University of the Pacific Theses and Dissertations

Graduate School

2018

Comparing Equivalence-Based Instruction with Lecture-Based Instruction to Teach College Students to Identify Logical Fallacies

Kelly Roughgarden
University of the Pacific

COMPARING EQUIVALENCE-BASED INSTRUCTION WITH LECTURE-BASED INSTRUCTION TO TEACH COLLEGE STUDENTS TO IDENTIFY LOGICAL FALLACIES

by

Kelly L. Roughgarden

A Thesis Submitted to the

Office of Research and Graduate Studies

In Partial Fulfillment of the

Requirements of the Degree of

MASTER OF ARTS

College of the Pacific
Behavioral Psychology

University of the Pacific
Stockton, California

2018

COMPARING EQUIVALENCE-BASED INSTRUCTION WITH LECTURE-BASED
INSTRUCTION TO TEACH COLLEGE STUDENTS TO IDENTIFY LOGICAL FALLACIES

by

Kelly L. Roughgarden

APPROVED BY:

Thesis Advisor: Matthew Normand, Ph.D.

Committee Member: Carolynn Kohn, Ph.D.

Committee Member: Thomas Critchfield, Ph.D.

Dean of Graduate Studies: Thomas Naehr, Ph.D.

COMPARING EQUIVALENCE-BASED INSTRUCTION WITH LECTURE-BASED
INSTRUCTION TO TEACH COLLEGE STUDENTS TO IDENTIFY LOGICAL FALLACIES

Copyright 2018

by

Kelly L. Roughgarden

ACKNOWLEDGEMENTS

Comparing Equivalence-Based Instruction with Lecture-Based Instruction to Teach College Students to Identify Logical Fallacies

Abstract

by Kelly L. Roughgarden

University of the Pacific
2018

Educators and practicing professionals in many fields emphasize the importance of critical thinking for effective decision-making. However, critical thinking skills are not usually directly taught in traditional educational settings. A subset of these skills, identifying logical fallacies, could be amenable to direct instruction using procedures that establish conditional discriminations, such as equivalence-based instruction (EBI). EBI procedures have been shown to be effective and efficient when teaching a variety of skills, including the identification of logical fallacies, when compared with no-instruction and self-instruction control groups. The purpose of this study is to compare the effectiveness of web-based EBI procedures to a more traditional lecture-based instruction format, with and without requiring participants to actively respond to the material, for teaching undergraduate students to identify logical fallacies. Participants were assigned to one of three groups: equivalence-based instruction, lecture-based instruction or lecture-based instruction with active responding. Using a pretest-train-posttest design, performance on multiple-choice tests that target relations among logical fallacy names, descriptions, and examples were compared. The results of this study suggest that EBI is an effective instruction method for teaching college students to identify logical fallacies. When compared to both lecture-based instruction teaching methods, EBI resulted in consistently higher posttest scores following instruction and more consistent acquisition of the nonprogrammed relations (i.e., BA, CA, CB, BC).

TABLE OF CONTENTS

LIST OF TABLES

Table

LIST OF FIGURES

Chapter 1: Introduction and Literature Review

The importance of critical thinking is emphasized as a vital product of education and a necessary tool in various professional fields. However, the methods used to teach critical thinking in higher education (e.g., projects, lectures, homework assignments) seem to fall short of establishing the skills necessary for graduates entering professional settings (Crenshaw, Harper & Hale, 2011; Hatcher, 2013). For example, in 2010, the *Wall Street Journal* surveyed 479 college recruiters about what skills new college graduates needed to improve the most before entering the workforce. Nearly all recruiters said, "critical thinking, problem solving skills, and the ability to think independently" (Taylor, 2010). Teaching critical thinking effectively is difficult for many reasons, including the lack of a widely used consensus definition and the lack of effective teaching strategies. Definitions of critical thinking typically refer to vague constructs such as "self-regulatory judgment" rather than to well-defined skills, and there seems to be no consensus concerning what it means to think critically across, and even within, fields. However, common components of most definitions of critical thinking include logical reasoning and the identification of flawed arguments (Facione, 1900; Forawi, 2015; Hatcher, 2013; Schick & Vaughn, 2014).

One method of teaching individuals to recognize flawed arguments is to teach them to identify common logical fallacies used to develop arguments. Identifying logical fallacies is a concrete skill that is amenable to specific instruction in typical educational settings. Students can be taught this subset of critical thinking skills by teaching multiple components of each fallacy: the name of the fallacy, the definition of the fallacy, and examples of the fallacy. This arrangement makes the identification of logical fallacies an ideal content area for the application

of equivalence-based instruction (EBI) procedures because these stimuli can be separated into stimulus classes such that responding between stimuli can be taught using a conditional discrimination procedure.

The stimulus-equivalence paradigm includes a tendency for untaught relational behavior to develop indirectly from only a few directly taught relations (Rehfeldt, 2011). Through conditional discrimination training, stimuli that have not been presented together or paired with each other can become members of the same stimulus class (Sidman & Tailby, 1982), in that the group of stimuli have the same effect on a particular behavior (Dube, McIlvane, Maguire, Mackay, & Stoddard, 1989). Such stimuli can be tested for stimulus equivalence by determining whether they exhibit the relations of symmetry, reflexivity, and transitivity. Reflexivity is the relation of a stimulus to itself (A1-A1) and typically is exhibited absent any instruction in most human research. Symmetry is the relation of one member of a stimulus class (A1) to another member of that stimulus class (B1) and the reverse relation (if A1-B1, then B1-A1 and not A2, A3, etc.). Transitivity is the relation of two members of a stimulus class which have only been trained through a third stimulus (e.g., if A1-B1 and A1-C1, then B1-C1 not C2, C3, etc.). When the stimuli are tested as samples and comparisons with themselves and each other, and all relations are shown to be bidirectional, the stimuli are said to be interchangeable members of an equivalence class (Barnes, McCullagh, & Keenan, 1990; Devany, Hayes, & Nelson, 1986; Hall & Chase, 1991). An equivalence class is described as three or more physically different stimuli that, when presented with any stimulus from the class, leads to the selection of other members of the class (Sidman & Tailby, 1982).

EBI is especially suited for classroom instruction because stimuli are arranged in a specific way that facilitates student learning with the least amount of instruction, and the stimuli

can be presented in a multiple-choice format that already is used in most classrooms. A lifetime is too short to directly teach everything, or even most things, one needs to know, so instructional methods should capitalize on the idea of un-programmed learning, or "free" learning, that comes out of previous learning experiences but is not specifically programmed into instruction. This learning occurs when the right relations are established between pieces of information (Sidman, 1994; Stromer et al., 1992). Instructional time is always in short supply, so instructors must carefully think about what will be specifically taught and how to maximize student and instructor efforts to promote student learning. One particular instruction method, equivalence-based instruction, might be more effective than using projects or case studies for teaching students to identify logical fallacies because it presents stimuli in such a way that facilitates the most learning from the least amount of instruction.

Researchers have noted the practical applications of EBI, which include frequent opportunities for feedback, ongoing evaluation, mastery-based learning, and the benefits of "free" learning, in which more skills are learned than are specifically taught (Critchfield & Twyman, 2014; Skinner, 2003). EBI programs are also noted for their efficiency (Fienup & Critchfield, 2011; Sidman & Tailby, 1982), and they have been successfully applied to a range of learning topics across diverse learner populations (see Rehfeldt, 2011, for a review). An EBI procedure, then, seems to be a good candidate for teaching logical fallacies.

Moreover, EBI procedures have been delivered using computer technology with much success (Fields et al., 2009; Fienup & Critchfield, 2010; Fienup & Critchfield, 2011; Lovett et al., 2011; Ninness et al., 2005; O'Neill et al., 2015; Walker & Rehfeldt, 2012). Recent studies have demonstrated that college students can be taught algebra and trigonometry (Ninness et al., 2005, 2006), statistics (Fields et al., 2009; Fienup & Critchfield, 2010; Fienup & Critchfield,

2011), single-subject research designs (Lovett et al., 2011), and brain–behavior relations (Fienup, Covey, & Critchfield, 2010) using online course management systems or other automated computer-based programs. In these studies, students were exposed to typical EBI arrangements, where specific stimulus relations are programmed into instruction and, following teaching, other non-programed relations are tested. When using computer-based delivery methods, these stimuli are presented either as multiple-choice questions or as stimuli appearing in specific parts of a computer screen to indicate sample and comparison stimuli. The online delivery of EBI addresses practical concerns such as eliminating the need to train educators to teach critical thinking, facilitating consistency of the materials presented to each student, and providing an efficient way to deliver educational material using only one teaching sequence for all students.

Although EBI procedures have been shown to be effective and efficient for teaching a variety of topics, EBI procedures typically are compared to a no-instruction or a self-instruction control group. These comparison groups might not be the most appropriate comparisons, as students are either not exposed to any intervention, in the case of no-instruction, or might not study the material thoroughly or attended to the material at all, in the case of self-instruction (Ong, Normand, & Schenk, 2018). However, when EBI has been compared to other teaching methods, such as complete instruction or lecture-based instruction, most participants in all groups preformed accurately (Fienup & Critchfield, 2011; Lovett et al., 2011). For example, Fienup and Critchfield (2011) used computer-based EBI to teach inferential statistics concepts to undergraduate students, and they compared EBI to both a no-intervention control and a comprehensive (non-EBI) instructional control. In the complete instruction group, participants received training on all possible relations (i.e., programed and non-programmed relations in the EBI format). Following training, participants in both groups preformed at about the same high

level of accurate responding, but the EBI group did so after significantly less time in instruction (Fienup & Critchfield, 2011).

Additionally, Lovett, Rehfeldt, Garcia, and Dunning (2011) compared equivalence-based instruction to a traditional lecture-style video for teaching undergraduate students single-subject experimental designs. Participants were assigned to one of two groups: equivalence-based instruction or a lecture group. Participant scores on paper-and-pencil tests, which assessed relations between the names of experimental designs, design definitions, design graphs, and clinical vignettes, were compared. Lovett et al. (2011) found that instruction using either the equivalence-based instruction procedures or the lecture format resulted in similar performance on the paper-and-pencil tests. Importantly, EBI procedures require participants to respond to the material during training whereas lectures may not. Requiring participant responses throughout training could affect participants' performance on posttests following instruction.

The results from Lovett et al. (2011) suggest that the EBI arrangement might not be the active component that leads to the learning demonstrated in most EBI studies. It would be useful to know if a lecture is sufficient for teaching students to identify logical fallacies if the students are required to respond in some way to the material during training. However, a lecture could be considered a method of delivering EBI depending on the way the stimuli are presented. Simply telling students the relations among various stimuli might be enough to produce equivalence relations (Critchfield, 2014; Smyth, Barnes-Holmes, and Barnes-Holmes, 2008).

For example, Smyth, Barnes-Holmes, and Barnes-Holmes (2008) presented participants with four instructions that described the relationship between shapes and colors (e.g., "the triangle goes with the red rectangle"). Following these instructions, the stimuli were presented on a screen and participants were asked to categorize them into left or right. During this stage of

the experiment, participants were in two groups: consistent (i.e., the relations were consistent with their prior training) or inconsistent (i.e., the relations were inconsistent with their prior training). Relations in the consistent group were arranged such that all shapes that were previously paired with a red rectangle were categorized to the left and those previously paired with the green rectangle were categorized to the right. Across multiple experiments, participants in the consistent group performed significantly more accurately than the inconsistent group (i.e., 95% correct compared to 56% correct and 98% correct compared to 42% correct) indicating that the acquired equivalence relations arose from instructions rather than the actual pairings. These results suggest that EBI can be streamlined by replacing match-to-sample procedures with verbal explanations. Smyth, Barnes-Holmes, and Barnes-Holmes (2008) suggested that this is important because interventions that require unusual resources, such as EBI procedures, are not likely to be widely adopted, so it simply telling students the relations if effective it might be more useful in a teaching setting.

Smyth, Barnes-Holmes, and Barnes-Holmes (2008) demonstrated that instructions can establish equivalence relations but is unclear whether this instruction method is as effective as other approaches. Therefore, the purpose of the current study was twofold: 1) to further evaluate the effectiveness and efficiency of a web-based EBI program for teaching a specific critical thinking skill—identifying logical fallacies, and 2) to compare EBI directly with two other teaching formats—a traditional lecture-based instruction format, with and without requiring active responding from participants.

Chapter 2: Methodology

Participants

Twenty-four undergraduate students (twenty-one female, three male), 18 to 25 years of age, enrolled in a psychology course participated in this study. Each participant received extra credit in their psychology course and had the opportunity to win one of four $25 Amazon gift cards in a raffle at the end of the study. Participants were recruited using the online Sona Systems research participation management software, which allows students to view all available studies at the university and sign-up to participate in those studies for extra credit. All participants who signed up for the study and arrived at the lab for their session were eligible to participate. Participants who had previously participated in a similar critical thinking study were not able to participate in this study. However, before this pre-screening tool was implemented, one participant signed up who had participated in a previous critical thinking study at the University of the Pacific. This participant scored above 80% on the pre-test during that study, so did not receive any training. During the current study, the same participant scored a 69% on the pre-test, approximately 6 months after participating in the previous study, so she was allowed to participate.

Prior to the start of the study, participants were randomly assigned to one of the three groups. A total of 30 participant numbers were randomized into 3 groups using a random number generator (Research Randomizer; https://www.randomizer.org; Urbaniak & Plous, 2013). After each participant arrived for their session, they were assigned the next available participant number and experienced the training for the corresponding group. Only participants who scored at or below 80% correct on the pretest were included in the data analysis to avoid limiting the potential score changes from pre- to posttest. That is, although all eligible students

were allowed to participate, only the students who scored at or below 80% (73 out of 91 points, or fewer) on the pre-test were included in the final data analysis.

Experimental Stimuli

Thirteen stimulus classes, each with three corresponding stimuli, were used (see Appendix B). Before they are used in the study, the faculty members of the thesis committee reviewed these stimuli for accuracy. The thirteen stimulus classes were created from material in *How to Think About Weird Things: Critical Thinking for a New Age* (7th edition), a popular critical thinking textbook (Schick & Vaughn, 2014). Each of the stimulus classes consisted of the following types of stimuli: (A) fallacy names (e.g., "Straw Man"), (B) descriptions of the fallacies (e.g., "When an opponent's claims are misrepresented to make them easier to reject or dismiss"), and (C) examples of the fallacies (e.g. "You support nationalized health care. So, did the Nazis. This makes you just like Nazi Germany").

General Procedure

A pretest-train-posttest design was used to assess changes in performance following EBI, lecture-based instruction (Lecture), or lecture-based instruction with active responding (Lecture +AR; Figure 1).

A no-treatment control group was not included in this study as previous research has shown that participants receiving no instruction show little to no change across pre- and posttest scores (e.g., Fienup & Critchfield, 2011; Ong et al., 2018). Pretests, EBI lessons, Lecture quizzes, posttests, generalization tests, and a social validity survey were administered via Canvas (https://community.canvaslms.com/), an online course management system.

Equivalence-Based Instruction	Lecture-Based Instruction	Lecture-Based Instruction with Active Responding
Pretest	Pretest	Pretest
Lesson 1 (A-B)		
Quiz 1 (B-A)	Lecture	Lecture with questions
Lesson 2 (A-C)		
Quiz 2 (C-A)		
Posttest	Posttest	Posttest
Generalization Test	Generalization Test	Generalization Test
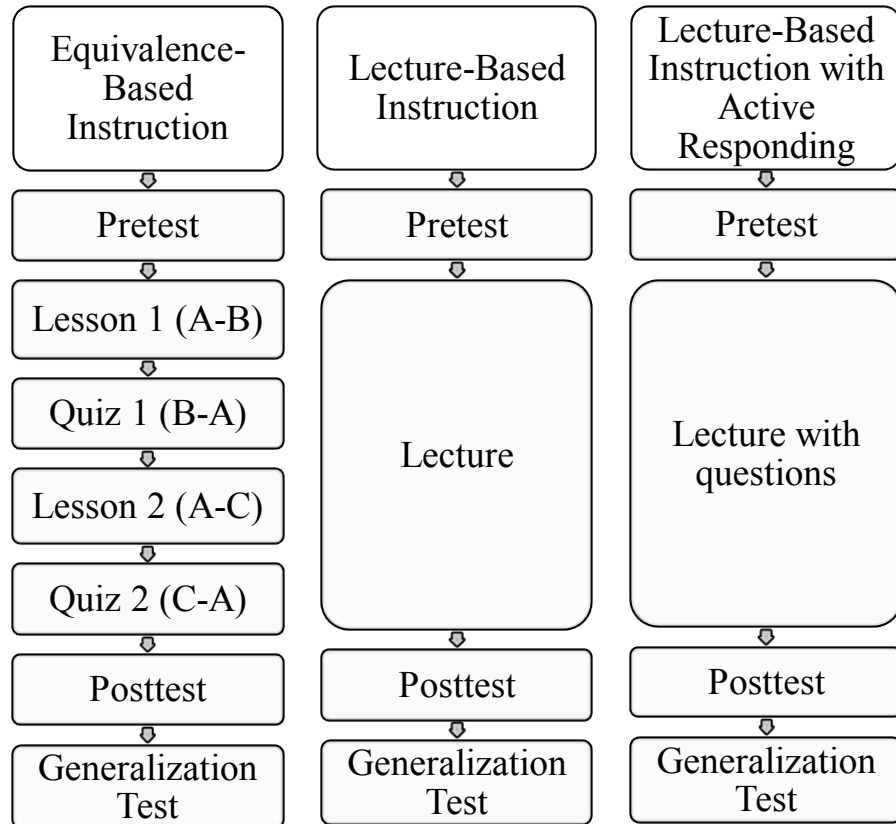
Figure 1. Flowchart of general procedures.

After completing the informed consent and demographics questionnaire (see Appendix C), participants completed all experimental tasks on a Mac desktop computer in a 7ft by 7ft room which contained a desk, desk chair, Mac desktop computer, and a one-way mirror on the right wall that allowed experimenters to observe participants from the adjacent room. Each component of the study was presented via the "Quizzes" feature of Canvas. For all quizzes, participants were required to submit each answer before advancing to the next question, and they could not return to a question after submitting an answer. All distractor answer choices on all quizzes were randomly selected for each question, but all options were presented the same number of times. For example, on the pretest there were 16 questions in the BC section and 13 logical fallacies. Therefore, each fallacy was presented as a distractor answer four times in that

section. Additionally, all participants were timed from when they enter the lab to when they

submit the social validity questionnaire to track the total session duration.

Pretest. Each participant began with a comprehensive pretest composed of 91 questions

in which all relations for all 13 fallacies were presented (see Appendix D). This pretest was

designed to test for preexisting relations prior to intervention. The questions were presented in a

random sequence, determined using a random number generator (Research Randomizer;

https://www.randomizer.org; Urbaniak & Plous, 2013), within the following sequence to test for

preexisting equivalence relations: BC, CB, BA, CA, AB, then AC. No feedback was provided

for responses on the pretest. Four participants who correctly matched more than 73 of the 91

pretest relations (i.e., 80% accuracy) completed the remaining training in order to receive full

research credit but were excluded from the data analysis.

Equivalence-based Instruction. The purpose of this condition was to assess the effects

of the stimulus equivalence arrangement on students' identification of logical fallacies. Each

fallacy (A stimuli) was presented in a trial as a question to be matched with a description (B

stimuli) or an example (C stimuli) in a one-to-many (OTM) training sequence (Green &

Saunders, 1998; see Figure 2).
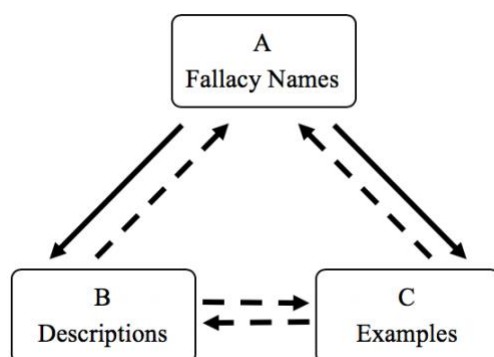
Figure 2. Visual representation of the equivalence-based instruction (EBI) arrangement. Solid
arrows indicate programmed instruction of relations while dashed arrows indicate tests for non-
programmed relation formation.

Each participant completed two lessons that taught the AB and AC relations and two quizzes that tested the symmetrical relations, BA and CA (see Appendices E through H for lessons and quizzes; see Figure 3 on the following page for a flowchart of procedures). During the lessons and quizzes, each question was presented one at a time, with five answer choices available (e.g., four fallacy descriptions and a "None of these" option). Five choices were presented for each question to mimic a typical multiple-choice question format. A "None of these" option was included in each question to account for the other stimuli that could have been used as comparison stimuli, as only four out of thirteen options were presented for each question. Additionally, the "None of these" option was the correct answer on 13 of the 96 questions, so participants did not simply ignore the option that the correct answer was not present. Most EBI studies present all comparison stimuli for each question, however those studies typically include three to five stimulus classes, as compared to the thirteen used in this study. There does not seem to be any research on this particular aspect of EBI procedures; therefore, to remain similar to typical teaching procedures, the "None of these" option was used instead of presenting 13 answer choices for each question.
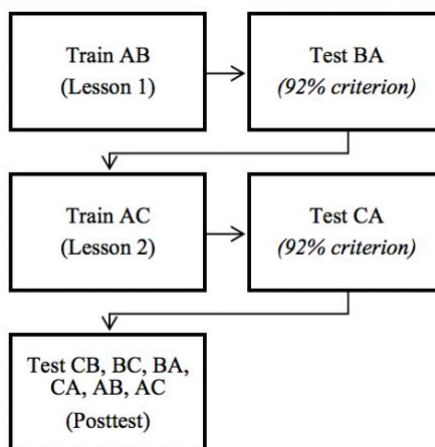
Figure 3. Flowchart of EBI procedures.

Each training and testing quiz in this phase comprised 13 questions, with one opportunity to match each fallacy name with its description or example. The order of the questions was randomized using the same random number generator used to assign participants to groups. During the lessons, feedback was presented for all questions after the quiz was submitted. A red arrow indicated incorrect responses and a green arrow indicated correct responses. We did not provide feedback during the quizzes that tested for symmetrical relations.

Lesson 1 consisted of a 13-question quiz that presented each fallacy name with the corresponding description (AB). Each participant was required to score a 100% on this lesson before moving on to the quiz which tested for the symmetrical relation (BA). Participants then took a 13-question quiz, which presented the fallacy description in the question with the fallacy names as the answer choices, with a mastery criterion of 12 out of 13 correct (92%). If the criterion was not attained on the description-to-fallacy-name (BA) symmetry test, fallacy-name-to-description (AB) training was repeated, and the description-to-fallacy-name (BA) symmetry test was administered again until mastery was achieved.

Following mastery, participants moved on to Lesson 2. Lesson 2 consisted of a 13-question quiz which presented each fallacy name with the corresponding example (AC). Participants were required to score 100% on this quiz before moving on to the next quiz, which tested for the symmetrical relation (CA). This quiz was presented in the same manner as the description-to-fallacy-name (BA) symmetry quiz, in which participants completed a 13-question quiz which presented the fallacy example in the question with the fallacy names as the answer choices, with a mastery criterion of 12 out of 13 correct (92%). If the criterion was not attained on the example-to-fallacy-name (CA) symmetry test, fallacy-name-to-example (AC) training was repeated, and the example-to-fallacy-name (CA) symmetry test was administered again until

mastery was achieved. The experimenter recorded the time that elapsed from when the participant began the first EBI lesson to when they submitted the second symmetry quiz at mastery criterion (i.e., 12 out of 13 correct) using a timer located in the research room.

Lecture-Based Instruction (Lecture). The purpose of this condition was to assess the effects of lecture-based instruction without active responding (i.e., answering quiz questions) as a positive-control comparison for the EBI method. This control condition was designed to approximate what a college-level student might experience during a class designed to teach logical fallacies and to evaluate if only exposure to the information in a traditional teaching format produces similar pre- to posttest score changes when compared to the other experimental groups. Each participant in this group viewed a lecture about logical fallacies which was approximately 18 min in duration. The length of the lecture was determined based on the median duration of time spent in instruction of several individuals who participated in EBI pilot testing prior to the start of the study, but who were not participants in the study. The experimenter recorded the total time in instruction for each of those individuals. The median time was used to determine the length of the lecture so the duration of instruction for each group was held relatively consistent.

The lecture material was created using the text from which the experimental stimulus set was created (Schick & Vaughn, 2014, pp. 49-55). This lecture was pre-recorded, so the material presented was the same for all participants. Participants viewed the pre-recorded lecture on Canvas. The lecture presented information about what a logical fallacy is, as well as names, definitions, and examples of all 13 fallacies presented in the EBI training. Throughout the lecture, there were multiple brief pauses, during which time the material on the screen remained for several seconds. These brief pauses were used to equate the time in instruction for

participants in this group and participants in the lecture-based instruction with active responding group (see below).

Lecture-Based Instruction with Active Responding (Lecture + AR). The purpose of this condition was to assess the effects of lecture-based instruction with an active-responding component as a positive control comparison for the EBI condition. This control condition was designed to approximate what a college student might experience during a class designed to teach logical fallacies, and to evaluate if requiring participant responding during training influences score changes between pre- and posttests. All procedures for this group were the same as the Lecture-based Instruction group, with the exception of the response requirement. During the video lecture, participants were asked to answer 13 multiple-choice questions composed of seven fallacy name-to-definition (AB) questions and six fallacy name-to-example (AC) questions (see Appendix I.). These questions were chosen so that neither AB or AC relation was presented in full, and so participants in the Lecture + AR training would not be exposed to other relations not presented during EBI training (e.g., BC, CB). These questions appeared one at a time throughout the lecture, during the several-second pauses arranged for the other lecture-based instruction group (see above). Feedback was provided on the quiz answers in the same manner as the feedback provided during the EBI lessons. There was no criterion score required for this quiz before moving to the posttest.

Posttest. All participants completed a comprehensive posttest, identical to the format of the pretest, which comprised of all programmed and non-programmed stimulus relations. The sequence of questions began with BC relations, then CB relations were presented to test for the emergence of symmetry and transitivity relations simultaneously (Green & Saunders, 1998).

The remaining question were presented in a random order within the following sequence: BA, CA, AB, AC.

Generalization quiz. All participants completed a 13-question generalization quiz that required participants to select a fallacy name when presented with a novel example stimulus (i.e., examples not included in training; see Appendix J). The purpose of this quiz was to determine how participants would respond to novel examples for each fallacy following training with specific examples. These questions were presented in two ways: (1) in a similar structure to the examples presented during training (i.e., three sentences with a conjunction), or (2) in a paragraph format. Two different formats were used in the generalization test to determine whether participants responded accurately both to new examples arranged in a form similar to those presented during training, and to novel examples arranged in forms that varied from the training examples.

Seven fallacies (i.e., faulty analogy, appeal to tradition, false dilemma, equivocation, appeal to authority, appeal to the masses, post hoc ergo propter hoc) were presented using a similar structure to those presented in training. For example, the appeal to tradition fallacy was trained using the following example, "Astrology has been around for ages. He is an astrologer. So, there must be something to it." During the generalization test, participants were asked to respond to the following example "This mode of government is the best. We have had this government for over 200 years and no one has talked about changing it in all that time. So, it has got to be good." Six fallacies (i.e., hasty generalization, ad hominem, slippery slope, appeal to ignorance, straw man, begging the question) were presented in paragraph format. For example, the hasty generalization fallacy was trained using the following example which follows the three-sentence training structure, "They tried out medical tests. None of the medical tests have helped.

Medical tests are useless." However, during the generalization test, participants were asked to respond to the following example, "Smith, who is from England, decides to attend graduate school at Ohio State University. He has never been to the US before. The day after he arrives, he is walking back from an orientation session and sees two albino squirrels chasing each other around a tree. In his next letter home, he tells his family that American squirrels are white." This novel example is formatted to be in a paragraph form which does not follow the training structure used.

 Social validity questionnaire. Each participant completed a social validity questionnaire composed of eight questions. Similar to Fields et al. (2009) and Fienup and Critchfield (2011), students used a 5-point Likert-type scale to rate each of eight statements concerning satisfaction with the procedures and the value of the learning outcomes (see Appendix K).

Data Analysis

 The primary dependent measures were the percentage of correct responses during pre- and posttests, duration of instruction, overall session duration and relational responding (i.e., responding on each type of relations, AB, BC, etc.). Mastery of the instructional material was defined as scoring at least 90% (i.e., 15 of 16 correct for CB or 14 of 15 correct for all other relations) on all six relations (AB, AC, etc.). Group means of the pre-posttest scores, duration of instruction, session duration, relational responding, and generalization test scores were calculated between EBI, Lecture, and Lecture + AR groups. One-way ANOVAs were conducted to evaluate differences between the means of pretest scores, posttest scores, score increases, duration of instruction, total session duration, and generalization test scores of the three experimental groups. A one-way ANOVA with repeated measures was conducted with the

pretest and posttest scores across groups. Eta squared effect sizes, calculated as the sum of squares of the dependent variable divided by the total sum of squares, are reported for each ANOVA test to estimate the proportion of variance explained by a dependent variable.

Chapter 3: Results

Participant Demographics

Demographic data were collected from all twenty-four undergraduate participants. These data are presented in Table 1 on the following page. Participants answered 16 questions related to their background, language proficiency, and education experience, which included experience with logical fallacies. Out of twenty-one female and three male students, who were between 18 and 25 years of age, seventeen participants were native English speakers. Seven participants indicated that English was not their native language, although 5 participants indicated that they have spoken English for between 13 and 24 years. One participant indicated they have spoken English for 4 years at an advanced level. Most participants identified as Asian or Pacific Islander, and most were also freshman. Eleven different majors were represented in this sample, with only 9 of the 24 participants majoring in psychology. Participants most often reported a GPA between 3.0 and 4.0 and reported taking between three and five psychology or philosophy courses before participating in this study. Additionally, one participant reported participating in a previous critical thinking study through the psychology department. This participant completed the pretest in a previous semester but did not complete any instruction. They scored below the exclusion criteria (i.e., at or below 80% correct) and therefore were included in the study. Each group had eight participants who were included in the data analysis.

Table 1: Participant Demographics

Measure	# of participants	Measure	# of participants
Gender		Major	
Male	3	Athletic Training	1
Female	21	Biology	2
		Business Management	1
Age		Exploratory Natural Science	1
18 – 20	18	Health Exercise Science	3
21 – 23	5	Mathematics	1
24 – 26	1	Music Therapy	1
		Pre-dental	1
Ethnicity		Pre-pharmacy	2
White	3	Psychology	9
Black or African	0	Speech Language Pathology	2
American	6		
Hispanic or Latino	15	# of relevant classes taken	
Asian or Pacific		0 – 2	2
Islander		3 – 5	17
	17	6 – 8	4
Native English Speaker	7	9 – 11	1
Yes			
No		Taken Critical Thinking Courses	
	1	Yes	
Native Language	1	No	2
Burmese	1		22
Korean	4	If yes, did the course cover	
Vietnamese		logical fallacies	
Spanish		Yes	
	11	No	0
Academic Standing	4	Don't know	1
Freshman	7		1
Sophomore	2	Receiving Extra Credit	
Junior		Yes	
Senior		No	24
	0		0
GPA	1	Participation in another critical	
0.0 - 1.0	11	thinking study	
1.0 - 2.0	12	Yes	
2.0 - 3.0	0	No	1*
3.0 - 4.0			23
4.0+			

*One participant completed the pretest the semester previous to this study but did not complete any instruction. Therefore, they were included in this study.

Pre-Posttest Scores

The primary dependent measure was the relative change in correctly identified logical

fallacies yielded after instruction in one of three ways: EBI, Lecture, and Lecture + AR. Mean

pretest and posttest scores are depicted in Figure 4.
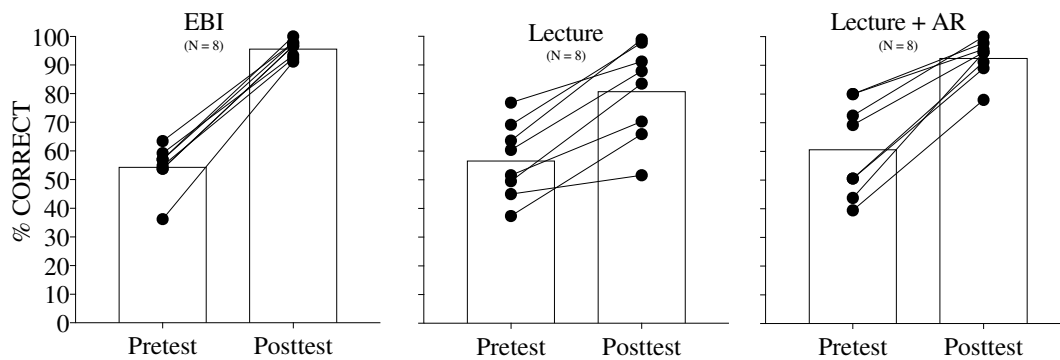
Figure 4. Pre-posttest line graphs displaying each participant's score with mean bar graphs.

The average pretest scores were greater for participants in the Lecture + AR group ($M =$

60.76, $SD = 16.46$) when compared to the EBI and Lecture + AR groups. The pretest scores

were comparable between EBI ($M = 54.46$, $SD = 8.05$) and Lecture ($M = 56.71$, $SD = 13.16$)

groups. The difference between pretest scores across the three groups was not statistically

significant [$F(2, 21) = 0.480$, $p = 0.626$, $\eta^2 = 0.044$]. Visual inspection of Figure 4 suggests that

the pretest scores of participants in EBI were less variable than the scores of participants in the

Lecture and Lecture + AR groups. Posttest scores were greater for participants in the EBI group

($M = 95.74$, $SD = 3.07$) than posttest scores in the Lecture group ($M = 80.88$, $SD = 16.76$). The

posttest scores from participants in the EBI group were comparable to the posttest scores from

participants in the Lecture + AR group ($M = 92.57$, $SD = 6.82$). The difference between posttest

scores across all three groups was statistically significant [$F(2, 21) = 4.256$, $p = 0.026$, $\eta^2 = 0.293$].

Pre-posttest score changes for participants in the EBI group ($M = 41.18$, $SD = 6.71$) were greater than participants in the Lecture group ($M = 24.16$, $SD = 10.03$) and Lecture + AR group ($M = 30.37$, $SD = 10.91$). Mean performance increases for the EBI group ($M = 41.18$, $SD = 6.71$) was almost double that of the Lecture group ($M = 24.16$, $SD = 10.03$) and higher than the Lecture + AR group ($M = 30.37$, $SD = 10.91$) by about 10 points on average, which translates into about a letter grade difference. Mean score increases with 95% confidence intervals were calculated by averaging each participant's posttest score minus their pretest score and are depicted in Figure 5.
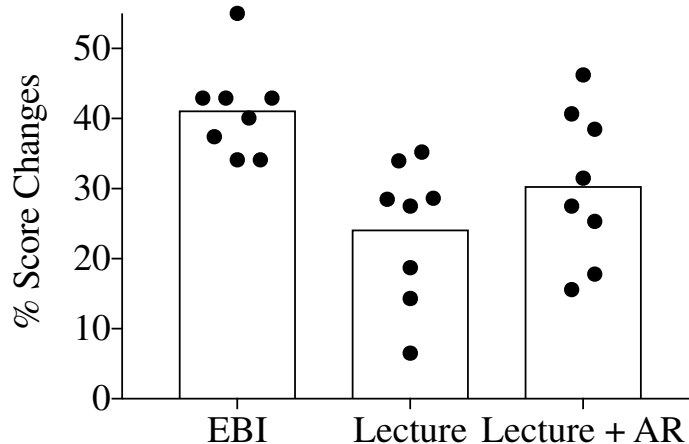
Figure 5. Mean score changes from pre- to posttest depicted as bar graphs and individual score changes from pre- to posttest for each participant depicted as filled circles.

The difference in mean score increase across the three groups was statistically significant [$F(2, 21) = 6.708$, $p = 0.006$, $\eta^2 = 0.390$]. All participants' pretest and posttest scores are individually depicted as a scatterplot in Figure 6.
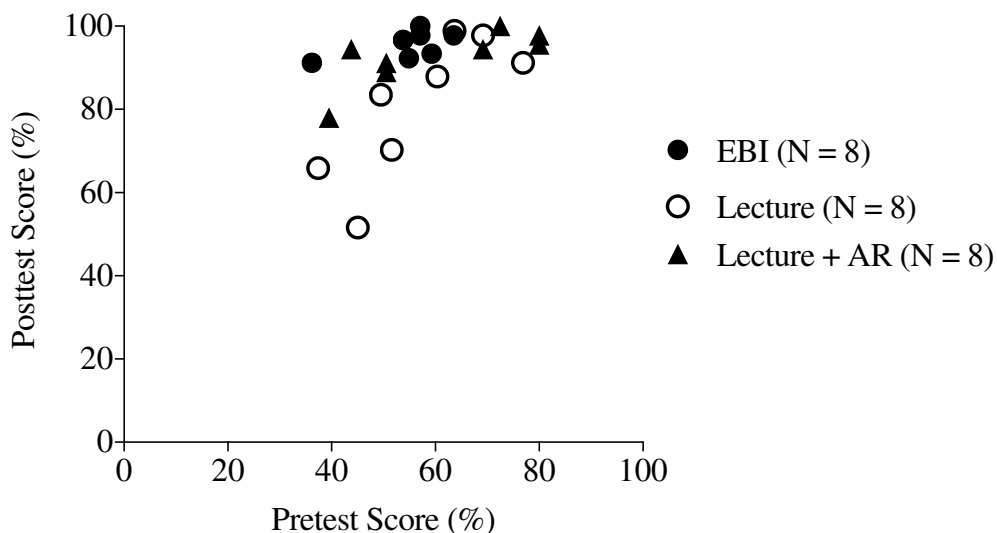
Figure 6. Participant scores on the Pre- and Posttest.

The spread of participant's pretest scores in the Lecture group and Lecture + AR group are similar, but the spread of participant's pretest scores in the EBI group was much narrower compared to the other groups (see figures 4 and 6). This grouping is likely a chance occurrence attributable to small sample size, as all participants in all groups received the same pretest. The spread of posttest scores is similar across EBI and Lecture + AR participants, but participant's scores in the EBI group tended to be greater than participant's scores in the Lecture + AR group. Posttest scores of participants in the Lecture group did increase compared to pretest scores, but these scores were not concentrated above 90% like the posttest scores of participants in the EBI group, rather they were spread throughout a range of 51% to 98%.

Comparative Efficiency

Mean duration of instruction in minutes for all groups are depicted in Figure 7. Mean duration of instruction for EBI ($M = 28.48$. $SD = 13.48$) was longer than Lecture ($M = 17.84$, $SD = 0.53$) and Lecture + AR ($M = 19.83$, $SD = 2.11$).
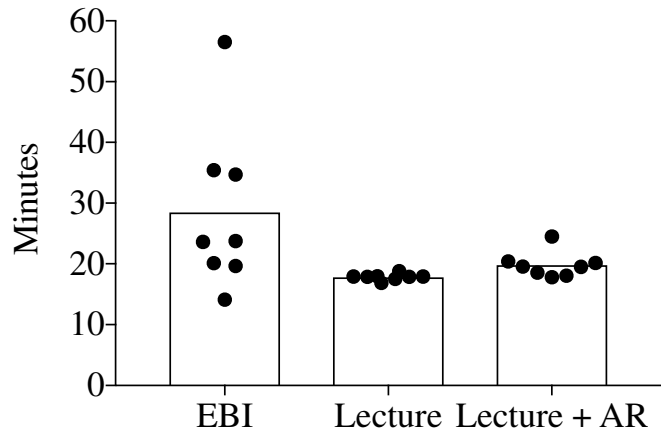
Figure 7. Bar graph depicting mean duration of instruction for EBI, Lecture, and Lecture + AR groups with individual participant data depicted as filled circles.

The differences in mean duration of instruction were statistically significant across the groups [$F(2, 21) = 4.115$, $p = 0.031$, $\eta^2 = 0.282$]. The duration of instruction and pre-posttest score change for the EBI, Lecture and Lecture + AR participants is depicted as a scatterplot in Figure 8.
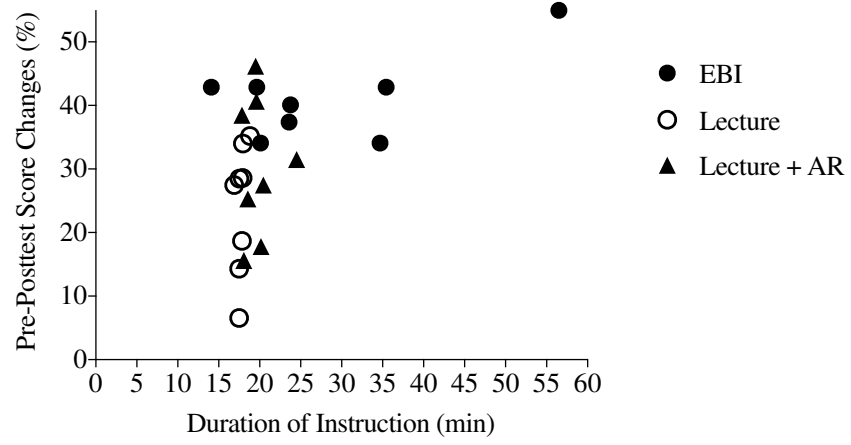
Figure 8. Pre-post test score changes compared with the duration of instruction for each participant.

Through the results are statistically significant, visual inspection suggests that the mean duration of instruction for the EBI group may be artificially inflated due to one outlier that needed 56 minutes to complete the instruction, whereas all other participants took between 14 minutes and 35 minutes. EBI participants required the same or more time in instruction to achieve greater performance increases in comparison to Lecture and Lecture + AR participants. However, EBI performance increases were greater with only two relations taught in instruction (i.e., AB, AC), while the Lecture and Lecture + AR groups were taught all relations (i.e., AB, BA, AC, CA, BC, CB) in less time but earned smaller score increases overall.

Mean session durations for the EBI, Lecture, and Lecture + AR groups are depicted in Figure 9.
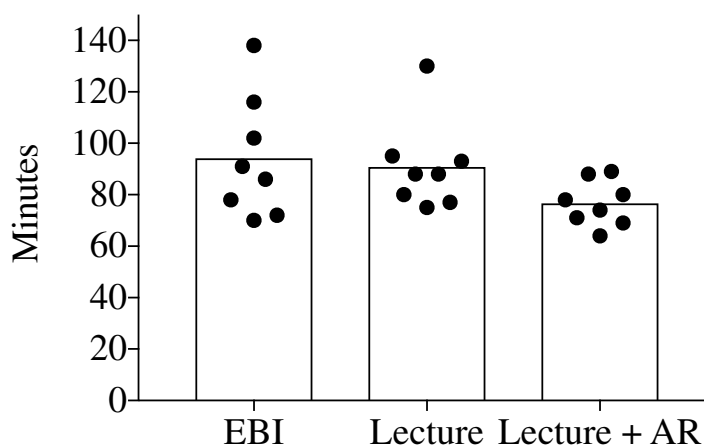
Figure 9. Bar graph depicting mean total session duration for EBI, Lecture, and Lecture + AR groups with individual participant data depicted as filled circles.

Session is defined as the entire time a participant was in the lab area engaged with study material. That is, a timer was started when they entered the lab and began filling out the consent

form and the timer was stopped when the participant submitted the final social validity question.

The mean session duration for EBI ($M = 94.12$, $SD = 23.52$) and Lecture ($M = 90.75$, $SD =$

17.44) were nearly equivalent. The mean session duration for the Lecture + AR group ($M =$

76.62, $SD = 8.87$) was less, though the differences in total session duration across the three

groups were not statistically significant [$F(2, 21) = 2.209$, $p = 0.135$, $\eta^2 = 0.174$]. The session

duration and pre-posttest score change for all participants are individually depicted on a

scatterplot in Figure 10.
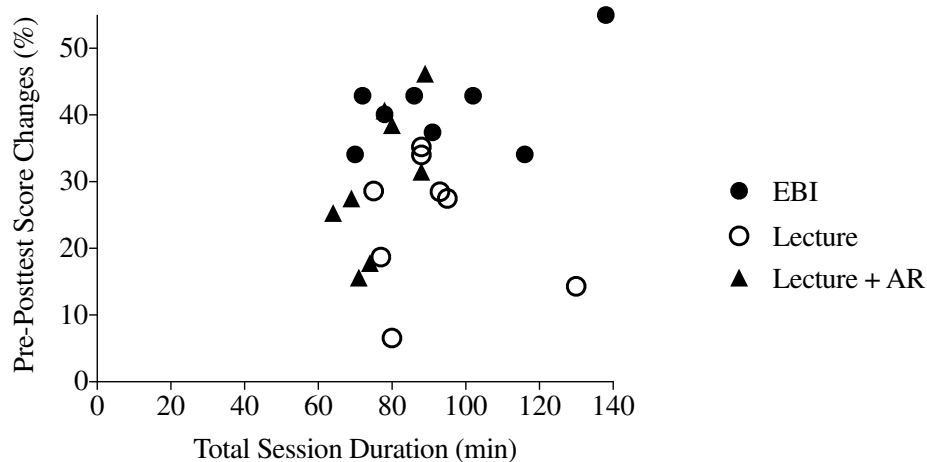
Figure 10. Pre-post test score changes compared with the total session duration for each participant.

The data show that while EBI participants generally required more time in instruction, these time

increases did not appear to translate to more overall time in session but did translate into greater

change in scores from pretest to posttest.

Relational Responding

Changes in individual relations tested (i.e., AB, BC, CA, etc.) from pre- to posttest were

expected to differ across groups with greater mastery in EBI than Lecture and Lecture + AR.

Mean pretest and posttest scores within relations are depicted for EBI, Lecture, and Lecture + AR in Figures 11 and 12.
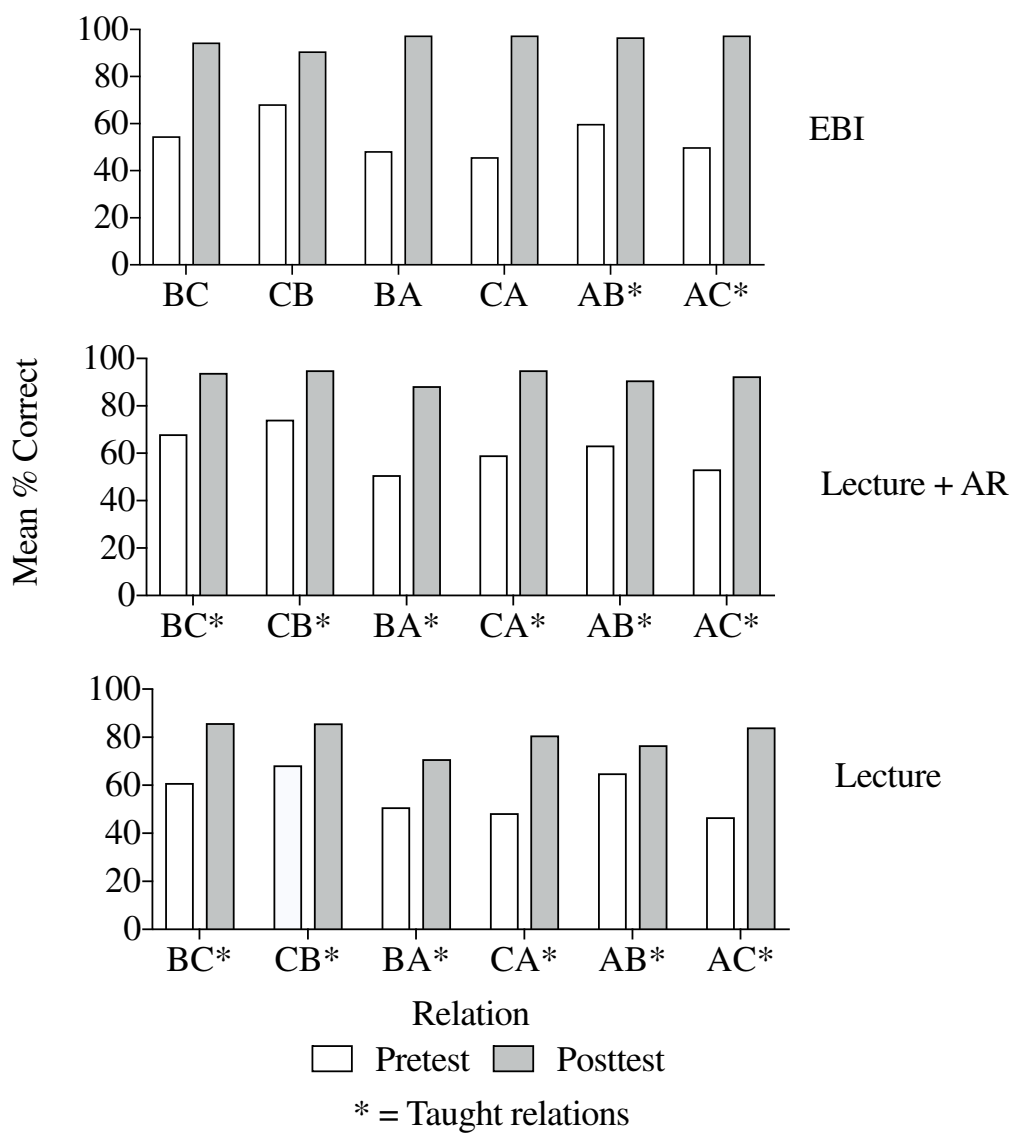
Figure 11. Bar graph depicting mean pre-posttest relational responding for each relation type by group.
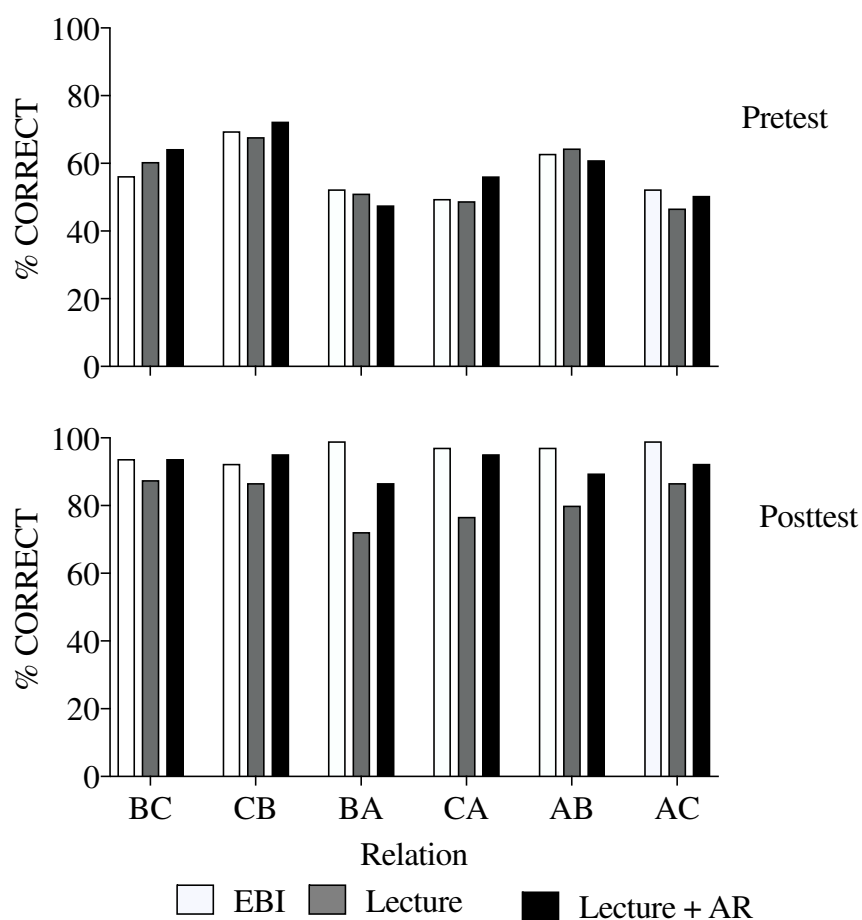
Figure 12. Bar graph depicting mean pre-posttest relational responding for each relation type by test.

Mean relational responding improved for all relations in EBI, Lecture, and Lecture + AR. EBI

lessons trained fallacy names to descriptions (AB) and names to examples (AC). The increase in

BC and CB relations, tested in the posttests, provides evidence that transitivity and symmetrical

relations emerged as a result of EBI. The performance increases observed in the BA and CA

relations provides further evidence that the emergence of symmetrical relation formation. Five

of eight (62.5%) participants who received EBI met mastery criterion of at least 90% correct on

all six relations. The other three participants (37.5%) who received EBI met mastery criterion of at least 90% for more than three out of five relations.

Mean relational responding in the Lecture group improved for all relations from about 46–68% correct on the pretest to 70–85% correct on the posttest. The lecture contained information about all programmed and non-programmed relations (i.e., AB, BA, AC, CA, BC, CB). Despite providing information about more of the relations, relational responding performance by participants was generally worse than the EBI group. Two of the eight (25%) participants who received Lecture instruction met the mastery criterion of at least 90% on all relations. Two participants (25%) met the mastery criterion for three out of six relations. Two of the eight participants (25%) did not meet the mastery criterion for any relations, while the two remaining participants (25%) met mastery for only one of the six relations.

Mean relational responding in Lecture + AR improved significantly for all relations. Similar to the Lecture instruction, the Lecture + AR instruction also contained the same information about all programmed and non-programmed relations (i.e., AB, BA, AC, CA, BC, CB) and required participants to answer questions about the AB and AC relations taught in the EBI training. Despite providing information about more of the relations and requiring responding from participants, relational responding performance was generally worse than the EBI group. Three of the eight (37.5%) participants who received Lecture + AR met mastery criterion of at least 90% on all relations. Four of the eight participants (50%) met the mastery criterion for four or five of the six relations, while one participant (12.5%) only met the mastery criterion for one relation.

Generalization Test

Mean generalization scores were slightly higher in EBI ($M = 74.01$, $SD = 9.15$) than

Lecture ($M = 62.46$, $SD = 17.18$) and Lecture + AR ($M = 70.16$, $SD = 18.61$). The observed

differences between mean generalization scores across groups were not statistically significant

[$F(2, 21) = 1.145$, $p = 0.337$, $\eta^2 = 0.098$]. Mean generalization scores per group and individual

scores are depicted in Figure 13.
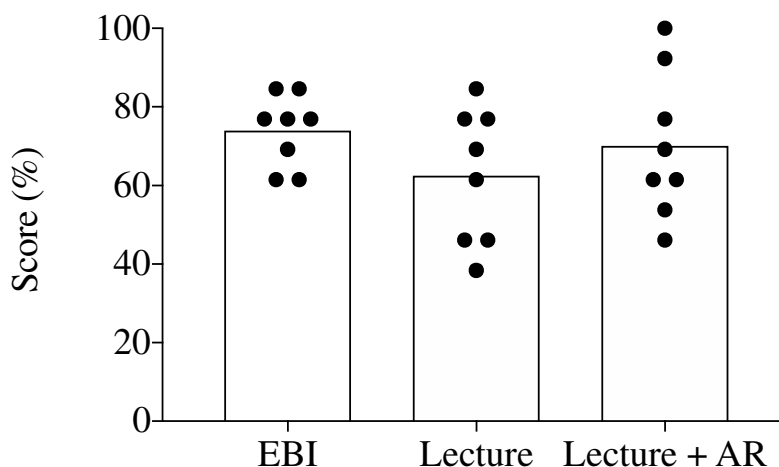
Figure 13. Mean Generalization test scores by group depicted by bars with individual participant data depicted by filled circles.

Social Validity

Following the generalization test, participants answered eight questions regarding the

acceptability and usefulness of the intervention. The means rating for each question is reported

in Table 2.

Generally, participants in the EBI group and Lecture group reported feeling confident

about their knowledge of logical fallacies and that the instruction method helped them master the

material, whereas participants in the Lecture + AR group reported that the instruction methods

used did not help then master the material presented with a mean rating of 2.88. All three groups

reported feeling moderately successful during all the tests with an overall mean rating of 3.66.

Table 2: Social Validity Questionnaire Results by group.

Item	Mean EBI	Range EBI	Mean LI	Range LI	Mean Lecture + AR	Range Lecture + AR
1. I am confident about my knowledge of logical fallacies.	3.75	2 - 5	3.75	3 - 5	3.5	2 - 5
2. The instruction helped me master information about logical fallacies	3.88	2 - 5	4.00	3 - 5	2.88	1 - 4
3. I felt successful during most of the tests	3.75	3 - 5	3.63	3 - 5	3.63	1 - 5
4. I prefer to learn using this instructional method as compared to other instructional methods	3.63	2 - 5	3.5	2 - 5	2.75	1 - 4
5. The time commitment for this instructional method was appropriate in relation to the amount of information I learned	3.88	2 - 5	3.38	1 - 5	3.25	1 - 4
6. I felt frustrated during the lessons	*3.12	2 - 5	*2.63	1 - 4	*2.00	1 - 4
7. If available, I would use this instructional method to learn information needed for my college courses	3.63	2 - 5	3.75	2 - 5	3.00	1 - 4
8. I would recommend the instructional methods in this study to other students	3.75	3 - 5	3.75	3 - 5	3.00	1 - 4

*indicates a lower score is preferred on this question

Additionally, participants in the Lecture + AR group reported feeling the least frustrated

during the instruction period. Despite the higher ratings of frustration, participants in the EBI and

Lecture groups reported that they preferred to learn using this instruction method compared to

other instructional methods, whereas the Lecture + AR group mostly disagreed with that statement. Though there were slight differences in the scores reported between groups, the average ratings generally remained around 3.0, suggesting that participants did not strongly prefer or dislike any of the teaching methods used in their group.

Chapter 4: Discussion

Equivalence-based instruction has been used to teach a range of skills to different populations of learners. EBI is claimed to be more efficient than standard instructional approaches because multiple stimulus relations are learned when only a few relations are taught. Despite these claims, only a few studies have directly compared the outcomes of EBI to outcomes of other instructional techniques. The purpose of the current study was to compare EBI procedures to a more typical teaching format, lecture-based instruction, for teaching students to identify logical fallacies. Overall, the results of this study suggest that EBI is an effective instruction method for teaching college students to identify logical fallacies. When compared to both lecture-based instruction teaching methods, EBI resulted in consistently higher posttest scores following instruction and more consistent acquisition of the nonprogrammed relations (i.e., BA, CA, CB, BC). However, the average time spent in instruction was higher for the EBI group compared to both lecture groups. Additionally, learning under EBI, lecture only, or lecture with active responding, did not lead to higher scores for any group on the generalization test.

In terms of efficiency, the EBI group spent more time in instruction but improved the most on the posttest following instruction when compared with the Lecture and Lecture + AR groups. Mean performance increases for the EBI group was almost double that of the Lecture group and higher than the Lecture + AR group by about 10 points on average, which translates into about a letter grade difference. EBI participants on average spent 28 minutes in instruction compared to about 18 minutes for the Lecture group and 19 minutes for the Lecture + AR group. These differences between instructional time are statistically significant but visual inspection suggests that the mean duration of instruction for the EBI group might be inflated due to one

participant who spent 56 minutes in instruction. All other participants in the EBI group took between 14 minutes and 35 minutes, which is similar to the time spent in instruction for both Lecture and Lecture + AR groups. The median value for each group highlights a smaller difference in instructional time between groups, with the median being 23 minutes for the EBI group, 18 minutes for the Lecture group, and 20 minutes for the Lecture + AR group. These results indicate that EBI participants required the same or slightly more time to complete the instruction but achieved greater performance increases in comparison to Lecture and Lecture + AR participants.

Spending more time in instruction may be seen as a limitation of using EBI procedures, but the tradeoff between mastering the material and spending a few extra minutes in instruction might be beneficial in the long run. For example, participants in the EBI group generally spent more time in instruction, but the mean session durations were similar between all three groups, which suggests that time could have been saved during other portions of testing possibly due to the higher level of mastery attained during EBI training. In an attempt to control for the time in instruction, the lecture was 18 minutes long and only covered the information presented in the pre- and posttests. The lecture length was developed based on the average time in EBI for individuals who participated prior to this study. The lecture could have been expanded to reflect a typical lecture, which might last as long as a college class (about 50 minutes) and cover more background information. Additionally, other alterations could have been made to make the lecture more similar to the EBI procedures used in this study. For example, a self-paced lecture, similar to the individualized nature of these EBI procedures, could have been developed. Nonetheless, the length of the lecture might be an important factor to consider when reviewing the results of this study as much more information can be presented in 50 minutes than 20

minutes. EBI is a set instruction method that programs stimuli in such a way that does not allow for much variation in instruction. However, in a lecture there is much more information that can be included or excluded which introduces more variability across lectures. Though more time might be available for instruction, the addition of more information might not be a good thing depending on the information included. The relevant information might be highlighted and supported by supplemental details or background, or important information may be ignored or missed due to the addition of too much extraneous detail. It seems that simply instructing participants is not as effective as structured EBI procedures; however, if the results of Critchfield (2014) suggest anything it is that a lecture can be an effective teaching tool for establishing equivalence responding in some circumstances. Therefore, future research might look into the content, length of a lecture, and arrangement of the lecture material used as a comparison for more traditional match-to-sample EBI procedures, as there are many different styles of developing and presenting information in a lecture, which might affect student's performance following instruction.

Additionally, it is important to note that EBI performance increases were greater with only two relations taught in instruction (i.e., AB, AC), while participants in the Lecture and Lecture + AR groups were taught all relations (i.e., AB, BA, AC, CA, BC, CB) in less time but participants achieved smaller score increases overall. Participants in the EBI group were exposed to less information but performed the best in terms of score and relational responding on the posttest following instruction. Demand is high for directly incorporating critical thinking instruction into educational curricula; however, doing so might conflict with instruction planned for the already limited time available in the classroom. The results from this study add to growing body of literature that suggests that EBI reliably produces effective and efficient

performance increases in a short amount of time. Additionally, mastery of the material was most consistent after EBI, with 5 out of 8 participants, or 62.5%, reaching mastery. While both the Lecture group (2 out of 8 participants, or 25%) and Lecture + AR group (3 out of 8 participants, or 37.5%) produced lower levels of mastery performance. These results suggest that the EBI arrangement may help instructors spend less time teaching fundamental concepts, such as terms and definitions, while freeing up time to teach other material.

Through EBI produced the greatest performance increases between participants pretest and posttest scores, the scores of the participants in the Lecture + AR group also increased more compared to the scores produced by participants in the Lecture group. Generally, the Lecture + AR group performed better on the posttest, despite spending about the same time in instruction as the Lecture group. The only difference between these two instruction methods included the addition of 13 questions within the lecture in the Lecture + AR group. The mean posttest score for the Lecture + AR group was about 12 points higher, or over a letter grade higher, than the Lecture group. These results suggest that even if an EBI training procedure is not adopted by educators, at least adding some response requirement from students could have a large effect on student performance. Based on all the results from this study, it seems that a lecture alone is not sufficient for teaching students to identify logical fallacies to the point of mastery. Prompting students to respond in some way to the material during instruction increased posttest scores by about 12 points. Instructional time is always in short supply, so instructors must think carefully about what will be taught and how to maximize student and instructor efforts to promote student learning. EBI materials might take more time to develop on the front end, but after the material is developed it can be implemented with large groups of students at a time. Given the performance increases observed following instruction, even with fewer relations taught in

instruction, EBI procedures seem to be a good resource for teaching many skills in higher education. EBI procedures could be incorporated into already existing course curricula, such as a lecture, to teach material that fits into the conditional discrimination format. However, if creating EBI materials does not work for specific subject matter, it seems that adding a number of questions into the instructional time already set aside to teach the material would be a beneficial way of facilitating further student learning.

Though EBI produced greater performance increases and more consistent mastery-level responding, EBI did not produce significantly higher generalization scores. Mean generalization scores were slightly higher in the EBI group than the Lecture group and Lecture + AR group though the results were not statistically significant. It is unclear if the statistically nonsignificant differences in generalization test scores across groups indicates that the different interventions produced no or similar changes in generalization scores because there were no pre-intervention scores for comparison. Similar to the slight differences observed in scores on the pretest, it is possible that there were pre-intervention differences in generalization scores across groups. Many published studies have shown that EBI is an effective intervention for teaching various skills, but if these skills do not generalize, the instruction methods could continue to be improved in order to facilitate generalization.

The current study used the train and hope method of programming for generalization. According to Stokes and Baer (1977), the most pragmatic stance behavior analysts can take is to assume that generalization does not occur unless it is specifically programmed into the behavior change procedures. The results of this study support this assertion, as training for generalization was not a feature of the methods in this study and generalization did not seem to occur. It is possible that generalization did not occur because participants were attending mostly or

exclusively to a specific portion of the question or answer, such as a name or the topic involved in the descriptions or examples. Therefore, participants might not have learned the fallacies but, rather, learned a specific set of questions and answers, which would not necessarily be expected to generalize to novel sets of stimuli. One method that might increase the generalizability of EBI interventions is to train sufficient exemplars. Stokes and Baer (1997) describe this method as one of the most valuable areas of programming for generalization because it is relatively simple and effective. Training sufficient exemplars involves increasing the number of different responses or stimuli used during training. For example, the number of examples used to teach each of the fallacies taught in this study could be increased to include several different scenarios. This type of programming might address the concern that participants are attending to portions of the stimuli that are extraneous (i.e., certain words, length of the sentence) by presenting a variety of examples that are all different (e.g., names used, subject of the example, amount of information presented) except the fallacy they exemplify.

To the extent possible, the stimuli used during training should be varied in every possible way except for the target dimension. For example, to teach the color "red" to a child, one would present the child with items of different sizes, shapes, dimensions, and shades of red, which all differ except for the target dimension: red. With this example in mind, the information for each of the fallacy examples used during training could be altered in terms of the format that the information is presented and the content of the examples. These alterations could take the form of written examples each with a different topic and differing amount of information provided, but these examples could also include video stimuli, such as TV commercials or YouTube videos, or entire articles from various news outlets. All of these various ways of presenting fallacies would differ across various dimensions except for the target dimension: the logical

fallacy. Future research could focus on increasing generalization of the skills taught during instruction by incorporating multiple exemplars of the definitions and examples trained for each fallacy. Increasing the generalizable effects of this instruction could further increase the utility of EBI as an instruction method.

Furthermore, increasing the generalization of skills taught using EBI could increase the social validity of the intervention and facilitate adoption of this intervention in classrooms. Participants were asked to answer multiple questions in relation to the social acceptability of each intervention used in this study. Presenting the empirical outcomes for an intervention does not guarantee that this intervention will be adopted by educators. One of the issues that drive dissemination of interventions is social validity (Wolf, 1978) or the degree to which the consumers like the particular intervention. These EBI lessons were not typical college-classroom experiences, so participants might have disliked them, which could affect student evaluations of instruction and instructor job security in a typical college environment. However, the social validity assessment indicated that participants in all three groups generally liked the intervention they experienced, through the Lecture + AR group consistently reported slightly lower ratings than the other two groups. These results suggest that student's preference might not impede the dissemination of EBI procedures into higher education classrooms, as the rating provided by the EBI group were generally the same or higher than both the Lecture and Lecture + AR group.

Despite the promising outcomes for EBI, there are some limitations of the EBI procedures and this study in particular that warrant further attention. First, there were only 8 participants in each experimental group, which might have contributed to the statistically nonsignificant but still noticeable differences in pretest scores across the groups. Lecture

participants tended to score better on pretests than EBI or Lecture + AR participants despite

random assignment to groups prior to taking the pretests. Additionally, the pretest scores of

participants in the EBI group were less variable than the scores of participants in the Lecture and

Lecture + AR groups.

A second limitation of this study is that the amount of feedback provided differed across

conditions. EBI participants received feedback on AB and AC relations multiple times (e.g.,

they were asked to repeat these questions until they scored a 100%), Lecture participants

received no feedback during instruction, and Lecture + AR participants only received feedback at

the end of the lecture concerning what score they received. The performance increases observed

across groups might have been affected by the number of trials on which participants received

feedback. Future research should equate the amount of feedback across groups when comparing

EBI to alternative instructional methods. For example, an improved control group similar to this

study's Lecture + AR group might provide participants with access to the test questions with

correct answers displayed for review.

A third limitation of this study is that a match to sample procedure was used to teach the

students to identify logical fallacies. This type of learning might mirror what it expected in a

college course for an exam, but some questions might also be asked in an open-ended format or

might not even be presented in a question format. However, if the goal is to increase critical

thinking skills as a whole, it would be good to consider that most situations that require critical

thinking in the real world will not involve a match-to-sample response format. Therefore, future

research should evaluate different EBI formats that could be used to promote generalization. For

example, including some questions that are not selection-based, but rather include questions that

require the participants to produce their own answers. For example, training and testing could

require fill-in-the-blank responses or short-answer responses, thereby using questions which do not provide answer choices for participants to select.

A fourth limitation, related to generalizability, involves maintenance of the material learned during training. This study did not include a test for mastery of the material at a later date. This study does not provide information about the degree to which the effects of these instruction methods will persist. Many published studies have shown that EBI can be used to teach various skills at the time of instruction, but few studies evaluate if participants continue to perform at or near mastery levels after instruction has ended. Future studies should evaluate whether skills taught using various teaching methods will maintain over time and further adapt those teaching methods to facilitate maintenance.

In summary, EBI was an effective and relatively efficient way to teach students to recognize and identify logical fallacies. The effectiveness of EBI was demonstrated through comparisons with both a lecture only group and a lecture plus active responding group, which required participants to respond to the instruction material in some way. When compared to both lecture-based instruction teaching methods, EBI resulted in consistently higher posttest scores following instruction and more consistent acquisition of the nonprogrammed relations (i.e., BA, CA, CB, BC). The average time spent in instruction was higher for the EBI group compared to both lecture groups; however, it is important to note that EBI performance increases were greater with only two relations taught in instruction (i.e., AB, AC), while participants in the Lecture and Lecture + AR groups were taught all relations (i.e., AB, BA, AC, CA, BC, CB) in less time but participants achieved smaller score increases overall. However, the generality of the findings in relation to broader critical-thinking skills is limited as there were no observed differences in scores on the generalization test administered to all groups. Given these results, researchers

should evaluate EBI procedures for teaching a wider range of critical thinking skills and develop

a potentially more effective EBI procedure which seeks to address the lack of generalization and

maintenance of the learned material during instruction.

References

Abraham, G. J., Dhume, V. G., & Diniz, R. S. (1981). Comparison of didactic lecture, self-reading and self-instruction as learning methods in medical students of western India. *Medical Education*, *15*(4), 222-225.

Almossawi, A. (2013). *An illustrated book of bad arguments.* New York, NY: JasperCollins Publishers.

APA Guidelines for the undergraduate psychology major: version 2.0. (2016). *American Psychologist, 71*(2), 102 – 111. http;//doi.org/10.1037/a0037562

Arntzen, E. (2012). Training and testing parameters in formation of stimulus equivalence: Methodological issues. *European Journal of Behavior Analysis*, 13, 123–135.

Arntzen, E., Grondahl, T., & Eilifsen, C. (2010). The effects of different training structures in the establishment of conditional discriminations and the subsequent performance on the tests for stimulus equivalence. *The Psychological Record, 60*, 437–462.

Barnes, D., McCullagh, P. D., & Keenan, M. (1990). Equivalence class formation in non-hearing impaired children and hearing-impaired children. *The Analysis of Verbal Behavior*, *8*, 19–30. https://doi.org/10.1007/BF03392844

Bassett, M. H. (2016), Teaching critical thinking without (much) writing: Multiple-choice and metacognition. *Teaching Theology & Religion*, 19: 20–40. doi:10.1111/teth.12318

Brunt, B. A. (2005). Critical thinking in nursing: An integrated review. *The Journal of Continuing Education in Nursing*, *36*(2), 60-67.

Cowley, B. J., Green, G., & Braunling-McMorrow, D. (1992). Using stimulus equivalence

    procedures to teach name-face matching to adults with brain injuries. *Journal of Applied*

    Behavior Analysis, 25, 461–475.

Crenshaw, P., Hale, E., & Harper, S. (2011). Producing intellectual labor in the classroom: the

    utilization of a critical thinking model to help students take command of their thinking.

    Journal of College Teaching & Learning, 8(7), 13–22.

Critchfield, T. S. (2014). Online equivalence-based instruction about statistical inference

    using written explanation instead of match-to-sample training. *Journal of applied*

    behavior analysis, *47*(3), 606-611.

Critchfield, T. S., & Twyman, J. S. (2014). Prospective instructional design: establishing

    conditions for emergent learning. *Journal of Cognitive Education and Psychology*, 13(2),

    201-217.

Desai, M. S., Berger, B. D., & Higgs, R. (2016). Critical thinking skills for business school

    graduates as demanded by employers: a strategic perspective and recommendations.

    Academy of Educational Leadership Journal, 20(1), 10-31.

De Carvalho, C. F., & And, O. (1977). Comparative analysis between guided self-instruction and

    conventional lectures in neuroanatomy. *Journal of Medical Education*.

De Souza, D. G., de Rose, J. C., & Domeniconi, C. (2009). Applying relational operants to

    reading and spelling. In R. A. Rehfeldt & Y. Barnes-Holmes (Eds.), *Derived relational*

    responding: Applications for learners with autism and other developmental disabilities

    (pp. 173–207). Oakland, CA: New Harbinger.

Devany, J. M., Hayes, S. C. & Nelson, R. O. (1986). Equivalence class formation in language-able and language-disabled children. *Journal of the Experimental Analysis of Behavior*, 46: 243–257. doi:10.1901/jeab.1986.46-243

Dewey, J. (1909). *How We Think*, New York: Houghton Mifflin. reprinted 1997.

Dube, W. V., McIlvane, W. J., Maguire, R. W., Mackay, H. A., & Stoddard, L. T. (1989). Stimulus class formation and stimulus-reinforcer relations. *Journal of the Experimental Analysis of Behavior*, *51*(1), 65–76. http://doi.org/10.1901/jeab.1989.51-65

Dykman, C. A., & Davis, C. K. (2008). Part one - The shift toward online education. *Journal of Information Systems Education*, *19*(1), 11-16.

Facione, P. A. (1990). Critical thinking: a statement of expert consensus for purposes of educational assessment and instruction. Millbrae, California: Author.

Fields, L., Travis, R., Roy, D., Yadlovker, E., de Aguiar-Rocha, L., & Sturmey, P. (2009). Equivalence class formation: a method for teaching statistical interactions. *Journal of Applied Behavior Analysis*, *42*(3), 575–593. http://doi.org/10.1901/jaba.2009.42-575

Fienup, D. M & Brodsky, J. (2017). Effects of mastery criterion on the emergence of derived equivalence relations. *Journal of Applied Behavior Analysis*, 50: 843–848. doi:10.1002/jaba.416

Fienup, D. M., Covey, D. P., & Critchfield, T. S. (2010). Teaching brain–behavior relations economically with stimulus equivalence technology. *Journal of Applied Behavior Analysis*, *43*(1), 19–33. http://doi.org/10.1901/jaba.2010.43-19

Fienup, D. M., & Critchfield, T. S. (2010). Efficiently establishing concepts of inferential statistics and hypothesis decision making through contextually controlled equivalence

classes. *Journal of Applied Behavior Analysis*, *43*(3), 437–462.

http://doi.org/10.1901/jaba.2010.43-437

Fienup, D. M. & Critchfield, T. S. (2011). Transportability of equivalence-based programmed

instruction: efficacy and efficiency in a college classroom. *Journal of Applied Behavior*

Analysis, 44, 435-450. doi:10.1901/jaba.2011.44-435

Fienup, D. M., Wright, N. A. and Fields, L. (2015), Optimizing equivalence-based instruction:

Effects of training protocols on equivalence class formation. Journal of Applied Behavior

Analysis, 48: 613–631. doi:10.1002/jaba.234

Forawi, S. A. (2016), Standard-based science education and critical thinking. *Thinking Skills and*

Creativity, 20: 52-6. http://dx.doi.org/10.1016/j.tsc.2016.02.005

Fox, E. J., & Chezzi, P. M. (2003). Effects of computer-based fluency training on concept

formation. *Journal of Behavioral Education, 12,* 1-21.

Glaser, E. M. (1941). An experiment in the development of critical thinking (No. 843). Teachers

College, Columbia University.

Green, G., & Saunders, R. R. (1998). Stimulus equivalence. In K. A. Lattal & M. Perone (Eds.),

Handbook of research methods in human operant behavior (pp. 229–

262). New York: Plenum Press.

Hall, G. A., & Chase, P. N. (1991). The relationship between stimulus equivalence and verbal

behavior. *The Analysis of Verbal Behavior, 9,* 107-119.

Hatcher, D, L., (2013) Is critical thinking across the curriculum a plausible goal? *OSSA*

Conference Archive. Paper 69.

http://scholar.uwindsor.ca/ossaarchive/OSSA10/papersandcommentaries/69

Hausman, N., Borrero, J. C., Fisher, A., & Kahng, S. (2014). Improving accuracy of

portion-size estimations through a stimulus equivalence paradigm. *Journal of Applied Behavior Analysis*, 47, 485–499. Doi:10.1002/jaba.139.

Huff, M. T. (2000). A comparison study of live instruction versus interactive television for teaching MSW students. *Research on Social Work Practice*, *10*(4), 400-416.

Leischow, S. J., & Milstein, B. (2006). Systems thinking and modeling for public health practice. *American Journal of Public Health,* 96(3) 403-405. doi:10.2105/AJPH.2005.082842

Lovett, S., Rehfeldt, R. A., Garcia, Y., & Dunning, J. (2011). Comparison of a stimulus equivalence protocol and traditional lecture for teaching single-subject designs. *Journal of Applied Behavior Analysis*, *44*(4), 819–833. http://doi.org/10.1901/jaba.2011.44-819

Lynch, D. C., & Cuvo, A. J. (1995). Stimulus equivalence instruction of fraction-decimal relations. *Journal of Applied Behavior Analysis*, 28, 115–126.

McDaniel, M. A., Anderson, J. L., Derbish, M. H., & Morrisette, N. (2007). Testing the testing effect in the classroom. *European Journal of Cognitive Psychology, 19*, 494–513. doi:10.1080/0954144070132615410.1080/09541440701326154

Mueller, M. M., Olmi, D. J., & Saunders, K. J. (2000). Recombinative generalization of within-syllable units in prereading children. *Journal of Applied Behavior Analysis*, 33, 515–531.

Murphy, C., & Barnes-Holmes, D. (2009). Derived more–less relational mands in children diagnosed with autism. *Journal of Applied Behavior Analysis*, 42, 253–268.

Ninness, C., Barnes-Holmes, D., Rumph, R., McCuller, G., Ford, A. M., & Payne, R., et al. (2006). Transformations of mathematical and stimulus functions. *Journal of Applied Behavior Analysis*, 39, 299–321.

Ninness, C., Dixon, M., Barnes-Holmes, D., Rehfeldt, R. A., Rumph, R., McCuller, G., et al. (2009). Constructing and deriving reciprocal trigonometric relations: A functional analytic approach. *Journal of Applied Behavior Analysis*, 42, 191–208.

Ninness, C., Rumph, R., McCuller, G., Harrison, C., Ford, A. M., & Ninness, S. K. (2005). A functional analytic approach to computer-interactive mathematics. *Journal of Applied Behavior Analysis*, *38*(1), 1–22. http://doi.org/10.1901/jaba.2005.2-04

O'Neill, J., Rehfeldt, R. A., Ninness, C., Muñoz, B. E., & Mellor, J. (2015). Learning skinner's verbal operants: comparing an online stimulus equivalence procedure to an assigned reading. *The Analysis of Verbal Behavior*, 31(2), 255-266. http://doi.org/10.1007/s40616-015-0035-1

Ong, T., Normand, M. & Schenk, M. (in press). Equivalence-based instruction for a critical thinking skill. *Unpublished Master's Thesis*, University of the Pacific, Stockton, CA.

Paul, R., Elder, L., & Bartell, T. (1997). Study of 38 Public Universities and 28 Private Universities to Determine Faculty Emphasis on Critical Thinking in Instruction. Retrieved September 16, 2017, from http://www.criticalthinking.org/pages/study-of-38-public-universities-and-28-private-universities-to-determine-faculty-emphasis-on-critical-thinking-in-instruction/598

Pytte, C. L., & Fienup, D. M. (2012). Using equivalence-based instruction to increase efficiency in teaching neuroanatomy. *Journal of Undergraduate Neuroscience Education*, *10*(2), 125–131.

Rehfeldt, R. A. (2011). Toward a technology of derived stimulus relations: An analysis of articles published in the *Journal of Applied Behavior Analysis*, 1992–2009. *Journal of Applied Behavior Analysis*, *44*(1), 109–119. http://doi.org/10.1901/jaba.2011.44-109

Scheffer, B. K. & Rubenfeld, M. G. (2000). A consensus statement on critical thinking in

   nursing. *Journal of Nursing Education*, *39*, 352-359.

Schick Jr., T. & Vaughn, L. (2014). *How to think about weird things: Critical thinking for a new*

   age (7th ed.). New York, NY: McGraw-Hill.

Sidman, M. (1971). Reading and auditory-visual equivalences. *Journal of Speech and*

   Hearing Research, 14, 5–13.

Sidman, M. (1994). Equivalence relations and behavior: A research story. *Boston:*

   Authors Cooperative.

Sidman, M., & Tailby, W. (1982). Conditional discrimination vs. match to sample: An

   expansion of the testing paradigm. *Journal of the Experimental Analysis of Behavior*, *37*,

   5–22. http://doi.org/10.1901/jeab.1982.37-5

Skinner, B. F. (2003). *The Technology of Teaching*. Acton, MA: Copley.

Smyth, S., Barnes-Holmes, D., & Barnes-Holmes, Y. (2008). Acquired equivalence in

   human discrimination learning: The role of propositional knowledge. *Journal of*

   Experimental Psychology: Animal Behavior Processes, *34*(1), 167.

Solon, T. (2007). Generic critical thinking infusion and course content learning in

   introductory psychology. *Journal of Instructional Psychology,* 34, 972–987.

Stokes, T. F., & Baer, D. M. (1977). An implicit technology of generalization. *Journal of*

   Applied Behavior Analysis, 10, 349-367. http://doi.org/10.1901/jaba.1977.10-349

Stromer, R. & Mackay, H. A. (1992). Spelling and emergent picture-printed word

   relations established with delayed identity matching to complex samples. *Journal of*

   Applied Behavior Analysis, 25, 893-904. doi:10.1901/jaba.1992.25-893

Taylor, M. (2010, September 12). Schools, businesses focus on critical thinking.

Wall Street Journal. Retrieved September 03, 2017, from

https://www.wsj.com/articles/SB10001424052748703882304575466100773788806

The National Education Goals Panel (NEGP): Building a Nation of Learners. (n.d.).

Retrieved September 03, 2017, from http://govinfo.library.unt.edu/negp/page3-13.htm

Walker, B. D. & Rehfeldt, R. A. (2012). An evaluation of the stimulus equivalence paradigm to

teach single-subject design to distance education students via Blackboard. *Journal of*

Applied Behavior Analysis, 45, 329-344. doi:10.1901/jaba.2012.45-329

Wells, L. A. (2015). Clinical thinking in psychiatry. *Journal of Evaluation in Clinical*

Practice, *21*(3), 514-517.

Wolf, M. M. (1978). Social validity: the case for subjective measurement or how applied

behavior analysis is finding its heart. *Journal of Applied Behavior Analysis*, *11*(2),

203–214. http://doi.org/10.1901/jaba.1978.11-203

Urbaniak, G. C., & Plous, S. (2013). Research Randomizer (Version 4.0) [Computer

software]. Retrieved from http://www.randomizer.org/

APPENDIX A: THESIS PROPOSAL INTRODUCTION

Critical thinking is important for effective decision-making, as emphasized by educators and professionals in many fields, including nursing (Brunt, 2005; Scheffer & Rubenfeld, 2000), psychiatry (Wells, 2015), social work (Huff, 2000), business (Desai, Berger, & Higgs, 2016), and public health (Leischow & Milstein, 2006), to name a few. However, the methods used to teach critical thinking in higher education (e.g., projects, lectures, homework assignments) seem to fall short of establishing the skills necessary for graduates entering professional settings (Crenshaw, Harper & Hale, 2011; Hatcher, 2013). For example, in 2010, the Wall Street Journal surveyed 479 college recruiters about what skills new college graduates needed to improve the most before entering the workforce. Nearly all recruiters said, "critical thinking, problem solving skills, and the ability to think independently" (Taylor, 2010).

Current best practices in higher-education aim to promote more efficient and effective instruction by outlining the expectations for student learning and setting goals based on those expectations (e.g., APA, 2016). The National Education Goals Panel (NGEP) formulated eight general educational goals that seek to improve learning and teaching in our education system. Goal 6, "Adult Literacy and Lifelong Learning," attempts to address the lack of critical thinking skills in our society by creating objectives aimed at increasing critical thinking skills. This goal states, "By the year 2000, every adult American will be literate and will possess the knowledge and skills necessary to compete in a global economy and exercise the rights and responsibilities of citizenship" (NEGP, n.d.). The recommendations for achieving this goal include statements such as, "The proportion of college graduates who demonstrate an advanced ability to think critically, communicate effectively, and solve problems will increase substantially" and "every major American business will be involved in strengthening the connection between education and work" (NEGP, n.d.). A missing component of such education goals, however, is how one

APPENDIX A: (CONT.) THESIS PROPOSAL INTRODUCTION

should go about achieving them, as specific teaching strategies are not identified. It is one thing to say the proportion of college students graduating with critical thinking skills will increase, but another to successfully teach college students to think critically.

Similarly, when examining educational practices in a narrower context (e.g., psychology), the same issues arise. Goals have been set concerning critical thinking but effective strategies for reaching these goals have not been identified. The *APA Guidelines for the Undergraduate Psychology Major: Version 2.0* (APA, 2016) list "Scientific Inquiry and Critical Thinking" as a student learning outcome that should result from the instruction available to students working towards a psychology degree. These goals operate on the assumption that standard curricula will need to be modified to include teaching methods that will help students acquire critical thinking skills by incorporating specific instruction on critical thinking. Setting goals is an important aspect of educational progress; however, setting goals without specifying necessary changes to the instructional methods used is unlikely to result in those goals being met (Forawi, 2016).

Additionally, teaching critical thinking in schools and universities continues to be difficult for a number of reasons, including that the definition of critical thinking across contexts is not clear, effective strategies for teaching critical thinking have not been clearly identified, and educators might not have the training necessary to teach critical thinking skills effectively (Crenshaw, Harper & Hale, 2011; Forawi, 2016). For example, Paul, Elder, and Bartell (1997) assessed current teaching practices and knowledge of critical thinking among instructors in teacher preparation programs in California in the 1990s. They found that 89% of educators claimed critical thinking to be a primary objective of their instruction, but only 19% could provide a clear explanation of what constitutes critical thinking. Additionally, 77% were unable

APPENDIX A: (CONT.) THESIS PROPOSAL INTRODUCTION

to identify how to incorporate teaching critical thinking into their normal course material, and only 9% were clearly teaching critical thinking on a typical day in class. If there are no changes in the education system and curricula used for teaching critical thinking skills, many graduates will fail to learn important critical thinking and problem-solving skills.

Definition of Critical Thinking

Some argue that the absence of a clear consensus definition of critical thinking acts as a barrier to developing specific plans for teaching critical thinking skills in educational settings (Crenshaw, Harper & Hale, 2011). However, in 1990, the American Philosophical Association published the Delphi Report, which sought to create a consensus definition of critical thinking to be used in educational settings (Facione, 1990). A panel of experts in the fields of philosophy, education, social sciences and physical sciences created a definition of critical thinking which includes six specific skill areas: interpretation, analysis, evaluation, inference, explanation, and self-regulation. The Delphi Report also developed multiple clearly defined sub-skills for each of the six skill areas. This extensive report also made 15 recommendations pertaining to critical thinking instruction and assessment based on these six skill areas. These recommendations focused on incorporating critical thinking into all levels and subject areas of education and setting minimum proficiency expectations for demonstrating critical thinking skills at each instructional level (Facione, 1990). The Delphi Report suggested that these skills should be targeted early in the education process because instruction on how to think critically will likely be ineffective if started at the higher-education level (Facione, 1990). Importantly, the Delphi Report provided examples of teaching components that could lead to more critical thinkers if instruction begins in university settings. For example, the report suggested that individuals

APPENDIX A: (CONT.) THESIS PROPOSAL INTRODUCTION

should be taught "to reason, to seek relevant facts, to consider options, and to understand the views of others" (Faicone, 1990, p. 12). This list provides a useful starting point for creating a critical thinking curriculum which incorporates the six components of critical thinking outlined in the Delphi Report.

After the Delphi Report was published, other fields continued to develop definitions of critical thinking pertaining to their specific subject matter, increasing the number of definitions for educators to consider when deciding how to teach critical thinking. For example, Scheffer and Rubenfeld (2000) defined critical thinking in the context of evidence-based practice and education in nursing. Individuals who think critically exhibit certain skills, such as, "analyzing, applying standards, discriminating, information seeking, logical reasoning, and predicting and transforming knowledge (p. 357)." Whereas a definition of critical thinking used in social work is described as "the process of purposeful, self-regulatory judgment. Critical thinking… is the cognitive engine which drives problem-solving and decision-making" (Huff, 2000, p. 402). These definitions, unlike the Delphi Report, refer to vague constructs, such as "self-regulatory judgment," rather than to well-defined skills that constitute critical thinking. Depending on the clarity of the definition used for critical thinking, different teaching methods could be developed to address what it means to think critically, but they might not actually teach critical thinking because the instruction methods were developed based on vague terms and constructs instead of concrete skills. Moreover, domain-specific instruction could result in students being considered good critical thinkers in one context but not in another. That is, a student might be considered a good critical thinker in a specific class but not necessarily when applying for a job.

APPENDIX A: (CONT.) THESIS PROPOSAL INTRODUCTION

Due to the importance placed on critical thinking in education and the apparent lack of consensus across disciplines about what it means to think critically, it seems important to at least determine if individuals within the same discipline agree on the skills necessary to think critically within that discipline. Toward this end, Desai, Berger, and Higgs (2016) investigated the current understanding of critical thinking skills by professors at five different business schools. Desai et al. (2016) examined each professor's descriptions of the components of critical thinking and the methods used for teaching and evaluating critical thinking skills. Professors were asked to answer the following question, "In your view, what are the specific elements of the definition of CT [Critical Thinking] as applied to the major field of study you teach?" The results were comprised of 15 different one-word answers, with some professors providing only one answer and others stating multiple answers. The top five one-word responses included: problem, solve, application, analysis, and logic. However, only 34% of professors agreed that all of these components were important parts of critical thinking. These results suggest that even within a specific field such as business, different professors teaching what they consider to be critical thinking might have different standards for acceptable critical thinking skills demonstrated by students.

Although the definition of critical thinking varies across, and even within, fields, common components of most definitions include logical reasoning and the identification of flawed arguments (Facione, 1900; Forawi, 2015; Hatcher, 2013; Schick & Vaughn, 2014). For example, famed educational psychologist John Dewey argued that critical thinking is "active, persistent, and careful consideration of a belief or supposed form of knowledge in the light of the

APPENDIX A: (CONT.) THESIS PROPOSAL INTRODUCTION

grounds which support it" (Dewey, 1909, p. 9). Later, Glaser (1941) expanded this definition, stating that critical thinking is

> knowledge of the methods of logical enquiry and reasoning and some skill in applying those
> methods. Critical thinking calls for a persistent effort to examine any belief or supposed
> form of knowledge in the light of evidence that supports it and further conclusions to which it
> tends. (p. 5)

A central focus of critical thinking, based on these definitions and others, is to formulate a logical argument or to evaluate the logic used to develop an argument. One method of teaching individuals to recognize flawed arguments is to teach them to identify common errors in the logic used to develop an argument. These common errors are referred to as logical fallacies, defined as, "an error in reasoning that results in an invalid argument…Logical fallacies are violations of one or more of the principles that make a good argument" (Almossawi, 2013, p. 10). An argument is considered fallacious if it contains an unacceptable premise, irrelevant premise, or insufficient premise (Schick & Vaughn, 2014). For example, the fallacy, "begging the question," is defined as an argument whose conclusion is used as one of its premises. If the argument "Jane is telepathic" is posed, a conversation between two individuals might proceed as such: "Jane is telepathic. How do you know? Because she can read my mind. How do you know she can read your mind? Because she is telepathic." In this conversation, the argument that Jane is telepathic is not supported by an acceptable premise, because the premise is the conclusion, and therefore is fallacious (Schick & Vaughn, 2014). Students could be taught this subset of critical thinking skills, identifying fallacious arguments, and learn logical fallacies, the definition of those fallacies, and examples of those fallacies. Identifying logical fallacies is a concrete skill that is amenable to specific instruction in educational settings.

APPENDIX A: (CONT.) THESIS PROPOSAL INTRODUCTION

Strategies for Teaching Critical Thinking

Critical thinking is considered an important educational goal, but it remains an elusive educational target, which is not surprising given the lack of consensus across fields about what constitutes good critical thinking. Teachers use many different methods in their attempts to teach critical thinking in their classrooms. For example, Desai et al. (2016) investigated the current methods used to teach and assess critical thinking by professors at five different business schools. Professors were asked to answer the following question, "How do you teach those CT skills in your major field of study?" Seventeen different responses were given, which included projects, assignments, case studies, group projects, and brainstorming exercises. Results indicated that there was a wide variety of methods used by professors to teach and assess critical thinking. For example, 47% of professors indicated that they primarily used projects to teach critical thinking skills, while 28% of professors indicated that they primarily used case studies. Depending on the definition used for critical thinking within certain educational contexts, any of these teaching methods could be used to address different aspects of what it means to think critically. Moreover, it is possible that none of these teaching methods address critical thinking effectively, as the strategies themselves are not very specific. There is a need for standards of teaching, measuring, and assessing critical thinking skills, as teachers might think they are successfully teaching critical thinking based on their own standards, but they might not be preparing students to apply their critical thinking skills (Desai, Berger & Higgs, 2016).

For example, a professor at Georgia State University decided that critical thinking in her classroom meant that students needed to think about thinking by considering how they know what they know (Bassett, 2017). That is, if a student displays metacognitive processes (i.e., awareness and understanding of one's own thought process), they are considered effective critical

APPENDIX A: (CONT.) THESIS PROPOSAL INTRODUCTION

thinkers. Bassett (2017) assessed her students critical thinking skills by administering multiple-choice tests with space to the side to write down how they chose their answer. If they chose the correct answer, her students also had to provide a clear and concise explanation of why they chose that answer in order to receive full credit. If her students chose an incorrect answer but provided a clear explanation of why they chose it, they received partial credit. Bassett (2017) did not specifically teach critical thinking in her course but rather assumed that through this multiple-choice and explanation testing arrangement, critical thinking would develop and generalize to other areas outside of a testing context.

A different professor (Solon, 2007) compared two groups of his psychology students who received either standard instruction about research methods or 10 additional hours of critical thinking instruction infused into the regular course content throughout the semester. The experimental group was required to complete 10 critical-thinking homework assignments, which included a reading component and a writing component. The control group completed the same introductory psychology course but did not receive additional critical thinking instruction. Both groups completed the 52-item Cornell Z Critical Thinking Test as a pre- and posttest measure of critical thinking. Prior to completing this course, both groups scored an average of 50% on the pretest. After completing the psychology course, the experimental group scored an average of 57% on the posttest, while the control group scored an average of 51% on the posttest. Solon (2007) reported these findings to be statistically significant and suggested that infusing critical thinking, using 10 homework assignments, is an effective way to teach students to think critically. However, due to the small percentage change from pretest to posttest in the experimental group, this might not be the most effective way to increase students critical thinking skills. Furthermore, these results suggest the need for well-defined definitions of what

APPENDIX A: (CONT.) THESIS PROPOSAL INTRODUCTION

it means to think critically, as using noisy definitions lead to noisy data, which might suggest important differences between groups when really there are no differences.

Fox and Ghezzi (2003) used a different method for teaching critical thinking. They administered computer-based training to undergraduate students, where students were separated into four groups and received either fluency or practice training with either examples or descriptions of logical fallacies. Each participant completed a pretest consisting of 20 examples and non-examples of four logical fallacies. Following the pretest, all participants received introductory instruction and accuracy training on the definitions. Introductory instruction described the terms fallacy, premise, and conclusion and presented an example of each of the three terms. Participants were required to identify the premise and conclusion in a sample argument before moving to accuracy training. Accuracy training on the definitions included presenting the definition of each fallacy to the participants and then, using a match-to-sample format, the participant matched the fallacy to its definition until they performed at 100% accuracy. Following the accuracy training, participants experienced either fluency training or practice with the same definitions or novel examples.

Fox and Ghezzi (2003) found that participants who trained with examples performed better on the posttest, which presented examples of each fallacy, compared to participants who trained with definitions. However, these results would be expected because the posttest presented examples of each fallacy and the participants in the example groups received training in both the definitions and the examples, while the participants in the definition groups received training in only definitions. Fox and Ghezzi noted that the overall changes between pretest scores and posttest scores were minimal for all groups, indicating that fluency training or practice was not an effective way to teach these four logical fallacies. Taken together, these

APPENDIX A: (CONT.) THESIS PROPOSAL INTRODUCTION

studies (Bassett, 2017; Desai et al., 2016; Fox & Ghezzi, 2003; Solon, 2007) highlight that there are different methods for teaching various topics (e.g., math, reading, critical thinking) and all are not equally effective or effective at all.

Developing effective instruction methods is predicated on the assumption that we can establish conditions that create learning. However, the goal for student learning is not only to master what is specifically taught but also to build on prior learning in untaught or un-programmed ways (Critchfield & Twyman, 2014). A lifetime is too short to directly teach everything one needs to know, so instructional methods should capitalize on the idea of un-programmed learning, which is "free" learning that comes out of previous learning experiences but is not specifically programmed into instruction. This learning occurs when the right relations are established between pieces of information (Sidman, 1994; Stromer et al., 1992). Instructional time is always in short supply, so instructors must carefully think about what will be specifically taught and how to maximize student and instructor efforts to promote student learning. One particular instruction method, (stimulus) equivalence-based instruction, might be more effective than using projects or case studies for teaching students to identify logical fallacies because it presents stimuli in such a way that facilitates the most learning from the least amount of instruction.

Equivalence-Based Instruction

The stimulus-equivalence paradigm includes a tendency for untaught relational behavior to develop indirectly from only a few directly taught relations (Rehfeldt, 2011). Through conditional discrimination training, stimuli that have not been presented together or paired with each other can become members of the same stimulus class (Sidman & Tailby, 1982). A stimulus class refers to a group of stimuli that have the same functional effect on a particular

APPENDIX A: (CONT.) THESIS PROPOSAL INTRODUCTION

behavior (Dube, McIlvane, Maguire, Mackay, & Stoddard, 1989). Such stimuli can be tested for

stimulus equivalence by determining whether they exhibit the relations of symmetry, reflexivity, and

transitivity. Reflexivity is the relation of a stimulus to itself (A1-A1) and is typically an untaught

relation for most verbal organisms. Symmetry is the relation of one member of a stimulus class (A1)

to another member of that stimulus class (B1) and the reverse relation (if A1-B1, then B1-A1 and not

A2, A3, etc.). Transitivity is the relation of two members of a stimulus class which have only been

trained through a third stimulus (e.g., if A1-B1 and A1-C1, then B1-C1 not C2, C3, etc.). When the

stimuli are tested as samples and comparisons with themselves and each other, and all relations are

shown to be bidirectional, the stimuli can be said to be interchangeable members of an equivalence

class (Barnes, McCullagh, & Keenan, 1990; Devany, Hayes & Nelson, 1986; Hall & Chase, 1991).

An equivalence class is described as three or more physically different stimuli that when presented

with any stimulus from the class, the other members of the class are selected (Sidman & Tailby,

1982). EBI is especially suited for classroom instruction because stimuli are arranged in a specific

way that facilitates student learning and can be presented in a multiple-choice format that is already

used in most classrooms.

The stimulus equivalence paradigm gives researchers a way to study an elusive kind of

stimulus generalization in which the participant comes to match stimuli that share no physical

properties and that have never been directly related to each other. For example, Sidman (1971) used

the concept of stimulus equivalence to inform how he taught a young child with severe intellectual

disabilities to read printed words, match those words to pictures, and match the pictures to spoken

words using conditional discrimination training. Prior to instruction, the child could select a picture

of an object (e.g., car, cat) if the object's name was spoken aloud (AB). He

APPENDIX A: (CONT.) THESIS PROPOSAL INTRODUCTION

could also name objects but could not say the name or select the object when presented with a written word. During training, the boy was taught to identify the correct written word when an object name was spoken (AC). Without further instruction, he could choose the correct printed word when shown a picture and vice versa (BC, CB), and he could say the correct object name when shown a written word (C-A). Sidman (1971) found that a vocabulary of about 20 words or more could be established through simple conditional discrimination training and that using stimulus equivalence procedures had a profound effect on the learning capabilities of real people.

Since 1971, stimulus equivalence-based instruction (EBI) has been shown to be an effective and efficient procedure for teaching various skills to individuals with developmental disabilities, typically developing children, and college students (Rehfeldt, 2011). In the typical EBI arrangement, a match-to-sample procedure is used to train a series of conditional discriminations (e.g., AB, AC). Following this training, participants are tested on other relations that are not programmed during instruction (e.g., BA, CA, BC, CB) to determine if these stimuli make up an equivalence class. When using this procedure, the direct teaching of a few relations yields more equivalence relations than were initially instructed; the learner learns more than the teacher explicitly teaches. In addition to instructional time saved, the stimulus equivalence framework can be used with a variety of stimuli such as teacher-defined arbitrary stimuli that share no physical properties, auditory stimuli in relation to visual stimuli, spoken words in relation to printed text, written words in relation to physical objects, and many other combinations of stimuli (Sidman & Tailby, 1982).

EBI studies employ unique intervention procedures, which can be arranged in different ways to produce different outcomes. The effectiveness of an EBI procedure has been shown to be affected by changing any of the following variables: the training structure (i.e., linear, one-to-

APPENDIX A: (CONT.) THESIS PROPOSAL INTRODUCTION

many, many-to-one), the sequencing of training and testing (i.e., training protocol), or the mastery

criterion (e.g., at least 80%, 90%, or 100% accuracy). For example, three different training structures

have been used when establishing the conditional discriminations necessary for testing non-

programmed relations: linear series (LS), many-to-one (MTO), and one-to-many (OTM). When

training three 3-member stimulus classes, LS involves training AB and BC relations before testing

for non-programmed relations. MTO involves training AC and BC relations, and OTM involves

training of AB and AC relations. Generally, the LS training structure produces the lowest outcomes

on the equivalence tests. The OTM training structure produces higher outcomes than the MTO

training structure when testing for 3-member classes, but these outcome differences between OTM

and MTO diminish if the number of members in the stimulus classes increases to four or more

(Arntzen, Grondahl & Eilifsen, 2010; Arntzen, 2012). Furthermore, the sequence of training and

testing, independent of the training structure used, affects the outcomes of EBI procedures. One of

two training sequences are used in most EBI studies: simple-to-complex or simultaneous training.

The simple-to-complex protocol intersperses non-programmed stimulus relation probes with training

baseline relations (e.g., train AB, test BA, train AC, test CA, etc.). The simultaneous protocol

conducts all training trials and test trials in separate portions of the protocol (e.g., train AB, AC, AD,

test BA, CA, DA, etc.). Fienup, Wright, and Fields (2015) conducted two experiments which

evaluated the effects of the simple-to-complex and simultaneous training protocols on undergraduate

student's formation of academically relevant equivalence classes (neuroanatomy stimuli). They

found that the simple-to-complex training protocol produced better learning outcomes when

compared with the simultaneous training protocol. All participants who experienced the simple-to-

complex protocol immediately formed the 3- or 4-member classes. However, participants who

experienced the simultaneous protocol formed the 3- and 4-member classes about 75% and 42% of the time, respectively (Fienup et al., 2015).

Additionally, the mastery criterion used during training and testing might change the effectiveness of EBI. Typically, the criterion considered to indicate responding in accordance with stimulus equivalence is 90% or above (Arntzen, 2012; Fienup & Brodsky, 2017). But, it is recommended that the mastery criterion should be even higher in training (e.g., 95–100%) than in testing (e.g., 90–100%; Arntzen, 2012). A strict mastery criterion helps to promote mastery across all relations. For example, if training is arranged to establish three potential 3-member classes, each training block will consist of 18 trials, with each trial type presented three times. If the mastery criterion is set at 88% (i.e., 16/18), then for one trial type, two of three trials can be incorrect, but the participant is still responding in accordance with the mastery criterion even though one relation is not mastered. Therefore, the mastery criterion used during any particular EBI procedure can alter the purported effectiveness of EBI.

Incorporating EBI procedures into educational curricula seems to be beneficial not only for the expansion of language skills, as described by Sidman (1971), but also for a multitude of other skills that involve responding relationally to stimuli (Rehfeldt, 2011). Researchers have noted the practical applications for EBI procedures; equivalence-based instruction incorporates a number of ideas about effective instruction expressed by Skinner (2003), including frequent opportunities for feedback, ongoing evaluation, and mastery-based learning. Consequently, equivalence based instruction has been used to teach a variety of subjects, including vocabulary and reading (Cowley, Green, & Braunling-Mcmorrow, 1992; De Souza, De Rose, & Domeniconi, 2009; Mueller, Olmi, & Saunders, 2000), math (Lynch & Cuvo, 1995), identification of appropriate portion sizes (Hausman, Borrero, Fisher, & Kahng, 2014), relations

APPENDIX A: (CONT.) THESIS PROPOSAL INTRODUCTION

between arbitrary stimuli (Murphy & Barnes-Holmes, 2009), inferential statistics and research designs (Fields et al., 2009; Fienup & Critchfield, 2011; Ninness et al., 2006; Ninness, et al., 2009; Lovett, Rehfeldt, Garcia & Dunning, 2011), and neuroanatomy (Pytte & Fienup, 2012).

Critical thinking is a subject area that might benefit from an EBI format. Specifically, teaching students to identify logical fallacies is a subcomponent of critical thinking in which stimuli can be arranged in a conditional discrimination format to promote relational responding between stimuli. Ideally, for EBI procedures to be used, stimuli would need to be separated into stimulus classes such that responding between stimuli can be taught using a conditional discrimination procedure. For example, Ong, Normand, and Schenk (in press) examined whether students could be taught to identify five specific logical fallacies using EBI procedures. Using a pretest-train-posttest group design, 30 undergraduate students were randomly assigned to one of three instructional groups: equivalence-based instruction, self-instruction, or no instruction. All participants took a general pretest which presented all of the relations between the logical fallacy name, definition, and example, to test for the presence of already existing relations between the stimuli prior to intervention. Following the pretest, participants in the EBI group completed lessons which presented a logical fallacy name and they were taught to identify the corresponding definition and example. For example, when presented with the question, "Which of the following is the definition for the "begging the question" fallacy?" the participant would select the answer, "A). When an argument's conclusion is used as one of its premises" from four multiple-choice options. Participants in the self-instruction (SI) group received a copy of the text from which the stimulus set was derived (Schick & Vaughn, 2014, p. 49-55) and were asked to review the material as if they were studying for a class; this control group was designed to approximate what a college student might realistically do to improve their critical

APPENDIX A: (CONT.) THESIS PROPOSAL INTRODUCTION

thinking skills. Participants in the no instruction (NI) group waited 10-minutes between taking the

pretest and posttest and were asked to refrain from discussing study material with anyone.

Ong et al. (in press) found that pre-posttest score changes for EBI (M = 44.33, SD = 21.55)

were greater than both SI (M = 18.67, SD =14.25) and NI (M = 1.67, SD = 14.84). Equivalence-

based instruction resulted in greater and more consistent score increases from pretest to posttest than

did self-instruction and no instruction, with EBI participants spending about 12 minutes in instruction

compared to about 20 minutes for the self-instruction participants. These results replicate the

characteristic effectiveness and efficiency of stimulus equivalence-based instruction methods used to

teach other skills and subjects (see Rehfeldt, 2011 for a review). However, Ong et al. (in press) also

noted that a self-instruction control group might not be the most rigorous comparison, as students

might not have read the material thoroughly or attended to the material at all. Therefore, EBI should

be compared to more standard classroom practices, such as lecture-based instruction method, to

further explore the relative efficacy, efficiency, and feasibility of equivalence-based instruction

procedures to teach individuals to identify logical fallacies.

Multiple studies have compared a lecture-based teaching format to a self-instruction teaching

format (Abraham, Dhume, & Diniz, 1981; de Carvalho & And, 1977) and found that students who

were exposed to a lecture format performed better than students who relied on self-

instruction. Furthermore, Lovett, Rehfeldt, Garcia, and Dunning (2011) compared equivalence-based

instruction to a traditional lecture-style video for teaching undergraduate students single-subject

experimental designs. Participants were assigned to one of two groups: equivalence-based

instruction or a lecture group. Participant scores on paper-and-pencil tests, which assessed

relations between the names of experimental designs, design definitions, design graphs, and clinical vignettes, were compared. Lovett et al. (2011) found that instruction using either the equivalence-based instruction procedures or the lecture format resulted in similar performance on the paper-and-pencil tests. However, the video lecture used in this study differed from a traditional lecture in that it was specifically designed to present the relations targeted in the equivalence-based instruction protocol. The lecture and EBI presented the same information to participants and resulted in similar score increases, but the difference was that EBI procedures required participants to respond to the material during training whereas the lecture did not. Requiring participant responses throughout training could affect participants' performance on posttests following instruction. The results from Lovett et al. (2011) suggest that the EBI arrangement might not be the "active" component that leads to the learning demonstrated in most EBI studies. Typically, EBI procedures are compared to a no-instruction control group or self-instruction control group, which do not require participant responses during training. It would be useful to know if a lecture, which is a widely used form of teaching in higher education currently, is sufficient for teaching students to identify logical fallacies if they are required to respond in some way to the material during training.

Other studies have found that participant responding might be a key feature in effective education. For example, McDaniel, Anderson, Debish and Morrisette (2007) found that participants who were quizzed using either multiple choice or short answer questions on class material showed greater improvements in performance on unit exams and a cumulative final exam relative to participants who were not tested but presented with material in a read-only format. In light of these studies, it would be useful to compare EBI procedures to a lecture-based

APPENDIX A: (CONT.) THESIS PROPOSAL INTRODUCTION

teaching method, with and without components requiring participant responding, to teach

identification of logical fallacies to undergraduate students.

Teaching Critical Thinking

An additional factor that could affect how critical thinking is taught in our society is that

teachers might not have the necessary training or skills to teach it (Forawi, 2016). For students to

learn how to think critically, educators must be able to effectively teach critical thinking. However,

due to the lack of a consensus definition and effective teaching strategies, it seems that expecting

educators to teach critical thinking skills effectively might be unrealistic. For example, Hatcher

(2013) outlined a critical thinking curriculum at Baker University that was intended to increase

students' critical thinking skills. This course sequence required every student to take a two-semester

first-year experience class and one senior capstone seminar. The freshman course sequence taught

students the fundamental components of critical thinking and how to apply them, while the senior

seminar required students prepare and defend a 15-page position paper that presented a specific

argument. When this course sequence began, Hatcher (2013) noted that most seniors found it

difficult to write such a paper, with the primary difficulty being they were unable to construct or

evaluate arguments.

In light of these difficulties, Baker University recruited experts in critical thinking to teach

their instructors how to teach critical thinking and acquired funding to further this training through

conferences and lectures on teaching critical thinking. However, Hatcher (2013) did not discuss the

specific teaching methods used by professors during this training process. It is unclear if these

professors were using methods of teaching critical thinking that actually promoted student learning.

Therefore, it is not surprising that after three years with this additional support, Hatcher (2013) found

that some professors were able to effectively teach

critical thinking, as indicated by their students' pre- and posttest scores on the Cornell Z Critical

Thinking Test, while some professors remained ineffective. Of course, these results might not be due

to the teacher's skills at all, but rather due to a lack of effective instruction methods which presents

itself as ineffective teaching. Still, Baker University's lack of success highlights the issue that

additional training may not be the most appropriate focus for increasing students critical thinking

skills, but rather the instruction methods used should be the focus of further evaluation. If teachers

are not trained in effective teaching strategies, their skills cannot be evaluated based on student

outcomes because the tools they are using might not be effective.

Critical thinking appears to be a difficult subject to define and to teach. Educators are

attempting to teach critical thinking by using strategies such as projects, case studies, homework

assignments, and readings, but these methods have not been convincingly established as useful

strategies for teaching critical thinking. Hatcher (2013) explains that many teachers do not have the

resources or training available to help them effectively teach critical thinking in the current education

system. However, even if more resources were dedicated to training teachers to teach critical

thinking skills, they might not be trained to use effective methods. Therefore, focusing on additional

training for teachers might not be the best starting point to increase students critical thinking skills. It

seems more useful to develop an effective strategy for teaching critical thinking based on clearly

defined skills, within the broader definition of critical thinking, before expecting teachers to be able

to teach these skills.

One way to remove the variable of teacher effectiveness to evaluate the effectiveness of the

method itself is to present that information to students using web-based instruction methods.

Dykman and Davis (2008) suggest that with the shift towards online teaching in higher education

settings, there is an "unbundling of teaching roles" resulting from the use of online course

management systems in which the teacher is not always responsible for the development of the academic content, the delivery of that content to students, interacting with students, and assessing student performance because there are certain technologies to support those behaviors. Additionally, Dykman and Davis (2008) suggest that a beneficial way to use course management systems is to develop effective standardized introductory classes that would need minimal professor involvement. Resources that might have been used to attempt to train instructors how to teach critical thinking could be used to create an online computer-based instruction system that provides instruction on critical thinking to many students.

EBI procedures have been delivered using computer technology with much success (Fields et al., 2009; Fienup & Critchfield, 2010; Fienup & Critchfield, 2011; Lovett et al., 2011; Ninness et al., 2005; O'Neill et al., 2015; Walker & Rehfeldt, 2012). Recent studies have demonstrated that college students can be taught algebra and trigonometry (Ninness et al., 2005, 2006), statistics (Fields et al., 2009; Fienup & Critchfield, 2010; Fienup & Critchfield, 2011), single-subject research designs (Lovett et al., 2011) and brain–behavior relations (Fienup, Covey, & Critchfield, 2010) using online course management systems, such as Blackboard, or other automated computer-based programs, which deliver equivalence-based instruction. In these studies, students were exposed to typical EBI arrangements, where specific stimulus relations are programmed into instruction and, following teaching, other non-programed relations are tested. When using computer-based delivery methods, these stimuli are presented either in the form of multiple-choice questions or stimuli appearing in specific parts of a computer screen to indicate sample and comparison stimuli.

For example, Ninness et al. (2005) used an automated procedure to teach complex mathematical relations to college students. Participants were taught to conditionally relate

APPENDIX A: (CONT.) THESIS PROPOSAL INTRODUCTION

various formulas and graphs using an online teaching format, where stimuli were presented as multiple-choice questions. Following training, most participants responded correctly to questions relating to the non-programmed relations between stimuli, and responding generalized to include other variations of the original instructional formulas and graphs (Ninness et al., 2005; see also Ninness et al., 2006). Fienup and Critchfield (2011) delivered equivalence-based instruction using a program called visual basics, which presented a series of screens with a sample stimulus and three comparison stimuli, to teach concepts related to inferential statistics and hypothesis decision-making to college students enrolled in a research methods course. Fienup and Critchfield (2011) compared EBI procedures to a complete instruction group, in which participants received training on all possible relations (i.e., programed and non-programmed relations in the EBI format). Following training, participants in both groups preformed at about the same high level of accurate responding, but the EBI group did so after significantly less time in instruction. Both Ninness (2005) and Fienup and Critchfield (2011) demonstrated the utility of EBI procedures delivered using online or computer-based programs for teaching various topics to college students.

Similarly, Walker and Rehfeldt (2012) assessed whether EBI procedures could be used to teach single-subject research designs to graduate students enrolled in an online behavior analysis course through the web-based course management system. They found that when tested, all participants responded correctly to questions that tested the non-programmed equivalence class relations, after only one to three trials, and this learning generalized to novel stimuli. However, few participants maintained accurate responding to the untrained relations during a follow-up test after 16 weeks. Importantly, however, the number of trials required to regain mastery level responding, even after 16 weeks, remained low. Despite the lack of overall skill maintenance, it

APPENDIX A: (CONT.) THESIS PROPOSAL INTRODUCTION

is important to note that these findings were obtained from a class that was taught exclusively online. Online course management systems might allow for the use of equivalence-based instruction protocols to teach a variety of topics to many students. EBI could be a useful online instruction method for teaching students to identify logical fallacies by arranging conditions where specific relations are taught directly, while other non-programmed relations are tested for following training.

The Current Study

The importance of critical thinking is emphasized as a vital product of education and a necessary tool in various professional fields. However, teaching critical thinking effectively is difficult for many reasons, including the lack of a widely used consensus definition and the lack of effective teaching strategies. Definitions of critical thinking typically refer to vague constructs such as "self-regulatory judgment" rather than to well-defined skills, and there seems to be no consensus concerning what it means to think critically across, and even within, fields. However, common components of most definitions of critical thinking include logical reasoning and the identification of flawed arguments (Facione, 1900; Forawi, 2015; Hatcher, 2013; Schick & Vaughn, 2014). One method of teaching individuals to recognize flawed arguments is to teach them to identify common logical fallacies used to develop arguments. Identifying logical fallacies is a concrete skill that is amenable to specific instruction in typical educational settings. Students could be taught this subset of critical thinking skills by teaching multiple components of each fallacy: the name of the fallacy, the definition of the fallacy, and examples of the fallacy. This arrangement makes the identification of logical fallacies an ideal content area for the application of EBI because for EBI procedures to be used, stimuli need to be separated into

APPENDIX A: (CONT.) THESIS PROPOSAL INTRODUCTION

stimulus classes such that responding between stimuli can be taught using a conditional discrimination procedure.

Researchers have noted the practical applications EBI, which include frequent opportunities for feedback, ongoing evaluation, mastery-based learning, and the benefits of "free" learning (Critchfield & Twyman, 2014; Skinner, 2003). EBI programs are also noted for their remarkable efficiency (Sidman & Tailby, 1982; Fienup & Critchfield, 2011), and they have been successfully applied to a range of learning topics across diverse learner populations (Rehfeldt, 2011). An equivalence-based instruction (EBI) procedure, then, seems to be a good candidate for delivering critical-thinking instruction. EBI is especially suited for classroom instruction because stimuli are arranged in a specific way that facilitates student learning with the least amount of instruction, and the stimuli can be presented in a multiple-choice format that already is used in most classrooms. Furthermore, the online delivery of EBI addresses practical concerns such as eliminating the need to train educators to teach critical thinking, facilitating consistency of the materials presented to each student, and providing an efficient way to deliver educational material using only one teaching sequence for all students. Currently, EBI procedures have been delivered using computer technology with much success (Fields et al., 2009; Fienup & Critchfield, 2010; Fienup & Critchfield, 2011; Lovett et al., 2011; Ninness et al., 2005; O'Neill et al., 2015; Walker & Rehfeldt, 2012).

Although EBI procedures have been shown to be effective and efficient for teaching a variety of topics, EBI procedures typically are compared to a no-instruction or a self-instruction control group. These comparison groups might not be the most rigorous comparison, as students are either not exposed to any intervention, in the case of no-instruction, or might not study the material thoroughly or attended to the material at all, in the case of self-instruction (Ong,

APPENDIX A: (CONT.) THESIS PROPOSAL INTRODUCTION

Normand, & Schenk, in press). However, when EBI has been compared to other teaching

methods, such as complete instruction or lecture-based instruction, participants in all groups

preformed at about the same high level of accurate responding (Fienup & Critchfield, 2011;

Lovett et al.,2011). For example, Lovett and colleagues, demonstrated that when a lecture and

EBI presented the same information, both teaching formats resulted in similar score increases.

Importantly, EBI procedures require participants to respond to the material during training

whereas lectures may not. Requiring participant responses throughout training could affect

participants' performance on posttests following instruction. The results from Lovett et al.

(2011) suggest that the EBI arrangement might not be the "active" component that leads to the

learning demonstrated in most EBI studies. It would be useful to know if a lecture is sufficient

for teaching students to identify logical fallacies if the students are required to respond in some

way to the material during training. Therefore, the purpose of the current study is to assess the

relative efficiency and effectiveness of online equivalence-based instruction procedures

compared to a traditional lecture-based instruction format, with and without requiring active

responding from participants, for teaching undergraduate students to identify logical fallacies.

APPENDIX B: EXPERIMENTAL STIMULUS SET

A Stimuli	B Stimuli	C Stimuli
Fallacy Name	Description	Example 1
Begging the question	When an argument's conclusion is used as one of its premises.	That student will not sit still in their seat. They must have ADHD. You can tell by how they will not sit still.
Equivocation	When a word is used in two different senses in an argument.	We have the right to watch television. Therefore, it's right for us to watch television. So, we should watch television all night instead of studying for an exam.
Appeal to the person	When someone tries to rebut an argument by criticizing or denigrating its presenter rather than the argument itself.	Women get abortions. He is a man. So, his opinion on abortion does not matter
Straw man	When an opponent's claims are misrepresented to make them easier to dismiss or reject.	You support nationalized health care. So, did the Nazis. This makes you just like Nazi Germany.
Hasty generalization	When general conclusions are drawn about all things of a type based on only a few things of that type.	They tried out medical tests. None of the medical tests have helped. Medical tests are useless.
False Dilemma	Proposing that only two alternatives exist when in actuality there are more than two.	Either science can explain how she was cured or it was a miracle. Science can't explain how she was cured. So, it must be a miracle.
Appeal to Authority	Citing the opinion of an expert rather than evidence for a claim, especially if the expert has no specific expertise related to the claim.	Global warming is a hoax. Dr. Jones says so. She is a math professor at Harvard.
Appeal to the Masses	It must be true or good because everyone does it or believes it.	There has to be a God. Just look at how many people go to church. They can't all be wrong.
Appeal to Tradition	It must be true or good because people have believed it or done it for such a long time.	Astrology has been around for ages. He is an astrologer. So, there must be something to it.
Appeal to Ignorance	Assuming a conclusion or fact based primarily on the lack of evidence to the contrary.	There is no compelling evidence that UFOs are not visiting the Earth. So, UFOs exist. This means there is intelligent life elsewhere in the Universe.
Faulty Analogy	Things that resemble one another in certain respects, resemble one another in further respects.	There are some people who cannot go without their coffee in the morning. They have coffee every morning. So, they are no better than alcoholics.
Post Hoc Ergo Propter Hoc	Supposing that two events are causally connected when they are not simply because one event followed the other event	She drank bottled water. Now, she is sick. The water must have made her sick.
Slippery Slope	Assuming a series of events is hard to stop or control once it has begun, leading to worse or more difficult things	We should ban SUVs because they are bad for the environment. Then the government will end up banning all cars. So, we should not ban SUVs.

Adapted from Schick and Vaughn (2014, pp. 49-55)

APPENDIX C: DEMOGRAPHICS SURVEY

1. What is your age?
2. What is your current gender identity?
   a. Male
   b. Female
   c. Other
3. With what ethnicity do you identify?
   a. Caucasian
   b. Hispanic or Latino
   c. Native American
   d. Black or African American
   e. Asian / Pacific Islander
   f. Other: _____
4. Are you a native English speaker?
   a. Yes
   b. No
   c. Decline to answer
5. If no, please indicate your native language: _____
6. If no, how long have you been speaking English? _____
7. What is your English proficiency level?
   a. Beginner
   b. Intermediate
   c. Advanced
8. What is your current academic standing at Pacific?
   a. Freshman
   b. Sophomore
   c. Junior
   d. Senior
   e. Other
9. What is your major? _____
10. What is your GPA? _____
1. Please select all the classes you have taken/are currently taking at University of the Pacific from the list below:
   - PACS 001   Pacific Seminar I: What is a Good Society?
   - PACS 002   Pacific II Topical Seminar on a Good Society
   - PACS 003   Pacific Seminar III: What is an Ethical Life?
   - PSYC 001   Orientation to the Psychology Major
   - PSYC 002   Professional Development in Psychology
   - PSYC 031   Introduction to Psychology
   - PSYC 101   Research Methods and Statistics in Psychology I
   - PSYC 102   Research Methods and Statistics in Psychology II
   - PHIL 037   Introduction to Logic
   - PHIL 061   Philosophy of Science
   - PSYC 125   History and Systems of Psychology
   - PSYC 015   Cognitive Psychology
   - PSYC 017   Abnormal and Clinical Psychology
   - PSYC 029   Developmental Psychology
   - PSYC 053   Behavioral Psychology
   - PSYC 069   Social Psychology

APPENDIX C: (CONT.) DEMOGRAPHICS SURVEY

---

     o   PSYC 079   Sensation and Perception
     o   PSYC 115   Advanced Lab in Cognitive Psychology
     o   PSYC 117   Advanced Lab in Clinical Psychology
     o   PSYC 118   Advanced Lab in Child Clinical Psychology
     o   PSYC 129   Advanced Lab in Developmental Psychology
     o   PSYC 169   Advanced Lab in Social Psychology
     o   Other Psychology Classes: _____

11. Have you taken any classes about critical thinking at this or any other institution?
    a.   Yes
    b.   No

12. If yes, please list the names of the courses you have taken related to critical thinking:
_____

13. If you have taken classes about critical thinking, did they specifically cover logical fallacies?
    a.   Yes
    b.   No
    c.   Don't know/remember

14. Are you receiving extra credit for participating in this study?
    a.   Yes
    b.   No

15. Have you participated in a critical thinking study for extra credit at the University of the Pacific before?
    a.   Yes
    b.   No

       Thank you. You may now inform the experimenter that you are ready to begin.

APPENDIX D: PRE/POSTTEST

1. Select the example described by this statement: When an opponent's claims are misrepresented to make them easier to dismiss or reject.
   a. You support nationalized health care. So, did the Nazis. This makes you just like Nazi Germany.
   b. There has to be a God. Just look at how many people go to church. They can't all be wrong.
   c. She drank bottled water. Now, she is sick. The water must have made her sick.
   d. Astrology has been around for ages. He is an astrologer. So, there must be something to it.
   e. None of these.
2. Select the example described by this statement: Assuming a series of events is hard to stop or control once it has begun, leading to worse or more difficult things
   a. There is no compelling evidence that UFOs are not visiting the Earth. So, UFOs exist. This means there is intelligent life elsewhere in the Universe.
   b. You support nationalized health care. So, did the Nazis. This makes you just like Nazi Germany.
   c. That student will not sit still in their seat. They must have ADHD. You can tell by how they will not sit still.
   d. We have the right to watch television. Therefore, it's right for us to watch television. So, we should watch television all night instead of studying for an exam
   e. None of these
3. Which of the following is an example of "an argument's conclusion is used as one of its premises?"
   a. That student will not sit still in their seat. They must have ADHD. You can tell by how they will not sit still.
   b. Astrology has been around for ages. He is an astrologer. So, there must be something to it.
   c. Global warming is a hoax. Dr. Jones says so. She is a math professor at Harvard.
   d. We have the right to watch television. Therefore, it's right for us to watch television. So, we should watch television all night instead of studying for an exam.
   e. None of these.
4. Select the example described by this statement: Assuming a conclusion or fact based primarily on the lack of evidence to the contrary.
   a. There is no compelling evidence that UFOs are not visiting the Earth. So, UFOs exist. This means there is intelligent life elsewhere in the Universe.
   b. Either science can explain how she was cured or it was a miracle. Science can't explain how she was cured. So, it must be a miracle.
   c. Global warming is a hoax. Dr. Jones says so. She is a math professor at Harvard.
   d. We should ban SUVs because they are bad for the environment. Then the government will end up banning all cars. So, we should not ban SUVs.
   e. None of these.

APPENDIX D: (CONT.) PRE/POSTTEST

5. Select the example described by this statement: Citing the opinion of an expert rather than evidence for a claim, especially if the expert has no specific expertise related to the claim.
   a. Global warming is a hoax. Dr. Jones says so. She is a math professor at Harvard.
   b. You support nationalized health care. So, did the Nazis. This makes you just like Nazi Germany.
   c. That student will not sit still in their seat. They must have ADHD. You can tell by how they will not sit still.
   d. Either science can explain how she was cured or it was a miracle. Science can't explain how she was cured. So, it must be a miracle.
   e. None of these.
6. Select the example described by this statement: When general conclusions are drawn about all things of a type based on only a few things of that type.
   a. They tried out medical tests. None of the medical tests have helped. Medical tests are useless.
   b. Global warming is a hoax. Dr. Jones says so. She is a math professor at Harvard.
   c. There is no compelling evidence that UFOs are not visiting the Earth. So, UFOs exist. This means there is intelligent life elsewhere in the Universe.
   d. Women get abortions, but he is a man. So, his opinion on abortion does not matter
   e. None of these.
7. Select the example described by this statement: Supposing that two events are causally connected when they are not simply because one event followed the other event
   a. She drank bottled water. Now, she is sick. The water must have made her sick.
   b. They tried out medical tests. None of the medical tests have helped. Medical tests are useless.
   c. We have the right to watch television. Therefore, it's right for us to watch television. So, we should watch television all night instead of studying for an exam
   d. There are some people who cannot go without their coffee in the morning. They have coffee every morning. So, they are no better than alcoholics.
   e. None of these.
8. Select the example described by this statement: Things that resemble one another in certain respects, resemble one another in further respects.
   a. There are some people who cannot go without their coffee in the morning. They have coffee every morning. So, they are no better than alcoholics.
   b. We should ban SUVs because they are bad for the environment. Then the government will end up banning all cars. So, we should not ban SUVs.
   c. She drank bottled water. Now, she is sick. The water must have made her sick.
   d. There has to be a God. Just look at how many people go to church. They can't all be wrong.
   e. None of these

9. Select the example described by this statement: Assuming a series of events is hard to stop or control once it has begun, leading to worse or more difficult things
   a. We should ban SUVs because they are bad for the environment. Then the government will end up banning all cars. So, we should not ban SUVs.
   b. There has to be a God. Just look at how many people go to church. They can't all be wrong.
   c. There are some people who cannot go without their coffee in the morning. They have coffee every morning. So, they are no better than alcoholics.
   d. We have the right to watch television. Therefore, it's right for us to watch television. So, we should watch television all night instead of studying for an exam
   e. None of these.

10. Select the example described by this statement: It must be true or good because people have believed it or done it for such a long time.
   a. Astrology has been around for ages. He is an astrologer. So, there must be something to it.
   b. There is no compelling evidence that UFOs are not visiting the Earth. So, UFOs exist. This means there is intelligent life elsewhere in the Universe.
   c. That student will not sit still in their seat. They must have ADHD. You can tell by how they will not sit still.
   d. She drank bottled water. Now, she is sick. The water must have made her sick.
   e. None of these.

11. Select the example described by this statement: Proposing that only two alternatives exist when in actuality there are more than two.
   a. Either science can explain how she was cured or it was a miracle. Science can't explain how she was cured. So, it must be a miracle.
   b. You support nationalized health care. So, did the Nazis. This makes you just like Nazi Germany.
   c. Women get abortions, but he is a man. So, his opinion on abortion does not matter
   d. Astrology has been around for ages. He is an astrologer. So, there must be something to it.
   e. None of these.

12. Select the example described by this statement: When a word is used in two different senses in an argument.
   a. Either science can explain how she was cured or it was a miracle. Science can't explain how she was cured. So, it must be a miracle.
   b. Global warming is a hoax. Dr. Jones says so. She is a math professor at Harvard.
   c. We should ban SUVs because they are bad for the environment. Then the government will end up banning all cars. So, we should not ban SUVs.
   d. They tried out medical tests. None of the medical tests have helped. Medical tests are useless.
   e. None of these.

APPENDIX D: (CONT.) PRE/POSTTEST

13. Select the example described by this statement: When someone tries to rebut an argument by criticizing or denigrating its presenter rather than the argument itself.
    a. Women get abortions, but he is a man. So, his opinion on abortion does not matter
    b. There is no compelling evidence that UFOs are not visiting the Earth. So, UFOs exist. This means there is intelligent life elsewhere in the Universe.
    c. There has to be a God. Just look at how many people go to church. They can't all be wrong.
    d. There are some people who cannot go without their coffee in the morning. They have coffee every morning. So, they are no better than alcoholics.
    e. None of these.
14. Select the example described by this statement: It must be true or good because everyone does it or believes it.
    a. There has to be a God. Just look at how many people go to church. They can't all be wrong.
    b. We should ban SUVs because they are bad for the environment. Then the government will end up banning all cars. So, we should not ban SUVs.
    c. They tried out medical tests. None of the medical tests have helped. Medical tests are useless.
    d. You support nationalized health care. So, did the Nazis. This makes you just like Nazi Germany.
    e. None of these
15. Select the example described by this statement: When an argument's conclusion is used as one of its premises.
    a. Either science can explain how she was cured, or it was a miracle. Science can't explain how she was cured. So, it must be a miracle.
    b. We have the right to watch television. Therefore, it's right for us to watch television. So, we should watch television all night instead of studying for an exam
    c. Astrology has been around for ages. He is an astrologer. So, there must be something to it.
    d. Women get abortions, but he is a man. So, his opinion on abortion does not matter
    e. None of these.
16. Select the example described by this statement: When a word is used in two different senses in an argument.
    a. We have the right to watch television. Therefore, it's right for us to watch television. So, we should watch television all night instead of studying for an exam
    b. That student will not sit still in their seat. They must have ADHD. You can tell by how they will not sit still.
    c. She drank bottled water. Now, she is sick. The water must have made her sick.
    d. Global warming is a hoax. Dr. Jones says so. She is a math professor at Harvard.
    e. None of these.
17. Select the description represented in this example: There has to be a God. Just look at how many people go to church. They can't all be wrong.
    a. It must be true or good because everyone does it or believes it.
    b. When a word is used in two different senses in an argument.
    c. When someone tries to rebut an argument by criticizing or denigrating its presenter rather than the argument itself.
    d. Assuming a conclusion or fact based primarily on the lack of evidence to the contrary.
    e. None of these.

APPENDIX D: (CONT.) PRE/POSTTEST

18. Select the description represented in this example: We should ban SUVs because they are bad for the environment. Then the government will end up banning all cars. So, we should not ban SUVs.
    a. Assuming a series of events is hard to stop or control once it has begun, leading to worse or more difficult things
    b. When an argument's conclusion is used as one of its premises.
    c. It must be true or good because people have believed it or done it for such a long time.
    d. It must be true or good because everyone does it or believes it.
    e. None of these.

19. Select the description represented in this example: Women get abortions, but he is a man. So, his opinion on abortion does not matter
    a. When someone tries to rebut an argument by criticizing or denigrating its presenter rather than the argument itself.
    b. Supposing that two events are causally connected when they are not simply because one event followed the other event
    c. When an opponent's claims are misrepresented to make them easier to dismiss or reject.
    d. When general conclusions are drawn about all things of a type based on only a few things of that type.
    e. None of these.

20. Select the description represented in this example: There is no compelling evidence that UFOs are not visiting the Earth. So, UFOs exist. This means there is intelligent life elsewhere in the Universe.
    a. Assuming a conclusion or fact based primarily on the lack of evidence to the contrary.
    b. Things that resemble one another in certain respects, resemble one another in further respects.
    c. Assuming a series of events is hard to stop or control once it has begun, leading to worse or more difficult things
    d. Citing the opinion of an expert rather than evidence for a claim, especially if the expert has no specific expertise related to the claim.
    e. None of these

21. Select the description represented in this example: You support nationalized health care. So, did the Nazis. This makes you just like Nazi Germany.
    a. When an opponent's claims are misrepresented to make them easier to dismiss or reject.
    b. Proposing that only two alternatives exist when in actuality there are more than two.
    c. Things that resemble one another in certain respects, resemble one another in further respects.
    d. Assuming a conclusion or fact based primarily on the lack of evidence to the contrary.
    e. None of these.

22. Select the description represented in this example: Either science can explain how she was cured or it was a miracle. Science can't explain how she was cured. So, it must be a miracle.
    a. Proposing that only two alternatives exist when in actuality there are more than two.
    b. When an opponent's claims are misrepresented to make them easier to dismiss or reject.
    c. When an argument's conclusion is used as one of its premises.
    d. Supposing that two events are causally connected when they are not simply because one event followed the other event
    e. None of these.

APPENDIX D: (CONT.) PRE/POSTTEST

23. Select the description represented in this example: Astrology has been around for ages. He is an astrologer. So, there must be something to it.
    a. It must be true or good because people have believed it or done it for such a long time.
    b. Citing the opinion of an expert rather than evidence for a claim, especially if the expert has no specific expertise related to the claim.
    c. Assuming a series of events is hard to stop or control once it has begun, leading to worse or more difficult things
    d. When someone tries to rebut an argument by criticizing or denigrating its presenter rather than the argument itself.
    e. None of these.

24. Select the description represented in this example: When someone tries to rebut an argument by criticizing or denigrating its presenter rather than the argument itself.
    a. It must be true or good because people have believed it or done it for such a long time.
    b. It must be true or good because everyone does it or believes it.
    c. When general conclusions are drawn about all things of a type based on only a few things of that type.
    d. When a word is used in two different senses in an argument.
    e. None of these.

25. Select the description represented in this example: That student will not sit still in their seat. They must have ADHD. You can tell by how they will not sit still.
    a. When an argument's conclusion is used as one of its premises.
    b. Proposing that only two alternatives exist when in actuality there are more than two.
    c. Supposing that two events are causally connected when they are not simply because one event followed the other event
    d. It must be true or good because everyone does it or believes it.
    e. None of these.

26. Select the description represented in this example: We have the right to watch television. Therefore, it's right for us to watch television. So, we should watch television all night instead of studying for an exam
    a. When a word is used in two different senses in an argument.
    b. Citing the opinion of an expert rather than evidence for a claim, especially if the expert has no specific expertise related to the claim.
    c. It must be true or good because people have believed it or done it for such a long time.
    d. When an opponent's claims are misrepresented to make them easier to dismiss or reject.
    e. None of these

27. Select the description represented in this example: She drank bottled water. Now, she is sick. The water must have made her sick.
    a. Supposing that two events are causally connected when they are not simply because one event followed the other event
    b. When someone tries to rebut an argument by criticizing or denigrating its presenter rather than the argument itself.
    c. Assuming a conclusion or fact based primarily on the lack of evidence to the contrary.
    d. Proposing that only two alternatives exist when in actuality there are more than two.
    e. None of these.

28. Select the description represented in this example: They tried out medical tests. None of the medical tests have helped. Medical tests are useless.
    a. When general conclusions are drawn about all things of a type based on only a few things of that type.
    b. When a word is used in two different senses in an argument.
    c. Assuming a series of events is hard to stop or control once it has begun, leading to worse or more difficult things
    d. Things that resemble one another in certain respects, resemble one another in further respects.
    e. None of these.
29. Select the description represented in this example: Global warming is a hoax. Dr. Jones says so. She is a math professor at Harvard.
    a. Citing the opinion of an expert rather than evidence for a claim, especially if the expert has no specific expertise related to the claim.
    b. When an argument's conclusion is used as one of its premises.
    c. When general conclusions are drawn about all things of a type based on only a few things of that type.
    d. Things that resemble one another in certain respects, resemble one another in further respects.
    e. None of these.
30. Select the description represented in this example: There are some people who cannot go without their coffee in the morning. They have coffee every morning. So, they are no better than alcoholics.
    a. Things that resemble one another in certain respects, resemble one another in further respects.
    b. Supposing that two events are causally connected when they are not simply because one event followed the other event
    c. It must be true or good because everyone does it or believes it.
    d. Assuming a conclusion or fact based primarily on the lack of evidence to the contrary.
    e. None of these.
31. Select the description represented in this example: You support nationalized health care. So, did the Nazis. This makes you just like Nazi Germany.
    a. Assuming a series of events is hard to stop or control once it has begun, leading to worse or more difficult things
    b. When someone tries to rebut an argument by criticizing or denigrating its presenter rather than the argument itself.
    c. When general conclusions are drawn about all things of a type based on only a few things of that type.
    d. Citing the opinion of an expert rather than evidence for a claim, especially if the expert has no specific expertise related to the claim.
    e. None of these.

APPENDIX D: (CONT.) PRE/POSTTEST

32. Select the fallacy described in this statement: Supposing that two events are causally connected when they are not simply because one event followed the other event
    a. Post Hoc Ergo Propter Hoc
    b. Straw Man
    c. Equivocation
    d. Appeal to Tradition
    e. None of these
33. Select the fallacy described in this statement: Assuming a series of events is hard to stop or control once it has begun, leading to worse or more difficult things
    a. Slippery Slope
    b. Begging the Question
    c. False Dilemma
    d. Post Hoc Ergo Propter Hoc
    e. None of these.
34. Select the fallacy described in this statement: When a word is used in two different senses in an argument.
    a. Equivocation
    b. Appeal to Authority
    c. Appeal to Ignorance
    d. Ad Hominem
    e. None of these.
35. Select the fallacy described in this statement: Assuming a conclusion or fact based primarily on the lack of evidence to the contrary.
    a. Appeal to Ignorance
    b. Equivocation
    c. Straw Man
    d. Faulty Analogy
    e. None of these.
36. Select the fallacy described in this statement: Things that resemble one another in certain respects, resemble one another in further respects.
    a. Faulty Analogy
    b. Appeal to Tradition
    c. Appeal to the Masses
    d. False Dilemma
    e. None of these.
37. Select the fallacy described in this statement: It must be true or good because people have believed it or done it for such a long time.
    a. Appeal to Tradition
    b. Begging the Question
    c. Slippery Slope
    d. Hasty Generalization
    e. None of these

APPENDIX D: (CONT.) PRE/POSTTEST

38. Select the fallacy described in this statement: When general conclusions are drawn about all things of a type based on only a few things of that type.
    a. Appeal to Authority
    b. Post Hoc Ergo Propter Hoc
    c. Begging the Question
    d. Straw Man
    e. None of these.
39. Select the fallacy described in this statement: Proposing that only two alternatives exist when in actuality there are more than two.
    a. False Dilemma
    b. Equivocation
    c. Ad Hominem
    d. Appeal to Tradition
    e. None of these
40. Select the fallacy described in this statement: When an opponent's claims are misrepresented to make them easier to dismiss or reject.
    a. Straw man
    b. Appeal to the Masses
    c. Faulty Analogy
    d. Hasty Generalization
    e. None of these.
41. Select the fallacy described in this statement: Citing the opinion of an expert rather than evidence for a claim, especially if the expert has no specific expertise related to the claim.
    a. Appeal to Authority
    b. Slippery Slope
    c. Appeal to Ignorance
    d. False Dilemma
    e. None of these.
42. Select the fallacy described in this statement: It must be true or good because everyone does it or believes it.
    a. Appeal to the Masses
    b. Appeal to Ignorance
    c. Appeal to Tradition
    d. Post Hoc Ergo Propter Hoc
    e. None of these.
43. Select the fallacy described in this statement: When general conclusions are drawn about all things of a type based on only a few things of that type.
    a. Hasty Generalization
    b. Appeal to the Masses
    c. False Dilemma
    d. Ad Hominem
    e. None of these.

APPENDIX D: (CONT.) PRE/POSTTEST

44. Select the fallacy described in this statement: When an argument's conclusion is used as one of its premises.
    a. Begging the Question
    b. Slippery Slope
    c. Straw Man
    d. Hasty Generalization
    e. None of these

45. Select the fallacy described in this statement: Proposing that only two alternatives exist when in actuality there are more than two.
    a. Appeal to Authority
    b. Equivocation
    c. Faulty Analogy
    d. Begging the Question
    e. None of these.

46. Select the fallacy described in this statement: When someone tries to rebut an argument by criticizing or denigrating its presenter rather than the argument itself.
    a. Ad Hominem
    b. Appeal to the Masses
    c. Equivocation
    d. Appeal to Ignorance
    e. None of these

47. Select the fallacy represented by this example: Astrology has been around for ages. He is an astrologer. So, there must be something to it.
    a. Appeal to Tradition
    b. Post Hoc Ergo Propter Hoc
    c. Appeal to the Masses
    d. False Dilemma
    e. None of these.

48. Select the fallacy represented by this example: Global warming is a hoax. Dr. Jones says so. She is a math professor at Harvard.
    a. Appeal to Authority
    b. Straw Man
    c. Ad Hominem
    d. Hasty Generalization
    e. None of these.

49. Select the fallacy represented by this example: They tried out medical tests. None of the medical tests have helped. Medical tests are useless.
    a. Hasty Generalization
    b. Begging the Question
    c. Faulty Analogy
    d. Appeal to Authority
    e. None of these.

APPENDIX D: (CONT.) PRE/POSTTEST

50. Select the fallacy represented by this example: Either science can explain how she was cured or it was a miracle. Science can't explain how she was cured. So, it must be a miracle.
    a. False Dilemma
    b. Appeal to Tradition
    c. Straw Man
    d. Appeal to Ignorance
    e. None of these.
51. Select the fallacy represented by this example: We should ban SUVs because they are bad for the environment. Then the government will end up banning all cars. So, we should not ban SUVs.
    a. Slippery Slope
    b. Faulty Analogy
    c. Ad Hominem
    d. Post Hoc Ergo Propter Hoc
    e. None of these
52. Select the fallacy represented by this example: There are some people who cannot go without their coffee in the morning. They have coffee every morning. So, they are no better than alcoholics.
    a. Faulty Analogy
    b. Appeal to Authority
    c. False Dilemma
    d. Slippery Slope
    e. None of these.
53. Select the fallacy represented by this example: Global warming is a hoax. Dr. Jones says so. She is a math professor at Harvard.
    a. Equivocation
    b. Appeal to Tradition
    c. Begging the Question
    d. Hasty Generalization
    e. None of these
54. Select the fallacy represented by this example: There has to be a God. Just look at how many people go to church. They can't all be wrong.
    a. Appeal to the Masses
    b. Slippery Slope
    c. False Dilemma
    d. Appeal to Tradition
    e. None of these.
55. Select the fallacy represented by this example: Women get abortions, but he is a man. So, his opinion on abortion does not matter
    a. Ad Hominem
    b. Appeal to the Masses
    c. Equivocation
    d. Post Hoc Ergo Propter Hoc
    e. None of these.

APPENDIX D: (CONT.) PRE/POSTTEST

56. Select the fallacy represented by this example: That student will not sit still in their seat. They must have ADHD. You can tell by how they will not sit still.
    a. Begging the Question
    b. Straw Man
    c. Appeal to Authority
    d. Faulty Analogy
    e. None of these.
57. Select the fallacy represented by this example: We have the right to watch television. Therefore, it's right for us to watch television. So, we should watch television all night instead of studying for an exam
    a. Equivocation
    b. Begging the Question
    c. Slippery Slope
    d. Hasty Generalization
    e. None of these.
58. Select the fallacy represented by this example: There has to be a God. Just look at how many people go to church. They can't all be wrong.
    a. Ad Hominem
    b. Appeal to Ignorance
    c. False Dilemma
    d. Appeal to Authority
    e. None of these
59. Select the fallacy represented by this example: You support nationalized health care. So, did the Nazis. This makes you just like Nazi Germany.
    a. Straw Man
    b. Appeal to Tradition
    c. Hasty Generalization
    d. Ad Hominem
    e. None of these.
60. Select the fallacy represented by this example: There is no compelling evidence that UFOs are not visiting the Earth. So, UFOs exist. This means there is intelligent life elsewhere in the Universe.
    a. Appeal to Ignorance
    b. Appeal to the Masses
    c. Faulty Analogy
    d. Slippery Slope
    e. None of these
61. Select the fallacy represented by this example: She drank bottled water. Now, she is sick. The water must have made her sick.
    a. Post Hoc Ergo Propter Hoc
    b. Equivocation
    c. Straw Man
    d. Appeal to Ignorance
    e. None of these.

62. Select the description of this fallacy: Equivocation
    a. When a word is used in two different senses in an argument.
    b. Supposing that two events are causally connected when they are not simply because one event followed the other event
    c. When an argument's conclusion is used as one of its premises.
    d. It must be true or good because people have believed it or done it for such a long time.
    e. None of these.
63. Select the description of this fallacy: Appeal to Tradition
    a. It must be true or good because people have believed it or done it for such a long time.
    b. Citing the opinion of an expert rather than evidence for a claim, especially if the expert has no specific expertise related to the claim.
    c. When a word is used in two different senses in an argument.
    d. It must be true or good because everyone does it or believes it.
    e. None of these.
64. Select the description of this fallacy: Slippery Slope
    a. Assuming a series of events is hard to stop or control once it has begun, leading to worse or more difficult things
    b. When an opponent's claims are misrepresented to make them easier to dismiss or reject.
    c. Proposing that only two alternatives exist when in actuality there are more than two.
    d. Assuming a conclusion or fact based primarily on the lack of evidence to the contrary.
    e. None of these.
65. Select the description of this fallacy: Hasty Generalization
    a. When general conclusions are drawn about all things of a type based on only a few things of that type.
    b. Things that resemble one another in certain respects, resemble one another in further respects.
    c. Assuming a series of events is hard to stop or control once it has begun, leading to worse or more difficult things
    d. When someone tries to rebut an argument by criticizing or denigrating its presenter rather than the argument itself.
    e. None of these
66. Select the description of this fallacy: Begging the Question
    a. When an argument's conclusion is used as one of its premises.
    b. Supposing that two events are causally connected when they are not simply because one event followed the other event
    c. When general conclusions are drawn about all things of a type based on only a few things of that type.
    d. Proposing that only two alternatives exist when in actuality there are more than two.
    e. None of these.

APPENDIX D: (CONT.) PRE/POSTTEST

67. Select the description of this fallacy: Appeal to Authority
    a. Citing the opinion of an expert rather than evidence for a claim, especially if the expert has no specific expertise related to the claim.
    b. When an argument's conclusion is used as one of its premises.
    c. When an opponent's claims are misrepresented to make them easier to dismiss or reject.
    d. Assuming a conclusion or fact based primarily on the lack of evidence to the contrary.
    e. None of these

68. Select the description of this fallacy: Post Hoc Ergo Propter Hoc
    a. Supposing that two events are causally connected when they are not simply because one event followed the other event
    b. When an argument's conclusion is used as one of its premises.
    c. When someone tries to rebut an argument by criticizing or denigrating its presenter rather than the argument itself.
    d. Citing the opinion of an expert rather than evidence for a claim, especially if the expert has no specific expertise related to the claim.
    e. None of these.

69. Select the description of this fallacy: Faulty Analogy
    a. Things that resemble one another in certain respects, resemble one another in further respects.
    b. Assuming a series of events is hard to stop or control once it has begun, leading to worse or more difficult things
    c. It must be true or good because people have believed it or done it for such a long time.
    d. Supposing that two events are causally connected when they are not simply because one event followed the other event
    e. None of these.

70. Select the description of this fallacy: Ad Hominem
    a. When someone tries to rebut an argument by criticizing or denigrating its presenter rather than the argument itself.
    b. Things that resemble one another in certain respects, resemble one another in further respects.
    c. It must be true or good because everyone does it or believes it.
    d. When a word is used in two different senses in an argument.
    e. None of these.

71. Select the description of this fallacy: False Dilemma
    a. Proposing that only two alternatives exist when in actuality there are more than two.
    b. When general conclusions are drawn about all things of a type based on only a few things of that type.
    c. When a word is used in two different senses in an argument.
    d. When an opponent's claims are misrepresented to make them easier to dismiss or reject.
    e. None of these.

APPENDIX D: (CONT.) PRE/POSTTEST

72. Select the description of this fallacy: Appeal to Ignorance
    a. Assuming a conclusion or fact based primarily on the lack of evidence to the contrary.
    b. When someone tries to rebut an argument by criticizing or denigrating its presenter rather than the argument itself.
    c. When general conclusions are drawn about all things of a type based on only a few things of that type.
    d. Supposing that two events are causally connected when they are not simply because one event followed the other event.
    e. None of these

73. Select the description of this fallacy: Appeal to the Masses
    a. It must be true or good because everyone does it or believes it.
    b. Assuming a conclusion or fact based primarily on the lack of evidence to the contrary.
    c. When an argument's conclusion is used as one of its premises.
    d. Citing the opinion of an expert rather than evidence for a claim, especially if the expert has no specific expertise related to the claim.
    e. None of these.

74. Select the description of this fallacy: Appeal to Tradition
    a. It must be true or good because everyone does it or believes it.
    b. Things that resemble one another in certain respects, resemble one another in further respects.
    c. Assuming a series of events is hard to stop or control once it has begun, leading to worse or more difficult things
    d. Proposing that only two alternatives exist when in actuality there are more than two.
    e. None of these

75. Select the description of this fallacy: Appeal to Ignorance
    a. It must be true or good because people have believed it or done it for such a long time.
    b. Proposing that only two alternatives exist when in actuality there are more than two.
    c. Things that resemble one another in certain respects, resemble one another in further respects.
    d. When someone tries to rebut an argument by criticizing or denigrating its presenter rather than the argument itself.
    e. None of these.

76. Select the description of this fallacy: Straw Man
    a. When an opponent's claims are misrepresented to make them easier to dismiss or reject.
    b. It must be true or good because people have believed it or done it for such a long time.
    c. When an argument's conclusion is used as one of its premises.
    d. Proposing that only two alternatives exist when in actuality there are more than two.
    e. None of these.

APPENDIX D: (CONT.) PRE/POSTTEST

---

77. Select the example representing this fallacy: False Dilemma
    a. Either science can explain how she was cured or it was a miracle. Science can't explain how she was cured. So, it must be a miracle.
    b. We should ban SUVs because they are bad for the environment. Then the government will end up banning all cars. So, we should not ban SUVs.
    c. They tried out medical tests. None of the medical tests have helped. Medical tests are useless.
    d. There has to be a God. Just look at how many people go to church. They can't all be wrong.
    e. None of these.

78. Select the example representing this fallacy: Appeal to Authority
    a. Global warming is a hoax. Dr. Jones says so. She is a math professor at Harvard.
    b. We have the right to watch television. Therefore, it's right for us to watch television. So, we should watch television all night instead of studying for an exam
    c. Either science can explain how she was cured or it was a miracle. Science can't explain how she was cured. So, it must be a miracle.
    d. There is no compelling evidence that UFOs are not visiting the Earth. So, UFOs exist. This means there is intelligent life elsewhere in the Universe.
    e. None of these.

79. Select the example representing this fallacy: Appeal to Ignorance
    a. There is no compelling evidence that UFOs are not visiting the Earth. So, UFOs exist. This means there is intelligent life elsewhere in the Universe.
    b. Global warming is a hoax. Dr. Jones says so. She is a math professor at Harvard.
    c. There are some people who cannot go without their coffee in the morning. They have coffee every morning. So, they are no better than alcoholics.
    d. You support nationalized health care. So, did the Nazis. This makes you just like Nazi Germany.
    e. None of these

80. Select the example representing this fallacy: Ad Hominem
    a. Women get abortions, but he is a man. So, his opinion on abortion does not matter
    b. There are some people who cannot go without their coffee in the morning. They have coffee every morning. So, they are no better than alcoholics.
    c. They tried out medical tests. None of the medical tests have helped. Medical tests are useless.
    d. There is no compelling evidence that UFOs are not visiting the Earth. So, UFOs exist. This means there is intelligent life elsewhere in the Universe.
    e. None of these.

81. Select the example representing this fallacy: Slippery Slope
    a. We should ban SUVs because they are bad for the environment. Then the government will end up banning all cars. So, we should not ban SUVs.
    b. We have the right to watch television. Therefore, it's right for us to watch television. So, we should watch television all night instead of studying for an exam
    c. She drank bottled water. Now, she is sick. The water must have made her sick.
    d. Either science can explain how she was cured or it was a miracle. Science can't explain how she was cured. So, it must be a miracle.
    e. None of these

APPENDIX D: (CONT.) PRE/POSTTEST

82. Select the example representing this fallacy: Faulty Analogy
   a. We should ban SUVs because they are bad for the environment. Then the government will end up banning all cars. So, we should not ban SUVs.
   b. Astrology has been around for ages. He is an astrologer. So, there must be something to it.
   c. You support nationalized health care. So, did the Nazis. This makes you just like Nazi Germany.
   d. There has to be a God. Just look at how many people go to church. They can't all be wrong.
   e. None of these.

83. Select the example representing this fallacy: Post Hoc Ergo Propter Hoc
   a. She drank bottled water. Now, she is sick. The water must have made her sick.
   b. That student will not sit still in their seat. They must have ADHD. You can tell by how they will not sit still.
   c. Women get abortions, but he is a man. So, his opinion on abortion does not matter
   d. Global warming is a hoax. Dr. Jones says so. She is a math professor at Harvard.
   e. None of these.

84. Select the example representing this fallacy: Hasty Generalization
   a. They tried out medical tests. None of the medical tests have helped. Medical tests are useless.
   b. There is no compelling evidence that UFOs are not visiting the Earth. So, UFOs exist. This means there is intelligent life elsewhere in the Universe.
   c. You support nationalized health care. So, did the Nazis. This makes you just like Nazi Germany.
   d. Astrology has been around for ages. He is an astrologer. So, there must be something to it.
   e. None of these.

85. Select the example representing this fallacy: Appeal to Tradition
   a. Astrology has been around for ages. He is an astrologer. So, there must be something to it.
   b. Either science can explain how she was cured or it was a miracle. Science can't explain how she was cured. So, it must be a miracle.
   c. She drank bottled water. Now, she is sick. The water must have made her sick.
   d. We have the right to watch television. Therefore, it's right for us to watch television. So, we should watch television all night instead of studying for an exam
   e. None of these.

86. Select the example representing this fallacy: Equivocation
   a. We have the right to watch television. Therefore, it's right for us to watch television. So, we should watch television all night instead of studying for an exam
   b. Global warming is a hoax. Dr. Jones says so. She is a math professor at Harvard.
   c. They tried out medical tests. None of the medical tests have helped. Medical tests are useless.
   d. There are some people who cannot go without their coffee in the morning. They have coffee every morning. So, they are no better than alcoholics.
   e. None of these

APPENDIX D: (CONT.) PRE/POSTTEST

87. Select the example representing this fallacy: Straw Man
    a. You support nationalized health care. So, did the Nazis. This makes you just like Nazi Germany.
    b. We should ban SUVs because they are bad for the environment. Then the government will end up banning all cars. So, we should not ban SUVs.
    c. That student will not sit still in their seat. They must have ADHD. You can tell by how they will not sit still.
    d. There has to be a God. Just look at how many people go to church. They can't all be wrong.
    e. None of these.

88. Select the example representing this fallacy: Begging the Question
    a. That student will not sit still in their seat. They must have ADHD. You can tell by how they will not sit still.
    b. Women get abortions, but he is a man. So, his opinion on abortion does not matter
    c. There has to be a God. Just look at how many people go to church. They can't all be wrong.
    d. You support nationalized health care. So, did the Nazis. This makes you just like Nazi Germany.
    e. None of these

89. Select the example representing this fallacy: Appeal to the Masses
    a. There has to be a God. Just look at how many people go to church. They can't all be wrong.
    b. That student will not sit still in their seat. They must have ADHD. You can tell by how they will not sit still.
    c. She drank bottled water. Now, she is sick. The water must have made her sick.
    d. Astrology has been around for ages. He is an astrologer. So, there must be something to it.
    e. None of these.

90. Select the example representing this fallacy: Faulty Analogy
    a. There are some people who cannot go without their coffee in the morning. They have coffee every morning. So, they are no better than alcoholics.
    b. Women get abortions, but he is a man. So, his opinion on abortion does not matter
    c. They tried out medical tests. None of the medical tests have helped. Medical tests are useless.
    d. We should ban SUVs because they are bad for the environment. Then the government will end up banning all cars. So, we should not ban SUVs.
    e. None of these.

91. Select the example representing this fallacy: Post Hoc Ergo Propter Hoc
    a. Global warming is a hoax. Dr. Jones says so. She is a math professor at Harvard.
    b. We have the right to watch television. Therefore, it's right for us to watch television. So, we should watch television all night instead of studying for an exam
    c. There is no compelling evidence that UFOs are not visiting the Earth. So, UFOs exist. This means there is intelligent life elsewhere in the Universe.
    d. Either science can explain how she was cured or it was a miracle. Science can't explain how she was cured. So, it must be a miracle.
    e. None of these.

APPENDIX E: EBI LESSON 1

1. Select the description of this fallacy: Straw Man
    a. When an opponent's claims are misrepresented to make them easier to dismiss or reject.
    b. Things that resemble one another in certain respects, resemble one another in further respects.
    c. Assuming a conclusion or fact based primarily on the lack of evidence to the contrary.
    d. When general conclusions are drawn about all things of a type based on only a few things of that type.
    e. None of these.
2. Select the description of this fallacy: Appeal to Ignorance
    a. Assuming a conclusion or fact based primarily on the lack of evidence to the contrary.
    b. It must be true or good because people have believed it or done it for such a long time.
    c. When an argument's conclusion is used as one of its premises.
    d. When an opponent's claims are misrepresented to make them easier to dismiss or reject.
    e. None of these.
3. Select the description of this fallacy: Hasty Generalization
    a. When general conclusions are drawn about all things of a type based on only a few things of that type.
    b. Supposing that two events are causally connected when they are not simply because one event followed the other event
    c. When a word is used in two different senses in an argument.
    d. When someone tries to rebut an argument by criticizing or denigrating its presenter rather than the argument itself.
    e. None of these.
4. Select the description of this fallacy: Appeal to the Masses
    a. It must be true or good because everyone does it or believes it.
    b. Citing the opinion of an expert rather than evidence for a claim, especially if the expert has no specific expertise related to the claim.
    c. Proposing that only two alternatives exist when in actuality there are more than two.
    d. Assuming a series of events is hard to stop or control once it has begun, leading to worse or more difficult things
    e. None of these.
5. Select the description of this fallacy: Appeal to Tradition
    a. It must be true or good because people have believed it or done it for such a long time.
    b. It must be true or good because everyone does it or believes it.
    c. When someone tries to rebut an argument by criticizing or denigrating its presenter rather than the argument itself.
    d. Things that resemble one another in certain respects, resemble one another in further respects.
    e. None of these.

APPENDIX E: (CONT.) EBI LESSON 1

6. Select the description of this fallacy: Slippery Slope
   a. Assuming a series of events is hard to stop or control once it has begun, leading to worse or more difficult things
   b. When general conclusions are drawn about all things of a type based on only a few things of that type.
   c. It must be true or good because everyone does it or believes it.
   d. Proposing that only two alternatives exist when in actuality there are more than two.
   e. None of these.

7. Select the description of this fallacy: Appeal to Authority
   a. Citing the opinion of an expert rather than evidence for a claim, especially if the expert has no specific expertise related to the claim.
   b. Assuming a series of events is hard to stop or control once it has begun, leading to worse or more difficult things
   c. It must be true or good because people have believed it or done it for such a long time.
   d. When a word is used in two different senses in an argument.
   e. None of these.

8. Select the description of this fallacy: Equivocation
   a. When a word is used in two different senses in an argument.
   b. Citing the opinion of an expert rather than evidence for a claim, especially if the expert has no specific expertise related to the claim.
   c. When an argument's conclusion is used as one of its premises.
   d. Assuming a conclusion or fact based primarily on the lack of evidence to the contrary.
   e. None of these.

9. Select the description of this fallacy: False Dilemma
   a. Proposing that only two alternatives exist when in actuality there are more than two.
   b. Supposing that two events are causally connected when they are not simply because one event followed the other event
   c. When an opponent's claims are misrepresented to make them easier to dismiss or reject.
   d. When a word is used in two different senses in an argument.
   e. None of these.

10. Select the description of this fallacy: Post Hoc Ergo Propter Hoc
    a. Supposing that two events are causally connected when they are not simply because one event followed the other event
    b. Things that resemble one another in certain respects, resemble one another in further respects.
    c. Assuming a series of events is hard to stop or control once it has begun, leading to worse or more difficult things
    d. When an argument's conclusion is used as one of its premises.
    e. None of these.

11. Select the description of this fallacy: Ad Hominem
    a. When someone tries to rebut an argument by criticizing or denigrating its presenter rather than the argument itself.
    b. Assuming a conclusion or fact based primarily on the lack of evidence to the contrary.
    c. Proposing that only two alternatives exist when in actuality there are more than two.
    d. It must be true or good because people have believed it or done it for such a long time.
    e. None of these.

APPENDIX E: (CONT.) EBI LESSON 1

12. Select the description of this fallacy: Faulty Analogy
    a. Things that resemble one another in certain respects, resemble one another in further respects.
    b. Supposing that two events are causally connected when they are not simply because one event followed the other event
    c. When someone tries to rebut an argument by criticizing or denigrating its presenter rather than the argument itself.
    d. Citing the opinion of an expert rather than evidence for a claim, especially if the expert has no specific expertise related to the claim.
    e. None of these.
13. Select the description of this fallacy: Begging the Question
    a. When an argument's conclusion is used as one of its premises.
    b. It must be true or good because everyone does it or believes it.
    c. When general conclusions are drawn about all things of a type based on only a few things of that type.
    d. When an opponent's claims are misrepresented to make them easier to dismiss or reject.
    e. None of these.

APPENDIX F: EBI LESSON 2

1. Select the example representing this fallacy: Hasty Generalization
    a. They tried out medical tests. None of the medical tests have helped. Medical tests are useless.
    b. Either science can explain how she was cured or it was a miracle. Science can't explain how she was cured. So, it must be a miracle.
    c. We should ban SUVs because they are bad for the environment. Then the government will end up banning all cars. So, we should not ban SUVs.
    d. Women get abortions. He is a man. So, his opinion on abortion does not matter
    e. None of these.
2. Select the example representing this fallacy: Equivocation
    a. We have the right to watch television. Therefore, it's right for us to watch television. So, we should watch television all night instead of studying for an exam
    b. They tried out medical tests. None of the medical tests have helped. Medical tests are useless.
    c. Global warming is a hoax. Dr. Jones says so. She is a math professor at Harvard.
    d. There has to be a God. Just look at how many people go to church. They can't all be wrong.
    e. None of these.
3. Select the example representing this fallacy: Appeal to Ignorance
    a. There is no compelling evidence that UFOs are not visiting the Earth. So, UFOs exist. This means there is intelligent life elsewhere in the Universe.
    b. She drank bottled water. Now, she is sick. The water must have made her sick.
    c. Astrology has been around for ages. He is an astrologer. So, there must be something to it.
    d. We have the right to watch television. Therefore, it's right for us to watch television. So, we should watch television all night instead of studying for an exam
    e. None of these.
4. Select the example representing this fallacy: Begging the Question
    a. That student will not sit still in their seat. They must have ADHD. You can tell by how they will not sit still.
    b. There are some people who cannot go without their coffee in the morning. They have coffee every morning. So, they are no better than alcoholics.
    c. You support nationalized health care. So, did the Nazis. This makes you just like Nazi Germany.
    d. There is no compelling evidence that UFOs are not visiting the Earth. So, UFOs exist. This means there is intelligent life elsewhere in the Universe.
    e. None of these.

APPENDIX F: EBI LESSON 2

5. Select the example representing this fallacy: Appeal to the Masses
   a. There has to be a God. Just look at how many people go to church. They can't all be wrong.
   b. That student will not sit still in their seat. They must have ADHD. You can tell by how they will not sit still.
   c. You support nationalized health care. So, did the Nazis. This makes you just like Nazi Germany.
   d. We have the right to watch television. Therefore, it's right for us to watch television. So, we should watch television all night instead of studying for an exam
   e. None of these.
6. Select the example representing this fallacy: Post Hoc Ergo Propter Hoc
   a. She drank bottled water. Now, she is sick. The water must have made her sick.
   b. There has to be a God. Just look at how many people go to church. They can't all be wrong.
   c. Either science can explain how she was cured or it was a miracle. Science can't explain how she was cured. So, it must be a miracle.
   d. They tried out medical tests. None of the medical tests have helped. Medical tests are useless.
   e. None of these
7. Select the example representing this fallacy: Straw Man
   a. You support nationalized health care. So, did the Nazis. This makes you just like Nazi Germany.
   b. She drank bottled water. Now, she is sick. The water must have made her sick.
   c. Astrology has been around for ages. He is an astrologer. So, there must be something to it.
   d. Women get abortions. He is a man. So, his opinion on abortion does not matter
   e. None of these.
8. Select the example representing this fallacy: Ad Hominem
   a. Women get abortions, but he is a man. So, his opinion on abortion does not matter
   b. Global warming is a hoax. Dr. Jones says so. She is a math professor at Harvard.
   c. That student will not sit still in their seat. They must have ADHD. You can tell by how they will not sit still.
   d. There are some people who cannot go without their coffee in the morning. They have coffee every morning. So, they are no better than alcoholics.
   e. None of these.
9. Select the example representing this fallacy: False Dilemma
   a. Either science can explain how she was cured or it was a miracle. Science can't explain how she was cured. So, it must be a miracle.
   b. We should ban SUVs because they are bad for the environment. Then the government will end up banning all cars. So, we should not ban SUVs.
   c. There is no compelling evidence that UFOs are not visiting the Earth. So, UFOs exist. This means there is intelligent life elsewhere in the Universe.
   d. You support nationalized health care. So, did the Nazis. This makes you just like Nazi Germany.
   e. None of these.

APPENDIX F: EBI LESSON 2

10. Select the example representing this fallacy: Appeal to Tradition
    a. Astrology has been around for ages. He is an astrologer. So, there must be something to it.
    b. She drank bottled water. Now, she is sick. The water must have made her sick.
    c. That student will not sit still in their seat. They must have ADHD. You can tell by how they will not sit still.
    d. Either science can explain how she was cured or it was a miracle. Science can't explain how she was cured. So, it must be a miracle.
    e. None of these.
11. Select the example representing this fallacy: Faulty Analogy
    a. There are some people who cannot go without their coffee in the morning. They have coffee every morning. So, they are no better than alcoholics.
    b. We should ban SUVs because they are bad for the environment. Then the government will end up banning all cars. So, we should not ban SUVs.
    c. Women get abortions. He is a man. So, his opinion on abortion does not matter
    d. There is no compelling evidence that UFOs are not visiting the Earth. So, UFOs exist. This means there is intelligent life elsewhere in the Universe.
    e. None of these.
12. Select the example representing this fallacy: Appeal to Authority
    a. Global warming is a hoax. Dr. Jones says so. She is a math professor at Harvard.
    b. We have the right to watch television. Therefore, it's right for us to watch television. So, we should watch television all night instead of studying for an exam
    c. There are some people who cannot go without their coffee in the morning. They have coffee every morning. So, they are no better than alcoholics.
    d. They tried out medical tests. None of the medical tests have helped. Medical tests are useless.
    e. None of these.
13. Select the example representing this fallacy: Slippery Slope
    a. We should ban SUVs because they are bad for the environment. Then the government will end up banning all cars. So, we should not ban SUVs.
    b. Global warming is a hoax. Dr. Jones says so. She is a math professor at Harvard.
    c. There has to be a God. Just look at how many people go to church. They can't all be wrong.
    d. Astrology has been around for ages. He is an astrologer. So, there must be something to it.
    e. None of these.

APPENDIX G: EBI QUIZ 1

1. Select the fallacy described in this statement: Things that resemble one another in certain respects, resemble one another in further respects.
    a. Faulty Analogy
    b. Appeal to Tradition
    c. Ad Hominem
    d. Begging the Question
    e. None of these.
2. Select the fallacy described in this statement: It must be true or good because everyone does it or believes it.
    a. Appeal to the Masses
    b. Appeal to Ignorance
    c. Hasty Generalization
    d. Slippery Slope
    e. None of these
3. Select the fallacy described in this statement: Citing the opinion of an expert rather than evidence for a claim, especially if the expert has no specific expertise related to the claim.
    a. Appeal to Authority
    b. Appeal to the Masses
    c. Post Hoc Ergo Propter Hoc
    d. Equivocation
    e. None of these.
4. Select the fallacy described in this statement: Proposing that only two alternatives exist when in actuality there are more than two.
    a. False Dilemma
    b. Appeal to Authority
    c. Straw Man
    d. Faulty Analogy
    e. None of these.
5. Select the fallacy described in this statement: When a word is used in two different senses in an argument.
    a. Equivocation
    b. False Dilemma
    c. Appeal to Authority
    d. Straw Man
    e. None of these.
6. Select the fallacy described in this statement: Supposing that two events are causally connected when they are not simply because one event followed the other event
    a. Post Hoc Ergo Propter Hoc
    b. Equivocation
    c. Ad Hominem
    d. Appeal to the Masses
    e. None of these.
7. Select the fallacy described in this statement: When an opponent's claims are misrepresented to make them easier to dismiss or reject.
    a. Straw man
    b. Post Hoc Ergo Propter Hoc
    c. Slippery Slope
    d. Hasty Generalization
    e. None of these

APPENDIX G: (CONT.) EBI QUIZ 1

8. Select the fallacy described in this statement: Assuming a conclusion or fact based primarily on the lack of evidence to the contrary.
    a. Appeal to Ignorance
    b. Faulty Analogy
    c. Begging the Question
    d. Appeal to Tradition
    e. None of these.
9. Select the fallacy described in this statement: When someone tries to rebut an argument by criticizing or denigrating its presenter rather than the argument itself.
    a. Ad Hominem
    b. Appeal to Ignorance
    c. False Dilemma
    d. Begging the Question
    e. None of these
10. Select the fallacy described in this statement: When an argument's conclusion is used as one of its premises.
    a. Begging the Question
    b. Ad Hominem
    c. Appeal to the Masses
    d. Appeal to Ignorance
    e. None of these.
11. Select the fallacy described in this statement: Assuming a series of events is hard to stop or control once it has begun, leading to worse or more difficult things
    a. Slippery Slope
    b. False Dilemma
    c. Straw Man
    d. Appeal to Authority
    e. None of these.
12. Select the fallacy described in this statement: It must be true or good because people have believed it or done it for such a long time.
    a. Appeal to Tradition
    b. Hasty Generalization
    c. Faulty Analogy
    d. Post Hoc Ergo Propter Hoc
    e. None of these.
13. Select the fallacy described in this statement: When general conclusions are drawn about all things of a type based on only a few things of that type.
    a. Hasty Generalization
    b. Appeal to Tradition
    c. Slippery Slope
    d. Equivocation
    e. None of these.

APPENDIX H: (CONT.) EBI QUIZ 2

1. Select the fallacy represented by this example: That student will not sit still in their seat. They must have ADHD. You can tell by how they will not sit still.
    a. Begging the Question
    b. Appeal to the Masses
    c. Hasty Generalization
    d. Straw Man
    e. None of these.
2. Select the fallacy represented by this example: They tried out medical tests. None of the medical tests have helped. Medical tests are useless.
    a. Hasty Generalization
    b. Begging the Question
    c. Post Hoc Ergo Propter Hoc
    d. Appeal to Ignorance
    e. None of these
3. Select the fallacy represented by this example: There is no compelling evidence that UFOs are not visiting the Earth. So, UFOs exist. This means there is intelligent life elsewhere in the Universe.
    a. Appeal to Ignorance
    b. Appeal to Authority
    c. Equivocation
    d. Faulty Analogy
    e. None of these.
4. Select the fallacy represented by this example: There has to be a God. Just look at how many people go to church. They can't all be wrong.
    a. Appeal to the Masses
    b. Slippery Slope
    c. False Dilemma
    d. Appeal to Tradition
    e. None of these.
5. Select the fallacy represented by this example: Either science can explain how she was cured or it was a miracle. Science can't explain how she was cured. So, it must be a miracle.
    a. False Dilemma
    b. Ad Hominem
    c. Appeal to the Masses
    d. Post Hoc Ergo Propter Hoc
    e. None of these.
6. Select the fallacy represented by this example: Astrology has been around for ages. He is an astrologer. So, there must be something to it.
    a. Appeal to Tradition
    b. Hasty Generalization
    c. False Dilemma
    d. Appeal to Authority
    e. None of these.

7. Select the fallacy represented by this example: We should ban SUVs because they are bad for the environment. Then the government will end up banning all cars. So, we should not ban SUVs.
   a. Slippery Slope
   b. Begging the Question
   c. Ad Hominem
   d. Straw Man
   e. None of these

8. Select the fallacy represented by this example: Women get abortions, but he is a man. So, his opinion on abortion does not matter
   a. Ad Hominem
   b. Equivocation
   c. Appeal to Tradition
   d. Slippery Slope
   e. None of these.

9. Select the fallacy represented by this example: She drank bottled water. Now, she is sick. The water must have made her sick.
   a. Post Hoc Ergo Propter Hoc
   b. Faulty Analogy
   c. Appeal to Ignorance
   d. Hasty Generalization
   e. None of these

10. Select the fallacy represented by this example: Global warming is a hoax. Dr. Jones says so. She is a math professor at Harvard.
    a. Appeal to Authority
    b. Faulty Analogy
    c. Begging the Question
    d. Appeal to the Masses
    e. None of these.

11. Select the fallacy represented by this example: There are some people who cannot go without their coffee in the morning. They have coffee every morning. So, they are no better than alcoholics.
    a. Faulty Analogy
    b. Ad Hominem
    c. Appeal to Tradition
    d. Equivocation
    e. None of these.

12. Select the fallacy represented by this example: You support nationalized health care. So, did the Nazis. This makes you just like Nazi Germany.
    a. Straw Man
    b. Appeal to Ignorance
    c. Slippery Slope
    d. Appeal to Authority
    e. None of these.

APPENDIX H: (CONT.) EBI QUIZ 2

13. Select the fallacy represented by this example: We have the right to watch television. Therefore, it's right for us to watch television. So, we should watch television all night instead of studying for an exam
    a. Equivocation
    b. Straw Man
    c. Post Hoc Ergo Propter Hoc
    d. False Dilemma
    e. None of these.

APPENDIX I: LECTURE QUESTIONS

Select the correct answer.

1. Which of the following is the definition of the "begging the question" fallacy?
   a. An argument's conclusion is used as one of its premises.
   b. When a word is used in two different senses in an argument.
   c. It must be good or true because people have believed it or done it for such a long time.
   d. General conclusions are drawn about all things of a type based on only a few things of that type.
   e. None of these.

2. Which of the following is an example of the "false dilemma" fallacy?
   a. She drank bottled water. Now, she is sick. The water must have made her sick.
   b. Global warming is a hoax. Dr. Jones says so. She is a math professor at Harvard.
   c. Astrology has been around for ages. He is an astrologer. So, there must be something to it.
   d. Either science can explain how she was cured or it was a miracle. Science can't explain how she was cured. So, it must be a miracle.

3. None of these. Which of the following is an example of the "equivocation" fallacy?
   a. We have the right to watch television. Therefore, it's right for us to watch television. So, we should watch television all night instead of studying for an exam.
   b. That student will not sit still in their seat. They must have ADHD. You can tell by how they will not sit still.
   c. We should ban SUVs because they are bad for the environment. Then the government will end up banning all cars. So, we should not ban SUVs.
   d. They did some medical tests. None of the medical tests have helped. Medical tests are useless.
   e. None of these

4. Which of the following is the definition of the "ad hominem" fallacy?
   a. It is true or good because people have believed it or done it for such a long time.
   b. Things that resemble one another in certain respects, resemble one another in further respects
   c. Supposing that two events are causally connected when they are not simply because one event follows the other event.
   d. Criticizing or denigrating the presenter of the argument rather than the argument itself.
   e. None of these.

5. Which of the following is the definition of the "appeal to authority" fallacy?
   a. It must be good or true because everyone does it or believes it.
   b. Things that resemble one another in certain respects, resemble one another in further respects.
   c. Assuming a conclusion or fact based primarily on the lack of evidence to the contrary.
   d. Citing the opinion of an expert rather than evidence for a claim, especially if the expert has no specific expertise related to the claim.
   e. None of these.

APPENDIX I: (CONT.) LECTURE QUESTIONS

6. Which of the following is the definition of the "appeal to tradition" fallacy?
    a. General conclusions are drawn about all things of a type based in only a few things of that type.
    b. It must be true or good because everyone does it or believes it.
    c. It must be true of good because people have believed it or done it for such a long time.
    d. Things that resemble one another in certain respects, resemble one another in further respects.
    e. None of these.
7. Which of the following is an example of the "appeal to the masses" fallacy?
    a. There are some people who cannot go without their coffee in the morning. They have coffee every morning. So, they are no better than alcoholics.
    b. There has to be a God. Just look at how many people go to church. They can't all be wrong.
    c. Global warming is a hoax. Dr. Jones says so. She is a math professor at Harvard.
    d. You support nationalized health care. So, did the Nazis. This makes you just like Nazi Germany.
    e. None of these.
8. Which of the following is an example of the "appeal to ignorance" fallacy?
    a. She drank bottled water. Now, she is sick. The water must have made her sick.
    b. Women get abortions. He is a man. So, his opinion on abortion does not matter.
    c. There are some people who cannot go without their coffee in the morning. They have coffee every morning. So, they are no better than alcoholics.
    d. There is no compelling evidence that UFOs are not visiting the Earth. So, UFOs exist. This means there is intelligent life elsewhere in the Universe.
    e. None of these.
9. Which of the following is an example of the "straw man" fallacy?
    a. There has to be a God. Just look at how many people go to church. They can't all be wrong.
    b. She drank bottled water. Now, she is sick. The water must have made her sick.
    c. You support nationalized health care. So, did the Nazis. This makes you just like Nazi Germany.
    d. There is no compelling evidence that UFOs are not visiting the Earth. So, UFOs exist. This means there is intelligent life elsewhere in the Universe.
    e. None of these.
10. Which of the following is the definition of the "faulty analogy" fallacy?
    a. Things that resemble one another in certain respects, resemble one another in further respects.
    b. It must be true or good because everyone does it or believes it.
    c. Criticizing or denigrating the presenter of the argument rather than the argument itself.
    d. Citing the opinion of an expert rather than evidence for a claim, especially if the expert has no specific expertise related to the claim.
    e. None of these.

APPENDIX I: (CONT.) LECTURE QUESTIONS

---

11. Which of the following is the definition of the "hasty generalization" fallacy?
    a. General conclusions are drawn about all things of a type based on only a few things of that type.
    b. Claims are misrepresented to make them easier to dismiss or reject.
    c. Assuming a series of events is hard to stop or control once it has begun, leading to worse or more difficult things.
    d. Supposing that two events are causally connected when they are not simply because one event follows the other event.
12. Which of the following is an example of the "post hoc ergo propter hoc" fallacy?
    a. Women get abortions. He is a man. So, his opinion on abortion does not matter.
    b. We have the right to watch television. Therefore, it's right for us to watch television. So, we should watch television all night instead of studying for an exam.
    c. She drank bottled water. Now, she is sick. The water must have made her sick.
    d. We should ban SUVs because they are bad for the environment. Then the government will end up banning all cars. So, we should not ban SUVs.
    e. None of these.
13. Which of the following is the definition of the "slippery slope" fallacy?
    a. It must be true of good because people have believed it or done it for such a long time.
    b. Assuming a conclusion or fact based primarily on the lack of evidence to the contrary.
    c. Criticizing or denigrating the presenter of the argument rather than the argument itself.
    d. Proposing that only two alternatives exist when in actuality there are more than two.
    e. None of these.

APPENDIX J: GENERALIZATION QUIZ

Select the correct answer.

1. Which of the following is the fallacy demonstrated by this example, "People who buy stocks are no different from people who bet on horse racing. They both risk their money with little chance of making a big profit. Therefore, people should not buy stocks or bet on horse racing."
    a. Faulty Analogy
    b. Hasty Generalization
    c. Appeal to Authority
    d. Slippery Slope
    e. None of these
2. Which of the following is the fallacy demonstrated by this example, "Trump stated, "Meryl Streep, one of the most over-rated actresses in Hollywood, doesn't know me but attacked me last night at the Golden Globes. She is a....."
    a. Equivocation
    b. Appeal to Ignorance
    c. Begging the Question
    d. Ad Hominem
    e. None of these
3. Which of the following is the fallacy demonstrated by this example, "Good students will study and learn without the threat of an exam. Bad students won't study and learn even with the threat of an exam. So, exams serve no purpose."
    a. Post Hoc Ergo Propter Hoc
    b. Hasty Generalization
    c. False Dilemma
    d. Slippery Slope
    e. None of these
4. Which of the following is the fallacy demonstrated by this example, "Gun control advocates should not get everything they want. People who think they should have a missile launcher in their backyard as a Constitutional right really shouldn't have a say in gun laws."
    a. False Dilemma
    b. Equivocation
    c. Straw Man
    d. Appeal to Ignorance
    e. None of these
5. Which of the following is the fallacy demonstrated by this example, "This mode of government is the best. We have had this government for over 200 years and no one has talked about changing it in all that time. So, it has got to be good."
    a. False Dilemma
    b. Appeal to Tradition
    c. Straw Man
    d. Appeal to the Masses
    e. None of these

APPENDIX J: (CONT). GENERALIZATION QUIZ

6. Which of the following is the fallacy demonstrated by this example, "Smith, who is from England, decides to attend graduate school at Ohio State University. He has never been to the US before. The day after he arrives, he is walking back from an orientation session and sees two albino squirrels chasing each other around a tree. In his next letter home, he tells his family that American squirrels are white."
   a. Begging the Question
   b. Faulty Analogy
   c. Hasty Generalization
   d. Ad Hominem
      None of these

7. Which of the following is the fallacy demonstrated by this example, "Philosophy helps you argue better, but do we really need to encourage people to argue? There's enough hostility in this world. So, we don't need to study philosophy."
   a. Faulty Analogy
   b. False Dilemma
   c. Appeal to Ignorance
   d. Equivocation
   e. None of these

8. Which of the following is the fallacy demonstrated by this example, "Everyone wants the new "Slap Me Silly Elmo" doll. It is sold out everywhere because it is the hottest toy of the season."
   a. Begging the Question
   b. Appeal to Tradition
   c. Straw Man
   d. Post Hoc Ergo Propter Hoc
   e. None of these

9. Which of the following is the fallacy demonstrated by this example, "We cannot unlock our child from the closet because if we do, she will want to roam the house. If we let her roam the house, she will want to roam the neighborhood. If she roams the neighborhood, she will get kidnapped by a stranger in a van. Therefore, we should keep her locked up in the closet."
   a. Slippery Slope
   b. Ad Hominem
   c. Appeal to Authority
   d. Appeal to the Masses
   e. None of these

10. Which of the following is the fallacy demonstrated by this example, "You have a family member that has a terminal disease. You hear of a possible new acupuncture cure being offered in another country. You contact the group promoting this cure and ask if it works. They say, "We have faith. We have seen it work and no one has been able to provide evidence that it doesn't.""
    a. Begging the Question
    b. Straw Man
    c. Appeal to Ignorance
    d. False Dilemma
    e. None of these

APPENDIX J: (CONT). GENERALIZATION QUIZ

11. Which of the following is the fallacy demonstrated by this example, "Isaac Newton was a believer in Creation. He is one of the most legendary physicists of all time. Are you going to argue with him?"
    a. Appeal to Authority
    b. Appeal to Tradition
    c. Hasty Generalization
    d. Appeal to the Masses
    e. None of these
12. Which of the following is the fallacy demonstrated by this example, "Everyone already believes that the defendant killed her husband. Everybody can't be wrong. She must be guilty."
    a. Ad Hominem
    b. Equivocation
    c. Appeal to Ignorance
    d. Appeal to the Masses
    e. None of these
13. Which of the following is the fallacy demonstrated by this example "I wore my purple sweater. My team won against all the odds. Therefore, I am going to wear that sweater to every game."
    a. Begging the Question
    b. Appeal to Tradition
    c. Straw Man
    d. Post Hoc Ergo Propter Hoc
    e. None of these

APPENDIX K: SOCIAL VALIDITY SURVEY

		Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
1.	I am confident about my knowledge of logical fallacies.	1	2	3	4	5
2.	The instruction helped me master information about logical fallacies	1	2	3	4	5
3.	I felt successful during most of the tests	1	2	3	4	5
4.	I prefer to learn using this instructional method as compared to other instructional methods	1	2	3	4	5
5.	The time commitment for this instructional method was appropriate in relation to the amount of information I learned	1	2	3	4	5
6.	I felt frustrated during the lessons	1	2	3	4	5
7.	If available, I would use this instructional method to learn information needed for my college courses	1	2	3	4	5
8.	I would recommend the instructional methods in this study to other students	1	2	3	4	5