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Online Student Peer-Assessment in Higher Education: A Systematic Review of the Literature

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Abstract

Peer-assessment is an active process of socially mediated learning that can enhance student learning and metacognitive abilities while developing skills required for success in the modern world. The process has been explored in previous reviews and shown to be valuable through in-person applications. However, a comprehensive review of the literature focusing on online higher education applications has yet to be completed. Our purpose was to conduct a systematic review of the literature on peer-assessment in online higher education classes. Guided by the PRISMA framework, we used a mixed-method integrated methodology to review and synthesize 66 peer-reviewed empirical quantitative, qualitative, and mixed-methods studies published between 2008 and 2023. Following the research context and insight regarding instructional design, two themes emerged: academic impact and student comfort. We identify eight limitations and five recommendations for further research at the end of the paper. The results reflect the context of use along with benefits and challenges related to perceptions of learning, motivation, academic achievement, quality, anonymity, open identification, and time. We provide further context and recommendations for implementation in the discussion section.

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Practitioner Notes

1. During the planning process, allocate time for the activity and platform set up, personal and student training, and student support such as resolving grade disputes.
2. Limit potential scheduling conflicts with summative exam periods.
3. Use a scored rubric with explicit context for each criterion and provide prompts for written feedback.
4. Follow a five or six-phase creation and review process where students review the materials, create their submission, are assigned review tasks, assess peers, reflect, and potentially revise.
5. Aggregate student scores from three-to-four assessors with a minimum of three individual peer-assessment sessions including a calibration or training session.

Keywords

Assessment, peer assessment, higher education, curriculum design, online learning, peer learning

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Introduction

Peer-assessment is the active practice of exchanging feedback from fellow students to enhance learning and metacognition (Roberts, 2006). At its core, peer-assessment is grounded in andragogy, active learning, and social-constructivism, which the online version builds on with the added inclusion of hybrid and distance learners and rapid analysis (Bates, 2019; Falchikov & Goldfinch, 2000). Assessment fosters socially mediated learning awareness, guided by processes of observing, gathering, interpreting and recognising learning proficiency over a defined time (Andrade & Brookhart, 2020; Walvoord, 2010). Often, higher education assessment is associated with achieving learning outcomes that result in certificates, diplomas, or degrees (MacFarlane & Brumwell, 2020).

Changes in Higher Education

The modern higher education assessment landscape is changing with two influential factors: online learning and enrolment. The diffusion of online learning continues to increase, building on pre- and intra-COVID-19 pandemic trends and institutional desires to meet student and industry needs (Duffin, 2020a, 2020b; Johnson et al., 2019; Johnson, 2021). Higher education enrolment practices have also been altered due to funding changes, increased access, and employment requirements (Education Intelligence Unit, 2021; Global Student Flows Project, 2023; Gümüş et al., 2020). For example, global student enrolment and class sizes are consistently growing to adapt to changes, requiring that educators adjust their teaching and assessment methods (Ake-Little et al., 2020; Kara et al., 2021; Kerr, 2011; Mulryan-Kyne, 2010). Learning outcomes and modern assessment can benefit from practices supported in the key nations of the US, UK, Canada, and Australia, China, Hong Kong, and India (British Council, 2023; Bukenova et al., 2020; CBIE, 2022; Institute of International Education, 2021), and an awareness of classroom diversity and standard global assessment practices (MacFarlane & Brumwell, 2020).

Online Assessment

Historically, educators used online assessment for low-stakes formative practices and relied on face-to-face exams for summative testing to assess learning outcomes (Brady et al., 2019; Kelly et al., 2022). As there is no commonly accepted definition of online learning or education which holds over time and technological change (Singh & Thurman, 2019); by extension, the online assessment definition is also challenging. For this paper, a remix of Singh and Thurman's (2019) online education definition results in the following:

> Online assessment is defined as an assessment delivered in an online environment using interconnected computer networks to understand the state of learning. This includes student assessment activities that are not dependent on time or their physical or virtual co-location.

Reflecting on the changes, online peer-assessment provides the unique opportunity to rethink high-stakes assessment with a focus on authentic tasks, modern competencies, and student success in and beyond university (Kelly et al., 2022; OECD & CERI, 2008; Phillips, 2016; Rourke et al., 2008; Sun et al., 2015; Topping, 1998). The changes to enrolment size necessitate assessment adaptation in the context of time assessment type, two further common online assessment challenges include increased workload and student potential to cheat (Brady et al.,

2019; Garg & Goel, 2022; Zachek, 2020). Furthermore, it can be adaptable to varying class sizes and potentially decrease educator workload, while common assignments used in peer-assessment such as essays, responses to open-ended questions, and group-based assignments, can reduce academic misconduct (Colby, 2022; Gamage et al., 2021).

Previous Peer-Assessment Research

Previous peer-assessment research has focused mainly on its use in face-to-face classrooms with pen and paper, and at least three previous literature reviews have concentrated on the use of peer-assessment in higher education (Topping, 1998; Falchikov & Goldfinch, 2000; Zheng et al., 2019). The research focused on the impact of peer-assessment on performance, understanding, confidence, anxiety levels (Topping, 1998), accuracy and quality of peer-assessment (Falchikov & Goldfinch, 2000), and key descriptive characteristics of peer-assessment practice (Zheng et al., 2019). Each of these reviews will be discussed in turn.

Topping (1998) analysed 109 peer-reviewed articles focusing on peer-assessment. The findings indicated that simple quantitative feedback can positively affect students' subjective perspectives and improve grades, and that peer-assessment is widely used across diverse subjects. Further, from an emotional standpoint, providing opportunities for more formative open-ended responses can improve confidence, while scoring can feel demanding but reduce anxiety. Topping (1998) proposes that future research should reference assessor and assessee characteristics to gain greater insights into possible cultural relationships with peer-assessment. Noting the increased role of technology in education, Topping (1998) also proposes that researchers specifically reflect on its relationship with peer-assessment.

Falchikov and Goldfinch's (2000) meta-analysis of 48 papers published between 1959 and 1999 explored the accuracy of summative peer assessment and determined that peer grading was significantly correlated with educator grading. The authors present six critical aspects for aligning student and educator grading. First, a summative mark should be determined based on multiple criteria. Second, alignment occurs more readily with a focus on academic contexts rather than professional practice. Next, well-designed studies indicate better alignment than poorly designed ones. Fourth, a singular assessor is likely as good as multiples, but 20 decreases efficacy. Also, the subject area does not appear to be a factor in validity. Finally, student familiarity and ownership of assessment criteria will also enhance validity. The authors proposed that future research explore factors that might increase the accuracy of peer-assessment, including experience with peer-assessment, single versus multiple assessors, gender, friendship and personal bias.

Zheng et al. (2019) conducted a review of 134 journal articles published between 2006 and 2017 exploring the use of technology and peer-assessment. Six key findings are outlined here. First, anonymity is a common practice for privacy and to reduce scoring bias and score inflation. Second, a single round of peer-assessment was most common, while (third) 73% of the studies did not include grade incentives. Fourth, assessment was often for individual over group work; and fifth, students commonly assessed more than one but less than ten peers. Lastly, social science faculty used peer-assessment more than other faculty. Zheng et al. (2019) propose that future studies should include a minimum of three peer assessors and be kept to odd numbers per assignment, focusing on learning outcomes, including attitude. Also, educators should blind

participants to support grading accuracy, and finally, peer-assessment itself is associated with an extrinsic reward such as a grade (Zheng et al., 2019).

Objectives

Although considerable research focuses on in-person peer-assessment conducted through traditional means such as pencil and paper (e.g., Falchikov & Goldfinch, 2000), the growing transition to and use of online peer-assessment has received less focused attention (Roberts, 2006; Zheng et al., 2019). Our research objective uses the Population, Exposure, Outcome (PEO) framework, which guides the development of answerable systematic review questions (Bettany-Saltikov, 2016; Moola et al., 2015; Pollock & Berge, 2018). Where the population refers to higher education students and faculty, the exposure is online peer-assessment, and the outcomes build on the following research questions:

RQ1. What is the context of online peer-assessment implementation?

RQ2. What are the benefits associated with using online peer-assessment?

RQ3. What are the challenges associated with using online peer-assessment?

Therefore, we seek to gain insights into the use of online peer-assessment in higher education settings through a systematic review and integrated synthesis. This study is grounded in a pragmatic worldview to provide practical insight for modern online assessment practices from pre-existing empirical research.

Method

Overview

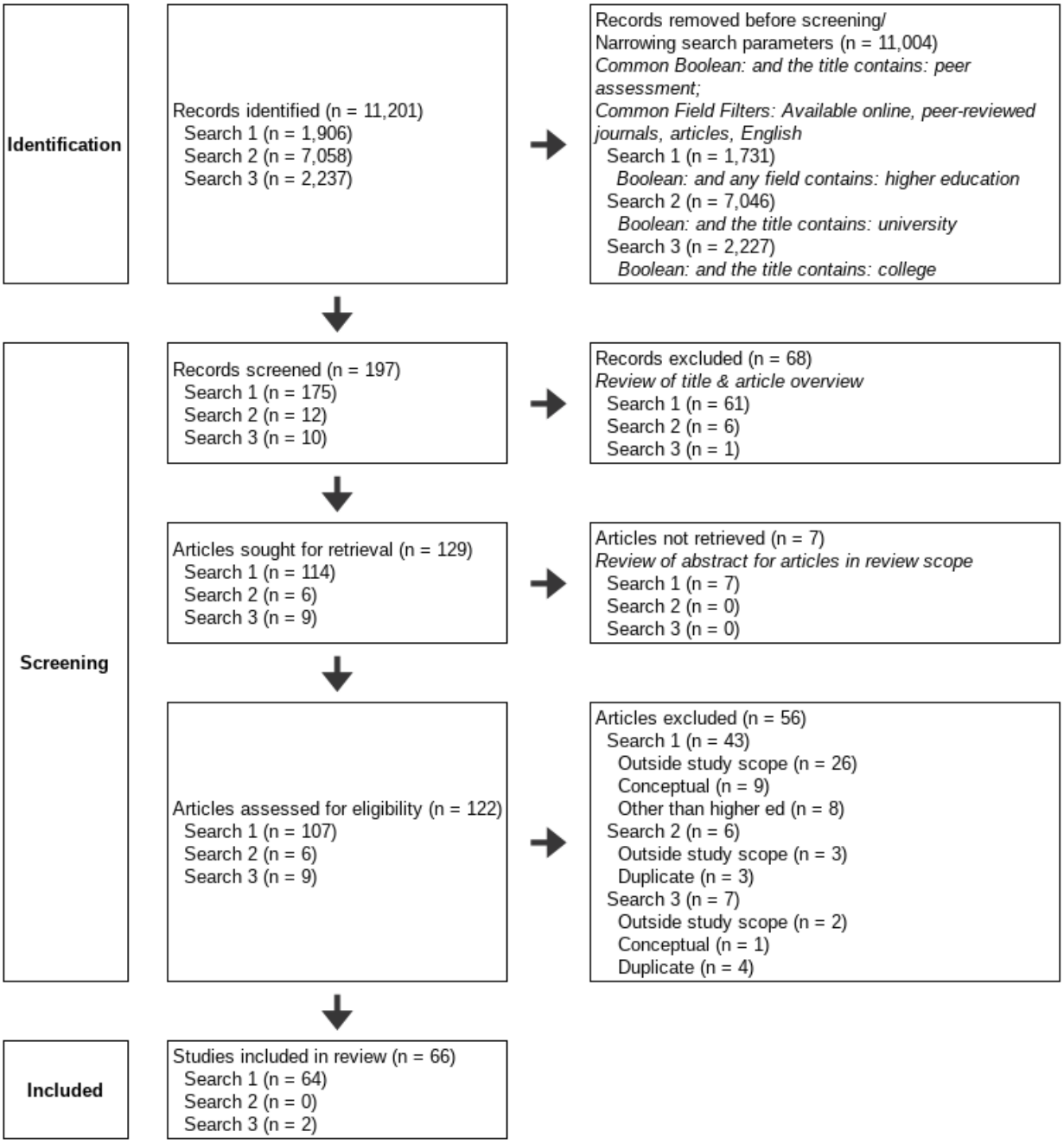
Our review follows Page et al.'s (2021a; b) Preferred Reporting Items for Systematic Reviews and Meta-Analyses 2020 (PRISMA) to support clear and transparent findings. We methodically followed three steps: Documenting the search process, articulating and applying article inclusion criteria, and a mixed research analysis and synthesis. Using van der Steen et al.'s (2018; 2019) taxonomy of bias determinants, the authors report low potential bias.

Search Process

The article search process included three searches focusing on online peer-assessment in higher education through the institutionally licensed Omni Search tool. The tool streamlines the search of 276 databases, including ABI/INFORM Complete, Academic Search Premier, CINAHL Complete, DOAJ, EBSCO, ERIC, IEEE Xplore, JSTOR, PLOS, ProQuest, PsycINFO, ScienceDirect, Scopus, and Web of Science. The three searches conducted in July 2023, were sequentially "online peer assessment higher education," "online peer assessment university," and "online peer assessment college," which returned 11,201 identified records.

Figure 1

PRISMA Flow Diagram



Note: Adapted from: Page, J. M., McKenzie, J. E., Bossuyt, P. M., Boutron, I., Hoffmann, T. C., Mulrow, C. D., Shamseer, L., Tetzlaff, J. M., Akl, E. A., Brennan, S. E., Chou, R., Glanville, J., Grimshaw, J. M., Hróbjartsson, A., Lalu, M. M., Li, T., Loder, E. W., Mayo-Wilson, E., McDonald, S., McGuiness, L. A., Stewart, L. A., Thomas, J., Tricco, A. C., Welch, V. A., Whiting, P., Moher, D. (2021). The PRISMA 2020 statement: An updated guideline for reporting systematic reviews. BMJ (Online), 372(71). https://doi.org/10.1136/bmj.n71 For more information, visit: http://www.prisma-statement.org/

Inclusion & Exclusion

Each search follows the same process, which is outlined in the PRISMA flow diagram (Figure 1). Step one involved applying Boolean and field filters to refine the search results (n = -11,004 articles). The initial Boolean filters include, “and the title contains: peer assessment; and any field contains: higher education,” “and the title contains: peer assessment; and the title contains: university,” and “and the title contains: peer assessment; and the title contains: college” for searches one through three respectively. Each search contained the same field filters: Available online, peer-reviewed journals, articles, and English. Step two included screening the remaining articles (n = 197) article titles and summaries for alignment with our objective (n = -68). We sought to retrieve 129 articles for further review in step three; however, seven were not retrieved after reviewing article abstracts. Step four included scrutinizing the remaining article abstracts, resulting in the removal of 56 articles and the final 66 included in this review (Appendix A). The most prominent reason for article exclusion was that they fell outside of our study’s scope (n = -31). Building from our objectives, our scope included empirical studies in the context of higher education online peer-assessment (college, university, tertiary, or level three institutions), solid transparency, and practices involving more than formative feedback.

Article Quality and Risk of Bias

Each article in this review was checked for quality and risk of bias following Page et al.’s (2021b) recommendations. The articles clearly outline the research problems or hypotheses, the findings, and moderate to high levels of collective insight into sample description, certainty, and transparency—which are common educational research challenges outlined by Oluwatayo (2012). The sample descriptions review included data on sample size, participant gender, and age (Appendix B). The certainty review included reliability, validity, and individual difference checks (Appendix C). Additionally, the transparency review checked for clear analysis processes, data credibility, positive/negative cases, triangulation, participant checks, and a rich description (Appendix C). Heidenreich et al. (2023) indicate that articles in higher-ranked journals provide a limited, but positive, correlation with study accuracy. According to the SJR (n.d.), 95% (n = 63) of the articles included in this review were published in journals with a quartile rank between Q1 and Q2 (Appendix A). The other three articles provided high levels of methodological insight.

Analysis & Coding

The literature analysis and synthesis provide a qualitative assimilation of findings from qualitative, quantitative, and mixed methods research towards collective insights (Sandelowski et al., 2006; 2011; 2013). The first three analysis steps summarise the research context, while the fourth—integrated synthesis— generates content for the findings. The first step—extracting contextual article summaries—focused on outlining the article location, database, resource, title and quartile rank. Second, we gathered methodological insight, including an overview of study duration, type, data collection, technology devices, sampling, and transparency. Third, we summarised the demographic variables associated with each study, including geography, sample size, gender, age, and subject area. The three steps provided a descriptive context for the research articles reviewed. The fourth step, an integrated synthesis (Sandelowski et al., 2006), starts with research question-directed deductive coding, while secondary themes were developed through emergent coding from a four-phase thematic analysis (Popay et al., 2006; Thornberg & Charmaz, 2014).

Phase one included exploring relationships between study characteristics to determine secondary themes. The second phase assessed the robustness of quality and quantity in the emergent themes through concept mapping (Popay et al., 2006). The third and fourth phases mimic one and two to determine the three primary themes. Mapping occurred through scaffolded online spreadsheet tables, chosen for their collaborative capabilities and efficiently customizable ability to store and locate data (Creswell, 2015), containing extracted data outlining study summaries, context, methods, and insights. Starting in tables and then transitioning to word documents, we used conceptual triangulation to identify and link variables and patterns to determine potential codes and emergent themes (Popay et al., 2006). The research questions provided the a-priori codes while the authors generated the emergent open codes. From a base of 30 articles, interrater reliability was moderate ($\kappa = 0.65$). The open codes were further developed and refined by navigating back and forth between the data and codes to develop, merge, remove, and refine codes to achieve almost perfect interrater agreement (Cole, 2023). Once themes were determined, the first author coded the remaining 36 articles.

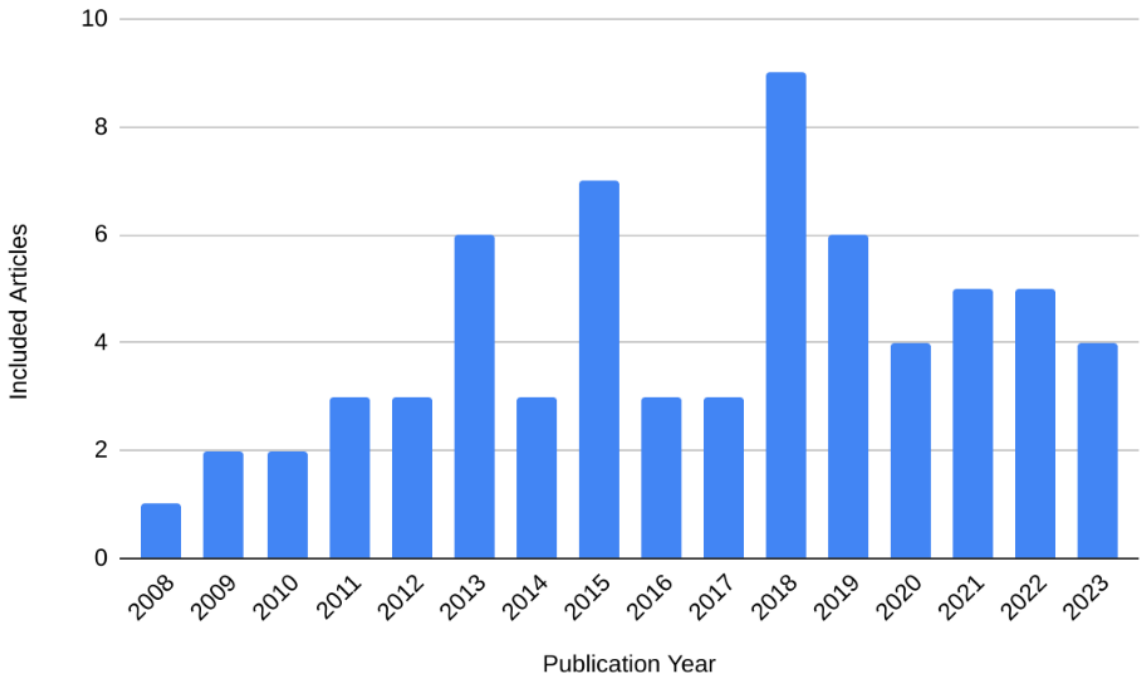
Results

Overview

From the 66 articles in this review, the analysis and coding process yielded research context including the emergent subtheme instructional design, two emergent themes and seven total subthemes. First is the Academic Impact of Online Peer-Assessment which reflects insight into learning outcomes consisting of four sub-themes: perceptions of learning, motivation, academic achievement, and quality. Second, the Student Comfort with Online Peer-Assessment theme outlines how the process affects learners with three sub-themes: anonymity, open identification, and time. Article summaries are further expanded in Appendix A and the number of articles based on their publication year is depicted in Figure 2.

Figure 2

Included Articles vs. Publication Year



Context of Online Peer-Assessment (n = 66 studies)

Articles in this review provide insight into study and participant demographics, including gender and global status, and the primary study methods. Characteristics associated with Instructional Design follow. Insight is analysed from 66 empirical peer-reviewed studies consisting of approximately 78,617 participants (M = 91, SD = 175; 32% females, 61% males) with an average age of 25 (SD = 9.4; range of 18 to 60). Of the 66 studies, three outline online peer-assessment in Massive Open Online Courses (MOOCs) focusing on engineering and science (n = 2) and arts (n = 1), with a total of 67,409 international participants (33% females, 67% males) and an average age of 27.2 (SD = 4.9; range 21 to 40). Fifty-five studies (83%) include undergraduate studies, 11 include graduate-level students (17%), and one directly seeks insight from educators. Engineering and science used online peer-assessment most often (n = 20), followed by other fields of study, including education (n = 18), the arts (n = 8), business (n = 8), interdisciplinary studies (n = 7), and social science (n = 5).

From a global perspective, research reflected diverse insights. Of 15 countries, Taiwan (n = 15 articles) produced the most literature, followed by the USA (n = 11), China (n = 10), and Australia (n = 8). However, Australia contributed the largest number of participants (n = 2,736), followed by the United States articles (n = 1,579) and Taiwan (n = 994). Five of six geographic regions, as outlined by the UN (2022), are represented, led by Asia (n = 30 articles), then North America (n = 12), Europe (n = 10 articles), and Oceania (n = 8). Similarly, studies from Asia contained the most participants (n = 3001, 30%), followed by Oceana (n = 2,736, 27%), Europe (n = 2048, 20%),

North America (n = 1687, 17%), and South Africa (n = 563, 6%). We outline the details in Appendix B.

Instructional Design (n = 66)

Focusing on implementing online peer-assessment, we outline six subthemes to inform research on instructional design fundamentals. The sub-themes include usage, peer-assessment platforms, planning and time management, rubric usage, review process, and scoring accuracy. Recognising that implementation is dynamic, each sub-theme is arranged from a broad to a narrower context.

Usage (n = 66 studies)

Of 23 different assignment types, the most popular was reflective writing (n = 24 studies)—where students engage with learning materials that inform a written response, such as essays or responses to open-ended questions, followed by group contributions (n = 10). Five education-focused studies also focused on instructional design activities such as creating lesson plans. Three focused on statistical analysis, while two included students' development of study questions. Each of the following occurred once: case study, computer programming, concept mapping, digital art, e-journal, formal writing, MATLAB simulation (programming), mechanical design, narrative writing, oral communication, portfolio development, public speaking, research protocol, vocal performance, website design, wiki, and workshop presentations.

Group contributions included the intent to provide more personalized grades and reduce the impact of free-riders or loafing by providing a rubric and feedback prompts to outline individual contributions (Agrawal & Rajapakse, 2018; Delaney et al., 2013). Groups conducted peer-assessment on their peers' contributions, and the averaged scores were used in conjunction with the mark associated with the group submission and further insight from self-assessment to construct individualized grades (Gunning et al., 2022; Havard et al., 2023; Heslop et al., 2017; Iglesias Pérez et al., 2022). While it is not a focus of this review, instructional designers may find it helpful to know that self-assessment was used in conjunction with online peer-assessment grades in 23 (35%) studies.

Peer-Assessment Platform (n = 44 studies)

Forty-four studies outlined which online platform they used to conduct peer-assessment, referencing twenty-eight different instruments. The learning management system's peer-assessment option was the most common resource. Individual applications include learning management systems (LMSs): Moodle Workshop (n = 7 studies); Blackboard LMS and Wiki (n = 3 studies each); Coursera LMS, OnPear, Pals, Peergrade, SPARKplus, SWoRD (n = 2 studies each); Calibrated Peer Review (CPR), eCampus, EduPCR, FeedbackFruits, Google Course Builder, Google Drive, Knowledge Forum, ANGEL LMS, Canvas LMS, Cloud Classroom LMS, Coursesites LMS, Smart Vocational Education LMS, Mosoteach LMS, PACE Tool, peerScholar, PeerWise, Stanford Online, and TEAMMATES (n = 1 study each).

Planning & Time Management (n = 62 studies)

With a focus on instructional design, 62 studies rationed planning time and materials for student training and peer-assessment phases. Twenty-nine studies provided insight into student training and support such as asynchronous videos, calibration or mock-assessment activities, feedback

prompts, instrument-embedded tools, rubrics, and worksheets (Gunning et al., 2022; Gielen & De Weyer, 2015; Kulkami et al., 2013; Lin et al., 2023; Liu et al., 2021; Phillips, 2016; Zhan, 2021). Furthermore, three other studies that did not provide student training concluded that it would have been beneficial (Cruz et al., 2013; Kaufman & Schunn, 2011; Zaky, 2021).

Planning is required to ensure students have access to peer-assessment instrument-focused support and training addressing scoring criteria, and context can minimize student perceptions of difficulty and enhance their feedback outcome quality through improved critical reflection and task-specific skills (Ashton & Davies, 2015; Gielen & De Weyer, 2015; Phillips, 2016). Adding situational context, early inquiry into students' previous experiences with peer-assessment can help educators understand the scale of a cohort's training needs (De Brún et al., 2022; Mao & Peck, 2013). When available, Phillips (2016) suggested planning and managing in-class time to conduct a calibration activity through the online peer-assessment platform, which is often a mock peer-assessment activity that also aligns student grades with that of the educator, is helpful and can increase reliability.

As online peer-assessment is an active learning process, it is not constrained to a single instance but rather a sequence over time. Where studies indicated moderate-to-high scoring efficacy when compared to experts and how many instances of peer-assessment occurred during the inquiry (n = 26), the mean and median number of instances was three. Most (n = 59, 95%) studies with instructional design insight outlined the assessment phases (n = 34). Most often, there were six phases that included students reviewing the learning materials (phase 1), followed by the production of the initial work to be assessed and its submission (phase 2). Next, peers were assigned (phase 3) and asked to review, score, and provide feedback on the submission (phase 4). The submitting student would then review the feedback that they received (phase 5) and revise their work for another review or formal grade (phase 6). Eighteen studies used five of these phases, while seven studies used four.

Rubrics Use (n = 61 studies)

Another critical aspect of implementing online peer-assessment is the assignment rubric, referenced in 61 studies. Fifty-six studies (90%) used scored and written feedback. Twenty-one studies contained scoring subsections providing greater context for the rubric theme. Using a scored rubric with sections and subsections (versus a holistic rubric) outlining scaffolded criteria can enhance scoring precision and efficacy (ArchMiller et al., 2017; Ashton & Davies, 2015; De Wever et al., 2011; Gunning et al., 2022; Havard et al., 2023; Tucker, 2013).

Written feedback with guiding prompts outlining what students needed to comprehend also enhanced peer-assessment learning outcomes and student satisfaction (Chen et al., 2009; Xiao & Lucking, 2008). Chen et al. (2009) reported that while combined scoring and feedback benefited student learning outcomes, feedback alone had no significant effect. Another approach that supported student comfort and confidence by providing continuity for each peer-assessment activity was maintaining the same rubric (Liu et al., 2018). Ashton and Davies (2015) recommended that the scoring focus on specific critical assessment areas rather than the overall outcomes. For example, Heslop et al. (2017) used a multi-section rubric for group contribution. Each contained three to four separately scored criteria associated with workload and effort, technical quality and proficiency, and teamwork.

One emerging practice is using pre-existing validated instruments for scored rubric sections (e.g., Fang et al., 2021; Gielen & De Weyer, 2015; Havard et al., 2023; Heslop et al., 2017). The approach was first recorded by Xiao and Lucking (2008) but has increased in application since 2015. As an illustration, Zheng et al. (2023) implemented a peer-assessment rubric using the Likert-based Personal Report of Public Speaking Anxiety and English Public Speaking scales to evaluate student anxiety and public speaking skills, respectively.

Another unique approach to acknowledging student fairness concerns was Li and Gao's (2016) weighting of peer-assessment quality. The authors rated an assessor's feedback to peers based on the rubric, and the scores were then applied to the student's grades instead of their peers. The intention was to disincentivize over-marking or under-marking a peer's work.

Review Process (n = 59 studies)

The reviewing process indicates how online peer-assessment was completed. Fifty-nine studies listed the number of peer reviewers for each activity, with an average of three per submission. Additionally, 57 (86%) studies outlined how often students completed unique online peer-assessment activities within a period of study, which resulted in an average of three. Finally, 44 (67%) anonymized peer reviews to increase grading accuracy and feedback quality.

Scoring Accuracy (n = 30 studies)

As student- or peer-based scoring accuracy concerns may exist (e.g., Kaufman & Schunn, 2011; Liu et al., 2019; Yang, 2019), understanding how it aligns with experts is an integral component of efficacy. A majority (n = 97%) of the studies that indicated student and expert scoring correlation (n = 29) reported moderate-to-high scoring reliability for online peer-assessment. The correlation was reported in diverse fields of study, including Engineering & Science (n = 69,487 participants), Education (n = 1,214), Business (n = 986), The Arts (n = 720), and Interdisciplinary Studies (n = 148).

A key finding outlined in nine studies was that student and expert scoring correlation increased after the first round of individual peer assessment and with more exposure to high-quality feedback (Cruz et al., 2013; Cheng et al., 2015; García-Martínez et al., 2019; Kulkarni et al., 2013; Lian & Tsai, 2010; Lian et al., 2023; Ma & Luo, 2022; Mao & Peck, 2013; Tsai & Liang, 2009). Furthermore, student and expert scoring correlation was high when students were provided training, felt more engaged, and when scoring and feedback were used jointly (Casey et al., 2014; Cheng et al., 2015; Cruz et al., 2013; García-Martínez et al., 2019; Kulkarni et al., 2013; Liu et al., 2018; Liu et al., 2021; Mao & Peck, 2013). Looking specifically at group-based online peer-assessment, four studies (Agrawal & Rajapakse, 2018; Gunning et al., 2022; Iglesias Pérez et al., 2022) reported that scoring was reliable and valid.

Individual Differences (n = 4 studies)

Several studies exploring individual differences were noted in online peer-assessment (Cheng et al., 2014; Heslop et al., 2017; Sun et al., 2015; Zaky, 2021). While three studies identified no statistically significant differences associated with age or gender (Cheng et al., 2014; Sun et al., 2015; Zaky, 2021), Zou et al. (2018) reported that female students were more likely to be engaged and complete more reviews than their male peers. Heslop et al. (2017) found that marginalized students were more likely to engage in the peer-assessment process.

Academic Impact of Online Peer-Assessment (n = 44 studies)

Results in this section build on insight from 44 articles about how online peer-assessment impacts academic learning outcomes. Four themes emerged: perceptions of learning, academic achievement, student motivation, and quality of peer assessment. The studies provide insight into the impact of online peer-assessment in diverse cultures (n > 15 countries), including Taiwan (n = 15), USA (n = 11), China (n = 10), Australia (n = 8), Portugal (n = 3), Israel (n = 3), Hong Kong (n = 2), Belgium (n = 2). Five studies provided findings from multiple countries while Canada, Denmark, Ireland, South Africa, Spain, Turkey, and the UK produced one study each (Appendix B). Benefits and challenges associated with each theme will be discussed in turn.

Perceptions of Learning - Benefits (n = 13 studies)

Thirteen studies from around the globe reported that online student peer-assessment positively impacted student perceptions of learning achievement. Overall, students from the USA, Taiwan, the UK, Ireland, and Hong Kong perceived online peer-assessment as beneficial for communication skills, learning, reflection, and group-based learning.

Peer-assessment supports students' ability to communicate effectively with their peers through the assessment process (Kulkarni et al., 2013; Tsai, 2012; Yu, 2011). Approximately a third of the students in the studies by Kulkarni et al. (2013) and Tsai (2012) reported that they learned how to communicate better, notably by considering varied peer insights. There was a greater consensus in Yu's (2011) study as most students indicated that the communication process with peers enhanced their ability to think critically about insight and engage in a socially acceptable manner.

Reflection through peer-assessment also shaped learning experiences (Cheng & Tsai, 2012; Yu, 2011). In Cheng and Tsai's (2012) study, 74% of students perceived that they received a broad depth of insight from the peer assessment feedback and that the process afforded them the ability to enhance their work through reflection. Likewise, findings from five studies (De Brún et al., 2022; Eppler et al., 2021; Yu, 2011; Xiao & Lucking, 2008; Zaky, 2021; Zhan, 2021) indicated that peer-assessment had positive implications, even with early apprehension, on student learning, building their ability to think critically through challenges and the exchange of insight.

Online peer-assessment can also support academic outcomes in group-based scenarios and minimize adverse outcomes associated with free-riding members, those with limited contributions to a project (Agrawal & Rajapakse, 2018; Delaney et al., 2013; Gunning et al., 2022; Havard et al., 2023). While students typically had negative perceptions of group or team-based assignments, providing them with the ability to rate contributions significantly anonymously enhanced perceptions of learning quality and reduced dissatisfaction (Gunning et al., 2022; Havard et al., 2023). Expanding on the premise, two studies noted that their students readily flagged free-riders and appreciated the ability to do so (Agrawal & Rajapakse, 2018; Delaney et al., 2013).

Perceptions of Learning - Challenges (n = 7 studies)

From the seven studies outlining challenging perceptions of learning, data reflects experiences from the USA, Australia, China, Taiwan, and the UK. One significant challenge associated with online peer assessment was students doubting their peers' ability to provide effective insight,

thereby reducing their perception of learning achievement (Casey et al., 2014; Li & Gao, 2016; Lin, 2018; Wang et al., 2020; Wang & Zong, 2019; Wilson et al., 2015; Zaky, 2021). Two studies (Casey et al., 2014; Wang et al., 2020) revealed that students perceived their peers' assessments as spamming or low-effort feedback. These perceptions negatively affected the recipients' learning outcomes. Two other studies reflected student concerns about fairness (Li & Gao, 2016; Lin, 2018). Students' perceptions of unfairness were amplified when feedback did not align with their self-perceptions of performance (Lin, 2018). High-achieving students may also find the process challenging as they can be less receptive to feedback that they don't feel is at their level of understanding (Wang & Zong, 2019; Zaky, 2021).

Building on the concept of fairness, Wilson et al. (2015) determined that their students had little confidence in the peer-assessment process, believing they would receive lower grades when their peers attempted to elevate their work. As a result, nearly half of the students in the study held a neutral to negative belief that peer-assessment could foster engagement, and a quarter did not believe that it positively impacted their critical thinking and reflection skills.

However, students' perceptions of online peer-assessment and reality may not fully align (Kaufman & Schunn, 2011; Sun et al., 2015). In Kaufman and Schunn's (2011) study, students had poor perceptions of their peers' feedback, especially when they did not feel it was valuable and positive. However, the same group indicated that their peers provided accurate feedback, which helped improve their writing quality. Following an analysis of a post-course survey and interview insight, the authors identified that student perceptions of fairness and quality are not congruent with their reflections on the usefulness of the received insight or learning outcomes. Sun et al. (2015) reported that the general student perceptions of peer assessment being somewhat helpful were not significantly correlated with the actual benefits and the learning outcomes.

Motivation - Benefits (n = 17 studies)

Seventeen studies indicated a relationship between the academic impact of online peer-assessment and student motivation to learn. Of the studies, twelve reported benefits from over five countries—including Taiwan, Australia, China, Hong Kong, Israel, and the UK—while seven illustrated challenges from studies based in the USA, Taiwan, China, Israel, and Portugal. Three key motivational factors include content that adds to life beyond the assignment, cooperative engagement, and early engagement, whereas students with limited internal motivation encounter challenges.

Being productive beyond an assignment's scope can positively impact learning motivation (Cheng & Hou, 2015; Cheng et al., 2014; Delaney et al., 2013; Seifert & Feliks, 2019; Yu, 2011). Yu (2011) declares that clear communication, feedback, and support enhanced student motivation and the ability to communicate with peers and acquire diverse insight. Furthermore, linking online peer-assessment with future professional practice—beyond formal education—also enhanced student motivation (Delaney et al., 2013; Seifert & Feliks, 2019). In Delaney et al.'s (2013) study, accounting students understood that working in a group is critical to employment readiness and that peer-assessment can serve as an accountability tool.

An emphasis on cooperative engagement over scoring positively affects academic motivations (Casey et al., 2014; Cheng & Tsai, 2012; Formanek et al., 2017; Kulkarni et al., 2013; Zhan, 2021;

Zou et al., 2018). Casey et al. (2014) determined that students greatly exceeded the minimum peer-assessment requirements and performed better on the final exam when focused on engagement rather than scoring. Similarly, Cheng and Tsai (2012) noted that students who believed peer insight received through cooperative learning was motivational, regardless of competitive or non-competitive contexts. Kulkarni et al. (2013) added that when students believed their insights were helpful, they were likelier to complete more peer-assessments than required. The researchers added that seeing peers' work enhanced student engagement within the course.

The timing of online peer assessment also plays a vital role in student motivation to learn (Cheng & Hou, 2015; Cheng et al., 2014; Formanek et al., 2017; Kulkarni et al., 2013; Tseng & Tsai, 2010; Yu, 2011). Students often exhibit higher motivation and cognitive engagement earlier in the period of study and when students are relatively comfortable with the process (Cheng & Hou, 2015; Cheng et al., 2014; Tseng & Tsai, 2010; Yu, 2011). Also, two studies on peer-assessment in MOOCs indicate a positive relationship between early voluntary engagement and long-term motivation (Formanek et al., 2017; Kulkarni et al., 2013). Formanek et al. (2017) expand on the findings, indicating that participants engaged early in the learning content, completing all of the required activities towards their completion, and exhibited greater motivation to complete the entire course.

Motivation - Challenges (n = 7 studies)

Students who lack internal motivation can be a critical challenge in the context of online peer-assessment (Kobayashi, 2020; Lin, 2018; Liu et al., 2019; Loureiro et al., 2012; Naveh & Bykhovsky, 2020; Yu, 2011; Zou et al., 2018). Two studies (Kobayashi, 2020; Naveh & Bykhovsky, 2020) discovered that student motivation to complete assessments decreased as a course progressed. In an education-focused course, Loureiro et al. (2012) note that students provided limited helpful feedback for their peers and only completed the minimum number of required scored assessments. The researchers indicate that the completion mark was more important to the students than the usefulness of the activity. One in five students in Yu's (2011) study noted that divergent peer insight resulted in cognitive overload that distracted them from the end goal and reduced their internal motivation. Similarly, Liu et al. (2019) reported that using grades as negative reinforcement—a loss of points for late or missing assessments—resulted in lower grade accuracy than the group awarded a mark for completion. Student motivation can also be related to course-based motivation. For example, business students enrolled in an English course were already less motivated than their peers and did significantly less work, including their contributions to PA (Zou et al., 2018).

Academic Achievement - Benefits (n = 13 studies)

From fifteen studies including insight into online student peer-assessment and academic achievement, thirteen reported a positive impact, and four reflected on challenges. Benefits include Improved domain knowledge, performance, and grading efficacy, from China, the USA, Australia, Taiwan, and Turkey. Additionally, research from at least China, Israel, and the UK outline student perceptions of peers' quality insights were the primary challenge.

Students engaged in online peer-assessment are likely to experience enhanced academic outcomes (Çevik, 2015; Li & Gao, 2016; Lin, 2019; Mao & Peck, 2013; Sun et al., 2015; Zheng et al., 2018). Furthermore, six studies identified significant increases in students' domain-specific

knowledge and performance, notably in writing ability (Jiang et al., 2022; Liang & Tsai, 2010; Mao & Peck, 2013; Zheng et al., 2018; Zheng et al., 2023). Additionally, Fang et al. (2021) and Zheng et al. (2018) reported notable improvements in cognition, metacognitive awareness, self-efficacy, and qualitative feedback quality skills, while Çevik (2015) reported enhanced problem-solving. Students with higher levels of self-efficacy are likely to experience greater academic success through and following online peer-assessment (Wang & Zong, 2019). From a group-based perspective, academic success was associated with being a better teammate by modelling context-dependent abilities and skills related to an activity (Tucker, 2013).

Adding nuance, gender, and previously high achievement can affect perceptions of achievement (Li & Gao, 2016; Tucker, 2014). From a large student sample (n = 1,523), including six case studies in four degree programs at two Australian universities, Tucker (2014) found that gender had a minor influence on PA scores in group evaluations. Specifically, "women received higher peer assessment scores than men, and men were more generous than women when making peer assessments" (Tucker, 2014, p. 307); however, the differences equalled out when three reviewer scores were aggregated to produce a single score. The authors echo insights from their earlier research indicating that multiple peer assessors cancel any remaining gender bias effects. Shifting the focus to general student abilities, Li and Gao (2016) revealed that students with lower grades prior to peer-assessment significantly improved, while higher achieving students made progress at a reduced level.

Academic Achievement - Challenges (n = 4 studies)

If students' reception of their peers' insights is negative, they may not associate much worth in the process (Casey et al., 2014; Formanek et al., 2017; Naveh & Bykhovsky, 2020; Zheng et al., 2023). In Casey et al.'s (2014) study, students expressed little confidence in their grades, believing that their peers often were more concerned with quantity rather than quality insight. In contrast, but to the same effect, student disregard for grades negatively impacted the overall learning experience (Formanek et al., 2017; Naveh & Bykhovsky, 2020). For example, in Formanek et al.'s (2017) study, students regularly scored their peers to ~75%, often underestimating higher-quality submissions and overvaluing lower-quality ones. Likewise, according to Naveh and Bykhovsky's (2020), students gave unnecessarily high grades to their peers, contributing to overall negative perceptions of the usefulness and quality of information generated from peer assessment and lower final exam scores than in previous years. Finally, with a focus on public speaking, while students' language proficiency improved through online peer-assessment, they retained higher anxiety levels than their peers, which the authors believe was associated with increased awareness (Zheng et al., 2023).

Quality of Peer Assessment - Benefits (n = 5 studies)

Often reflecting on student beliefs in peer-assessment quality, five articles from Australia, Hong Kong, Israel, Taiwan, the Uk, and the USA reflected on the positive aspects and six (Australia, Israel, Taiwan, the UK, and the USA) illustrated challenges. While the process was frequently received well, students expressed doubt about the quality of insight gained from their peers. Student perceptions of online peer-assessment quality appear generally favourable (Kobayashi, 2020; Lai, 2016; Li & Huang, 2023; Yang, 2019; Yu, 2011).

Two studies indicated that online peer-assessment may help develop a deeper understanding of the topic, especially with diverse insight (Kobayashi, 2020; Lai, 2016), while Yang (2019) and Yu's (2011) studies indicated that engaging in peer-assessment had positive implications on the quality of their work. In a video-based application, Li and Huang's (2023) participants with greater pre-existing subject-based abilities provided more cognitive and total comments and had more active engagement. However, similar to earlier studies, students with lower abilities were more likely to provide positive feedback, prompting the authors to propose that differences in self-regulation and motivation can play a critical role in quality.

Quality of Peer Assessment - Challenges (n = 6 studies)

The primary recorded challenge for quality was students' shallow belief in their peers (Casey et al., 2014; Cheng & Tsai, 2012; Kobayashi, 2020; Naveh & Bykhovsky, 2020; Sridharan et al., 2018; Wilson et al., 2015). Many of Casey et al.'s (2014) study participants were concerned about their peers' work quality, citing that they believed peer work quality was poor, yet they received high marks. Students in two studies had faith in their peers' ability to assess but expressed limited confidence in the grades that they received from peers (Cheng & Tsai, 2012; Kobayashi, 2020). Naveh and Bykhovsky (2020) indicated that students in their study believed they provided high-quality content, but their peers' work was not as solid. The authors suggested that the belief likely relates to students giving high grades to their peers, often without reason, contributing to overall negative perceptions of the usefulness and quality of information. Others indicate that peer responses did not align with learning outcomes (Sridharan et al., 2018) or that the professional status of the course instructors results in a higher quality of assessment (Wilson et al., 2015).

Student Comfort with Online Peer-Assessment (n = 20 studies)

Twenty studies focused on student comfort levels when providing online peer feedback. Three themes emerged: anonymity, open identification, and time. The studies provide insight into the impact of online peer-assessment in diverse cultures (n > 10 countries) which included the Australia (n = 3 studies), China (n = 3), Israel (n = 3), Taiwan (n = 3), the USA (n = 3); while one study each provides insight from Canada, Denmark, Hong Kong, Portugal, and Turkey. Each theme will be discussed in turn.

Anonymity - Benefits (n = 9 studies)

With anonymous online peer-assessment, feedback providers do not know the identity of the student's work they are evaluating. Furthermore, the students receiving feedback do not know who is evaluating them. Of the 11 studies that explored the impact of anonymity on peer-assessment, nine from diverse countries including Australia, Taiwan, Denmark, Hong Kong, Israel, Portugal, and the USA reported an overall positive impact from blinding, and two, both from Israel, reported challenges.

Students are more comfortable and honest when online peer-assessment is anonymous (Cheng & Tsai, 2012; Seifert & Feliks, 2019; Sridharan, 2018; Stenalt, 2020; Wang et al., 2020; Wilson et al., 2015; Zhan, 2021). Participants indicated that anonymity allowed them to overcome inhibitions regarding assessing their peers, affording them comfort to provide honest insight with limited risk of social harm (Cheng & Tsai, 2012; Seifert & Feliks, 2019; Sridharan, 2018; Stenalt, 2020; Wang et al., 2020; Wilson et al., 2015; Zhan, 2021). Tsai (2012) outlined two benefits from anonymizing

peer-assessment. First, blinding reduced students' belief that negative comments would result in some form of personal harm. Second, the state of anonymity is common in online environments and can help translate learning experiences into the world beyond higher education.

Anonymity also helped improve learning-oriented communication and reduce pre-existing personal peer bias (Rotsaert et al., 2018; Stenault, 2020; Tsai, 2012). Rotsaert et al. (2018) discovered that when comparing anonymous and identified groups, the former more frequently shared cognitive and metacognitive comments with limited affective comments. Furthermore, Stenalt (2020) reported that participants felt that anonymity helped free them from previous perceptions of their peers' quality of work. Likewise, Tsai (2012) found that anonymity provided a neutral starting point, allowing students to focus solely on evaluating the work and not on who did the work.

Anonymity - Challenges (n = 2 studies)

Even though anonymity may increase student comfort level and honesty, reduce bias, and limit negative peer exposure, some challenges of anonymity have been reported (Naveh & Bykhovsky, 2020; Usher & Barak, 2018). Naveh and Bykhovsky (2020) revealed that participant perceptions were negative and linked to social and emotional pressures, even with double-blinding—where both the assessor and assessee were unknown. Another potential issue is that fully online asynchronous groups may not gain a sense of kinship or desire to be courteous to one another. In a study comparing online peer-assessment between in-person and online groups, the fully online students provided more sarcastic and unkind feedback (Usher & Barak, 2018). The authors reflected that awareness of peers' existence by proximity might enhance insight quality.

Open Identification - Benefits (n = 4 studies)

Open identification in online peer-assessment reflects a student's ability to know their peer, while anonymous or blinded identification is the opposite. While the two concepts may be conceptually connected, they act as separate intentional acts. Seven studies examined the benefits and challenges, from China and Israel and Australia, China, Taiwan, and the USA respectively, of open or blinded identification in higher education peer-assessment. Each subsequent paragraph illustrates the relationship between students' awareness of identity and the assessment outcomes.

While previous research indicates that peer-assessment is best served through student anonymity, it is not required in all situations (Lin et al., 2023; Liu et al., 2018; Naveh & Bykhovsky, 2020; Zheng et al., 2018). When exploring the relationship between project-based learning and peer evaluation, Liu et al. (2018) detected that if students did not feel personally connected to the learning content, they were less averse to unflattering peer insights. Two studies offered another perspective, proposing that participants believed increased peer awareness improved their desire to engage in peer-assessment through personal connection (Lin et al., 2023; Zheng et al., 2018). Taking a different approach, Naveh and Bykhovsky (2020) believe that blinding may be helpful but likely will only partially eliminate perceptions of elevated emotional and social pressures: Students will understand the concept of blinding but find it challenging to understand without experience.

Open Identification - Challenges (n = 4 studies)

Several challenges were observed when peer-assessment was not anonymous, indicating that open identity in online peer-assessment is likely to disrupt effective implementation (Cheng & Hou, 2015; Delaney et al., 2013; Kobayashi, 2020; Rotsaert et al., 2018). For example, Cheng and Hou (2015) and Rotsaert et al. (2018) noted that friendly peer relationships resulted in emotions-based and irrelevant responses that did not result in cognitively enhancing insight. The challenge was most evident when reviewing responses from lower performers. Both Delaney et al. (2013) and Kobayashi (2020) note that a lack of anonymity appears to have contributed to discomfort related to the delivery of peer criticism. Specifically, the discomfort was demotivating due to concerns of potential alienation if a bad grade was delivered.

Time - Challenges (n = 6 studies)

While we did not find any studies providing the explicit benefits of time, based on the above finding, it seems that time is an important construct for success. Six studies outlined how the time required to engage in peer-assessment can provide challenges for student buy-in (Çevik, 2015; Naveh & Bykhovsky, 2020; Phillips, 2016; Stenalt, 2020; Wilson et al., 2015; Zaky, 2021). Emerging from studies originating in Australia, Canada, Denmark, Israel, Turkey, and the USA two primary findings include issues related to complexity and perceived usefulness. Students in two studies (Çevik, 2015; Phillips, 2016) expressed that their studies' peer-assessment platform was unduly complex, challenging to follow, and time-consuming. Furthermore, negative self-perceptions of technological ability, and previous experiences, can negatively impact online peer-assessment experiences (Zaky, 2021). The perceptions fostered negative perceptions of the process' usefulness and the time it took to complete the tasks.

Similarly, students outlined that they believed time was a critical asset in academic life, and when they felt as if they did not have enough time, they were more likely to provide lower-quality insight (Naveh & Bykhovsky, 2020; Stenalt, 2020; Wilson et al., 2015). For example, final exams in other courses can reduce the desire to spend time assessing peer assignments, as students expressed the process as time-intensive and inferior to educator-led learning (Wilson et al., 2015).

Discussion

The beginning of the discussion can revisit the research questions and outline the key findings. The themes of the research questions can be used to structure the discussion and potentially use subheadings to clearly demonstrate the outcomes and answers to the original research questions (Purvis et al., 2024). For example, a research question "what are students' expectations and understanding of inclusive practice?" could provide a subheading of "Expectations and Understanding of Inclusive Practice". However the discussion is structured, you should be providing an interpretation and analysis of the presented results.

Context of Online Peer-Assessment

The literature provided insight from mixed-method (62%), quantitative (30%), and qualitative (8%) studies, which included 78,617 study participants. Undergraduate (83%) and graduate (17%) students are the primary study focus, while engineering and science, education, the arts, business, interdisciplinary studies, and social sciences contribute insight. Our review indicates

that online peer-assessment has the potential to reliably scale from small to extra-large student groups, which is a critical consideration for modern higher education.

Application. For individual assessment, there is most often a five or six-phase process: students 1) review learning materials, 2) produce their initial work guided by the rubric and learning content, 3) you or the peer-assessment platform assign anonymous reviewers, 4) reviewers score the submission and provide feedback, 5) a review of feedback occurs, and 6) revise the initial submission if applicable. For group assignments, online peer-assessment is typically a single-use scenario including the first four phases of the six outlined earlier, as the feedback is used to guide individualized grades.

Reliability and validity. Like Falchikov and Goldfinch (2000), we observed a positive alignment between student and expert scoring. Studies reflecting moderate to strong consistency often provided students with training and support such as mock or calibration activities, asynchronous guides, and educator presence. It also involved aggregated scores from approximately four peer reviewers and an average of three peer-assessment activities, with scoring alignment improving sequentially. Rubrics guiding scored marks based on multiple criteria and qualitative feedback are also recommended, as either element in isolation is less reliable. An emerging trend to support validated student scoring includes using pre-existing validated scales, such as the English Public Speaking instrument as part of a group presentation rubric, to ensure the measurement of appropriate dimensions.

Anonymity. This review presents findings regarding anonymity and scoring comparable to those of Zheng et al. (2019). Sixty-seven percent of the studies included in our review anonymized or blinded the peer-assessment process to enhance student comfort and response quality. We provide further insight in the benefits and challenges section below.

Geography. This review provides context into online peer-assessment practices from over 15 countries and five geographic regions. The findings indicate that research addresses Topping's (1998) recommendation to gain further context into participant characteristics and culture. Additionally, we found continuity in the application and findings in prominent nations involved with international student mobility, including the United States, United Kingdom, Canada, Australia, China, and Hong Kong. Inductive reasoning would indicate that online peer-assessment holds strong potential in our evolving educational structures.

Individual Differences. The current research on individual differences within online peer-assessment is still emerging. However, the existing findings indicate that students globally, as well as minority students in Western settings, have a positive relationship with online peer-assessment. Furthermore, the potential for gender bias is minimal in blinded applications and may be negligible with the aggregation of student scores.

Benefits of Online Peer-Assessment

Recognising that the process can be challenging to adjust to, especially if it is new, the online peer-assessment process positively impacts students' academic performance and achievement. Students can gain an appreciation that the process affords for enhanced communication as it exposes them to new, diverse and new perspectives that require critical thinking while distanced from potentially harmful social implications. Furthermore, the process affords a brisk volume of feedback that is not attainable in most formal learning environments.

Similarly, in group-based scenarios, students appreciated that the process allows individual members to highlight their contributions and reduce the negative impact of free-riders or loafers. Motivation often built from the communication process and increased when the process provided benefits beyond the classroom, such as mimicking real-life scenarios.

The ability to anonymize or purposefully use student identification also provides situational benefits. Anonymous peer-assessment was typically preferred as it increased student comfort and improved learning outcome achievement. The review posits that blinding helped reduce student personal bias and fears associated with social risks. Alternatively, students' awareness of peer identity can enhance personal connection in some scenarios.

Online Peer-Assessment Challenges

While there are many learning benefits of the online peer-assessment process, challenges still exist. A prominent challenge involves student doubts about the process's academic impact, commonly rooted in unfounded perceptions of fairness or validity. For example, self-doubt, doubts about peer capabilities, concerns about academic sabotage in competitive environments, and the process's potential to improve critical skills are prevalent even when the outcomes indicate contrary outcomes.

Another challenge is related to internal motivation. In scenarios where students are less inclined to be engaged or see competitive disadvantages in supporting their peers, individual peer-assessment may present more challenges than desired. Alternatively, when there is a strong potential for student buy-in, anonymity may not always be possible even with the best efforts, which can reduce comfort and increase negative stress associations with the experience.

Finally, time and timing are critical considerations that impact how successful the online peer-assessment process can be. We recommend the early implementation of online peer-assessment processes to support student engagement, especially when students are enrolled in other courses with traditional summative exam practices. Later implementations currently have negative associations with student time management and distress states. However, the process in a group contribution scenario is less likely to be bound by timing challenges, likely due to the summative nature of its potential relationship to positively affect student grades in a shorter duration. Early implementation also ensures that potential technology-based issues, including accessibility or technical glitches, are identified and have less impact on the student experience and the grading process.

Limitations & Future Research

We acknowledge that there may be threats to the reliability and validity of studies included in this review due to the high levels of convenience sampling, which can impact bias. Furthermore, we only included articles published in English, which may omit key global insights. This review identified at least eight limitations in online peer-assessment from the current research that can help guide future studies. The following list outlines limitations in the current research and our suggestions for future research.

1. *The prominence of academic misconduct*. Future research needs to address if online peer-assessment can address academic misconduct such as plagiarism, and if so, how?

2. *Countries with the highest education levels*. We would benefit from insights from more diverse, educated populations. For example, many of the OECD's (2023) most educated countries, including Korea, Canada (n = 1 article), Japan, Luxembourg, Ireland, Russia, Lithuania, Netherlands, and Norway, account for approximately 0.14% of the participants and 2% of the articles within this review.
3. *Students originating from India*. Students from India are an impactful aspect of modern institutional enrolment; however little English data reflects insight from the region. As such, we require more insight from their perspective.
4. *Limited gender-based findings*. Early findings are promising; however, further gender-based insights are required. Furthermore, if variation exists, does the aggregation of their differences enhance or detract from the scoring, feedback reliability and validity?
5. *Limited long-term insight*. Many studies focused on a single period of study; however, extended insight from muti-term applications may be novel.
6. *Student grade aggregation insight*. As grade aggregation plays a role in student and expert scoring consistency, explicit references would benefit future practitioners.
7. *Peer-assessment and final grades*. As grades intertwine with motivation, they are critical variables when correlating outcomes (Richardson et al., 2012). Although grades are referenced often, explicitly referencing their impact on final grades is critical for the following stages of research.
8. *Limited insight from social sciences-based courses*. Contrasting Zheng et al. (2019), we found online peer-assessment use in social sciences is limited outside of schools of education. Additionally, what is present provides little context into student and expert scoring correlation.

Recommendations

Please note there is room for nuance as many use cases will be different, and blinding student reviewers and reviewees is not always necessary or an option. Based on our findings, a concise, general guide outlining effective practice for individual application is as follows:

- **Give yourself time**. You will need to budget time to set up the activities and the platform, to ensure that you and your students engage in training or calibration activities, and that you can offer student support throughout the process.
- **Use peer-assessment early**. Recognize that student motivation to fully engage in peer-assessment may wane with time, especially when positioned against high-stakes summative exam periods. Early implementation reduces potential scheduling and attention-based conflicts.
- **Use a scored rubric**. Using a scored rubric with explicit context for each criterion helps students understand what they need to look for, what they are marking, and it can act as a prompt guide for providing written feedback.
- **Use a multi-phase process**. Follow a five or six-phase creation and review process where students review the learning materials, create the work to be assessed, are assigned peer-review roles, complete the peer-review process, reflect on the scored feedback received, and potentially revise the original work for further review or an educator review.

- **Aggregate student scoring**. To ensure greater grading efficacy, aggregate the student peer-assessment scores from three-to-four assessors for each submission. Additionally, provide a calibration activity to align individual scoring with yours and afford students the opportunity engage in at least three unique activities. **For group assignments**, online peer-assessment follows the same process; however, it commonly is a single-use scenario, includes the first four phases, and the feedback provides context for individualizing grades for group-based assignments.

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Appendix A – Article Summaries

Primary articles **bolded**, and supporting review articles are plain text

Citation	Search Terms	Database	Journal	AVG. Quartile	Title	Purpose
Agrawal & Rajapakse, 2018	online peer assessment higher education	Emerald	International Journal of Educational Management	2	Perceptions and practice of peer assessments: An empirical investigation	To investigate the relationship between educator perceptions of PA and student scoring veracity.
ArchMiller et al., 2017	online peer assessment higher education	Taylor & Francis	Assessment and Evaluation in Higher Education	1	Group peer assessment for summative evaluation in a graduate-level statistics course for ecologists	To evaluate the validity of using PA for unit-based summative assessment.
Ashton & Davies, 2015	online peer assessment higher education	Taylor & Francis	Distance Education	1	Using scaffolded rubrics to improve peer assessment in a MOOC writing course	To explore the value of a guided rubric in the context of reliability in a MOOC writing course.
Casey et al., 2014	online peer assessment higher education	IOPScience	European Journal of Physics	2	Scaffolding student engagement via online peer learning	To validate the effect of online self-assessment as a formative assessment to support student success.
Çevik, 2015	online peer assessment higher education	ScienceDirect	Computers in Human Behavior	1	Assessor or assessee? Investigating the differential effects of online peer assessment roles in the development of students' problem-solving skills	To explore the effects of being an assessor or assessee on student performance in problem-solving.
Chen et al., 2009	online peer assessment higher education	Elsevier	Computers and Education	1	Effects of high level prompts and peer assessment on online learners' reflection levels	To explore the impact of high-level prompts and online peer assessment on a learner's reflection levels.
Cheng & Hou, 2015	online peer assessment higher education	Taylor & Francis	Technology, Pedagogy and Education	1	Exploring students' behavioural patterns during online peer assessment from the affective, cognitive, and metacognitive perspectives: a progressive sequential analysis	to explore students' behavioural transition patterns from the three perspectives when they engage in an online peer assessment over a two week period.
Cheng & Tsai, 2012	online peer assessment higher education	LearnTechLib	Australasian Journal of Educational Technology	1	Students' interpersonal perspectives on, conceptions of and approaches to learning in online peer assessment	To explore interpersonal student perspectives of peer assessment activities in relation to the creation of digital artistic works.

Citation	Search Terms	Database	Journal	AVG. Quartile	Title	Purpose
Cheng et al., 2014	online peer assessment higher education	Taylor & Francis	Interactive Learning Environments	1	Exploring students' emotional responses and participation in an online peer assessment activity: A case study	to explore learners' emotions related to peer comments and responses in relation to learning and participation behaviours.
Cheng et al., 2015	online peer assessment higher education	ScienceDirect	The Internet and Higher Education	1	Examining the role of feedback messages in undergraduate students' writing performance during an online peer assessment activity	To examine the relationship between peer feedback in writing performance.
Cruz et al., 2013	online peer assessment higher education	EBSCO	International Journal of Engineering Pedagogy	2	Web-based peer assessment: A case study with civil engineering students	To examine student factors related to peer feedback and attitudes towards peer-assessment.
De Brún et al., 2022	online peer assessment higher education	Elsevier	Nurse Education Today	1	Evaluation of a formative peer assessment in research methods teaching using an online platform: A mixed methods pre-post study	To evaluate the implementation of online peer assessment in a nursing midwifery research methods course.
De Wever et al., 2011	online peer assessment higher education	Elsevier	The Internet and Higher Education	1	Assessing collaboration in a wiki: The reliability of university students' peer assessment	To examine the reliability of intra-group peer assessment guided by rubrics.
Delaney et al. (2013)	online peer assessment higher education	Emerald	Accounting Research Journal	3	Online self and peer assessment of team work in accounting education	To describe, implement, and evaluate an online self and peer assessment model in the context of accounting student teamwork skills.
Eppler et al., 2021	online peer assessment higher education	Springer	Research in Science Education	1	Enhancing scientific communication skills : A real-world simulation in a tertiary-level life science class using e-learning technology in biomedical literature perception, reflective review writing on a clinical issue, and self and peer assessments	To explore the learning value and feasibility of a literacy exercise with established tools of blended learning.
Fang et al., 2021	online peer assessment higher education	Springer	Educational Technology Research and Development	1	An online collaborative peer-assessment approach to strengthening pre-service teachers' digital content development competence and higher-order thinking tendency	To develop and evaluate the potential effectiveness of different collaborative peer-assessment approaches.
Formanek et al., 2017	online peer assessment	ScienceDirect	Computers & Education	1	Insights about large-scale online peer assessment from an analysis of an astronomy MOOC	To assess the role of peer-graded assignments and how they contribute to students' learning and motivation.

Citation	Search Terms	Database	Journal	AVG. Quartile	Title	Purpose
	higher education					
García-Martínez et al., 2019	online peer assessment higher education	Wiley	Journal of Computer Assisted Learning	1	Improving essay peer grading accuracy in massive open online courses using personalized weights from student's engagement and performance	To analyse the use of students' engagement and performance measures to determine personalized weights, studying the validity of the aggregated scores.
Gielen & De Weyer, 2015	online peer assessment higher education	Elsevier	Computers and Education	1	Scripting the role of assessor and assessee in peer assessment in a wild environment: Impact on peer feedback quality and product improvement	To examine the effect of implementing structures to support the assessee and assessor.
Gunning et al., 2022	online peer assessment higher education	Springer	International Journal of Educational Technology in Higher Education	1	Who engaged in the team-based assessment? Leveraging EdTech for a self and intra-team peer-assessment solution to free-riding	To implement and review the effectiveness of a strategy for improving managing team-based assessments in the context of peer accountability.
Havard et al., 2023	online peer assessment higher education	Springer	TechTrends	2	Peer assessment collaboration evaluation: An innovative assessment tool for online learning environments	To determine if the use Peer Assessment Collaboration Evaluation (PACE) Tool influenced the key determinants of behavioural intention and loafing in group learning scenarios.
Heslop et al., 2017	online peer assessment higher education	Taylor & Francis	Australasian Journal of Engineering Education	2	Respondent disengagement from a peer assessment instrument measuring Collaboration Viability	To explore the role of PA in understanding within-team factors influencing engagement.
Iglesias Pérez et al., 2022	online peer assessment higher education	Taylor & Francis	Studies in Higher Education	1	The role of self and peer assessment in higher education	To verify the reliability and validity of peer- and self-assessment in an online learning environment.
Jiang et al., 2022	online peer assessment college	Taylor & Francis	Interactive Learning Environments	1	Fostering college students' critical thinking skills through peer assessment in the knowledge building community	To explore the relationship between PA and students' critical thinking skills.
Kaufman & Schunn, 2011	online peer assessment higher education	Springer	Instructional Science	2	Students' perceptions about peer assessment for writing: Their origin and impact on revision work	To investigate student perceptions of using an online PA system to support writing.

Citation	Search Terms	Database	Journal	AVG. Quartile	Title	Purpose
Kobayashi, 2020	online peer assessment higher education	ASCILITE	Australasian Journal of Educational Technology	1	Does anonymity matter? Examining quality of online peer assessment and students' attitudes	Investigate how varied peer assessment conditions affect students' relationship with peer feedback including anonymity, attitudes, and quality.
Kulkami et al., 2013	online peer assessment higher education	ACM	ACM Transactions on Computer-Human Interaction	2	Peer and self assessment in massive online classes	To explore and report experiences and techniques related to improving assessment accuracy and qualitative feedback.
Lai, 2016	online peer assessment higher education	ScienceDirect	Computers & Education	1	Training nursing students' communication skills with online video peer assessment	To implement and examine an online video peer assessment system for scaffolding nursing student communication skills and the related validity.
Li & Huang, 2023	online peer assessment higher education	JSTOR	Educational Technology & Society	1	Effects of undergraduate student reviewers' ability on comments provided, reviewing behavior, and performance in an online video peer assessment activity	To examine the relationship between reviewers' abilities and the espoused comments.
Li & Gao, 2016	online peer assessment higher education	Taylor & Francis	Assessment and Evaluation in Higher Education	1	The effect of peer assessment on project performance of students at different learning levels	To examine the relationship between student learning levels and the impact of PA.
Liang & Tsai, 2010	online peer assessment higher education	Elsevier	The Internet and Higher Education	1	Learning through science writing via online peer assessment in a college biology course	To examine the relationship between students' learning of biology, writing, and peer assessment.
Lin, 2019	online peer assessment higher education	Springer	Computers & Education	1	An online peer assessment approach to supporting mind-mapping flipped learning activities for college English writing courses	To explore the effects of using PA in a flipped classroom on English writing performance, student perceptions, and time involvement.
Lin, 2018	online peer assessment higher education	Springer	Computers & Education	1	Anonymous versus identified peer assessment via a Facebook-based learning application: Effects on quality of peer feedback, perceived learning, perceived fairness, and attitude toward the system	To investigate the impact of anonymity on PA.
Lin, 2018	online peer assessment higher education	Taylor & Francis	Behaviour & Information Technology	2	Effects of an online team project-based learning environment with group awareness and peer evaluation on socially shared regulation of learning and self-regulated learning	Explore PBL and the impact of peer assessment on socially shared regulation of learning

Citation	Search Terms	Database	Journal	AVG. Quartile	Title	Purpose
Lin et al., 2023	online peer assessment higher education	Springer	Journal of Computing in Higher Education	1	“Free selection and invitation” online peer assessment of undergraduates’ research competencies, flow, motivation and interaction in a research methods course	To compare the effect of free and open PA versus assigned pair PA.
Liu et al., 2021	online peer assessment higher education	ASCLITE	Australasian Journal of Educational Technology	1	A WSQ-based mobile peer assessment approach to enhancing university students’ vocal music skills and learning perceptions	To investigate the effectiveness of PA on students' perceptions of vocal skills learning.
Liu et al., 2019	online peer assessment higher education	Taylor & Francis	Assessment & Evaluation in Higher Education	1	Students’ learning outcomes and peer rating accuracy in compulsory and voluntary online peer assessment	To investigate the accuracy and learning outcomes associated with online peer assessment.
Liu et al., 2018	online peer assessment higher education	Taylor & Francis	Assessment & Evaluation in Higher Education	1	Small group discussion as a key component in online assessment training for enhanced student learning in web-based peer assessment	To examine the effect of online assessment training on subsequent web-based peer assessment.
Loureiro et al., 2012	online peer assessment higher education	Taylor & Francis	Educational Media International	2	The quality of peer assessment in a wiki-based online context: a qualitative study	Explore validity and reliability of PA
Ma & Luo, 2022	online peer assessment higher education	EBSCO	International Journal of Emerging Technologies in Learning	2	The effect of student and peer assessment engagement on learning performance in online open courses	To examine the role of peer assessment engagement as a moderating variable in student engagement through learning performance.
Mao & Peck, 2013	online peer assessment higher education	Eric	Quarterly Review of Distance Education	NR	Assessment strategies, self-regulated learning skills, and perceptions of assessment in online learning	To investigate the relationship between assessment strategies and self-regulated learning skills with students' perceptions of learning.
Mostert & Snowball, 2013	online peer assessment higher education	Taylor & Francis	Assessment & Evaluation in Higher Education	1	Where angels fear to tread: Online peer-assessment in a large first-year class	To support the development of student writing abilities at a South African university.
Naveh & Bykhovsky, 2020	online peer assessment higher education	IEEE	IEEE Transactions on Education	2	Online Peer Assessment in Undergraduate Electrical Engineering Course	To explore students' perceptions, behaviour, and academic performance in relation to peer assessment.

Citation	Search Terms	Database	Journal	AVG. Quartile	Title	Purpose
Phillips, 2016	online peer assessment higher education	AAA	Issues in Accounting Education	2	The power of giving feedback: Outcomes from implementing an online peer assessment system	To examine the role and outcomes of PA in an intro accounting course.
Rotsaert et al., 2018	online peer assessment higher education	Springer	European Journal of Psychology of Education	1	Anonymity as an instructional scaffold in peer assessment: its effects on peer feedback quality and evolution in students' perceptions about peer assessment skills	To investigate the implications of transitioning from anonymous to non-anonymous PA to experience two-way interactive feedback genuinely.
Seifert & Feliks, 2019	online peer assessment higher education	Taylor & Francis	Assessment & Evaluation in Higher Education	1	Online self-assessment and peer-assessment as a tool to enhance student-teachers' assessment skills	To identify student-teacher attitudes towards self- and peer-assessment and develop models to improve implementation in teaching.
Sridharan et al., 2018	online peer assessment higher education	Taylor & Francis	Assessment & Evaluation in Higher Education	1	Researching student agency in digital education as if the social aspects matter: Students' experience of participatory dimensions of online peer assessment	To examine the relationship between student perceptions of peer-assessment attributes and the perceived effectiveness of enhancing positive experiences in teamwork.
Stenalt, 2020	online peer assessment higher education	Taylor & Francis	Assessment & Evaluation in Higher Education	1	Researching student agency in digital education as if the social aspects matter: Students' experience of participatory dimensions of online peer assessment	To explore the relationship of online peer-assessment with social aspects and individual agency in digital education.
Sun et al., 2015	online peer assessment college	PLoS	PloS One	1	Peer assessment enhances student learning: The results of a matched randomized crossover experiment in a college statistics class	To examine if PA could aid in developing conceptual understanding and problem-solving skills.
Tsai, 2012	online peer assessment higher education	JSTOR	Educational Technology & Society	1	The development of epistemic relativism versus social relativism via online peer assessment, and their relations with epistemological beliefs and internet self-efficacy	To explore student views of peer-assessment and how those views were associated with epistemological beliefs and internet self-efficacy.
Tsai & Liang, 2009	online peer assessment higher education	Springer	Instructional Science	2	The development of science activities via on-line peer assessment: The role of scientific epistemological views	To explore the relationship between PA and developing science activities for future instruction.
Tseng & Tsai, 2010	online peer assessment higher education	Science Direct	The Internet and Higher Education	1	Taiwan college students' self-efficacy and motivation of learning in online peer assessment environments	To gain an understanding of students' motivation and self-efficacy for PA and develop a questionnaire for practical application of the constructs.

Citation	Search Terms	Database	Journal	AVG. Quartile	Title	Purpose
Tucker, 2013	online peer assessment higher education	Taylor & Francis	Assessment and Evaluation in Higher Education	1	The architecture of peer assessment: Do academically successful students make good teammates in design assignments?	To determine the impact of students' prior academic achievements on how well they will work in teams and its impact on assessing peer skills.
Tucker, 2014	online peer assessment higher education	Taylor & Francis	Assessment and Evaluation in Higher Education	1	Sex does not matter: Gender bias and gender differences in peer assessments of contributions to group work	To examine the possibility of gender bias in group-based peer ratings.
Usher & Barak, 2018	online peer assessment higher education	Taylor & Francis	Assessment & Evaluation in Higher Education	1	Peer assessment in a project-based engineering course: Comparing between on-campus and online learning environments	To compare the implication of three learning environments: on-campus course, small private online course (SPOC) and MOOC on the feedback quality and grading accuracy of students' peer assessment in a project-based engineering course.
Wang et al., 2020	online peer assessment higher education	Taylor & Francis	Assessment & Evaluation in Higher Education	1	Factors associated with students' attitude change in online peer assessment–a mixed methods study in a graduate-level course	To investigate underlying factors about students' attitude to change in the context of peer assessment.
Wang & Zong, 2019	online peer assessment higher education	MDPI	Sustainability	2	Why students have conflicts in peer assessment? An empirical study of an online peer assessment community	To explore why students have task conflict in online peer assessment learning environments.
Wilson et al., 2015	online peer assessment higher education	Taylor & Francis	Assessment & Evaluation in Higher Education	1	'I'm not here to learn how to mark someone else's stuff': an investigation of an online peer-to-peer review workshop tool	To explore the intersecting relationship and perceptions of fairness, trust, and temporality related to the implementation of the online peer-to-peer review.
Xiao & Lucking, 2008	online peer assessment higher education	Science Direct	The Internet and Higher Education	1	The impact of two types of peer assessment on students' performance and satisfaction within a Wiki environment	To compare the impact of qualitative feedback versus quantitative-only on PA outcomes.
Yang, 2019	online peer assessment higher education	EBSCO	TESL-EJ	2	Student responses to online peer assessment in tertiary english language classrooms	To explore the implications and student perceptions of using PA in a language-based course.
Yu, 2011	online peer assessment	ScieneDirect	Computers & Education	1	Multiple peer-assessment modes to augment online student question-generation processes	To determine which peer-assessment mode(s) students perceive most positively in the context of

Citation	Search Terms	Database	Journal	AVG. Quartile	Title	Purpose
	higher education					quantity and quality of interaction in an online discourse experience.
Zaky, 2021	online peer assessment higher education	Springer	SN Social Sciences	NR	Peer assessment for teaching quality of online writing classes in higher education: Investigating learning styles' impact	To investigate UG perceptions of PA through its use factors and their learning preferences.
Zhan, 2021	online peer assessment higher education	Taylor & Francis	Assessment and Evaluation in Higher Education	1	What matters in design? Cultivating undergraduates' critical thinking through online peer assessment in a Confucian heritage context	To investigate the effect of online PA in a GenEd course.
Zheng et al., 2023	online peer assessment higher education	Taylor & Francis	Computer Assisted Language Learning	1	Self-assessment first or peer-assessment first: Effects of video-based formative practice on learners' English public speaking anxiety and performance	To explore the effects of two different sequences of video-based formative assessment on English language learners' public speaking anxiety and their performance.
Zheng et al., 2018	online peer assessment higher education	Taylor & Francis	Assessment & Evaluation in Higher Education	1	Synchronous discussion between assessors and assessees in web-based peer assessment: Impact on writing performance, feedback quality, meta-cognitive awareness and self-efficacy	To examine how synchronous discussion between assessors and assessees through web-based peer assessment impacts writing performance, qualitative feedback quality, meta-cognitive awareness and self-efficacy.
Zou et al., 2018	online peer assessment higher education	Taylor & Francis	Assessment and Evaluation in Higher Education	1	Student attitudes that predict participation in peer assessment	To explore the relationship between peer-related attitudes and participation in PA.

Appendix B – Demographic

Primary articles **bolded**, and supporting review articles are plain text

Citation	Academic Level	Sample Size	Gender Female	Gender Male	Age	Academic Level	Field of Study	Country
Agrawal & Rajapakse, 2018	UG, Grad, Educator	653	32	59	25-60+	UG, Grad, Educator	Business	International
ArchMiller et al., 2017	Grad	20	x	x	x	Grad	Engineering & Science	USA
Ashton & Davies, 2015	MOOC	520	x	x	x	MOOC	The Arts	International
Casey et al., 2014	UG	848	x	x	x	UG	Engineering & Science	UK
Çevik, 2015	UG	70	43	27	M = 22	UG	Education	Turkey
Chen et al., 2009	UG	157	x	x	21-26	UG	Engineering & Science	Taiwan
Cheng & Hou, 2015	UG	65	58	7	18-19	UG	The Arts	Taiwan
Cheng & Tsai, 2012	UG	23	15	8	M = 19	UG	The Arts	Taiwan
Cheng et al., 2014	UG	65	58	7	18-19	UG	The Arts	Taiwan
Cheng et al., 2015	UG	47	26	21	x	UG	Engineering & Science	Taiwan
Cruz et al., 2013	UG	47	21	26	x	UG	Engineering & Science	Portugal
De Brún et al., 2022	Grad	74	x	x	M = 37	Grad	Engineering & Science	UK
De Wever et al., 2011	UG	659	x	x	x	UG	Education	Belgium
Delaney et al. (2013)	UG	93	64	29	M = 25	UG	Education	Australia
Eppler et al., 2021	UG	75	53	22	x	UG	Engineering & Science	Australia
Fang et al., 2021	UG	97	83	14	x	UG	Education	China
Formanek et al., 2017	MOOC	1607	536	1071	M = 21-40	MOOC	Engineering & Science	International
García-Martínez et al., 2019	MOOC	91	38	53	M = 22	MOOC	The Arts	International
Gielen & De Weyer, 2015	UG	125	x	x	x	UG	Education	Belgium

Citation	Academic Level	Sample Size	Gender Female	Gender Male	Age	Academic Level	Field of Study	Country
Gunning et al., 2022	UG, Grad	39	x	x	x	UG, Grad	Engineering & Science	Australia
Havard et al., 2023	UG, Grad	104	68	33	18-51	UG, Grad	Interdisciplinary	USA
Heslop et al., 2017	UG	458	4x4	54	M = 20	UG	Engineering & Science	Australia
Iglesias Pérez et al., 2022	UG	144	93	51	x	UG	Business	Spain
Jiang et al., 2022	UG	33	32	1	x	UG	Education	China
Kaufman & Schunn, 2011	UG	84	55	29	x	UG	Interdisciplinary	USA
Kobayashi, 2020	UG	58	55	3	M = 18-20	UG	Education	USA
Kulkami et al., 2013	MOOC	65711	21356	44354	M = 25-34	MOOC	Engineering & Science	International
Lai, 2016	UG	50	x	x	x	UG	Engineering & Science	Taiwan
Li & Huang, 2023	UG	38	18	20	x	UG	The Arts	Taiwan
Li & Gao, 2016	UG	130	x	x	x	UG	Education	USA
Liang & Tsai, 2010	UG	47	26	21	x	UG	Engineering & Science	Taiwan
Lin, 2019	UG	57	x	x	x	UG	The Arts	Taiwan
Lin, 2018	UG	32	23	9	x	UG	Education	Taiwan
Lin, 2018	UG	83	61	23	19-21	UG	Business	Taiwan
Lin et al., 2023	UG	93	75	18	M = 20	UG	Interdisciplinary	China
Liu et al., 2021	UG	44	x	x	M = 20	UG	The Arts	China
Liu et al., 2019	Grad	124	92	32	x	Grad	Education	USA
Liu et al., 2018	UG	81	71	10	M = 21.5	UG	Business	China
Loureiro et al., 2012	Grad	22	x	x	M = 30-40	Grad	Education	Portugal
Ma & Luo, 2022	UG	217	139	78	x	UG	Engineering & Science	China
Mao & Peck, 2013	UG	264	123	141	18-24	UG	Engineering & Science	USA
Mostert & Snowball, 2013	UG	563	x	x	x	UG	Business	South Africa

Citation	Academic Level	Sample Size	Gender Female	Gender Male	Age	Academic Level	Field of Study	Country
Naveh & Bykhovsky, 2020	UG	243	x	x	x	UG	Engineering & Science	Israel
Phillips, 2016	UG	108	x	x	x	UG	Business	Canada
Rotsaert et al., 2018	UG	46	39	x	M = 21	UG	Education	Portugal
Seifert & Feliks, 2019	UG, Grad	300	x	x	M = 28	UG, Grad	Education	Israel
Sridharan et al., 2018	Grad	95	x	x	x	Grad	Business	Australia
Stenalt, 2020	UG	13	9	4	20-30	UG	Social Science	Denmark
Sun et al., 2015	UG	387	239	148	x	UG	Engineering & Science	USA
Tsai, 2012	Grad	40	x	x	x	Grad	Education	Taiwan
Tsai & Liang, 2009	UG	36	x	x	x	UG	Education	Taiwan
Tseng & Tsai, 2010	UG	205	146	59	18-22	UG	Interdisciplinary	Taiwan
Tucker, 2013	UG	178	58	120	17-25	UG	Engineering & Science	Australia
Tucker, 2014	UG	1505	603	902	x	UG	Interdisciplinary	Australia
Usher & Barak, 2018	UG	339	127	182	20-55	UG	Engineering & Science	Israel
Wang et al., 2020	Grad	31	21	10	x	Grad	Education	USA
Wang & Zong, 2019	UG	84	32	52	M = 21	UG	Business	China
Wilson et al., 2015	UG	293	x	x	x	UG	Interdisciplinary	Australia
Xiao & Lucking, 2008	UG	232	184	48	x	UG	Education	USA
Yang, 2019	UG	163	82	81	x	UG	Social Science	Hong Kong
Yu, 2011	UG	49	x	x	x	UG	Education	Taiwan
Zaky, 2021	UG	145	116	29	M = 25-34	UG	Engineering & Science	USA
Zhan, 2021	UG	93	59	34	18-23	UG	Social Science	Hong Kong
Zheng et al., 2023	UG	51	19	32	18-21	UG	Social Science	China

Citation	Academic Level	Sample Size	Gender Female	Gender Male	Age	Academic Level	Field of Study	Country
Zheng et al., 2018	UG	64	54	10	M = 20	UG	Interdisciplinary	China
Zou et al., 2018	UG	105	57	48	x	UG	Social Science	China

Appendix C - Certainty and Confidence Review

Primary articles **bolded**, and supporting review articles are plain text

Citation	*Reliab*[*]	*Valid*[**]	*Ind. Dif.*[***]	*Sample Description*[†]	*Certainty Review*[††]	*Transparency*[†††]	Quality[Σ]
Agrawal & Rajapakse, 2018	*1*	*1*	*1*	*3*	*3*	*3*	3.0
ArchMiller et al., 2017	*1*	*1*	*1*	*1*	*3*	*3*	2.3
Ashton & Davies, 2015	*1*	*1*	*0*	*1*	*2*	*1.5*	1.5
Casey et al., 2014	*1*	*1*	*1*	*1*	*3*	*3*	2.3
Çevik, 2015	*1*	*0*	*1*	*3*	*3*	*3*	3.0
Chen et al., 2009	*1*	*1*	*0*	*2*	*2*	*3*	2.3
Cheng & Hou, 2015	*1*	*0*	*1*	*3*	*2*	*3*	2.7
Cheng & Tsai, 2012	*0*	*0*	*1*	*3*	*1*	*1.5*	1.8
Cheng et al., 2014	*1*	*1*	*1*	*3*	*3*	*3*	3.0
Cheng et al., 2015	*1*	*1*	*0*	*3*	*2*	*3*	2.7
Cruz et al., 2013	*1*	*1*	*0*	*2*	*2*	*3*	2.3
De Brún et al., 2022	*1*	*1*	*0*	*2*	*2*	*3*	2.3
De Wever et al., 2011	*1*	*1*	*1*	*1*	*3*	*3*	2.3
Delaney et al. (2013)	*1*	*1*	*1*	*3*	*3*	*3*	3.0
Eppler et al., 2021	*1*	*1*	*1*	*2*	*3*	*3*	2.7
Fang et al., 2021	*1*	*1*	*1*	*2*	*3*	*3*	2.7
Formanek et al., 2017	*1*	*1*	*1*	*3*	*3*	*3*	3.0
García-Martínez et al., 2019	*1*	*1*	*0*	*3*	*2*	*3*	2.7
Gielen & De Weyer, 2015	*1*	*1*	*1*	*1*	*3*	*3*	2.3
Gunning et al., 2022	*1*	*1*	*1*	*1*	*3*	*3*	2.3
Havard et al., 2023	*1*	*1*	*1*	*3*	*3*	*3*	3.0
Heslop et al., 2017	*1*	*1*	*1*	*3*	*3*	*3*	3.0
Iglesias Pérez et al., 2022	*1*	*1*	*1*	*2*	*3*	*3*	2.7
Jiang et al., 2022	*1*	*1*	*1*	*2*	*3*	*3*	2.7
Kaufman & Schunn, 2011	*1*	*1*	*1*	*2*	*3*	*3*	2.7
Kobayashi, 2020	*1*	*1*	*1*	*3*	*3*	*3*	3.0
Kulkami et al., 2013	*0*	*0*	*1*	*3*	*1*	*3*	2.3
Lai, 2016	*1*	*1*	*0*	*1*	*2*	*1.5*	1.5

Citation	*Reliab*[*]	*Valid*[**]	*Ind. Dif.*[***]	*Sample Description*[†]	*Certainty Review*[††]	*Transparency*[†††]	Quality[Σ]
Li & Huang, 2023	*1*	*1*	*1*	*2*	*3*	*3*	2.7
Li & Gao, 2016	*1*	*1*	*1*	*1*	*3*	*1.5*	1.8
Liang & Tsai, 2010	*1*	*1*	*1*	*2*	*3*	*3*	2.7
Lin, 2019	*1*	*1*	*1*	*1*	*3*	*3*	2.3
Lin, 2018	*1*	*1*	*1*	*2*	*3*	*3*	2.7
Lin, 2018	*1*	*1*	*1*	*3*	*3*	*3*	3.0
Lin et al., 2023	*1*	*1*	*1*	*3*	*3*	*3*	3.0
Liu et al., 2021	*1*	*1*	*0*	*2*	*2*	*2*	2.0
Liu et al., 2019	*1*	*1*	*1*	*2*	*3*	*3*	2.7
Liu et al., 2018	*1*	*1*	*1*	*3*	*3*	*3*	3.0
Loureiro et al., 2012	*1*	*1*	*0*	*1*	*2*	*1.5*	1.5
Ma & Luo, 2022	*1*	*1*	*1*	*1*	*3*	*3*	2.3
Mao & Peck, 2013	*1*	*1*	*1*	*3*	*3*	*3*	3.0
Mostert & Snowball, 2013	*1*	*1*	*1*	*1*	*3*	*3*	2.3
Naveh & Bykhovsky, 2020	*1*	*1*	*1*	*1*	*3*	*3*	2.3
Phillips, 2016	*1*	*1*	*0*	*1*	*2*	*1.5*	1.5
Rotsaert et al., 2018	*1*	*1*	*1*	*2*	*3*	*3*	2.7
Seifert & Feliks, 2019	*1*	*1*	*1*	*2*	*3*	*3*	2.7
Sridharan et al., 2018	*1*	*1*	*1*	*1*	*3*	*3*	2.3
Stenalt, 2020	*1*	*1*	*0*	*3*	*2*	*3*	2.7
Sun et al., 2015	*1*	*1*	*1*	*2*	*3*	*3*	2.7
Tsai, 2012	*1*	*1*	*0*	*2*	*2*	*1.5*	1.8
Tsai & Liang, 2009	*1*	*1*	*0*	*1*	*2*	*3*	2.0
Tseng & Tsai, 2010	*1*	*1*	*1*	*3*	*3*	*3*	3.0
Tucker, 2013	*1*	*1*	*0*	*3*	*2*	*3*	2.7
Tucker, 2014	*1*	*1*	*1*	*2*	*3*	*3*	2.7
Usher & Barak, 2018	*1*	*1*	*1*	*3*	*3*	*3*	3.0
Wang et al., 2020	*1*	*1*	*0*	*2*	*3*	*3*	2.7
Wang & Zong, 2019	*0*	*0*	*1*	*2*	*1*	*3*	2.0
Wilson et al., 2015	*1*	*1*	*1*	*1*	*3*	*3*	2.3
Xiao & Lucking, 2008	*1*	*1*	*1*	*2*	*3*	*3*	2.7

Citation	*Reliab*[*]	*Valid*[**]	*Ind. Dif.*[***]	*Sample Description*[†]	*Certainty Review*[††]	*Transparency*[†††]	Quality[Σ]
Yang, 2019	*1*	*1*	*1*	*2*	*3*	*3*	2.7
Yu, 2011	*1*	*1*	*1*	*1*	*3*	*1.5*	1.8
Zaky, 2021	*1*	*1*	*1*	*3*	*3*	*3*	3.0
Zhan, 2021	*1*	*1*	*1*	*3*	*3*	*3*	3.0
Zheng et al., 2023	*1*	*1*	*1*	*3*	*3*	*3*	3.0
Zheng et al., 2018	*1*	*1*	*1*	*3*	*3*	*3*	3.0
Zou et al., 2018	*0*	*0*	*1*	*2*	*1*	*1.5*	1.5

[*]Evidence of test-retest, parallel, interrater, or internal consistency; score of 0 = No, 1 = Yes

[**]Evidence of face, content, criterion, or bias; score of 0 = No, 1 = Yes

[***]e.g., gender or group differences, style, etc.; score of 0 = No, 1 = Yes

[†] 0 = No info; score of 1,2,3 = 1,2, or 3 instances of sample size, gender, age

[††] 0 = No info; score of 1,2,3 = 1,2, or 3 instances of reliability, validity, individual differences

[†††] Evidence of transparent analysis, Data Credibility, Positive/Negative cases?, Triangulation, Participant Check, or Rich Description; score of 0 = Limited; 1.5 = Some Checks; 3 = Multiple Checks

[Σ]Average score of description, certainty, and transparency

Appendix D - Emergent Subtheme Citations

Primary articles **bolded**, and supporting review articles are plain text

	Context	Academic Impact								Student Comfort				
		Motivation		Academic Achievement		Quality		Perceptions of Learning		Anonymity		Open ID		Time
Citation		+*	-**	+*	-**	+*	-**	+*	-**	+*	-**	+*	-**	-**
Agrawal & Rajapakse, 2018	1	0	0	0	0	0	0	1	0	0	0	0	0	0
ArchMiller et al., 2017	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Ashton & Davies, 2015	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Casey et al., 2014	1	0	0	0	0	1	1	1	1	1	0	0	0	1
Çevik, 2015	1	0	0	1	0	0	0	0	0	0	0	0	0	1
Chen et al., 2009	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Cheng & Hou, 2015	1	1	0	0	0	0	0	0	0	0	0	0	1	0
Cheng & Tsai, 2012	1	1	0	0	0	1	1	0	0	1	0	0	0	0
Cheng et al., 2014	1	1	0	0	0	0	0	0	0	0	0	0	0	0
Cheng et al., 2015	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Cruz et al., 2013	1	0	0	0	0	0	0	0	0	0	0	0	0	0
De Brún et al., 2022	1	0	0	0	0	0	0	1	0	0	0	0	0	0
De Wever et al., 2011	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Delaney et al. (2013)	1	1	0	0	0	0	0	1	0	0	0	0	1	0
Eppler et al., 2021	1	0	0	0	0	0	0	1	0	0	0	0	0	0
Fang et al., 2021	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Formanek et al., 2017	1	1	0	0	1	0	0	0	0	0	0	0	0	0
García-Martínez et al., 2019	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Gielen & De Weyer, 2015	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Gunning et al., 2022	1	0	0	0	0	0	0	1	0	0	0	0	0	0
Havard et al., 2023	1	0	0	0	0	0	0	1	0	0	0	0	0	0
Heslop et al., 2017	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Iglesias Pérez et al., 2022	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Jiang et al., 2022	1	0	0	1	0	0	0	0	0	0	0	0	0	0
Kaufman & Schunn, 2011	1	0	0	1	0	0	0	0	1	0	0	0	0	0
Kobayashi, 2020	1	0	1	0	0	1	1	0	0	0	0	0	1	0
Kulkami et al., 2013	1	1	0	0	0	0	0	1	0	0	0	0	0	0

	Context	Academic Impact								Student Comfort				
		Motivation		Academic Achievement		Quality		Perceptions of Learning		Anonymity		Open ID		Time
Citation		+*	-**	+*	-**	+*	-**	+*	-**	+*	-**	+*	-**	-**
Lai, 2016	1	0	0	0	0	1	0	0	0	0	0	0	0	0
Li & Huang, 2023	1	0	0	0	0	1	0	0	0	0	0	0	0	0
Li & Gao, 2016	1	0	1	0	0	0	0	1	1	0	0	0	0	0
Liang & Tsai, 2010	1	0	0	1	0	0	0	0	0	0	0	0	0	0
Lin, 2019	1	0	0	1	0	0	0	0	0	0	0	0	0	0
Lin, 2018	1	1	0	0	1	1	1	1	1	0	0	0	0	0
Lin, 2018	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Lin et al., 2023	1	0	0	0	0	0	0	0	0	0	0	1	0	0
Liu et al., 2021	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Liu et al., 2019	1	0	1	0	0	0	0	0	0	0	0	0	0	0
Liu et al., 2018	1	0	0	0	0	0	0	0	0	0	0	1	0	0
Loureiro et al., 2012	1	0	1	0	0	0	0	0	0	0	0	0	0	0
Ma & Luo, 2022	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Mao & Peck, 2013	1	0	0	1	0	0	0	0	0	0	0	0	0	0
Mostert & Snowball, 2013	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Naveh & Bykhovsky, 2020	1	0	1	0	1	1	1	0	0	0	1	1	0	1
Phillips, 2016	1	0	0	0	0	0	0	0	0	0	0	0	0	1
Rotsaert et al., 2018	1	0	0	0	0	0	0	0	0	1	0	0	0	0
Seifert & Feliks, 2019	1	1	0	0	0	0	0	0	0	1	0	0	0	0
Sridharan et al., 2018	1	0	0	0	0	1	1	0	0	1	0	0	0	0
Stenalt, 2020	1	0	0	0	0	0	0	0	0	1	0	0	0	1
Sun et al., 2015	1	0	0	0	0	0	0	1	1	0	0	0	0	0
Tsai, 2012	1	0	0	0	0	0	0	1	0	1	0	0	0	0
Tsai & Liang, 2009	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Tseng & Tsai, 2010	1	1	0	0	0	0	0	0	0	0	0	0	0	0
Tucker, 2013	1	0	0	1	0	0	0	0	0	0	0	0	0	0
Tucker, 2014	1	0	0	1	0	0	0	0	0	0	0	0	0	0
Usher & Barak, 2018	1	0	0	0	0	0	0	0	0	0	1	0	0	0
Wang et al., 2020	1	0	0	1	0	0	0	1	1	0	0	0	0	0

	Context	Academic Impact								Student Comfort				
		Motivation		Academic Achievement		Quality		Perceptions of Learning		Anonymity		Open ID		Time
Citation		**+***	**-****	**+***	**-****	**+***	**-****	**+***	**-****	**+***	**-****	**+***	**-****	**-****
Wang & Zong, 2019	1	0	0	1	0	0	0	1	1	0	0	0	0	0
Wilson et al., 2015	1	0	0	0	0	0	0	1	1	1	0	0	0	0
Xiao & Lucking, 2008	1	0	0	0	0	0	0	1	0	0	0	0	0	0
Yang, 2019	1	0	0	0	0	1	0	0	0	0	0	0	0	0
Yu, 2011	1	1	1	0	0	1	0	1	0	0	0	0	0	0
Zaky, 2021	1	0	0	0	0	0	0	1	1	0	0	0	0	1
Zhan, 2021	1	1	0	0	0	0	0	1	0	1	0	0	0	0
Zheng et al., 2023	1	0	0	1	1	0	0	0	0	0	0	0	0	0
Zheng et al., 2018	1	0	0	1	0	0	0	0	0	0	0	1	1	0
Zou et al., 2018	1	1	1	0	0	0	0	0	0	0	0	0	0	0

* Benefits

** Challenges