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Assessing the Implementation of a Short Psychological Critical Thinking Intervention in Traditional and Online Courses

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The *American Psychological Association* (APA) and a recent survey of employers identified critical thinking as one of the most important skills for baccalaureate psychology students to develop. Given recent efforts that have focused on making college education accessible through distance learning, identifying effective pedagogical techniques for developing critical thinking skills in different instructional modalities represents a new problem for educators. Developing online curriculums with similar outcomes to the traditional face-to-face delivery presents many unique challenges and evaluating what constitutes effective teaching of psychological critical thinking in online delivery remains unclear. The purpose of this study was to examine changes in psychological critical thinking in online and traditional face-to-face courses following a 15-min lesson. Three raters scored the revised psychological critical thinking exam (Lawson et al., 2015) to assess pretest and posttest performance of 63 college students enrolled in online and traditional sections of introductory psychology and abnormal psychology at two universities. Data from a 2 × 2 mixed factorial analysis of covariance suggested no significant differences in psychological critical thinking between the online and traditional modalities in the pretest, but a significant difference in critical thinking in the posttest assessment such that critical thinking significantly improved in the online sections. Grade point average (GPA) was a significant predictor of increased performance as well. A short critical thinking intervention may be effective at teaching online students how to think critically when compared to students in a traditional classroom. These results suggest similar interventions may improve critical thinking in undergraduates enrolled in online courses, though limitations exist.

Keywords: psychological critical thinking, online learning, traditional classroom, ADDIE model

Supplemental materials: https://doi.org/10.1037/stl0000339.supp

Critical thinking is frequently suggested to be one of the most important skills that baccalaureate psychology students should develop if they wish to be successful (*American Psychological Association [APA]*, 2013; National Association of Colleges & Employers, 2021). While precise definitions differ, critical thinking involves three major components: (a) a skill involving goal-directed thinking used to solve problems and formulate inferences, (b) content-specific knowledge, and (c) a desire to use these skills (Sternberg & Halpern, 2020). Teaching students how to improve their critical thinking skills through evidence-based techniques and the scientific method is important if we wish them to avoid falling prey to biases and logical fallacies (Schmaltz et al., 2017). Put another way, undergraduate students need to learn how to think and process information—not just memorize facts (Burke et al., 2014). After students have developed a foundation of the tenets of critical

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thinking, they can apply the process within their specific subject areas. Domain-specific skills like psychological critical thinking are valuable because psychology majors can apply both content knowledge about psychology and scientific methods to evaluating claims (Burke et al., 2014). Lawson (1999, p. 207) defines psychological critical thinking (PCT) as one's ability to "evaluate claims in a way that explicitly incorporates basic principles of psychological science." For example, psychology majors should be able to identify that an argument about the benefits of an intervention is flawed if it includes a biased sample (Lawson et al., 2015). The goal of teaching PCT is to enable students to apply and incorporate principles of psychological science in their lives (Lawson et al., 1999). Previous published literature has demonstrated success in teaching students to think critically after explicit instruction (Bensley et al., 2016), though little research has explored the contributions of the classroom setting (i.e., face-to-face or online modalities).

Comparing Online and Traditional Education

Online education is a growing enterprise in education and business. In a 2016 survey conducted on psychology programs in higher education, 26% of psychology courses were offered online, and 17% of credits were earned online by students (Hailstorks et al., 2019). It is estimated that the global e-learning market will reach over $388 billion by 2026 (Research & Markets, 2021). Based on these recent trends and given that psychology is one of the most popular fields of study (National Center for Education Statistics, 2021), institutions are expected to offer more online psychology courses with some programs providing entirely online degrees. Many higher education institutions were prepared to expand their online capabilities given they had prior experience with such technology, though challenges remain for data privacy, involving multiple stakeholders, and providing equal access for students (García-Morales et al., 2021). In fact, in the era of COVID-19, some researchers argue that online education is a growing necessity (Ali, 2020). As such, its use continues to grow. It is important to distinguish between online education and emergency remote teaching, however. Online education typically includes an instructor who plans and develops the delivery of their educational material to students over a period of months (Castro & Tumibay, 2021; Hodges et al., 2020). On the other hand, emergency remote teaching, while sharing many characteristics with online education, occurred as a response to the COVID-19 pandemic in which instructors were required to temporarily shift face-to-face courses online very quickly with little planning or support (Hodges et al., 2020; Hughes et al., 2020). This study represents the former; the online sections of these courses were predeveloped by the instructors before the semester began and data were collected in the pre-COVID educational environment.

With this newfound popularity for online education comes growing pains. One of the most important questions becomes, "Is online education effective when compared to traditional modalities?" (Castro & Tumibay, 2021; Schmid et al., 2014). Assessment of online psychology courses can be traced back more than two decades (Wang & Newlin, 2000). Castro and Tumibay (2021) suggest that well-designed online courses in higher education are indeed effective, at least as much as traditional modalities when comparing student learning outcomes, student satisfaction, and problem-based learning outcomes. Even so, there are significant challenges associated with effective online education such as infrastructure support and having to adopt new technology (Sun & Chen, 2016). On the instructor side, developing engaging and pedagogically sound material, poor readiness, the lack of research and tools available to develop accessible materials for those with disabilities, and poor student evaluations are challenges (Ali, 2020; Bawa, 2016; Castro & Tumibay, 2021; Cinquin et al., 2019; Liu, 2012; Norris & Conn, 2005; Panigrahi et al., 2018). On the student side, online education challenges include the potential for lower student retention, and that individual differences like motivation, self-regulation, and time management skills are predictors of online student success (Bawa, 2016; Kauffman, 2015; Panigrahi et al., 2018). In other words, students with low motivation perform worse in the online setting (Kerr et al., 2006; Randi & Corno, 2022), though low-motivation students tend to perform worse in their first year already (van der Zanden et al., 2018). Finally, from an administrative perspective, current estimates suggest that depending upon the type of institution, about one-third to one-half of all psychology courses are offered by non-full-time faculty (Hailstorks et al., 2019). The increasing reliance on non-full-time

faculty (e.g., contingent or adjunct faculty) presents a unique challenge. Adjunct faculty lead to mixed results regarding student learning outcomes, enrollment, and other performance measures. For example, adjuncts in the humanities have a negative impact on student enrollment, though a positive impact for vocational classes. Further, the use of adjuncts negatively affects the distribution of departmental service and administrative burden caused by the need for more supervision and frequent adjunct faculty turnover (Bettinger & Long, 2010). Despite these perceived barriers to online education (Lloyd et al., 2012), its use has grown in popularity as a cost-effective and easily accessible method of education.

Psychological Critical Thinking in Undergraduate Students

Critical thinking in general is important because it is associated with community college student success outcomes such as completing courses, earning higher test scores, and graduating with a degree (Fong et al., 2017). Fong et al. suggest that critical thinking is considered especially valuable because it is a malleable skill that students can develop in school, and it translates well into workforce skills. For example, critical thinking is one important contributor in nursing students making effective clinical judgments (Cazzell & Anderson, 2016). However, current research on PCT specifically is limited and is mostly focused on validity and reliability (Lawson et al., 2015). Further, few published studies have examined the potential differences of teaching PCT in an online versus traditional classroom setting. Given that many psychology departments are increasing their online offerings and aim to develop critical thinking skills, it is valuable to explore the relationship between online teaching and PCT interventions.

When we are studying how to improve psychological critical thinking skills, it is also important to consider other potential contributors like grade point average (GPA). This fills a gap in the literature because to our knowledge, no researcher to date has studied if GPA affects PCT. What is known is that there is a small and positive relationship between critical thinking in college students and their GPAs (see Richardson et al., 2012, for meta-analysis). One explanation for the link between critical thinking and GPA is that critical thinking is a cognitive learning strategy that leads to deeper learning by applying old knowledge to new problems (Pintrich, 2004). Though correlational in nature (Richardson et al., 2012), it is entirely likely that students with a higher GPA perform better on PCT skills as well—because they already know how to use effective deep learning strategies.

Critical Thinking Interventions

Because critical thinking strategies can be trained, classroom interventions aimed at teaching critical thinking are effective (Blessing & Blessing, 2010; Cascio, 2017; Lanagan-Leitzel & Diller, 2018; Lawson et al., 2015; Nieto & Saiz, 2008). Looking at a contemporary PCT intervention, Cascio (2017) studied improvements in introductory psychology students. They provided students with a 75-min in-class activity across four time points during the semester. At each time point, students were asked to read a different short description of psychology research from a popular press blog (e.g., the New York Times Well Blog). The articles covered a variety of psychology topics and methodologies, and students were asked to answer 10 "critical thinking drill questions" analyzing claims in the article. For example, "Identify one potential confounding variable that could limit the internal validity of the study." After answering the questions, students engaged in reflective self-grading of their responses during a classroom discussion led by the instructor, where they were able to ask questions and clarify answers. Their self-graded responses were collected and reported, and results suggest that students showed improvement in PCT throughout the semester. Ultimately, all the interventions found some improvement in critical thinking, though it is important to note the variation in critical thinking assessments.

Puig et al. (2019) reviewed critical thinking interventions across higher education fields and reported that critical thinking skills vary by domain because such skills are structured around a certain knowledge base (e.g., psychology, biology). What these differing interventions did have in common is their focus on analysis and evaluation of claims. Beyond introductory college courses, one review on science, technology, engineering, and mathematics (STEM) critical thinking at the community college level found a similar

theme among interventions: they include an educational component containing critical thinking strategies, vignettes that allow students to evaluate relevant claims, and a critical thinking evaluation (Evangelisto, 2021). Puig et al. (2019) report that most critical thinking interventions focus on teaching skills rather than assessing dispositions, with a particular emphasis on analysis and evaluation skills in the social science fields. Explicit domain-specific instruction within students' field is an important component when evaluating which methods improve critical thinking (Puig et al., 2019). However, these interventions have been conducted in face-to-face courses and not in online courses. Measuring the learning effectiveness between face-to-face and online classes is challenging, and results have been mixed for many reasons. For example, there are multiple confounding variables that affect student performance such as the instructor, course topic, student individual differences and motivation, selection effects and other environmental factors (Cavanaugh & Jacquemin, 2015; Driscoll et al., 2012; Ni, 2013). However, research suggests that when instructors use pedagogically effective practices, there may be equal learning environments for students (Driscoll et al., 2012) and students perform at similar levels in online and face-to-face courses according to a recent review (Cavanaugh & Jacquemin, 2015). Thus, the present study considers an explicit domain-specific PCT intervention across online and face-to-face classes.

The Present Study

It is evident that critical thinking interventions are effective, but they are quite varied. Further, because grading written and oral arguments in any critical thinking intervention can be time intensive, it is valuable for instructors to have a readily available grading rubric that can be easily revised to meet their needs. Across two universities, two modalities (online and face-to-face), and two classes (introduction to psychology and abnormal psychology), this study explored a short critical thinking intervention using the ADDIE model (to be introduced below) as guide. We also provide a grading rubric for instructors and researchers to use (see Supplemental Material).

Hypothesis 1: There will be no difference in PCT scores between the traditional modality and online modality after accounting for GPA.

Hypothesis 2: PCT scores in the traditional modality and online modality will improve following the PCT lesson.

Method

The ADDIE Model

Using the analysis, design, development, implementation, and evaluation (ADDIE) model as a framework (Morrison et al., 2019), this study sought to compare the efficacy of an explicit instructional lesson in PCT in an online classroom with that of a traditional classroom. There are few instructional models that have been applied to the design and evaluation of online education (Castro & Tumibay, 2021). The ADDIE model represents a generic systematic approach to creating and evaluating efficient and effective content that increases learning (Morrison et al., 2019) after first defining what knowledge learners need. The ADDIE model is popular and widely used by educators (Serhat, 2018). For example, instructional design models like Quality Matters (Chen, 2016) have created rubrics based upon the ADDIE model as a method of ensuring high-quality online instruction. It is a useful framework for instructors to model and revise their instructional resources (Castro & Tumibay, 2021), such as a PCT intervention.

The five steps of the ADDIE model represent a cycle in which instructional designers and educators continually refine their online course (Serhat, 2018). In the present study, we applied one iteration of the ADDIE model to increase PCT skills in undergraduate students. The first step in *Analysis* is to identify the problem: graduating students need to think critically, classroom activities aimed at improving critical thinking are varied and difficult to access, and research on effective PCT interventions in an online setting is limited. In the *Design* phase of the intervention, we developed the pre–post scaffolded assignment and a short 15-min PowerPoint lesson on PCT (described more below). We recognized that some undergraduates may have more experience with PCT than others, so we developed a 2×2 mixed design (pre–post across two modalities) to assess improvement in PCT. The pretest was

given in Week 1, and the lesson and posttest were given 2–3 weeks later (see Table 1). One challenge at this phase was determining the best way to implement the assignment (i.e., how to set up the assignments in two different learning management systems [LMS]). Given that our courses differ in length (4-, 8-, and 16-week courses), we decided that approximately a semester midpoint window between the pre and post was a long enough time that participants would not improve due to test effects, but recent enough such that the students would still retain some knowledge of the PCT lesson across the varying semester lengths. We selected the midpoint of the courses to balance two potential confounds: the knowledge effects that occur from learning course materials and the testing effects that occur from pre- to posttest. While students in the 4-week course covered course material at a different rate compared to the 16-week course (which represents an uncontrolled variable), the potential for testing effects remained consistent across the courses due to the time window between the pre- and post-test. This led to a 14–21-day window, which is consistent with Lawson et al. (2015). Abnormal psychology was taught by one author at one university and Introductory Psychology was taught by another author at the other university. After this phase was *Development*, in which the PCT lesson and two required assignments were developed and then approved by the institutional review board (IRB). The PCT lesson is described in more detail in the Procedure section. One challenge at this phase was to minimize potential coercion because the class assignments were linked to students' names and grades. Thus, we made students aware of the true purpose of these assignments and they were given the option to *opt out* of their data being included in the research project. *Implementation* took place over the period of two semesters (summer and fall 2018). In the first week, students were given the pretest. Responses were graded by the authors, and feedback on why answers were incorrect were indicated for each student. A few weeks later, students received the PCT lesson and posttest assignment. This article represents the summative *evaluation* component in which we assess whether our goals were met and then provide recommendations for the future.

Participants

Seventy-three students who were enrolled in either an online or traditional section of an Abnormal Psychology or Introductory Psychology class at two 4-year public universities were recruited for this study (see Table 1, for the full timeline of these classes). The online modality functioned as

Table 1
PCTE Intervention Timeline

Intervention type	Semester	Week of semester implemented
Online—Abnormal (4 wk)	Summer	
Pretest		Week 1
Intervention		Week 3
Posttest		Week 3
Online—Introductory (8 wk)	Summer	
Pretest		Week 1
Intervention		Week 4
Posttest		Week 4
Traditional—Abnormal (16 wk)	Fall	
Pretest		Week 2
Intervention		Week 4
Posttest		Week 4
Traditional—Introductory (8 wk)	Summer	
Pretest		Week 1
Intervention		Week 4
Posttest		Week 4

Note. PCTE = psychological critical thinking exam. Abnormal Psychology was taught by one instructor and Introductory Psychology was taught by the second instructor.

the experimental group, and the traditional modality was the comparison group. The number of students enrolled in each class determined the sample size of the corresponding group. Ten students declined to have their data included, which resulted in a final sample size of 63 students (86.3% participation rate). G*Power V3.1.9.7 (Faul et al., 2007) was used to conduct a post hoc power analysis based on a repeated measures within-between interaction; with an effect size f of .25, $\alpha = .05$, sample size = 63, 2 groups and 2 measurements, $r = .47$ between pre- and post-test, and assumed sphericity, we achieved power = .97, which suggests a very low probability of making a Type II error (failing to reject the null when the null hypothesis is indeed false). Self-reported demographic information indicated that the composition of this sample was majority female (73%), Caucasian (69.80%), and mostly not psychology majors (72.4%). The average age was 20.06 ($SD = 6.48$) and average self-reported cumulative GPA was 3.17 ($SD = 0.84$). Students reported having completed an average of two psychology courses including the current one ($M = 2.24$, $SD = 2.97$). Students received no compensation for participating.

Materials

Critical Thinking

The revised psychological critical thinking exam (PCTE; Lawson et al., 2015) measured psychological critical thinking. Odd-numbered PCTE items constituted the seven-question pretest and even-numbered items the seven-question posttest. Each of the seven items are related to one the seven PCT questions (e.g., "Is the person claiming to have found the cause of some behavior or phenomenon? Most complex behaviors or phenomena have multiple causes."). This item split is counterbalanced such that students must identify each correct PCT question for a claim in the pretest and posttest. This also reduces test effects that might occur if we were to include the same questions on both assessments. Prior literature indicates that this measure has very good split-half reliability and test–retest reliability (Lawson et al., 2015). Three independent raters graded responses using a rubric adapted from those previously published (Lawson et al., 2015; Williams et al., 2003; see Supplemental Material, for the grading rubric). A score of 0 indicates that a student did not answer the question. A score of 1 (competent) occurred when students identified the incorrect PCT question. A score of 2 (proficient) occurred when students identified both the correct *and* less-relevant PCT questions. A score of 3 (outstanding) was earned when a student correctly identified only the relevant PCT question, ignoring extraneous issues. We calculated reliability coefficients for both the pretest (Krippendorff's $\alpha = .98$; Hayes & Krippendorff, 2007) and posttest ($\alpha = .98$) which indicated high interrater agreement.

Procedure

We received IRB approval (#050418-2) before the study began. The PCTE was administered as two take-home course assignments (pretest and posttest items) in the first part of the semester. The instructions for each assignment read,

> This journal assignment will introduce you to psychological research in order to help you develop your psychological critical thinking. This is defined as the ability to evaluate claims through the use of psychological science. Instructions: Below are seven claims. For each of the following examples, state whether or not there is a problem with the person's conclusions and explain the problem (if there is one).

Students received individualized feedback 1 week after submission on why their answers were incorrect for both their pre- and post-test (Bourdeaux & Schoenack, 2016). The pretest was given in Week 1 and constituted the seven odd-numbered items on the PCTE (each of the seven claims are related to the seven PCT questions). The lesson and posttest (seven even-numbered items on the PCTE assigned after the lesson) were given 2–3 weeks later.

The lesson itself was based on Bensley's (2010) seminal guide on teaching psychological critical thinking. For example, it is important to start by stating the goals and objectives. Bensley also recommends practicing PCT skills that meet the level of the students, and the Lawson et al. (2015) update is the leading framework for measuring PCT in first-year college students. Accordingly, the 15-min lesson included slides first explaining the lesson's three learning objectives. The first objective was to define PCT (Lawson et al., 1999). Second, students were told why PCT matters (because we are tempted by commonsense beliefs and outrageous claims every day, it is important for us to ask hard questions and

challenge conventional wisdom; Ruggiero, 2014). More slides covered objective three: practicing PCT by first understanding the seven questions students should ask to think critically about a psychological claim (see Lawson et al., 1999, 2015). Finally, two tables explained scientific and nonscientific sources of evidence, respectively (Bensley, 2010). At the end of the lesson, we provided a handout of the seven PCT questions (printed for the traditional classes, pdf for the online sections). Immediately after the lesson, students were assigned the seven posttest items, which were also graded and given individualized feedback.

The same standardized lecture, developed and presented by the first author, was provided to all students. One section received an in-person lecture (first author traditional class), and the exact same lecture was recorded into a Voicethread presentation (slides with accompanying audio) and shared with the other three sections. Of the three remaining, the in-person section watched the video during class, and the online sections accessed it asynchronously. This was done to keep the instructor and information consistent across all conditions. Due to technology issues, we were unable to track video viewings in Voicethread to determine how many students watched the online PCT lecture, and thus no attendance record was maintained.

Results

First, in terms of demographic comparisons, both universities were about two-thirds female (Georgia: 64%; Nebraska: 60%). Psychology represented one of the more popular majors on campus, and the racial composition of each university (Georgia: 45% White, 40% Black/African American, 8% Hispanic/Latino, 4% Multiracial, 1% Asian; Nebraska: 75% White, 2% Black/African American, 13% Hispanic/Latino, 2% Multiracial, 1% Asian) approximated each state's racial composition according to 2020 census data.

Hypothesized Results

In general, students' pretest scores moved from competent (average scores 9.85 and 11.46) to closer to proficient in the posttest average scores. See Table 2, for the estimated marginal means of all conditions. Studentized residuals indicated no outliers (values greater than ±3) on PCTE scores. PCTE scores were normally distributed per the normal Q–Q plot. There was homogeneity of variance according to Levene's test ($p > .05$) and homogeneity of covariance according to Box's test ($p = .59$). Using listwise deletion for the analysis of covariance (ANCOVA) procedure, 3.2% of data were missing. This 2 (time) × 2 (class modality) mixed ANCOVA (mean-centered GPA as a covariate) was collapsed across courses and institutions. Schneider et al. (2015) recommend mean centering the covariate in an ANCOVA because not doing so affects the interpretation of the simple main effects by distorting within-subjects estimates and increasing the risk of Type I errors. We begin by explaining the interaction results, as these are often considered the most interesting part of a mixed ANCOVA.

There was a significant interaction between class modality (online vs. traditional) and time (pre- vs. post-test), $F(1, 57) = 11.61$, $p = .001$, partial $\eta^2 = .17$. See Figure 1. Further, there was a

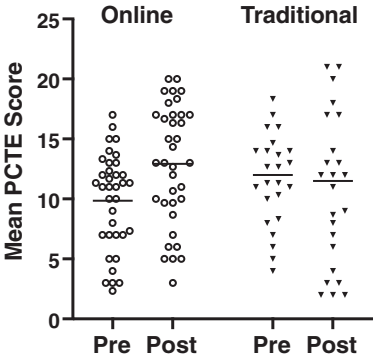
Table 2
Marginal Means on Psychological Critical Thinking Between Online and Traditional Classrooms

Condition	Estimated marginal means	Standard error	*N*
Online classroom			36
Pretest	9.85	0.65	
Posttest	12.93	0.92	
Traditional classroom			26
Pretest	11.46	0.76	
Posttest	10.65	1.13	

Note. Pretest and posttest scores ranged from 0 to 21. Higher scores indicate higher performance.

Figure 1

Individual PCTE Scores for Online (Open Circles) and Traditional (Closed Triangles) Groups Are Plotted for Both Pre- and Post-Test Periods



Note. Horizontal bars represent group means. PCTE = psychological critical thinking exam.

significant interaction between time and GPA, $F(1, 57) = 8.39$, $p = .01$, partial $\eta^2 = .13$, indicating that GPA significantly predicted increases in test scores from pre- to post-test. Because including the covariate in further analyses can affect the interpretation of the simple main effects by distorting within-subjects estimates and increasing the risk of Type I errors, we removed GPA from the simple main effects analyses (Schneider et al., 2015) of modality and time on PCTE scores.

The first univariate ANOVA examined the simple main effects of modality on pretest and posttest scores. There was no significant difference in PCT scores between the online and traditional modalities in the pretest, $F(1, 60) = 2.60$, $p = .11$, partial $\eta^2 = .04$. In the posttest, there was no significant difference in PCT scores between modalities, $F(1, 58) = 2.45$, $p = .12$, partial $\eta^2 = .04$. Thus, Hypothesis 1 was supported.

Finally, we inspected the simple main effects of time using a repeated-measures ANOVA. In the online modality, there was a significant effect of time on performance, $F(1, 35) = 17.48$, $p < .001$, partial $\eta^2 = .33$, indicating that online students significantly improved from the pretest to the post-test. In the traditional modality, there was no significant effect of time on performance, $F(1, 23) = 0.85$, $p = .37$, partial $\eta^2 = .04$, such that these students' scores did not increase significantly after the lesson. Hypothesis 2 was partially supported.

Follow-Up Analyses

The online modality experienced improvement in PCT, while the traditional modality did not. This discrepancy cannot be explained by age differences between the traditional and online courses, $t(60) = 0.46$, two-sided $p = .65$, 95% CI [−2.59, 4.13]. It was also not a function of the number of psychology courses students had taken, $t(60) = 1.88$, two-sided $p = .06$, 95% CI [−0.09, 2.91]. However, we tested the number of psychology classes for normality, and the Kolmogorov–Smirnov test ($p > .001$) indicated that this variable was not normally distributed. The average student had completed 2.2 psychology courses, but two students completed many more classes than that (14 and 20 courses). We removed these two cases and found that a significant difference in number of psychology classes emerged, $t(58) = 2.10$, two-sided $p = .04$, 95% CI [.03, 1.13] such that online students had completed more psychology classes on average (2.0 classes) compared to traditional students (1.42 classes). Ultimately, we could find no theoretical justification for removing these participants, so they remained in the data set. Taken together, students in the online modality exhibited higher PCTE scores after the short intervention. The results suggest that the intervention was moderately successful at improving PCT for online students.

Discussion

The purpose of the present study was to investigate the effectiveness of a psychological critical thinking intervention implemented in online and in-person classrooms to determine whether course modality influences PCT skill acquisition by undergraduate students after accounting for GPA. There is strong evidence that critical thinking is associated with college student success (see Fong et al., 2017). The *American Psychological Association* (2013) and the National Association of Colleges and Employers (2021) suggest that critical thinking skills are an important part of an undergraduate education. Consequently, PCT interventions are an avenue by which higher education instructors can align their learning objectives with the *APA* and future employers' needs. They also act as a way for undergraduates in an introductory psychology course to develop

an important scientific skill that crosses psychological topic areas (Gurung et al., 2016).

Using the ADDIE model as a framework, we investigated how well both traditional face-to-face and online students learn to think critically about psychological claims using a scaffolded assignment on critical thinking. For educators who wish to use online pedagogical techniques that meet the needs of their students, the ADDIE model represents a systematic approach to instructional design (Shelton & Saltsman, 2011). It is a useful guide for instructors seeking to develop and revise instructional resources because it provides instructors with a framework around which to develop intentional and effective classroom activities and assignments. Within this process, we also developed a rubric that instructors can use to evaluate their students' responses to the PCTE. In the following sections, we conduct a second round of *Analysis* on the present study to inform future iterations of the ADDIE model as applied to PCT interventions.

Students in the online modality significantly improved their PCT performance following a short lesson. As expected, GPA was significantly related to posttest performance in PCT (Howard et al., 2015), indicating that those students with higher performance may be more likely to improve their critical thinking (Bensley & Spero, 2014). Consistent with a prior meta-analysis on general critical thinking (Richardson et al., 2012), GPA was a significant predictor of PCTE scores in the present study such that students who had achieved a higher cumulative GPA performed better performed better on the PCTE. Critical thinking is a cognitive learning strategy in which people apply old information to new situations (Pintrich, 2004). When online students engage in self-regulated learning strategies like critical thinking, time management, metacognition, and persistence, they exhibit better academic outcomes (Broadbent & Poon, 2015). This is especially important for online students, as the nature of their program necessitates autonomy, self-directed learning, and active engagement in their education (Serdyukov & Hill, 2013; Wang et al., 2013). Put another way, perhaps students taking online courses are better at learning critical thinking skills because in order to be successful, they need to be able to recognize when they are receiving confusing or biased information and make an effort to understand the information—even when it seems uninteresting (Broadbent & Poon, 2015). The significant increase in performance for the online students may also suggest that online education that uses formative assessment can be effective in teaching critical thinking, engaging students, and improving learning outcomes (Gikandi et al., 2011). Our online findings are consistent with other comparable critical thinking interventions such as Blessing and Blessing (2010) who found a similar effect size for the condition and time interaction from T1 to T2 (partial $\eta^2 = 0.10$) and Lanagan-Leitzel and Diller's (2018) T1 to T11 improvement in PCT scores (partial $\eta^2 = 0.78$).

The lack of a similar significant improvement in the traditional classroom was inconsistent with prior literature that suggests similar levels of performance between online and traditional classes (Cavanaugh & Jacquemin, 2015). This is surprising and may suggest that this intervention had differential effectiveness depending on instructional modality—or perhaps that other study variables contributed to a different outcome for those students. This was a quasi-experimental study, and there were many variables, including course length, course content, and total amount of information that were not controlled for as would be expected in an experimental design. Indeed, the complexities of this study make it more of a proof-of-concept approach that may provide ideas for others to investigate in future. For example, course length could be a variable that contributed to the discrepancy in performance increases pretest to posttest between modalities. The online modality comprised an intensive 4-week online course and 8-week online course, while the traditional modality comprised either an 8-week or a 16-week in-person course. The students in the online courses would have been exposed to more course content than the students in the traditional courses at the time of intervention and testing (Table 1). Furthermore, there is some evidence that students perform better in intensive courses than in traditional-length courses (Hall et al., 2012). Teacher effectiveness might also be marginally higher during intensive courses versus traditional-length courses (Kucsera & Zimmaro, 2010).

It could be that the students in the online courses demonstrated higher levels of motivation like previous reports (Quesada-Pallarès et al., 2019). Touré-Tillery and Fishbach (2011) argue that certain facets of motivation fluctuate in distinct ways over the course of the pursuit of

a goal. Means-oriented motivation may follow a "u-shaped pattern" (p. 421), whereas goal-oriented motivation may increase as goal achievement approaches. Since the posttest was given closer to the end of a short term in some courses (Week 3 of 4), these students may have been highly motivated to keep their grades up near the end of the term, translating to high levels of effort on the PCT posttest assignment. Meanwhile, students in the in-person courses took the posttest closer to the middle of their respective terms, perhaps experiencing a dip in motivation (i.e., Touré-Tillery and Fishbach's "u-shaped" curve). Thus, it is possible that fluctuations in motivation can explain the difference between the posttest PCTE scores in the present study. Finally, it is possible that the students who chose online courses are more self-disciplined and motivated to succeed in the course, which could explain the significant improvement for the online condition (Stark, 2019). Regardless, it is important to note that these conclusions are purely speculative because measures of motivation and effort were not included in the present study.

One limitation to consider is that there were significant differences in pretest scores between schools and classes. Specifically, the abnormal psychology classes in Nebraska ($N = 33$, $M = 11.68$, $SD = 3.74$) performed significantly better than the introductory psychology classes in Georgia ($N = 29$, $M = 9.22$, $SD = 3.78$), $t(60) = 2.57$, two-sided $p = .01$, 95% CI [.54, 4.37]. This effect might be a function of location or the type of student who chooses to take an introductory versus abnormal psychology class. It is essential to note that at the authors' universities, both courses meet general studies requirements and have no prerequisites. However, students who elect to take an introductory abnormal psychology class may be more invested (presumably because it is a specialized course that may relate to their future career interests, or because they may have personal experience with mental illness) compared to an introductory course that many students take to simply meet a general education requirement. Further, it is possible that in-person students did not benefit from watching the video version of the lesson, or perhaps the PowerPoint itself was the issue (Harlin & Brown, 2007). In the present study, it was unclear if students watched the PCT lecture versus used the PCT handout because we were not able to track video viewings. Tracking student engagement through a LMS may be an effective way to predict PCT performance (Zacharis, 2015).

Data collection took place in the summer and fall of 2018 before COVID-19, and online students at that time may have been more engaged than online students in a post-COVID-19 world (Daniels et al., 2021). College students experienced decreased motivation for online college courses during and following COVID-19 (Corpus et al., 2022). Thus, how our results generalize to online courses in the context of socially distanced classrooms is unclear. Further, the distinction between online education (Castro & Tumibay, 2021; Hodges et al., 2020) and emergency remote teaching (Hodges et al., 2020; Hughes et al., 2020) is especially important to consider when interpreting the present study. In light of these considerations, an alternative interpretation of this quasi-experimental study is that it acts as a proof-of-concept that lessons in the context of courses across varying lengths and topics may be effective in improving PCT in undergraduate students. Although there may be many reasons for differences between the sections of this course, we cannot attribute these differences to any one variable. Ultimately, continued research on how to improve PCT is critical as technology and the needs of our students change over time.

Teaching and Research Implications

This project represents a starting point for future research aimed at improving critical thinking in traditional and online modalities, especially if students are able to engage in inquiry-based reasoning and thinking (van der Zanden et al., 2018). The ADDIE model is one method by which instructors can intentionally design and refine such classroom materials (Castro & Tumibay 2021; Trust & Pektas, 2018). While prior studies have created their own grading rubrics (e.g., Blessing & Blessing, 2010; Lanagan-Leitzel & Diller, 2018), none have published them to date. We provide a grading rubric that can be easily revised to meet an activity or assignment's needs for instructors and future researchers. Online students have different expectations from courses than traditional students, such as preferring courses that have been developed intentionally (Bourdeaux & Schoenack, 2016). More valuable intentional universal design strategies include making the course

creative, accessible, allowing students ways to develop mastery, and ensuring the course is effective. However, faculty are oftentimes unfamiliar with how to make their classes more accessible (Huss & Eastep, 2016). Developing accessible materials that provide equal access for all students is critical (King & Piotrowski, 2021) for instructors wishing to implement more universal instructional designs (Cinquin et al., 2019). To remain compliant with the Americans with Disabilities Act, we encourage instructors to prepare subtitles or transcripts when developing a new instructional video on PCT and take time to include accurate alternative text describing images for students who need accommodations. Instructors should also consider examining ways to monitor engagement in online coursework, such as through tracking student activities in a LMS. For example, Canvas now has a "must view the item" option that requires students to view a video before moving on in the course. Finally, this research may be valuable to program administrators who want to incorporate an easy critical thinking measure into their department's assessment program (Dunn et al., 2020).

Future research should explore factors that could affect PCT acquisition during a course, such as the examining adding more components to a critical thinking lesson, the effects of length of the course, refining the rubric, and assessing students' evaluations of the lesson and their changing motivations throughout the course of the semester. It is also valuable to obtain reaction-level data (e.g., student feedback on the lesson) as well as other levels, like actual learning (Kirkpatrick & Kirkpatrick, 2016). Meanwhile, the long-term effects of critical thinking interventions remain unclear. Students do learn to think more critically in college, but these skills decline over time (Huber & Kuncel, 2016). Thus, not only is it important to study the effectiveness of teaching PCT skills, but it is also important to consider the extent to which these acquired skills are acquired and lost over time.

Conclusion

Teaching students to interpret research results, challenge conclusions, identify logical fallacies, and recognize biases are all methods to help them develop critical thinking skills in the classroom and beyond (Bellaera et al., 2021; Bezanilla et al., 2019). PCT is intertwined with possessing psychology-specific content knowledge (Willingham, 2020). Without this foundational knowledge, it is difficult for students to identify anomalous conclusions. While the results of this study indicated some success for online students, continued inquiry into the subject is valuable because it provides instructors with resources, researchers with future goals, and most importantly—it benefits students. Undoubtedly, one semester of practice cannot teach students to think beyond the surface level and consider abstract connections, though results are promising. PCT instruction should integrate critical thinking strategies using Bloom's taxonomy for low-level or high-level activities (see Halonen & Dunn, 2020). In the end, the goal of teaching students how to think critically about psychology is not to tell them *what* to think but rather teach them *how* to think (Burke et al., 2014). Providing students with the questions and skills necessary to think critically and instructors a grading rubric to evaluate that process is a step in that direction. The assessment of student PCT offers educators an evidence-based test for efficacy in instruction. This is especially important as teaching modalities are rapidly changing. The results of the present study indicate that it is possible to effectively implement a PCT intervention in an online classroom, reassuring educators that online instruction can be effective.

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