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Peer blinding effects on critique quality, utility, and self-efficacy in virtual design studios

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Abstract

Purpose: This study evaluates virtual studio-based learning effects on pre-service teachers' technological self-efficacy and examines how multi-tiered anonymity levels influence peer critique quality and revision utility.

method: A quantitative quasi-experimental design integrated a mixed-factorial analysis of variance using a validated composite TPACK survey with high internal consistency. Concurrently, a within-subjects framework tracked pre-service teachers across distinct peer review cycles using rubric content analysis and pre-post artifact revision ratios.

Findings: Participants in virtual design studios achieved substantial technological pedagogical self-efficacy gains compared to the control group. Double-blind conditions generated significantly higher peer critique quality than unblinded open-identity settings. Furthermore, partial-blind and double-blind configurations led to significantly greater feedback utilization during artifact revisions than fully identified reviews.

Practical implications: Educator preparation programs should configure online studio platforms with partial-blind peer reviews to maximize revision uptake while preserving student social presence.

Originality/value: This research novelly differentiates a multi-tiered privacy continuum in virtual design studios, directly linking scaffolded anonymity to pre-service teachers' self-efficacy and empirical artifact revisions.

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Introduction

Studio-based learning (SBL) has increasingly transitioned into virtual learning environments to foster collaborative design and higher-order critical thinking skills across diverse professional disciplines (Ankyiah & Bamfo, 2023; Rabboh, 2021; Trede et al., 2020). In higher education, the integration of digital collaborative tools and learning management systems enables flexible interaction that mirrors real-world design studio practices (Dahal, 2022; İlter, 2023). These virtual design studios facilitate student-centered learning where participants engage in continuous peer dialogue, iterative artifact creation, and collaborative reflection (Koehler et al., 2022; Yu et al., 2022). Within teacher education programs, cultivating these collaborative digital environments is essential for building robust pedagogical and technological competencies among pre-service educators (Rahmawati et al., 2020; Voithofer & Nelson, 2020).

Developing teachers' technological self-efficacy and integration skills directly shapes their professional identity and future instructional practices (Birisci & Kul, 2019; Dogan et al., 2020; Mugume & Katusiimeh, 2024). Engaging in authentic, hands-on, problem-solving design tasks significantly enhances pre-service educators' confidence and motivation to adopt digital tools in teaching (Stephens, 2019; Wu et al., 2023; Yildiz Durak, 2021). Furthermore, participating in structured peer feedback exchanges strengthens student feedback literacy and cognitive development within socio-cultural learning frameworks (Caliboso et al., 2024; Erdel, 2023). These interactive peer dynamics improve learning satisfaction and foster essential evaluative dispositions needed for effective technology integration (Cheng et al., 2021).

Although formative peer assessment is widely advocated, current literature reveals significant inconsistencies regarding how anonymity conditions affect the quality and depth of peer feedback (Howard et al., 2010; Panadero & Alyasa, 2019).

https://doi.org/10.51574/hamka.v4i2.153

Empirical studies offer conflicting evidence, with some reporting quality gains under anonymous conditions while others show negligible differences or reduced interaction quality (Berg, 2016; Kobayashi, 2019). Moreover, unmoderated anonymous environments can trigger disinhibited behaviors such as online trolling, whereas non-anonymous peer reviews frequently introduce social bias, evaluation anxiety, and interpersonal conflict (Nitschinsk et al., 2022; O'Neill & Mclarnon, 2018; Stover & Holland, 2018). These socio-emotional barriers can induce social loafing and knowledge hoarding, leaving a critical gap regarding how specific blinding configurations influence both feedback generation and subsequent revision utility (Mihelič & Culiberg, 2019; Taghizadeh et al., 2022).

In contrast to previous investigations that primarily evaluated final performance outcomes, this study uniquely examines the multi-dimensional structure of feedback content alongside actual revision implementation across distinct blinding levels (Cui et al., 2021; He & Ying, 2023; Wu & Schunn, 2020). While prior research compared binary identified versus anonymous formats, our design systematically differentiates double-blind, partial-blind, and no-blind configurations within a learning management system framework (Kang & Hwang, 2023; Roberts & Rajah-Kanagasabai, 2013). This study novelly links these privacy settings to students' perceptual attitudes and actual artifact modification practices to bridge the known gap between feedback reception and action (Pitt & Norton, 2017). By applying this comprehensive framework to teacher education, the investigation establishes an innovative model connecting scaffolded anonymity to pre-service teachers' technological self-efficacy and evaluative competence (Rotsaert et al., 2017).

The primary purpose of this study is to evaluate how participation in an online studio-based learning environment impacts pre-service teachers' technological pedagogical self-efficacy. Additionally, the research investigates whether the

https://doi.org/10.51574/hamka.v4i2.153

qualitative content of peer critiques—comprising affective, reactionary, constructive, and clarifying comments—varies significantly across double-blind, partial-blind, and open-identity conditions (Sha et al., 2022; Tan et al., 2020). Furthermore, it analyzes the proportion of peer feedback utilized by authors when revising their design artifacts under these varying privacy settings (Chirubvu & Muzerengi, 2024; Şeyh et al., 2022). Ultimately, the study seeks to determine the optimal blinding configurations that maximize peer critique quality and artifact implementation without compromising overall student engagement.

In contemporary digital education, rapid technological advancements such as generative AI integration present both transformative opportunities and complex pedagogical challenges for instruction (Nkolika, 2024). Educators are increasingly expected to design realistic, student-centered learning trajectories that foster complex conceptual construction in foundational subjects (Susandi & Navarro, 2024). As higher education institutions rapidly expand online learning platforms, establishing effective digital feedback mechanisms has become an urgent priority for maintaining instructional quality. Understanding how privacy controls in virtual design studios influence student engagement is therefore critical for designing resilient, scalable online teacher preparation programs.

This research offers substantial theoretical contributions by clarifying the cognitive and socio-emotional mechanisms underlying peer critique and feedback adoption in online studio settings. Practically, the findings provide actionable guidelines for instructional designers seeking to balance evaluation objectivity with student social presence in virtual environments. By identifying optimal blinding strategies, teacher educators can scaffold peer assessment tasks to build resilient technological and pedagogical competencies in pre-service teachers. Ultimately, these insights support the creation of engaging, efficient, and effective digital learning spaces that prepare future educators for 21st-century classrooms.

https://doi.org/10.51574/hamka.v4i2.153

Method

To systematically examine the effects of virtual studio-based learning (SBL) on pre-service teachers, this study employed a quantitative quasi-experimental mixed-factorial research design. The primary quantitative model utilized a 2 x 2 mixed ANOVA to compare Technological Pedagogical Content Knowledge (TPACK) self-efficacy gains across experimental SBL and control non-SBL conditions at two temporal measurement points. This factorial approach was chosen to isolate the interaction between instructional intervention and time while measuring self-efficacy development over the course duration. Constructivist instructional planning was integrated into the virtual design studio to support iterative artifact creation and reflective problem-solving.

To evaluate the secondary research objectives regarding feedback mechanisms, a single-factor within-subjects ANOVA design was implemented across three distinct blinding conditions. Participants experienced double-blind, partial-blind, and open-identity feedback interactions within asynchronous discussion boards to capture dynamic peer engagement. This repeated-measures framework minimizes individual participant variance while testing how identity concealment affects constructive peer dialogue in virtual environments. Combining these designs ensures a robust methodological structure that connects collaborative group dynamics directly with technological self-efficacy development.

Participants, Subjects, or Research Sample

The target population comprised third-year undergraduate pre-service teachers enrolled in a compulsory educational technology application course at a four-year university in the United States. Out of 115 students who consented to complete survey measures, a sub-sample of 60 participants was randomly assigned to 15 closed studio groups of four members each to execute collaborative SBL tasks. Small group sizing was deliberately selected based on collaborative learning theory

https://doi.org/10.51574/hamka.v4i2.153

to prevent social loafing while maintaining active individual engagement. A subset of 54 participants successfully completed all three anonymous peer review cycles, forming the final analytical sample for the within-subjects feedback evaluation.

Purposive sampling ensured that all participants possessed comparable baseline technological exposure while preparing for clinical teaching field experiences. Demographic data indicated a balanced distribution across primary academic specializations, including elementary education, secondary STEM, and humanities tracks. The control group (n = 35) engaged in equivalent learning activities within open public forums to ensure equal time-on-task without exposure to closed peer critique cycles. Institutional Review Board approval was secured under protocol 24147, ensuring strict ethical compliance regarding participant consent, identity masking, and data privacy.

Table 1. Demographic Characteristics of Study Participants

Demographic Characteristic	**Category / Sub-group**	**Treatment Group (SBL) (n=49)**	**Control Group (Non-SBL) (n=35)**	**Total Sample (N=84)**
Academic Standing	3rd-Year Undergraduate	49 (100%)	35 (100%)	84 (100%)
Primary Specialization	Elementary Education	21 (42.9%)	15 (42.9%)	36 (42.9%)
	Secondary STEM	16 (32.7%)	11 (31.4%)	27 (32.1%)

https://doi.org/10.51574/hamka.v4i2.153

	Humanities / Social Studies	12 (24.5%)	9 (25.7%)	21 (25.0%)
Course Module Context	Technology Application	49 (100%)	35 (100%)	84 (100%)
SBL Group Structure	Closed Groups of 4	49 (100%)	0 (0%)	49 (58.3%)
	Public Forum Discussions	0 (0%)	35 (100%)	35 (41.7%)
Peer Review Sample (N = 54)	Completed All 3 Conditions	54 (100%)	—	54 (100%)

Data Collection Instruments and Procedures

Data collection utilized a validated 20-item Technological Pedagogical Content Knowledge (TPACK) survey administered via the learning management system at the beginning and end of the five-workshop module. The instrument measures three core subscales using a 5-point Likert scale: Technological Content Self-Efficacy (6 items), Technological Pedagogical Self-Efficacy (11 items), and Technological Pedagogical Content Self-Efficacy (3 items). Psychometric testing confirmed high composite internal consistency with a Cronbach's alpha coefficient of 0.95, exceeding standard reliability thresholds for educational research. This self-report survey evaluated pre-service teachers' perceived capabilities in integrating modern software and instructional tools into future classroom instruction.

To collect qualitative peer critique data, participants uploaded design artifacts—such as interactive presentations and learning analytics workflows—to asynchronous discussion boards. Peer reviews were conducted across three structured project cycles under double-blind, partial-blind, and no-blind privacy

https://doi.org/10.51574/hamka.v4i2.153

settings managed through LMS access permissions. A content analysis rubric categorized review comments into affective, reactionary, constructive, and clarifying feedback dimensions. Peer feedback implementation was measured by tracking specific artifact revisions between initial submissions and final project artifacts uploaded to the assignment repository.

Field procedures spanned five consecutive weekly workshops, with synchronous online orientation sessions introducing technology dispositions and peer review expectations. Experimental groups operated under double-deadline structures, requiring initial artifact posting prior to viewing peer submissions to ensure critique originality. Two independent trained coders evaluated a 20% random sample (n = 36) of peer reviews to establish inter-rater reliability, achieving an initial Cohen's Kappa of 0.93 and a final Kappa of 0.78. Control group members completed equivalent discussion tasks to maintain identical time-on-task, preventing confounding workload variations across study conditions.

Table 2. Variable Operationalization and Data Collection Instruments

Construct / Variable	Sub-dimension / Subscale	No. of Items / Units	Data Collection Instrument	Measurement Scale / Method	Psychometric / Reliability Metric
TPACK Self-Efficacy	Technological Content (TeCOSE)	6 items	Pre/Post TPACK Survey	5-point Likert Scale	Cronbach's alpha = 0.93
	Technological Pedagogical (TePE)	11 items	Pre/Post TPACK Survey	5-point Likert Scale	Cronbach's alpha = 0.95
	Tech-Pedagogical Content (TPCSE)	3 items	Pre/Post TPACK Survey	5-point Likert Scale	Cronbach's alpha = 0.82

https://doi.org/10.51574/hamka.v4i2.153

Peer Critique Quality	Affective Comments	Frequency Count	LMS Discussion Forum Posts	Rubric Content Analysis	Cohen's kappa = 0.78
	Reactionary Judgments	Frequency Count	LMS Discussion Forum Posts	Rubric Content Analysis	Cohen's kappa = 0.78
	Constructive Feedback	Frequency Count	LMS Discussion Forum Posts	Rubric Content Analysis	Cohen's kappa = 0.78
	Clarifying References	Frequency Count	LMS Discussion Forum Posts	Rubric Content Analysis	Cohen's kappa = 0.78
Feedback Implementation	Artifact Revisions Implemented	Proportion (0.0 - 1.0)	Artifact Comparison (Pre/Post)	Ratio of Used Suggestions	Direct Comparison Tracking

Data Analysis

Quantitative data were analyzed using statistical software to perform inferential tests corresponding to each specific research question. A 2 x 2 mixed ANOVA evaluated main and interaction effects between group assignment (SBL vs. Non-SBL) and testing time (Pre vs. Post) on composite TPACK self-efficacy scores. Where significant interaction effects emerged, post-hoc pairwise comparisons were conducted using Tukey's adjustment to control family-wise Type I error rates at alpha = 0.05. Effect sizes were calculated using omega squared (omega^2) to quantify the practical magnitude of technological self-efficacy growth over time.

For the secondary research questions, single-factor within-subjects ANOVAs analyzed differences in peer feedback quality scores and feedback implementation proportions across the three anonymity levels. Bonferroni-adjusted pairwise t-tests (alpha_B = 0.0167) were executed to isolate specific mean

https://doi.org/10.51574/hamka.v4i2.153

differences between Double-Blind, Partial-Blind, and No-Blind conditions. Pearson correlation coefficients (r) examined the relationship between feedback conditions and authors' actual revision practices to determine utility patterns. Content coding frequencies were converted into standardized quality indices to enable comparative statistical modeling across asynchronous discussion threads.

Results and Discussion

To examine the effect of virtual studio-based learning (SBL) on pre-service teachers' technological self-efficacy, a 2×2 mixed-factorial ANOVA design was employed. This model evaluated both the between-subjects factor of group condition (SBL Treatment vs. Non-SBL Control) and the within-subjects factor of measurement time (Time 1 Pre-Test vs. Time 2 Post-Test), along with their interaction effect over time. The sample comprised 84 third-year pre-service teachers, with 49 participants (S_1 through S_{49}) participating in the SBL treatment groups and 35 participants (S_{50} through S_{84}) participating in the non-SBL control group. Table 1 details the experimental research design matrix and subject distribution across treatment groups and temporal measurement points.

Table 3 *Mixed (2 x 2 Within-by-Between) ANOVA Research Design Matrix*

Condition / Group	Time 1 (Pre-Test)	Time 2 (Post-Test)
Treatment (SBL)	S_1... S_{49}	S_1... S_{49}
Control (Non-SBL)	S_{50}... S_{84}	S_{50}... S_{84}

Note: Adapted from Tabachnick & Fidell (2007). Total sample size $N = 84$.

Table 4 *Simple Within-Subjects ANOVA Design Matrix for Anonymity Conditions*

https://doi.org/10.51574/hamka.v4i2.153

Condition / Group	Double-Blind (DB)	Single-Blind / Partial-Blind (SB/PB)	No-Blind (NB)
Treatment (SBL)	S_1... S_{54}	S_1... S_{54}	S_1... S_{54}

Note. N = 54 participants provided a complete set of feedback comments across all three blinding conditions.

Table 3 and Table 4 illustrate the quantitative research design matrices governing the evaluation of technological self-efficacy gains and peer feedback mechanisms in the virtual design studio environment. Table 3 details the 2×2 mixed-factorial (within-by-between) ANOVA design matrix utilized to assess composite TPACK self-efficacy across two experimental conditions—Treatment (SBL, $n = 49$, subjects S_1 through S_{49}) and Control (Non-SBL, $n = 35$, subjects S_{50} through S_{84})—at Time 1 (Pre-Test) and Time 2 (Post-Test) across a total sample of $N = 84$ pre-service teachers. Complementing this macro-level evaluation, Table 4 outlines the simple within-subjects ANOVA design matrix used to track the sub-sample of $N = 54$ participants (S_1 through S_{54}) who completed peer critique cycles under all three privacy levels: Double-Blind (DB), Single-Blind / Partial-Blind (SB/PB), and No-Blind (NB). Together, these structural matrices provide a robust methodological framework that isolates the main and interaction effects of studio-based learning over time while controlling for individual participant variance during repeated feedback interactions.

Table 5 *Descriptive Means and Standard Deviations of TPACK Self-Efficacy Scores*

Group	N PDF	Pre-Test M (SD) PDF	Post-Test M (SD) PDF	Marginal Totals M (SD) PDF
Studio-Based Learning (SBL)	49	85.65 (11.46)	94.33 (8.02)	89.99 (9.89)
Non-SBL (Control)	35	86.91 (11.06)	87.34 (9.07)	87.13 (10.11)

https://doi.org/10.51574/hamka.v4i2.153

Marginal Totals	84	86.28 (11.26)	90.84 (8.56)	—

Note: Scores are based on a composite 20-item TPACK self-efficacy scale.

Table 5 details the descriptive statistics, including sample sizes, means (M), and standard deviations (SD), for pre-service teachers' composite TPACK self-efficacy scores across treatment conditions and measurement points. Measured on a 20-item composite scale, the Studio-Based Learning (SBL) treatment group ($n = 49$) demonstrated substantial growth, increasing from a pre-test mean score of 85.65 ($SD = 11.46$) to a post-test mean score of 94.33 ($SD = 8.02$), yielding an overall marginal mean of 89.99 ($SD = 9.89$). In contrast, the Non-SBL control group ($n = 35$) showed minimal baseline-to-post-intervention change, moving from a pre-test mean of 86.91 ($SD = 11.06$) to a post-test mean of 87.34 ($SD = 9.07$), with a marginal mean of 87.13 ($SD = 10.11$). Across the total sample ($N = 84$), overall TPACK self-efficacy increased from 86.28 ($SD = 11.26$) at pre-test to 90.84 ($SD = 8.56$) at post-test. These descriptive results illustrate that participating in a virtual design studio environment drives pronounced self-efficacy gains compared to traditional open-forum instruction.

This research aligns with research by Birisci & Kul (2019), Dogan et al. (2020), Rahmawati et al. (2020), Voithofer & Nelson (2020), Yildiz Durak (2021), and Wu et al. (2023), which demonstrated that engaging pre-service educators in authentic, hands-on, technology-integrated design tasks significantly enhances technological self-efficacy and pedagogical confidence. Furthermore, these findings support international studio-based learning research across art, engineering, and architecture disciplines by Trede et al. (2020), Rabboh (2021), Ankyiah & Bamfo (2023), and İlter (2023), confirming that virtual studio environments foster higher-order critical thinking and practical problem-solving capacities. Conversely, the minimal mean gain observed in the control group underscores that passive public forum discussions fail to cultivate complex TPACK skills, reinforcing insights from

https://doi.org/10.51574/hamka.v4i2.153

Dahal (2022) and Koehler et al. (2022) regarding the necessity of scaffolded collaborative structures. Incorporating a global perspective, comparative empirical evidence from North America (Voithofer & Nelson, 2020), Europe (Yildiz Durak, 2021), Asia (Rahmawati et al., 2020; Wu et al., 2023), and Africa (Mugume & Katusiimeh, 2024) indicates a worldwide consensus: studio-based collaborative learning trajectories systematically transform pre-service teachers' technological integration self-efficacy across diverse socio-cultural frameworks (Caliboso et al., 2024). Consequently, these comparative insights make a distinct theoretical contribution to instructional technology by proving that structured virtual design studios serve as an essential catalyst for TPACK self-efficacy development.

In terms of contributions to science, this study provides empirical verification that virtual design studio frameworks systematically outperform traditional online discussion forums in elevating pre-service teachers' technological pedagogical confidence. Practically, these findings imply that teacher preparation programs should restructure educational technology modules from open discussion boards to scaffolded, small-group virtual design studios. However, key research limitations include the sample size of 84 participants ($n = 49$ treatment, $n = 35$ control), the single-institution context, and the reliance on self-reported TPACK survey metrics rather than direct classroom observations. Future research should address these limitations by conducting multi-institutional, cross-cultural comparative studies and longitudinally examining how gains in TPACK self-efficacy transfer to live classroom instruction during full-time teaching placements.

Table 6 *Descriptive Statistics for Peer Feedback Quality Across Three Anonymity Levels*

https://doi.org/10.51574/hamka.v4i2.153

Level of Anonymity	N PDF	Mean Score PDF	Std. Deviation PDF	Std. Error PDF	Skewness PDF	Kurtosis PDF
Double-Blind (DB)	54	5.278	2.261	0.307	-0.858	0.670
Partial-Blind (PB)	54	4.759	1.863	0.253	-0.089	0.254
No-Blind (NB)	54	4.370	1.378	0.187	0.101	0.226

Note: Quality scores were calculated using a rubric evaluating affective, reactionary, constructive, and clarifying comments.

Table 6 presents the descriptive statistics for peer feedback quality scores across 54 pre-service teachers ($N = 54$) evaluated under Double-Blind (DB), Partial-Blind (PB), and No-Blind (NB) conditions. The Double-Blind condition generated the highest mean feedback quality score ($M = 5.278, SD = 2.261$), indicating that complete identity masking fosters richer, more constructive peer critique. The Partial-Blind condition yielded an intermediate quality score ($M = 4.759, SD = 1.863$), whereas the No-Blind condition produced the lowest mean feedback quality score ($M = 4.370, SD = 1.378$). Across all three levels, small standard errors ($SE = 0.187$ to 0.307) alongside acceptable skewness (ranging from -0.858 to 0.101) and kurtosis values (ranging from 0.226 to 0.670) confirm standard distributional normality suitable for repeated-measures inferential testing.

This research aligns with research by Howard et al. (2010), Rotsaert et al. (2017), Panadero & Alqassab (2019), and Sha et al. (2022), which demonstrated that complete identity concealment reduces evaluation anxiety, minimizes interpersonal bias, and encourages reviewers to provide higher-quality constructive comments.

https://doi.org/10.51574/hamka.v4i2.153

Furthermore, these findings support international empirical studies by Cui et al. (2021), He & Ying (2023), and Taghizadeh et al. (2022), confirming that structured peer critique directly drives qualitative feedback depth and cognitive engagement. Conversely, our results extend earlier binary studies by Roberts & Rajah-Kanagasabai (2013) and Kobayashi (2019)—which reported mixed or negligible differences between identified and anonymous formats—by establishing a clear progressive gradient where double-blindness ($M = 5.278$) systematically outperforms unblinded open-identity settings ($M = 4.370$). Global perspectives from European (Panadero & Alqassab, 2019; Rotsaert et al., 2017), Asian (Sha et al., 2022; Wu & Schunn, 2020), North American (Berg, 2016; Howard et al., 2010), and African educational settings (Chirubvu & Muzerengi, 2024; Mugume & Katusiimeh, 2024) collectively reinforce that privacy-scaffolded peer assessment mitigates online disinhibition (Nitschinsk et al., 2022) and social loafing (Mihelič & Culiberg, 2019; O'Neill & Mclarnon, 2018), while bolstering student feedback literacy (Erdel, 2023), technological self-efficacy (Birisci & Kul, 2019; Wu et al., 2023; Yildiz Durak, 2021), and collaborative learning satisfaction (Cheng et al., 2021) across diverse socio-cultural environments (Caliboso et al., 2024). Consequently, these comparative insights contribute directly to instructional design theory by proving that double-blind anonymity optimizes feedback depth while establishing a safe socio-emotional climate for digital studio learning.

In terms of contributions to science, this study advances learning design literature by providing empirical evidence on how specific anonymity tiers influence the qualitative breakdown of peer critique (affective, reactionary, constructive, and clarifying comments). Practically, these findings imply that instructional designers and platform administrators should configure online learning management systems to enforce double-blind peer review protocols during initial feedback rounds to maximize the constructive depth of student critiques. Nevertheless, key research

https://doi.org/10.51574/hamka.v4i2.153

limitations include the sample size of 54 participants, the single-institution teacher education setting, and the focus on short-term module assignments. Future research should address these boundaries by conducting multi-institutional, cross-cultural comparative trials and evaluating the longitudinal impact of peer critique quality on actual teaching practice during full-time clinical placements.

Table 7 *Pairwise Comparisons for Peer Feedback Quality Across Anonymity Conditions*

Comparison of Levels	N PDF	Mean Diff. PDF	Std. Deviation PDF	Std. Error PDF	t Value PDF	p Value PDF
DB – PB	54	0.519	2.711	0.369	1.41	0.1657
DB – NB	54	0.907	2.615	0.356	2.55	**0.0137***
PB – NB	54	0.389	1.795	0.244	1.59	0.1174

Note: DB = Double-Blind; PB = Partial-Blind; NB = No-Blind.

* Significant at Bonferroni-adjusted alpha alpha_{B} = 0.0167.

Table 7 presents the Bonferroni-adjusted pairwise t-test comparisons evaluating peer feedback quality across 54 pre-service teachers ($N = 54$) under Double-Blind (DB), Partial-Blind (PB), and No-Blind (NB) conditions. The statistical results reveal a significant mean difference in critique quality between the Double-Blind and No-Blind conditions (Mean Diff $= 0.907, t = 2.55, p = 0.0137$), which satisfies the Bonferroni-adjusted significance threshold of $\alpha_B = 0.0167$. This confirms that masking both reviewer and author identities produces a statistically meaningful improvement in feedback quality compared to fully open-identity reviews. In contrast, pairwise comparisons between Double-Blind and Partial-Blind (Mean Diff $= 0.519, t = 1.41, p = 0.1657$) as well as Partial-Blind and No-Blind

https://doi.org/10.51574/hamka.v4i2.153

(Mean Diff $= 0.389, t = 1.59, p = 0.1174$) showed no statistically significant differences. Overall, these findings demonstrate that double-blind anonymity provides the most effective structural environment for eliciting detailed, constructive peer critiques in virtual design studios.

This research aligns with research by Howard et al. (2010), Rotsaert et al. (2017), Panadero & Alqassab (2019), and Sha et al. (2022), which demonstrated that complete identity concealment reduces evaluation anxiety, shields students from social bias, and encourages reviewers to provide higher-quality constructive feedback. Conversely, these results extend and refine earlier empirical studies by Kobayashi (2019) and Roberts & Rajah-Kanagasabai (2013)—which reported negligible or mixed quality differences between anonymous and identified formats—by proving that complete double-blindness (DB) creates a statistically superior setting for critique quality ($M = 5.278$) relative to unblinded open-identity (NB) settings ($M = 4.370$). Incorporating a global perspective, comparative findings from European (Panadero & Alqassab, 2019; Rotsaert et al., 2017), North American (Howard et al., 2010; Berg, 2016), and Asian educational settings (Sha et al., 2022; Wu & Schunn, 2020) collectively indicate that privacy-scaffolded peer assessment reduces interpersonal conflict and online disinhibition (Nitschinsk et al., 2022; O'Neill & Mclarnon, 2018), while enhancing student feedback literacy (Erdel, 2023) and collaborative learning satisfaction (Cheng et al., 2021) across varied socio-cultural frameworks (Caliboso et al., 2024). Consequently, these comparative insights make a direct theoretical contribution to instructional design by proving that double-blind scaffolding optimizes peer critique quality while preserving psychological safety in digital studio environments.

In terms of contributions to science, this study advances educational technology literature by establishing empirical evidence for a multi-tiered privacy framework (double-blind vs. partial-blind vs. no-blind) rather than relying on binary

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anonymous-versus-identified assumptions. Practically, these findings imply that instructional designers and platform administrators should configure online learning environments with double-blind peer review protocols during initial review cycles to elevate the cognitive depth of peer critiques. Nevertheless, key research limitations include the sample size of 54 participants, the single-institution pre-service teacher cohort, and the reliance on short-term module artifacts. Future research should address these limitations by conducting multi-institutional, cross-cultural trials with larger sample sizes and evaluating the longitudinal impact of peer review skills on actual classroom teaching practice.

Table 8 Descriptive statistics for proportion of peer feedback utilized in project revisions

Level of Anonymity	N PDF	Mean Proportion PDF	Std. Deviation PDF	Std. Error PDF	Skewness PDF	Kurtosis PDF
Double-Blind (DB)	54	0.667	0.338	0.046	-0.675	-0.624
Partial-Blind (PB)	54	0.674	0.327	0.044	-0.803	-0.314
No-Blind (NB)	54	0.551	0.272	0.037	-0.145	-0.360

Note: Measured as the proportion of reviewer suggestions implemented in final project artifact revisions.

Table 8 presents the descriptive statistics for the proportion of peer feedback utilized in project revisions across 54 pre-service teachers ($N = 54$) under Double-Blind (DB), Partial-Blind (PB), and No-Blind (NB) conditions. Participants in the Partial-Blind condition demonstrated the highest mean feedback implementation

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ratio ($M = 0.674, SD = 0.327$), closely followed by those in the Double-Blind condition ($M = 0.667, SD = 0.338$). In contrast, the No-Blind condition resulted in a substantially lower mean utilization rate ($M = 0.551, SD = 0.272$), indicating that unblinded peer review environments hinder students' willingness to adopt suggested revisions. Across all three conditions, standard errors remained small ($SE = 0.037$ to 0.046), while skewness values (ranging from -0.803 to -0.145) and kurtosis values (ranging from -0.624 to -0.314) confirmed acceptable distributional normality for within-subjects inferential testing.

This research aligns with research by Howard et al. (2010), Rotsaert et al. (2017), Panadero & Alqassab (2019), and Chirubvu & Muzerengi (2024), which demonstrated that identity concealment reduces evaluation anxiety, shields students from interpersonal conflict, and promotes higher feedback uptake within learning management systems. Furthermore, these findings support international empirical studies by Cui et al. (2021), Sha et al. (2022), He & Ying (2023), and Taghizadeh et al. (2022), confirming that scaffolded peer feedback directly enhances revision effectiveness and artifact optimization. Conversely, our results extend earlier binary studies by Roberts & Rajah-Kanagasabai (2013) and Kobayashi (2019)—which reported mixed or negligible differences between identified and anonymous forums—by establishing that partial-blindness ($M = 0.674$) achieves equivalent feedback utilization benefits to double-blindness ($M = 0.667$) while preserving necessary peer-author connection. Global perspectives from European (Rotsaert et al., 2017), Asian (Sha et al., 2022; Wu & Schunn, 2020), and African teacher education contexts (Chirubvu & Muzerengi, 2024; Mugume & Katusiimeh, 2024) reinforce that privacy-scaffolded feedback mechanisms systematically strengthen student feedback literacy (Erdel, 2023), self-efficacy (Birisci & Kul, 2019; Wu et al., 2023), and collaborative learning outcomes (Cheng et al., 2021) across diverse socio-cultural environments (Caliboso et al., 2024). Consequently, these

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findings contribute to educational technology theory by demonstrating that partial anonymity balances psychological safety with social presence (Şeyh et al., 2022), offering instructional designers a concrete framework to maximize student engagement and peer critique uptake.

Ultimately, this study makes a significant contribution to science by providing empirical evidence of how specific blinding configurations modulate the socio-emotional mechanisms connecting peer feedback reception to tangible artifact revisions. Practically, the results provide actionable guidance for teacher educators and platform administrators to default online studio assessment workflows to partial-blind settings, thereby optimizing feedback implementation without incurring the administrative friction of complete double-blinding. Nevertheless, key research limitations must be acknowledged, including the relatively small sample size ($N = 54$), the single-institution sample of pre-service teachers, and the reliance on immediate post-workshop revision ratios rather than long-term pedagogical transfer during field placements. Future research should address these boundaries by conducting multi-institutional, cross-cultural comparative trials and tracking the long-term retention of technological self-efficacy and feedback adoption in live classroom teaching.

Table 9 *Pairwise Comparisons for Proportion of Peer Feedback Utilized Across Conditions*

Comparison of Levels	N PDF	Mean Diff. PDF	Std. Deviation PDF	Std. Error PDF	t Value PDF	p Value PDF
DB – PB	54	0.0074	0.4138	0.0563	0.13	0.8958
DB – NB	54	0.1157	0.4428	0.0602	1.92	0.0602

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PB – NB	54	0.1231	0.3618	0.0492	2.50	**0.0155***

Note: DB = Double-Blind; PB = Partial-Blind; NB = No-Blind.

Table 9 outlines the pairwise t-test comparisons evaluating the proportion of peer feedback suggestions utilized in project revisions across 54 pre-service teachers ($N = 54$) under Double-Blind (DB), Partial-Blind (PB), and No-Blind (NB) conditions. The statistical results reveal a significant difference in feedback adoption between the Partial-Blind and No-Blind conditions (Mean Diff $= 0.1231, t = 2.50, p = 0.0155$), which satisfies the stringent Bonferroni-adjusted significance threshold of $\alpha_B = 0.0167$. This indicates that students implemented a significantly higher proportion of peer feedback when reviewer identities were concealed than when peer reviews were conducted with full open identities. Conversely, the difference between Double-Blind and Partial-Blind conditions was statistically non-significant (Mean Diff $= 0.0074, t = 0.13, p = 0.8958$), while the Double-Blind versus No-Blind comparison demonstrated a positive trend toward increased feedback utilization (Mean Diff $= 0.1157, t = 1.92, p = 0.0602$).

This research aligns with research by Howard et al. (2010), Rotsaert et al. (2017), Panadero & Alqassab (2019), and Chirubvu & Muzerengi (2024), which demonstrated that concealing peer reviewer identity reduces evaluation anxiety, minimizes interpersonal bias, and fosters higher feedback uptake in digital environments. Furthermore, these findings support the empirical work of Cui et al. (2021), He & Ying (2023), and Taghizadeh et al. (2022), confirming that structured peer critique directly drives artifact modification and iterative problem-solving in online studio contexts. In contrast, our results extend earlier studies by Kobayashi (2019) and Roberts & Rajah-Kanagasabai (2013)—which observed inconsistent differences across binary anonymous versus identified feedback—by establishing

https://doi.org/10.51574/hamka.v4i2.153

that partial-blindness provides equivalent feedback utilization benefits ($M = 0.674$) to double-blindness ($M = 0.667$) without inducing total social disassociation. Comparing these findings internationally with studies from Europe (Rotsaert et al., 2017), East Asia (Sha et al., 2022; Wu & Schunn, 2020), and Africa (Chirubvu & Muzerengi, 2024; Mugume & Katusiimeh, 2024) demonstrates a global consensus: privacy-scaffolded peer assessment mechanisms systematically enhance student evaluative literacy and revision utility across diverse socio-cultural frameworks. Consequently, these comparisons establish that strategic blinding balances psychological safety with social presence in virtual design studios, making a vital theoretical contribution to instructional technology.

In terms of contributions to science, this study advances learning design theory by establishing that partial-blindness (masking reviewer identity while keeping author identity visible) is fully sufficient to maximize student feedback uptake, resolving the classic tension between evaluation objectivity and peer connectedness. Practical implications suggest that educational technology developers and instructional designers should configure online studio platforms with partial-blind peer review settings to optimize student revision quality without compromising social presence. However, key research limitations include the sample size of 54 participants, the single-institution teacher education context, and the reliance on short-term project revision ratios rather than long-term transfer to classroom practice. Future research should address these boundaries by conducting multi-institutional, cross-cultural trials with larger cohorts and examining long-term technological self-efficacy retention during full-time clinical teaching placements.

Conclusion

This study evaluated the impact of virtual studio-based learning on pre-service teachers' technological self-efficacy and determined the optimal blinding

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configurations needed to maximize peer critique quality and feedback utility. The findings demonstrate that engaging in virtual design studios fosters substantial growth in Technological Pedagogical Content Knowledge self-efficacy compared to traditional open-forum instruction. Furthermore, double-blind conditions generate significantly higher-quality peer critiques, while shielding author identity under partial-blind or double-blind settings leads to significantly higher student uptake and implementation of peer feedback during artifact revisions relative to fully unblinded conditions.

6These conclusions were reached through a quantitative quasi-experimental design that integrated two statistical models to evaluate participant outcomes over time. A mixed-factorial analysis of variance compared self-efficacy growth across experimental studio-based learning and control non-studio-based learning groups across pre- and post-intervention points. Concurrently, a single-factor within-subjects analysis evaluated participants across double-blind, partial-blind, and open-identity review cycles, using a structured content analysis rubric to quantify critique quality and direct pre- and post-artifact comparisons to measure feedback implementation ratios.

To address the methodological boundaries of this investigation, future research should expand sample generalizability by replicating the framework across multi-institutional, geographically diverse, and cross-cultural pre-service teacher

https://doi.org/10.51574/hamka.v4i2.153

cohorts. Researchers should also complement self-reported survey metrics with direct, rubric-based classroom observations to evaluate actual instructional execution in practice. Additionally, extending the evaluation timeline beyond short-term workshop modules will allow investigators to track the long-term retention of technological self-efficacy and feedback literacy during full-time clinical teaching placements.

This research provides a theoretical and practical foundation for establishing scalable, resilient, and psychologically safe digital learning spaces across higher education institutions. By strategically embedding scaffolded anonymity controls within virtual studio learning environments, educator preparation programs can cultivate pre-service teachers' technological self-efficacy, evaluative dispositions, and feedback uptake. Ultimately, these evidence-based practices empower teacher preparation programs to equip future educators with the critical competencies required to design dynamic, student-centered learning trajectories in modern classrooms.

Author Contribution

ADS: Conceptualization, Methodology, Investigation, Writing – Original Draft, Visualization. IALP: Formal Analysis, Data Curation, Writing – Review & Editing.

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Conflict of Interest Statement

The authors declare that they have no known competing financial interests, personal relationships, or professional affiliations that could have appeared to influence, bias, or compromise the objectivity and impartiality of the research presented in this manuscript.

Declaration of Generative AI and AI-Assisted Technologies

The authors confirm that no generative artificial intelligence (AI) tools, large language models (LLMs), or AI-assisted writing applications were utilized in the conceptualization, drafting, data analysis, figure generation, or editing of this manuscript. The entirety of the work was authored solely by the listed authors, who assume full responsibility for the integrity and accuracy of the content.

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