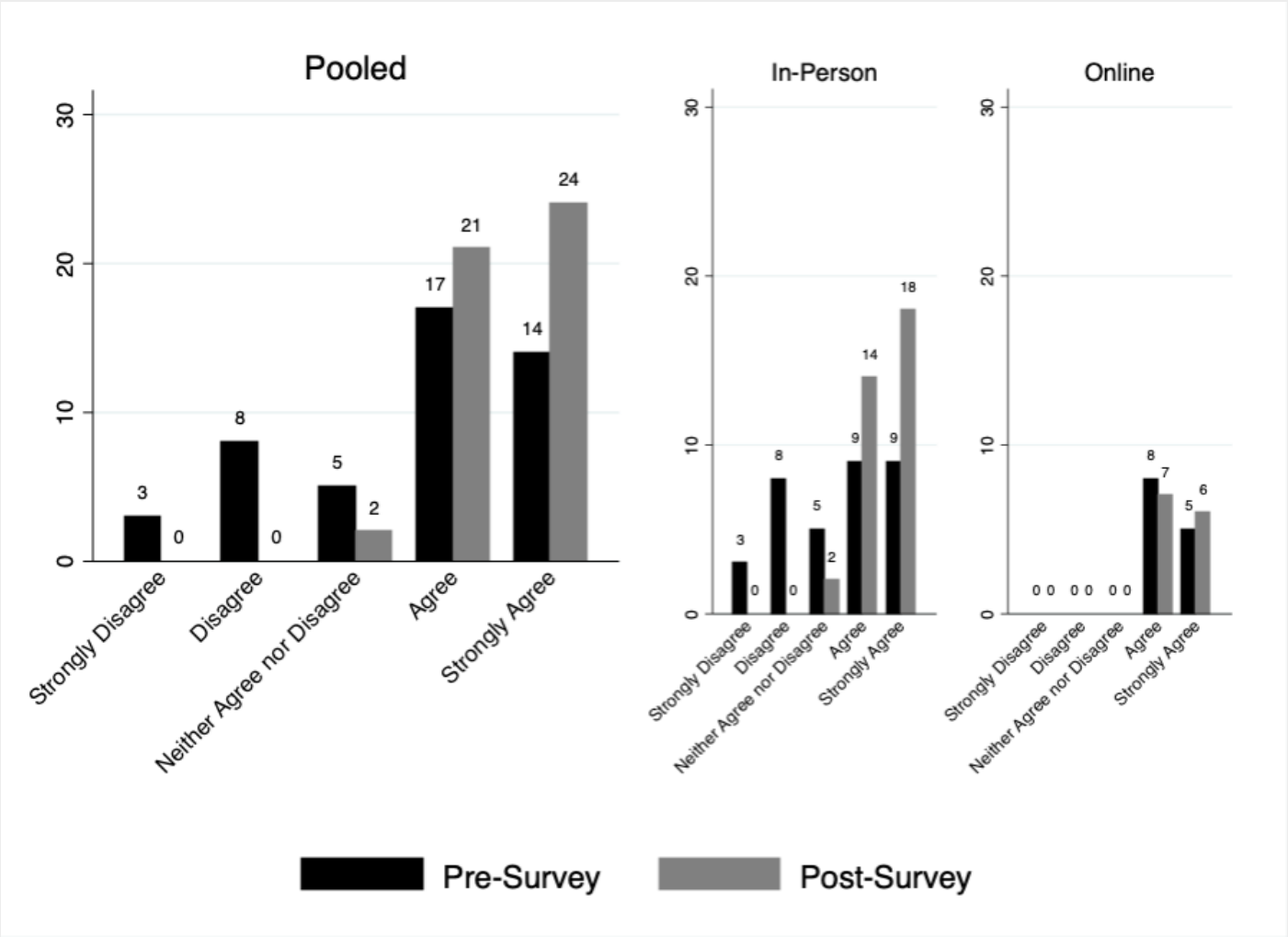

Figure 3A. Frequency of pooled (Spring 2018, Fall 2019, and Fall 2020), in-person (Spring 2018 and Fall 2019), and online (Fall 2020) responses by students to question 3, which stated: "Wicked policy problems often span multiple disciplines."

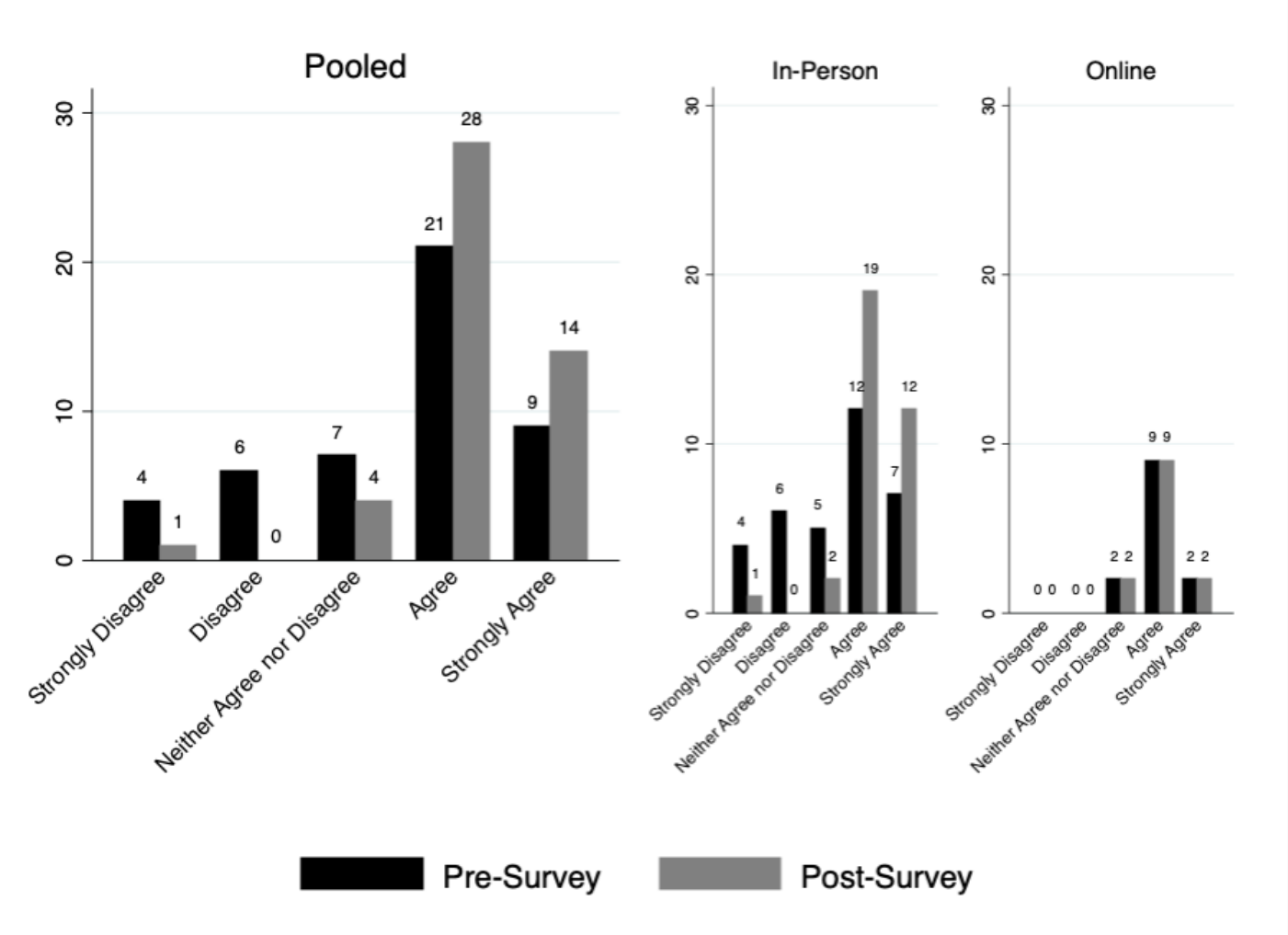

Figure 4A. Frequency of pooled (Spring 2018, Fall 2019, and Fall 2020), in-person (Spring 2018 and Fall 2019), and online (Fall 2020) responses by students to question 4, which stated: "Solutions to wicked problems are not true-or-false, but better or worse."

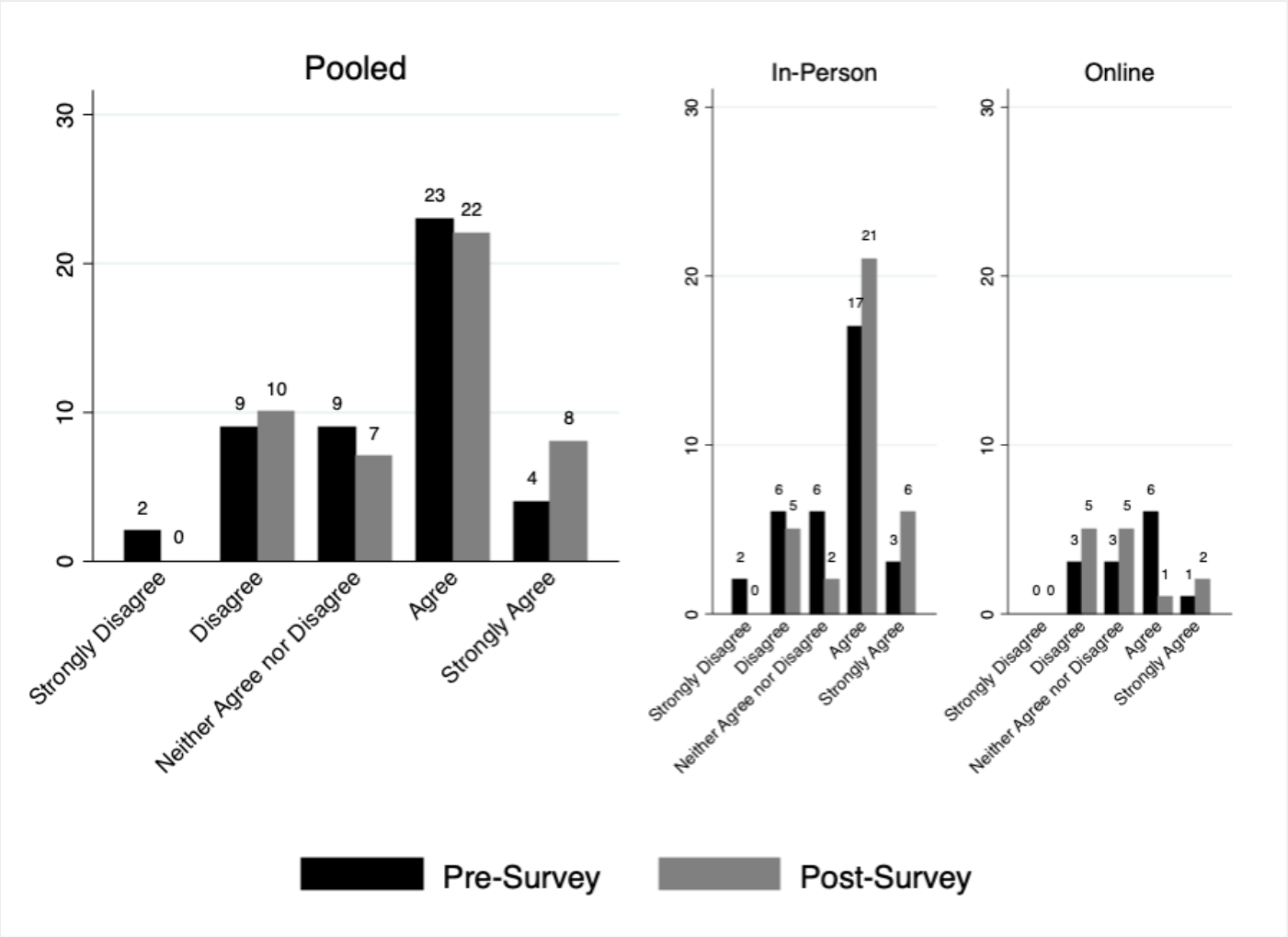

Figure 5A. Frequency of pooled (Spring 2018, Fall 2019, and Fall 2020), in-person (Spring 2018 and Fall 2019), and online (Fall 2020) responses by students to question 1, which stated: "Wicked problems do not have an exhaustive set of potential solutions, nor is there a well-described set of permissible operations that may be considered when reaching a solution."

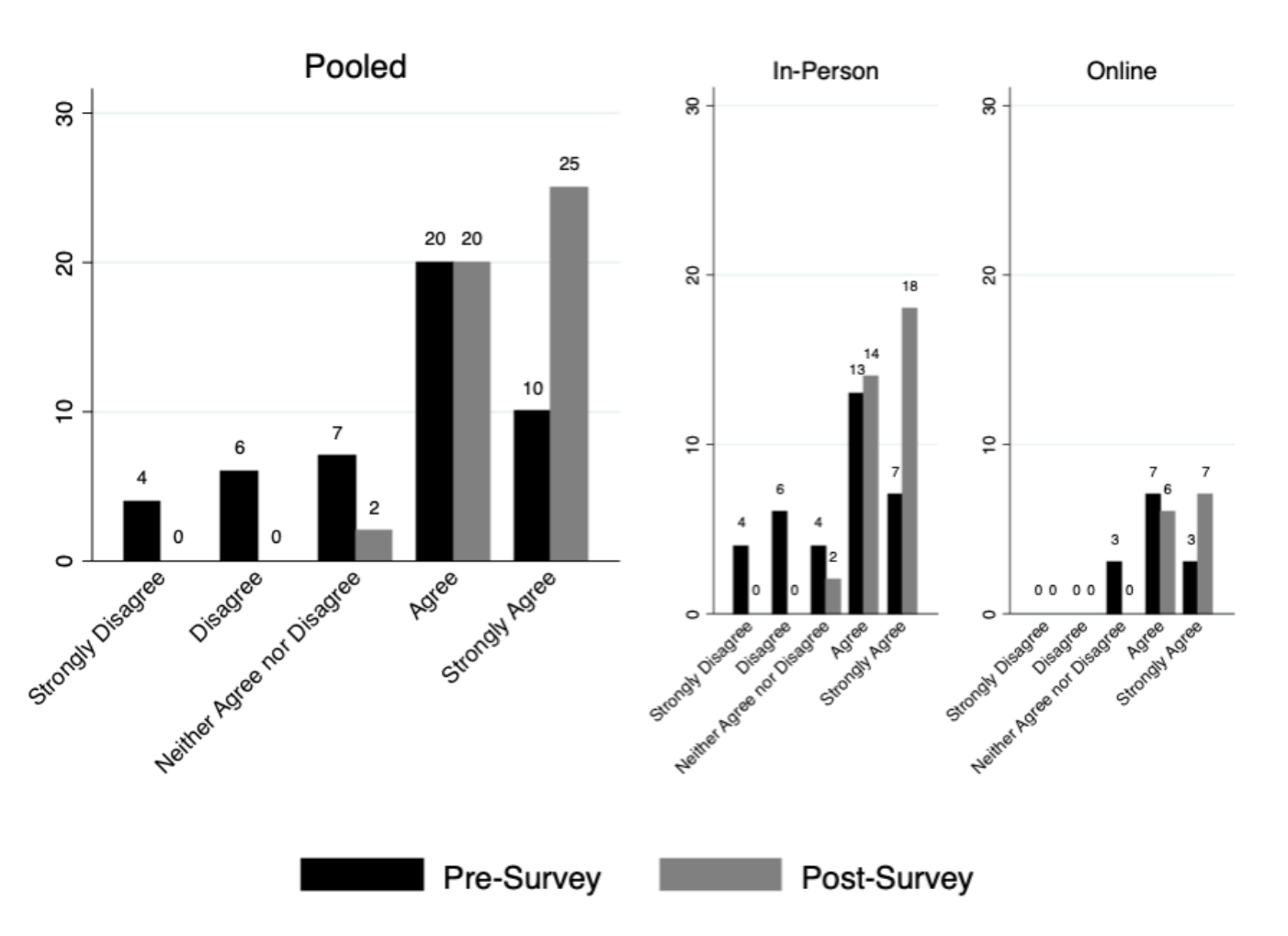

Figure 6A. Frequency of pooled (Spring 2018, Fall 2019, and Fall 2020), in-person (Spring 2018 and Fall 2019), and online (Fall 2020) responses by students to question 6, which stated: "It is important to consider what assumptions realistically hold when solutions to wicked problems are determined."

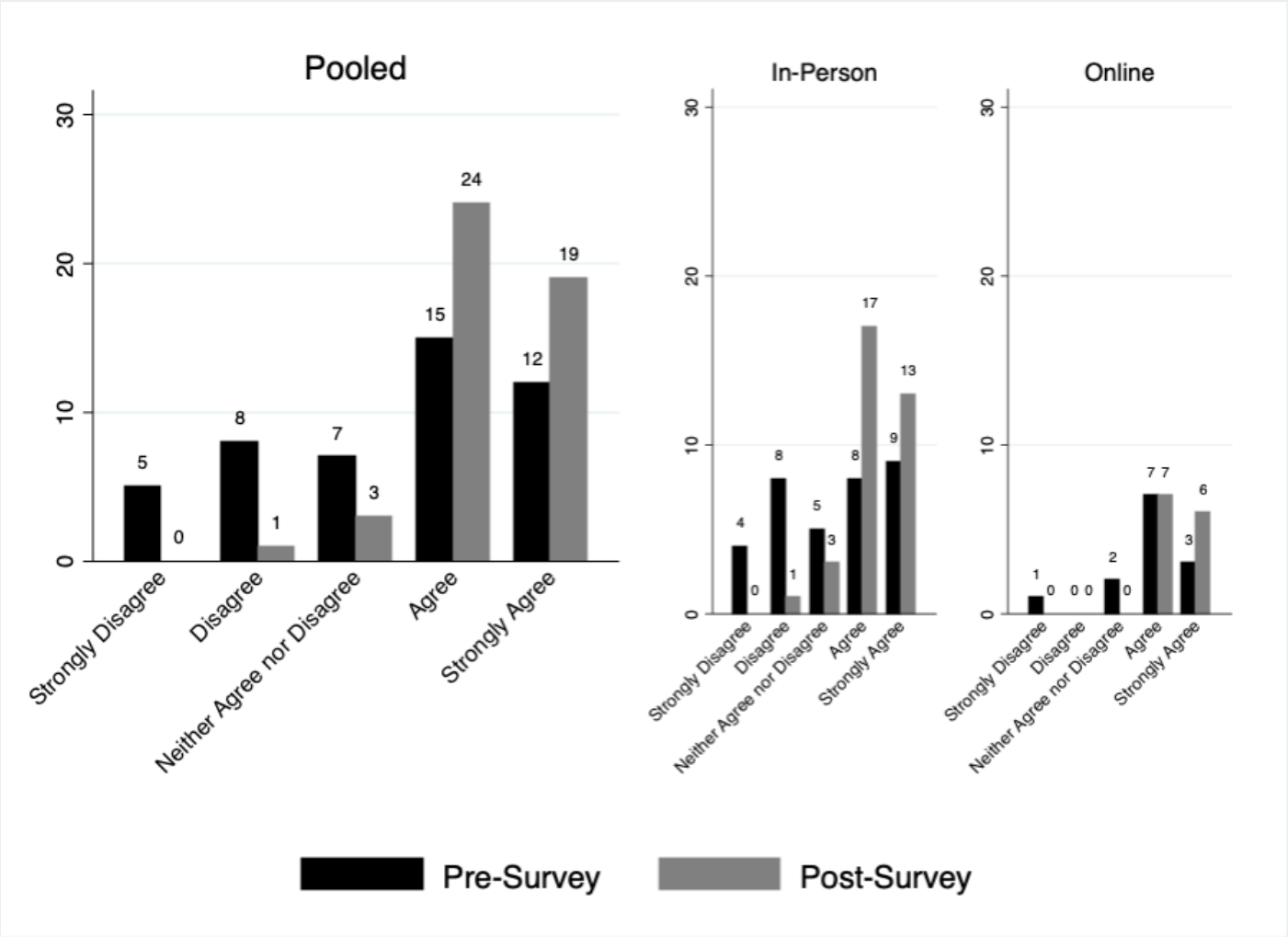

Figure 7A. Frequency of pooled (Spring 2018, Fall 2019, and Fall 2020), in-person (Spring 2018 and Fall 2019), and online (Fall 2020) responses by students to question 7, which stated: "The solution to a wicked policy problem could be influenced by how the problem is presented."

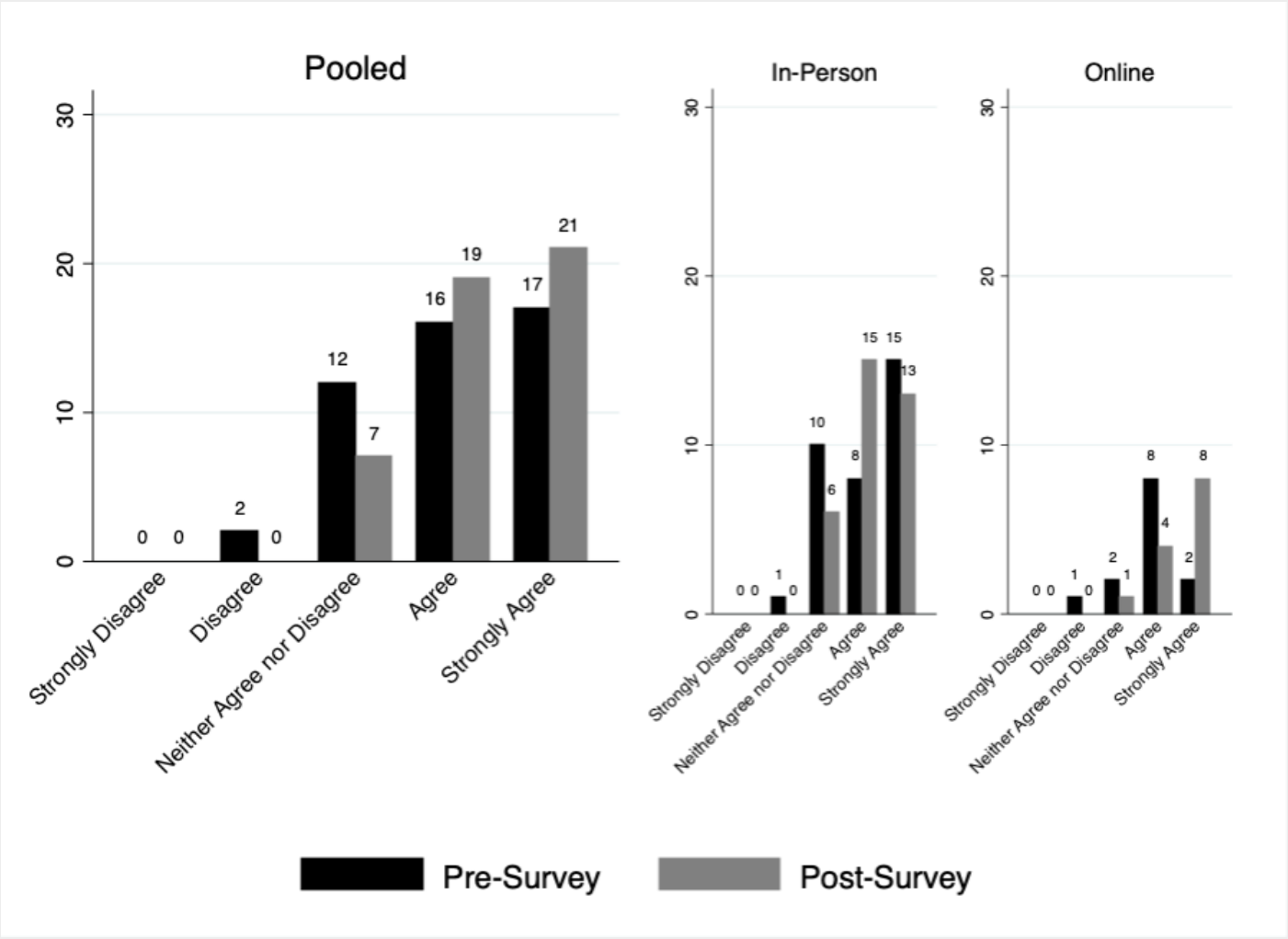

Figure 8A. Frequency of pooled (Spring 2018, Fall 2019, and Fall 2020), in-person (Spring 2018 and Fall 2019), and online (Fall 2020) responses by students to question 8, which stated: "It is imperative the graduate students studying applied economics receive formal training on how to deal with, account for, and solve wicked policy problems."

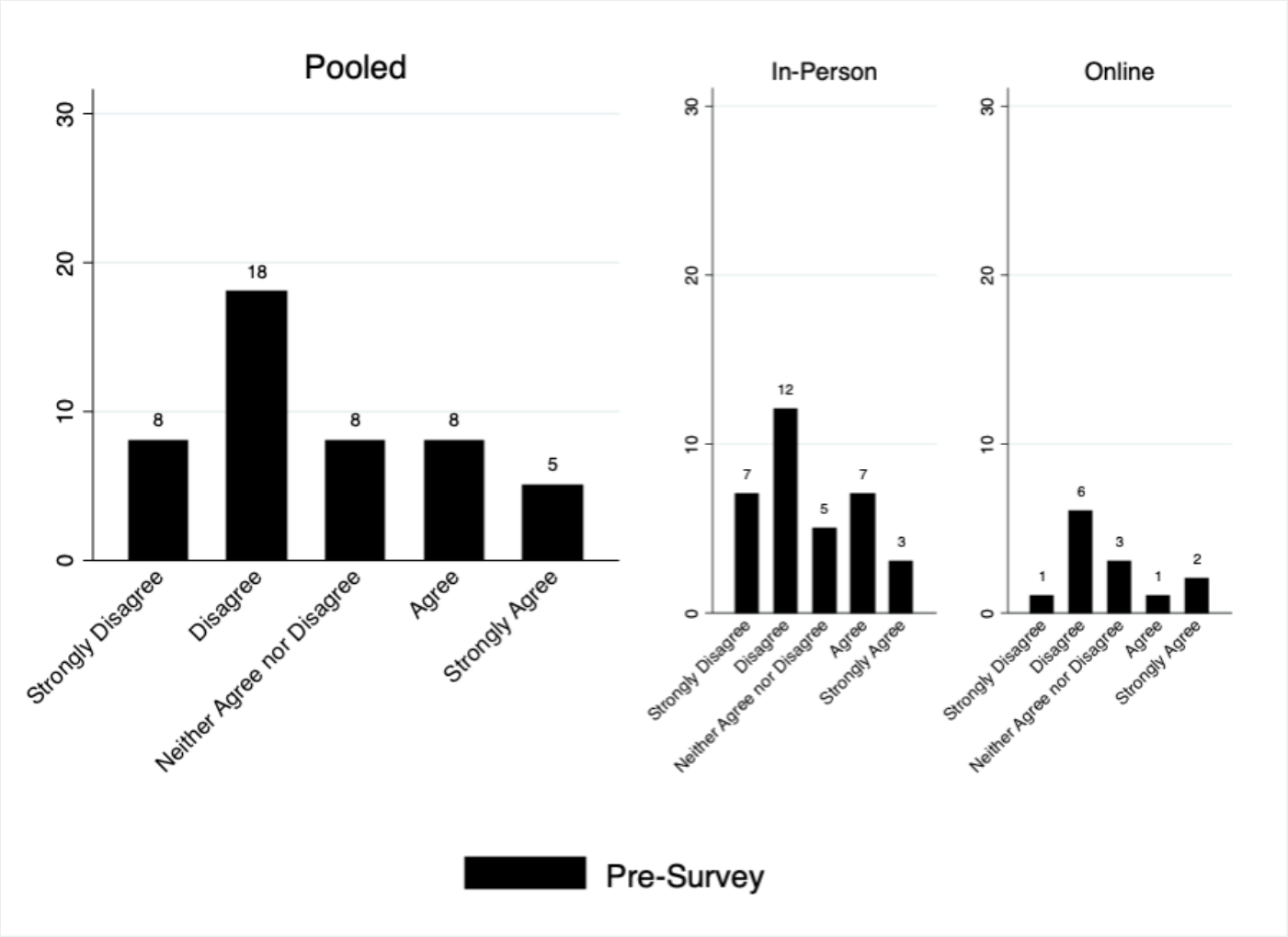

Figure 9A. Frequency of pooled (Spring 2018, Fall 2019, and Fall 2020), in-person (Spring 2018 and Fall 2019), and online (Fall 2020) responses by students to question 9, which stated: "Prior to this study, you received formal training on how to solve wicked policy problems in either an economics, applied economics, or other course taught here at the university."

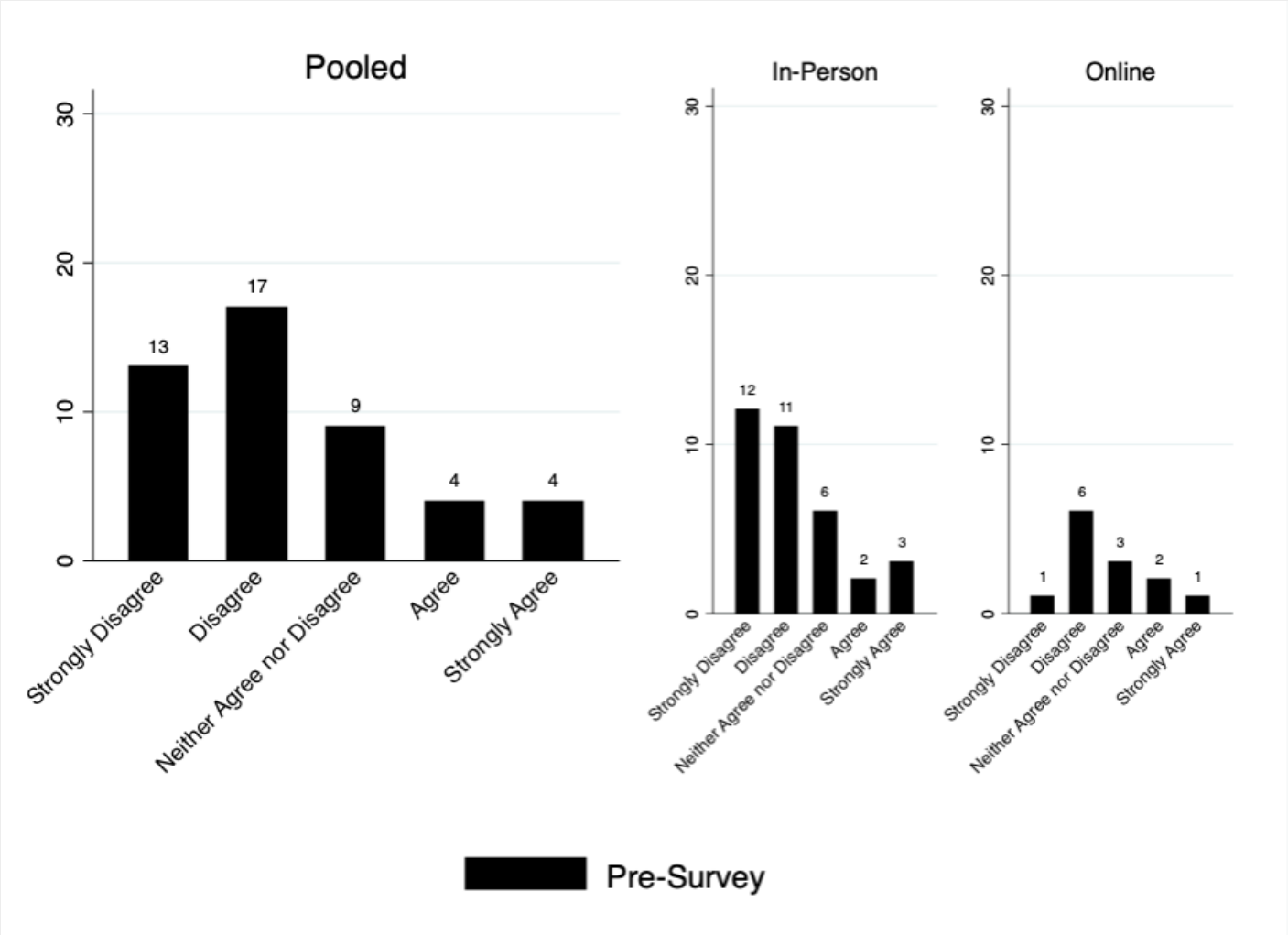

Figure 10A. Frequency of pooled (Spring 2018, Fall 2019, and Fall 2020), in-person (Spring 2018 and Fall 2019), and online (Fall 2020) responses by students to question 10, which stated: "Prior to this study, you were familiar with wicked policy problems."

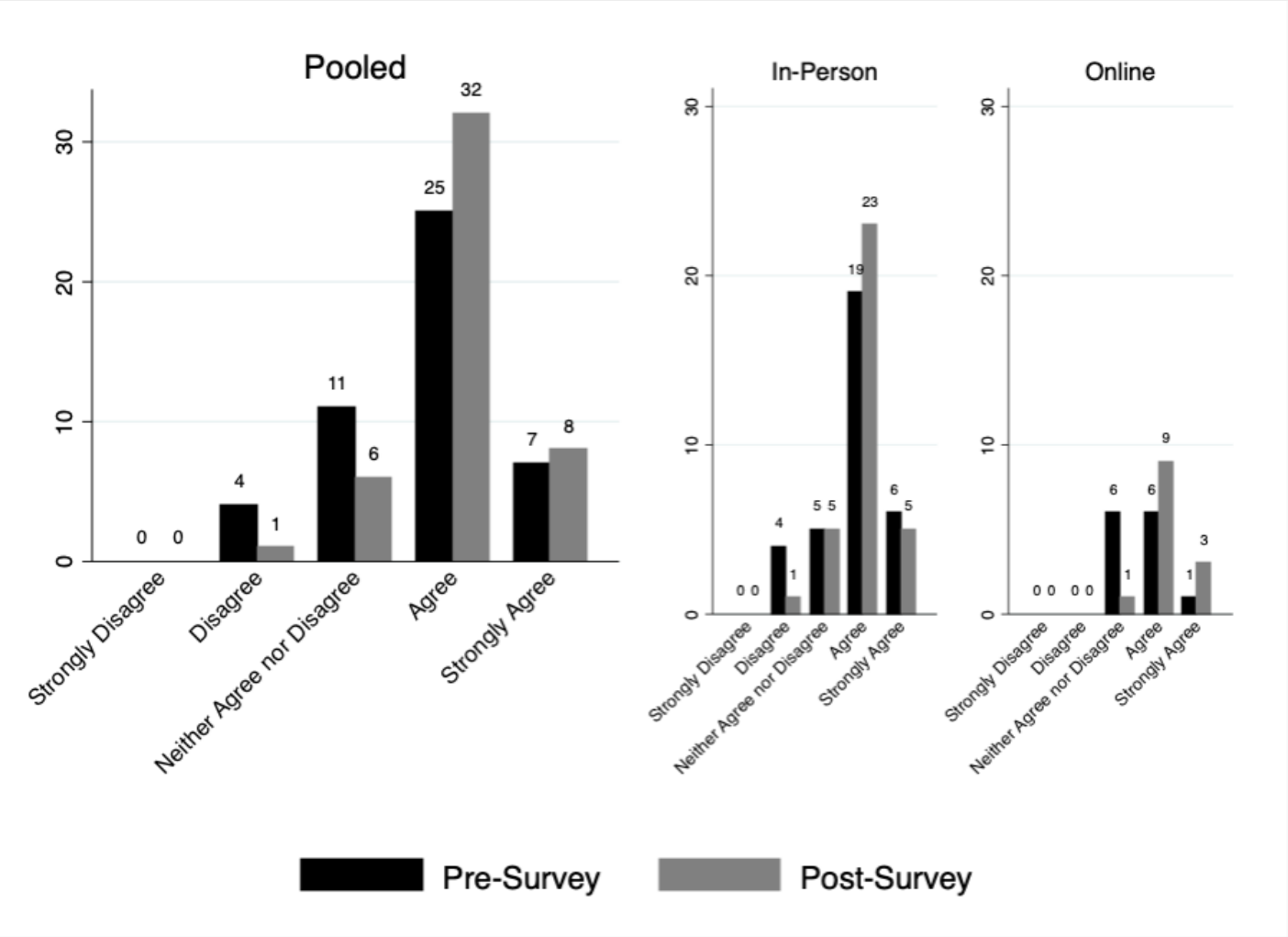

Figure 11A. Frequency of pooled (Spring 2018, Fall 2019, and Fall 2020), in-person (Spring 2018 and Fall 2019), and online (Fall 2020) responses by students to question 11, which stated: "Benefit-cost analysis is an appropriate and effective tool that can be used to reach a conclusion regarding whether or not to pursue an economic policy or project involving a wicked problem."

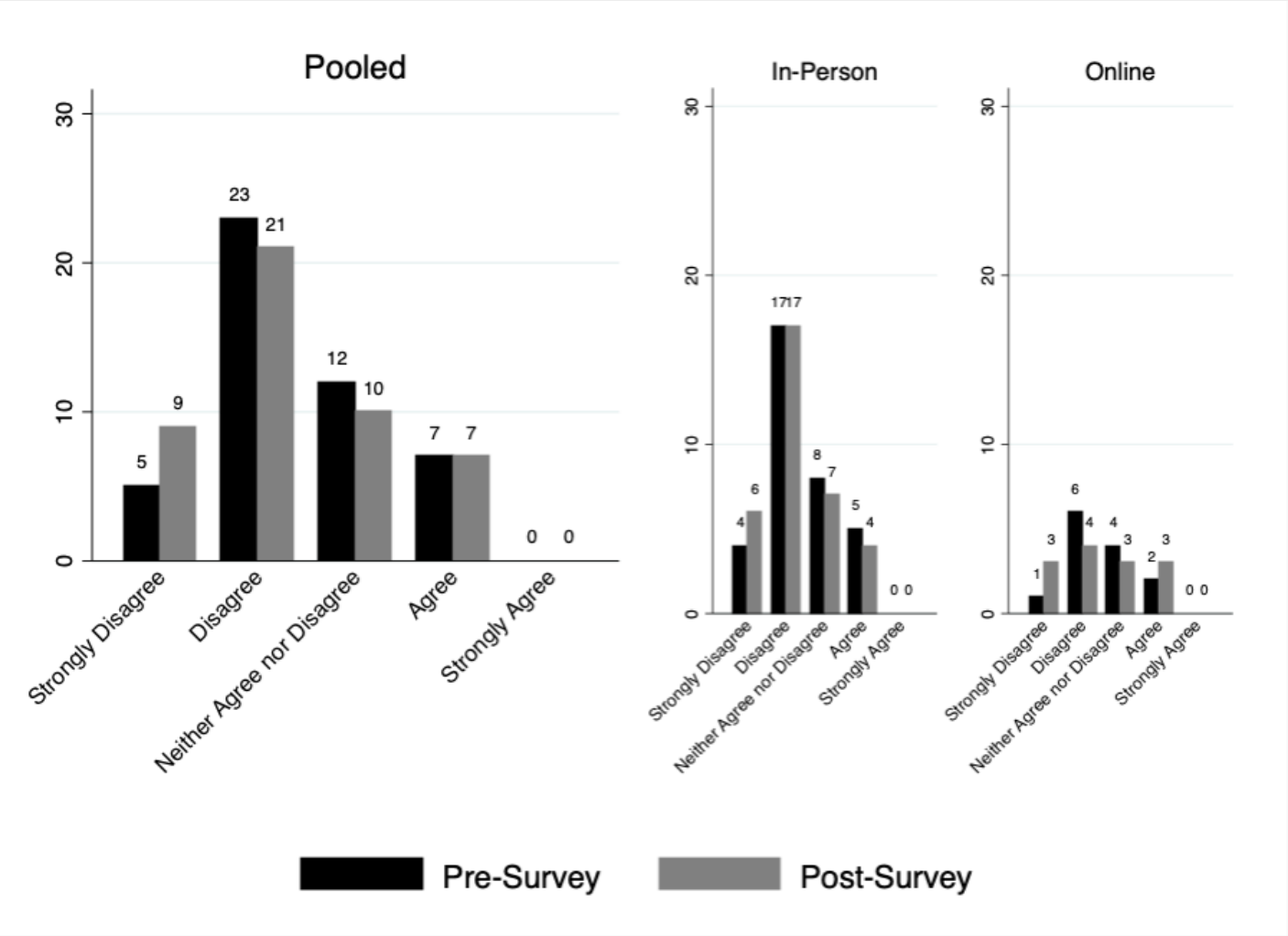

Figure 12A. Frequency of pooled (Spring 2018, Fall 2019, and Fall 2020), in-person (Spring 2018 and Fall 2019), and online (Fall 2020) responses by students to question 12, which stated: "No matter the context of the problem at hand, an economist can and should always rely on the results of benefit-cost analysis to support their policy recommendations."

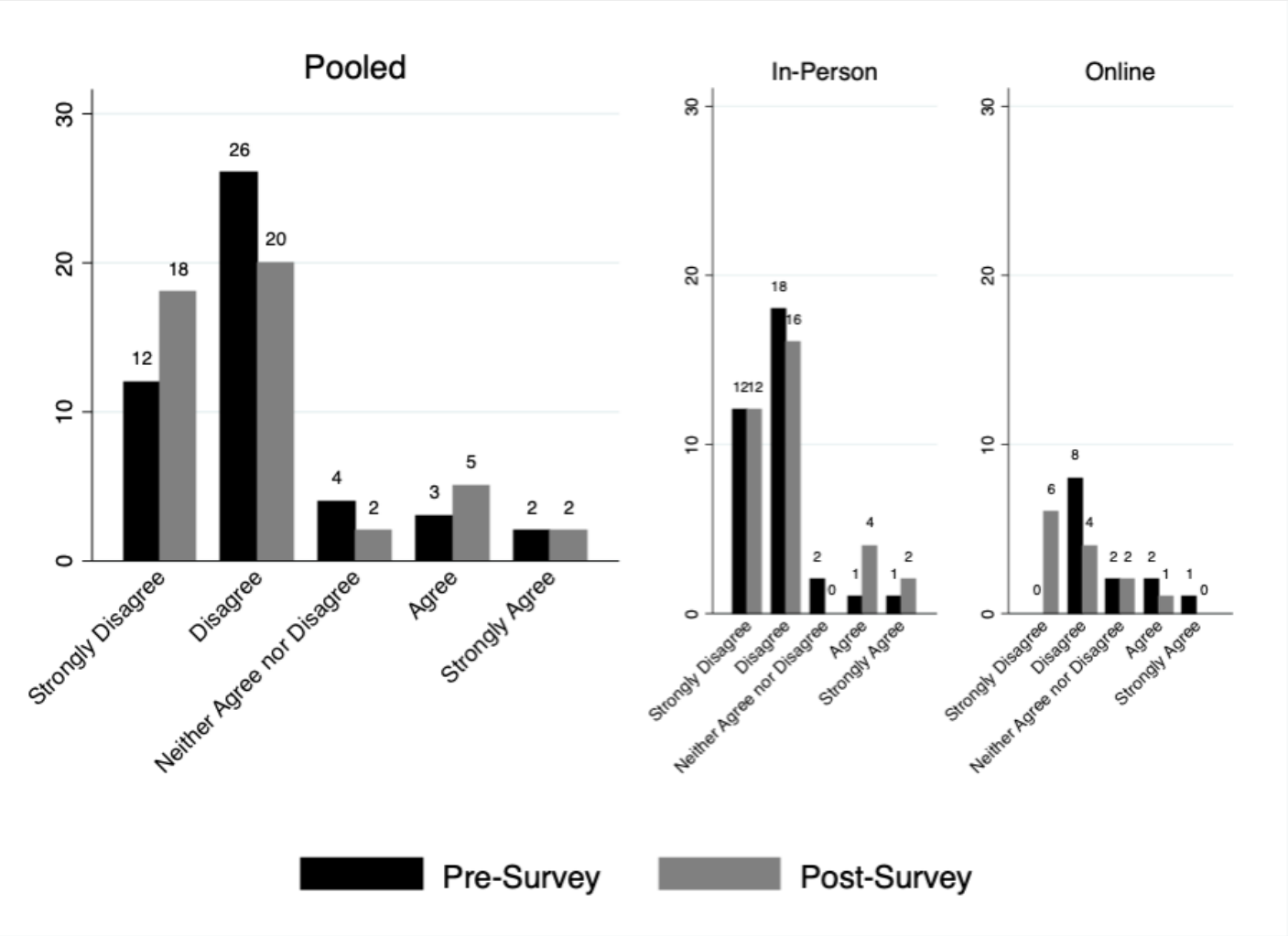

Figure 13A. Frequency of pooled (Spring 2018, Fall 2019, and Fall 2020), in-person (Spring 2018 and Fall 2019), and online (Fall 2020) responses by students to question 13, which stated: "As a graduate student in applied economics, you should plan to analyze any economic policy or project using only benefit-cost analysis."

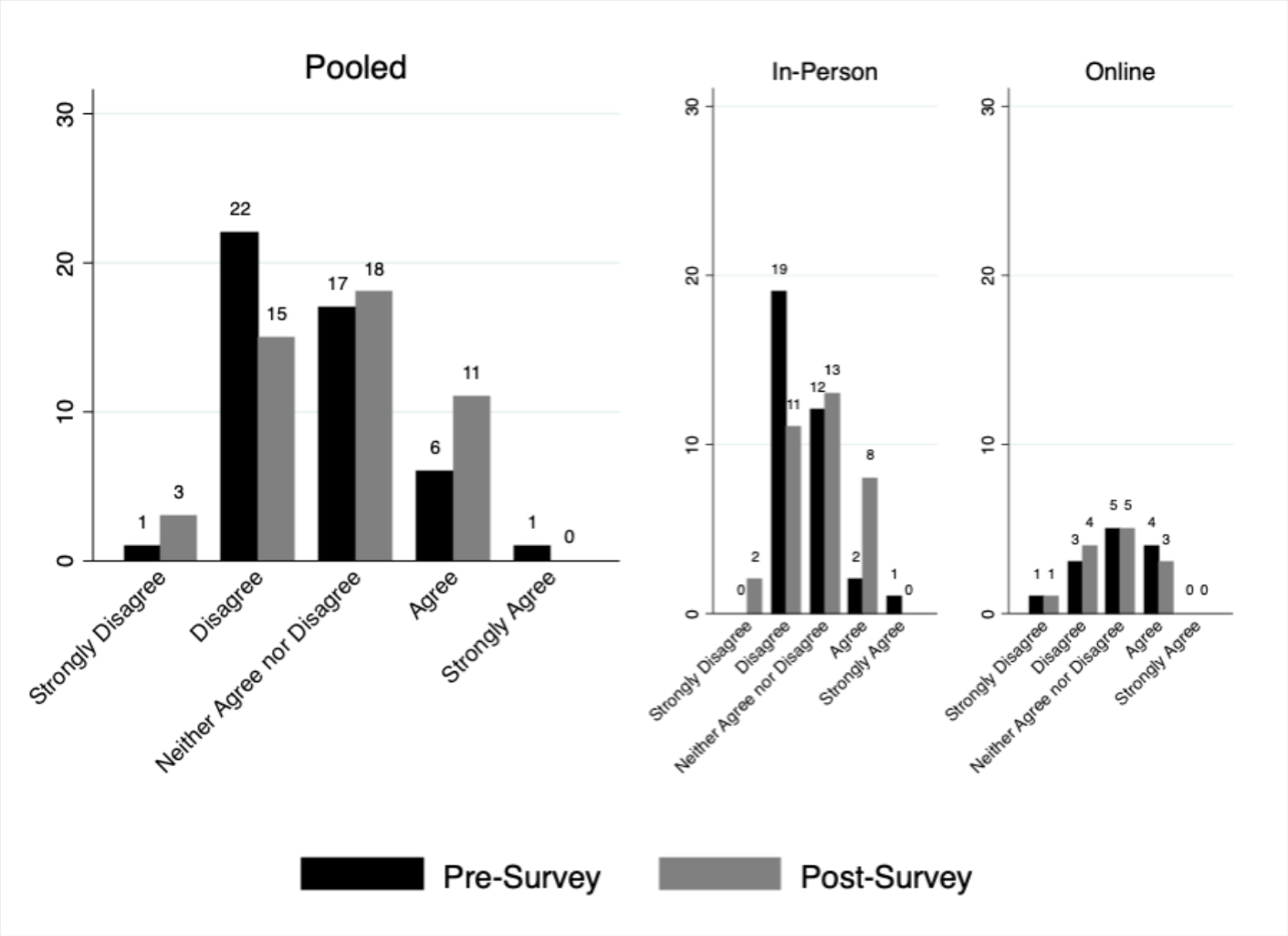

Figure 14A. Frequency of pooled (Spring 2018, Fall 2019, and Fall 2020), in-person (Spring 2018 and Fall 2019), and online (Fall 2020) responses by students to question 14, which stated: "The results of a benefit-cost analysis exercise should always be the leading factor in the decision of whether or not to approve an economic policy or project involving a wicked policy problem."

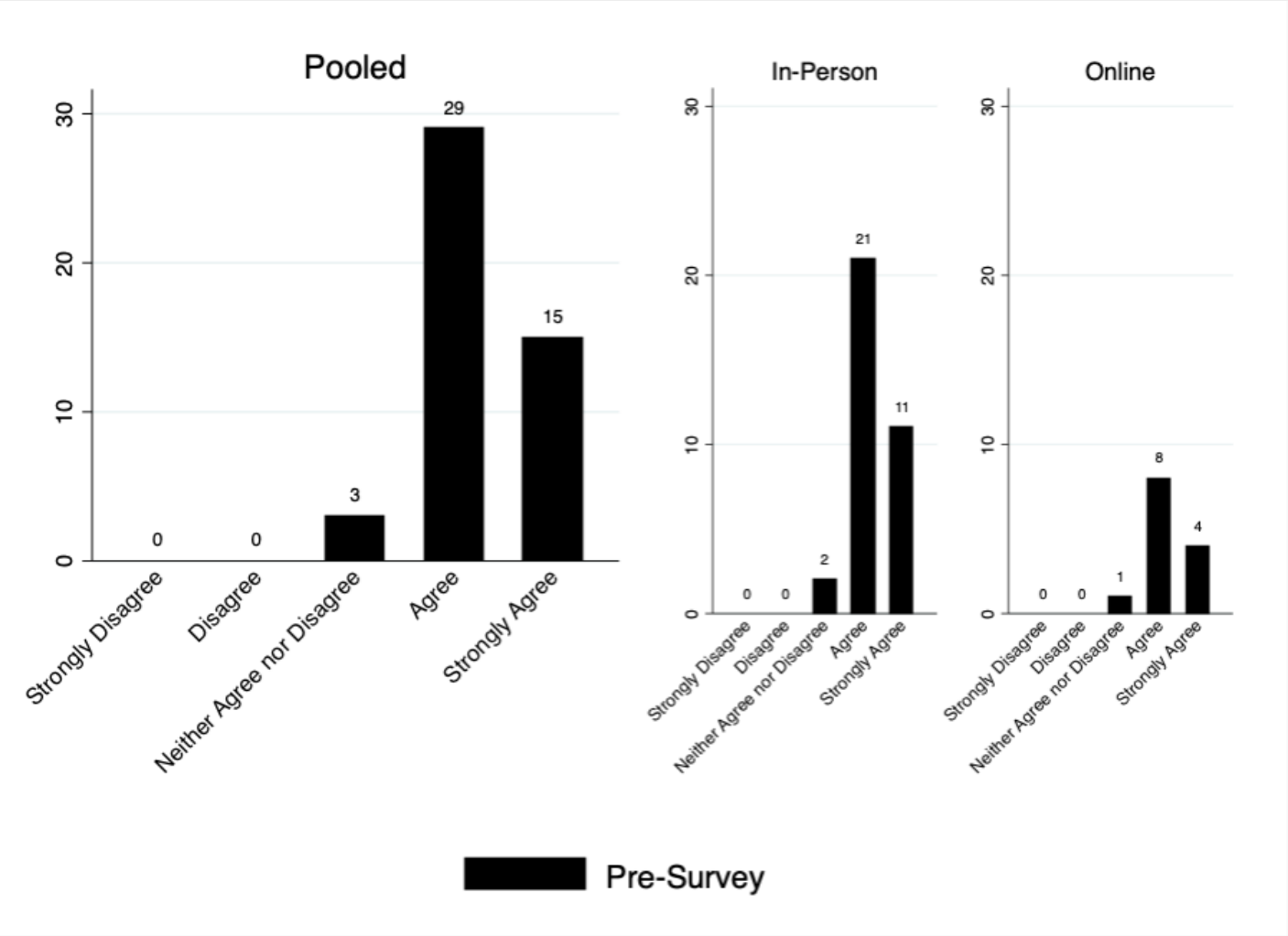

Figure 15A. Frequency of pooled (Spring 2018, Fall 2019, and Fall 2020), in-person (Spring 2018 and Fall 2019), and online (Fall 2020) responses by students to question 15, which stated: "When a conducting benefit-cost analysis it can be difficult to identify and measure all relevant commensurable benefits and costs that can be monetarized."

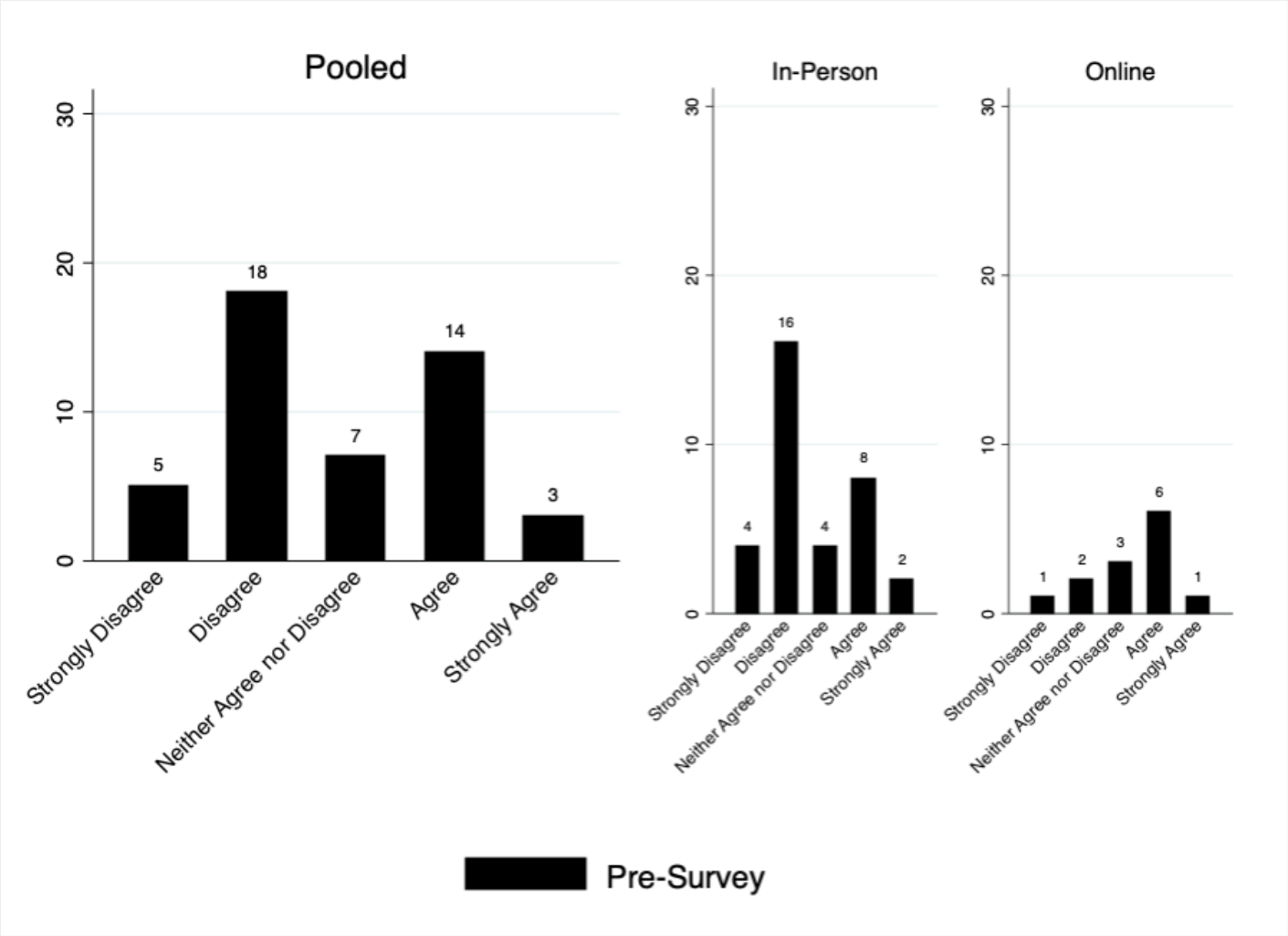

Figure 16A. Frequency of pooled (Spring 2018, Fall 2019, and Fall 2020), in-person (Spring 2018 and Fall 2019), and online (Fall 2020) responses by students to question 16, which stated: "You have received sufficient training on how to solve policy problems using benefit cost analysis in either an economics or applied economics course here at the University of Georgia."