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What Factors Contribute to Effective Online Higher Education?

A Meta-Review

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ORIGINAL RESEARCH

What Factors Contribute to Effective Online Higher Education? A Meta-Review

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Abstract

Although much research has focused on factors that contribute to effective online education in higher education (HE), insights remain scattered. In this study, we provide a more holistic perspective on how to facilitate effective online HE by concurrently examining factors that were hitherto treated separately. In our meta-review, we synthesized insights from 47 literature reviews and meta-analyses published between 2010 and 2022 concerning factors that contribute to effective online HE. Factors were identified at the level of the *course* (i.e., a clear structure; challenging, authentic, and inclusive learning activities; high-quality online interaction; and multiple assessment formats), *student* (i.e., high self-regulation skills, sufficient digital literacy, and a positive attitude towards online education), *teacher* (i.e., online teaching competences and professional development opportunities), and *institution* (i.e., an institution-wide vision on online education, adequate technological infrastructure, and accommodating student and teacher support). Further research is needed to better understand how these factors may interact with each other.

Keywords Effective online education · Online higher education · Systematic review · Meta-review

With the growth of access to digital technologies and their affordances, many have speculated about the future role of online higher education (HE; e.g., Mayadas et al., 2009; Morris et al., 2020; Wallace, 2003). The consensus among educational researchers is that online education should be an integral part of the long-term strategies of HE institutions (Means et al., 2014). HE institutions increasingly adopted online education following

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the COVID-19 pandemic, but this transition occurred ad hoc and was not a planned and research-informed innovation (Bozkurt & Sharma, 2020; Hodges et al., 2020). Given the expectation that online education is expected to remain part of HE policies (Bakker et al., 2021; Gupta et al., 2021), institutions are in dire need of more research-informed insights on how to integrate online education so that it can live up to its potential, for example, by increasing student performance (Bernard et al., 2014; Vo et al., 2017) and widening access to high-quality education (Buhl & Andreasen, 2018; Tchamyou, 2020).

To date, most reviews and meta-analyses have examined online HE by zooming in on specific components such as use of technology (Gegenfurtner & Ebner, 2019; Kay, 2012) and online assessment (Gikandi et al., 2011), or otherwise restricted their scope to specific student outcomes (Bolliger & Wasilik, 2009) or domains (Cooke et al., 2010; Grandzol & Grandzol, 2006; Rowe et al., 2019). In addition, most reviews have primarily taken the perspective of single actors, namely, the student (Money & Dean, 2019; Vo et al., 2017), the teacher (Jonker et al., 2018; Philipsen et al., 2019), or the institution (Awan et al., 2021; Liu et al., 2020). Acknowledging that these actors are interdependent, as are the different types of learning outcomes (Ng, 2019; Wei et al., 2021), this study synthesizes reviews and meta-analyses investigating factors that contribute to effective online HE, and can thus be characterized as a *meta-review*, a review of systematic reviews and meta-analyses. It discusses the synthesized empirical insights about factors at different levels (e.g., course and student) and how these factors contribute to multiple types of learning outcomes.

1 Conceptual Framework

The number of studies on online (higher) education has significantly increased since the COVID-19 pandemic (Zhang et al., 2022), and many have speculated about how important online learning and teaching will be beyond the pandemic (e.g., Walletzký et al., 2023). Before the pandemic, online or distance education had a clear, but narrower target group than it has now. While online education had been a topic of interest prior to the pandemic, it is now at the top of the list for all HE institutions, and nearly all HE institutions around the globe grapple with what the future role of online teaching and learning should be (Wangenge-Ouma & Kupe, 2022). Previous research has suggested that online education is more than just a way to meet social distancing needs, because it could potentially result in better learning outcomes than traditional on-site learning and teaching (e.g., Stevens et al., 2021). The COVID-19 pandemic served as an incentive to rethink educational systems and consider how online education in HE may help to overcome barriers; for example, those due to geography and disabilities (Lennox et al., 2021).

To reap the benefits of online education in HE, it is important to gain a proper understanding of what contributes to its effectiveness. To this end, dozens of reviews and meta-analyses have been conducted on the topic of online education in order to generate more aggregated findings on effective online teaching and learning strategies—particularly in the last few years, as evidenced by the high number of recent studies included in the present meta-review. Most of these studies, however, still have a specific focus, for example, by examining only students' perspective, or only looking at performance. As a result, the knowledge is scattered, and it is difficult to acquire a comprehensive view on what facilitating effective online HE encompasses. The present study thus set out to provide a comprehensive overview of empirical insights on effective online HE that were hitherto treated separately.

Based on an extensive inspection of literature which identified factors that contribute to effective online education (e.g., Baeten et al., 2013; Muljana & Luo, 2019; Wallace, 2003; Yunusa & Umar, 2021), this meta-review was guided by a framework consisting of factors at four levels: the course level, the student level, the teacher level, and the institutional level. Such a multi-level approach can be found within both research on online education (Chung et al., 2022; Wallace, 2003) and other related educational research areas, such as technology use (e.g., Chew et al., 2018; Zhao & Frank, 2003). Although this shows that adopting a multi-level approach is not new in research on online education, to our knowledge this review is the first to address factors at all four levels simultaneously and to explicitly relate these factors to multiple types of learning outcomes. In line with other research on online education (e.g., Post et al., 2019; Wei et al., 2021), learning outcomes were categorized according to Bloom's taxonomy (Bloom et al., 1956), meaning that we examined affective outcomes (e.g., motivation), behavioral outcomes (e.g., retention), and cognitive outcomes (e.g., performance). Taken together, the following research question guided this study: *What course-related, student-related, teacher-related and institution-related factors contribute to effective online education in higher education?* The effectiveness of the factors was assessed in terms of their contribution to achieving affective, behavioral, and cognitive outcomes.

Figure 1 illustrates how the factors on these levels conceptually relate to each other. The intended learning outcomes are central to the framework, as they are the main aim of HE.

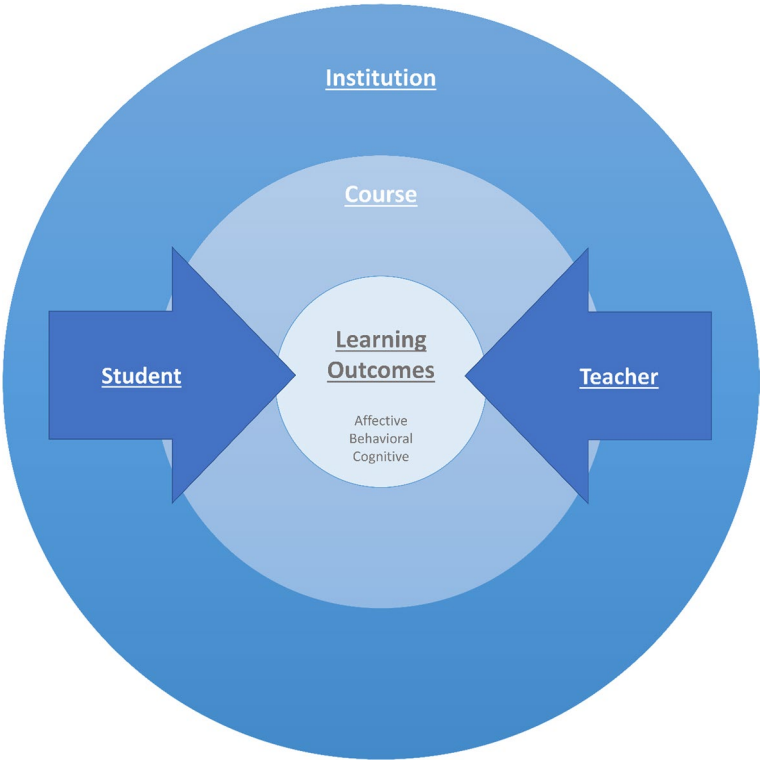


Fig. 1 Four levels that affect the effectiveness of online higher education

In HE, these learning outcomes are mainly pursued in course-structured curricula, making course factors (e.g., course structure and assessment) central for effectively achieving these outcomes. Whether and how effectively the intended outcomes are achieved within these courses depends on student and teacher factors, such as their (prior) knowledge, skills and beliefs. In turn, the institutional context can either enhance or mitigate course, student, and teacher factors. Institutional factors can be formal (e.g., student counselling, teacher professional development programs, and technological infrastructure) as well as informal (e.g., institutional culture and staff collegiality). The findings are presented in line with these four levels. Importantly, effectiveness is a term that is often used with various meanings in educational research (Reynolds et al., 2014). In this study, the term was adopted as it was originally used in the included studies, implying that the operationalization of effectiveness varied per included study, albeit generally in terms of affective, behavioral, or cognitive outcomes. Concerning affective outcomes, for example, effectiveness could pertain to satisfaction with online education as well as one's attitude towards online education. Similarly, effectiveness was assessed from the perspectives of students, teachers, or institutions, depending on the scope of the included studies.

It is also important to note that many of the factors identified throughout this study are relevant to all forms of education, not just online education. What differs, however, is the impact these factors have. For example, self-regulation proves to be a cardinal skill in online education for students and is more important than in on-site education (Broadbent & Poon, 2015). Similarly, collegial learning is a particularly important strategy for online teachers, since online teaching is new to many teachers and pedagogical strategies for online teaching are yet to be systematically described in teacher training materials (García-Martínez et al., 2022).

2 Methodology

2.1 Search Design

We collected peer-reviewed studies concerned with factors that contribute to effective online education in HE published between 2010 and 2022. The search was conducted in February 2023 on *Web of Science* (Appendix A shows the search string and parameters used, and also indicates what synonyms for online education were included). Web of Science was chosen for its reputable comprehensiveness with respect to indexing social sciences research and its practical filters. An exploratory search in other search engines (e.g., Scopus and Google Scholar) did not suggest that using only Web of Science generated a significant bias in our results. To keep the number of hits manageable, the search was limited to English-language studies within the research categories "education educational research" or "education scientific disciplines".

2.2 Selection Process and Criteria

Figure 2 depicts the data reduction process, which was aligned with the PRISMA statement on how to conduct and report systematic reviews (Moher et al., 2009). The initial search resulted in 4911 hits. The search was then refined to reviews and meta-analyses only: a meta-review. This approach allowed for efficient identification and analysis of the most prominent research insights and current debates on the topic of effective online education.

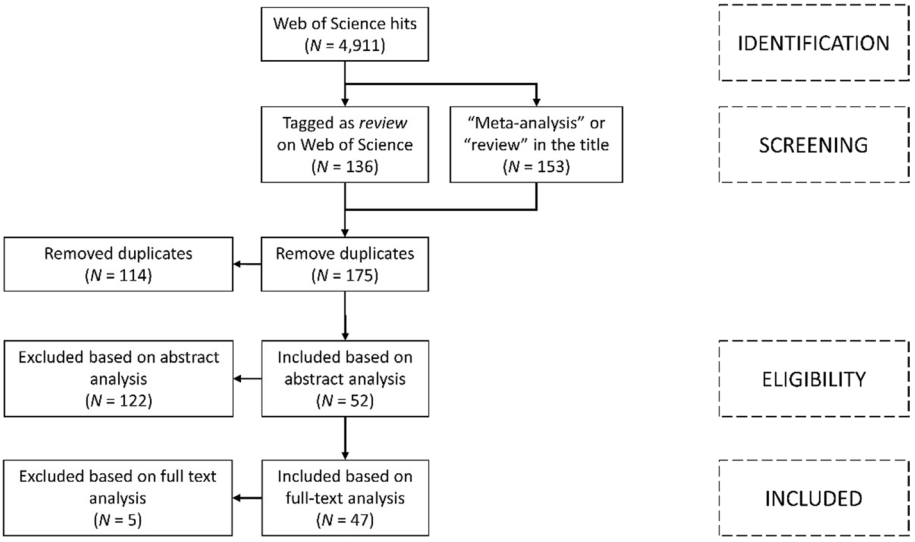


Fig. 2 PRISMA flow diagram of the data reduction process

Moreover, this approach yielded a synthesis of both qualitative and quantitative findings, where the qualitative findings were, broadly speaking, represented by the included literature reviews and the quantitative findings by meta-analyses. All studies that were classified as a "Review" on Web of Science ($n = 136$) were included for abstract screening, as well as studies with either "review" or "meta-analysis" in the title ($n = 153$). After removing duplicates, 175 studies were eligible for abstract screening.

Next, for each study, the first two authors screened all abstracts based on the following inclusion criteria: the study (a) is a review or meta-analysis; (b) reports outcomes related to online education in HE; and (c) discusses factors that contribute to, or impede, attaining these outcomes. Studies with a COVID-specific focus (i.e., related only to emergency remote education) were excluded. Based on the abstract, 52 articles met the criteria, but five articles were excluded after full-text analysis per the same criteria, resulting in a final sample of 47 included reviews and meta-analyses.

2.3 Data Coding

All articles were coded in Atlas.ti by the first two authors. To identify the factors that contribute to effective online education, a codebook (see Appendix B) was created deductively using the conceptual framework and subsequently inductively refined following the initial data analyses. Subcodes were created for all four groups of factors. For example, the subcode "instructional resources" (e.g., use of tools) was one of the course factors; "cognitive skills" (e.g., digital literacy) was one of the student factors; "affective characteristics" (e.g., attitude towards online teaching) was one of the teacher factors; and "structural institutional factors" (e.g., ICT support) was one of the institutional factors. In addition, general information was coded pertaining to: (1) background information (e.g., author(s), title, year, journal); (2) the reported definition or description of online education and how effectiveness was operationalized; (3) methodological characteristics of the study (e.g., research

questions, method, sampling details); and 4) the main findings and overall conclusion of the study.

Each of the first two authors coded half of the sample. To ensure intercoder agreement, the full text of 10% of the included studies was double-coded and discrepancies were discussed until agreement was reached. When in doubt, regular meetings were held among all authors to discuss the coding and analysis for all included studies. No generative artificial intelligence was used during the coding process.

2.4 Data Analysis

Based on the codebook, quotes were extracted from the studies and analyzed by one of the main authors. For each level (i.e., course, student, teacher, and institution), narratives were written by identifying emerging themes, which were extensively discussed among all authors.

3 Results

First, general characteristics of the included studies are presented, after which the main themes that emerged across the selected studies pertaining to the factors on the course, student, teacher, and institutional level, respectively. To increase readability, only the studies that most extensively discuss the topic are referenced, rather than all studies that discuss that particular topic. The discussion includes an overarching reflection across all levels.

3.1 Characteristics of the Included Studies

The characteristics of the included studies are described in Table 1. The sample consisted of 27 systematic reviews, nine literature reviews, seven meta-analyses, two scoping reviews, and two combinations of a systematic review and meta-analysis. Thirty-one studies focused only on online education, six only on blended education, and 10 on both online and blended. On average, the studies synthesized 50 publications, with a range from 12 to 228.

Most studies assessed the effectiveness of online education by examining affective (e.g., motivation, $n=21$), behavioral (e.g., dropout rates, $n=12$), and cognitive (e.g., achievement, $n=26$) outcomes. Sixteen studies (also) focused on other outcomes (e.g., cost-effectiveness or teacher networking). The vast majority of the studies concerned the effectiveness of online HE with respect to student outcomes, as opposed to only a few studies primarily examining teacher or institutional outcomes.

3.2 Course Factors

The included studies suggest that well-designed and clear online courses result in high student satisfaction (Martin & Bolliger, 2022; Muljana & Luo, 2019), high achievement (Castro & Tumibay, 2021; Cheng et al., 2019), and low dropout rates (Delnoij et al., 2020; Ng, 2019). Four themes were identified related to how course factors contribute to effective online education: (1) a clear course structure; (2) challenging, authentic, and inclusive

Table 1 Overview of the included review studies and meta-analyses (in alphabetical order of first author)

References	Review or meta-analysis	Online/blended	Main subject (all apply to higher education)	Out-comes[1]	Time span	N^2
Al-Samarraie (2019)	Scoping review	Online and blended	Videoconferencing systems	A, B, C	1995–2018	31
Anthonysamy (2020)	Systematic review	Blended	Self-regulation and non-academic outcomes in higher education blended learning environments	A, B, O	2005–2019	14
Awan (2021)	Systematic review	Online	Adoption of e-learning at HE institutions	A, O	2008–2020	15
Bernard (2014)	Meta-analysis	Blended	Blended learning and technology use	C	1990–2010	96
Broadbent (2015)	Systematic review	Online	Self-regulated learning strategies	C	2004–2014	12
Butler-Henderson (2020)	Systematic review	Online	Challenges and opportunities for online examinations	C, O	2009–2018	36
Castro (2021)	Literature review	Online	Efficacy of online learning courses	A, C	2000–2016	50
Cheng (2019)	Meta-analysis	Blended	Effects of flipped classroom instructional strategies	C	2000–2016	55
Chung (2022)	Systematic review	Online	Factors that are associated with online student performance	C	2009–2021	34
Cook (2010)	Systematic review and meta-analysis	Online	Instructional design in health education	A, B, C	2013–2016	50
Deacon et al., (2023)	Systematic review	Online	Implementation of educational technologies	O	2010–2020	47
Delnoij (2020)	Literature review	Online and blended	Non-completion of higher online education	B	1990–2008	16
Eggers (2021)	Systematic review	Blended	Self-regulation strategies in blended environments	A, C	2000–2019	21
Farley (2022)	Systematic review	Online	Online education from an equity perspective	A, B, C	N/A	29
Fermín González (2019)	Systematic review	Online	Virtual education, inclusion, and diversity	O	2007–2017	89
García-Martínez et al. (2022)	Systematic review	Online	Networking for online teacher collaboration	O	2009–2019	16
Gegenfurtner (2019)	Systematic review and meta-analysis	Online and blended	Webinars and student achievement	C	–2018	12
Gikandi et al., (2011)	Systematic review	Online and blended	Online formative assessment	C	2000–2010	18
Hachey (2022)	Systematic review	Online	Prediction of enrollment, retention, and success in online learning	B, C	2010–2021	84
Hehir et al., 2021	Systematic review	Online and blended	Student connectedness in remote learning	A	1999–2020	17
Holden (2021)	Literature review	Online	Integrity in online assessment	O	N/A	–
Katsarou (2021)	Systematic review	Online and blended	Learner-centered interaction in online learning	A, C	2010–2019	22

Table 1 (continued)

References	Review or meta-analysis	Online/blended	Main subject (all apply to higher education)	Out-comes[1]	Time span	N^2
Kim (2020)	Systematic review	Online	Adoption of Community of Inquiry framework in online education research	C	2009–2019	23
Liu (2020)	Systematic review	Online	Academics' adoption of learning technologies	O	1982–2018	131
Margulieux (2016)	(Content) meta-analysis	Blended	A taxonomy to define courses that mix face-to-face and online learning	O	2000–2015	49
Martin (2022)	Systematic review	Online	Online learner satisfaction framework	A	2010–2019	98
Means (2013)	Meta-analysis	Online and blended	Effectiveness of online and blended learning	C	1996–2008	45
Mikić (2022)	Systematic review	Online	Personalisation methods in e-learning	O	–2021	228
Money (2019)	Literature review	Online	Student population differences and effective online education	C	2009–2019	36
Muljana (2019)	Systematic review	Online	Student retention in online learning	B	2010–2018	40
Ng (2019)	Literature review	Online	Motivational research in the journal Distance Education	A	1980–2019	74
O'Donnell (2015)	Literature review	Online	Personalised E-learning	O	N/A	–
Ogunyemi (2022)	Systematic review	Online	Learner engagement in Massive Open Online Courses	A, B	2013–2020	83
Philipsen (2019)	Systematic review	Online and blended	Teacher professional development for online and blended learning	A, C	2004–2015	15
Regmi (2020)	Systematic review	Online and blended	E-learning in health sciences education	A, B, C	1980–2019	24
Rodrigues (2019)	Systematic review	Online	Research on e-learning	A, B, C	2010–2019	99
Rowe (2019)	Systematic review	Online	Open online courses in health professions education	A, B, O	–2019	54
Stevens (2021)	Meta-analysis	Online	Efficacy of face-to-face and online university teaching methods	A, C, O	2000–2020	91
Sun (2016)	Literature review	Online and blended	Effective practices in online education	A, C	–2016	47
Thomas (2019)	Literature review	Online	Facilitation of online groups	O	N/A	–
Topping (2021)	Systematic review	Online	Digital peer assessment in teacher education	C	2000–2020	43

Table 1 (continued)

References	Review or meta-analysis	Online/blended	Main subject (all apply to higher education)	Out-comes[1]	Time span	N^2
Vo (2017)	Meta-analysis	Blended	Student performance in blended learning	C	2001–2015	40
Wang (2022)	Systematic review	Online	Learning engagement in Massive Open Online Courses	A, B, C	2015–2022	30
Wei (2021)	Systematic review	Online	Learning outcomes in Massive Open Online Courses	A, B, C	2017–2019	65
Yadav (2017)	Literature review	Online	Internet-based learning	A	2005–2017	27
Yunusa (2021)	Scoping review	Online	Critical predictive factors in e-learning environments	A	2000–2019	53
Zhao (2021)	Meta-analysis	Online	Cultural differences and e-learning adoption	O	2004–2017	45

[1] Indicates the type(s) of outcome(s) the study (primarily) addresses: A = affective; B = behavioural; C = cognitive; O = other

[2] N = number of included publications in the review or meta-analysis

learning activities and content; (3) facilitation of high-quality online (social) interaction; and 4) online assessment formats.

3.2.1 A Clear Course Structure

Effective online education requires more than transferring existing face-to-face courses to an online setting. While a clear course structure is important for all types of education, the structure becomes extra important in online settings because there is less room for instantaneous "on-the-fly" adjustments (Castro & Tumibay, 2021; Money & Dean, 2019). Online education requires students to learn in a more self-regulated way than in face-to-face education, and they therefore have to know where to find all relevant information (Kim & Gurvitch, 2020), either by having the information readily available or by knowing whom to contact (Anthonysamy et al., 2020; Castro & Tumibay, 2021). The analysis suggests that a clear, well-designed online course structure consists of a prespecified set of learning activities, a logical format for instructional materials, a realistic course timeline, communication protocols, and clear assessment criteria. Further, in a literature review on the use of internet-based tools in HE, Yadav et al. (2017) advised explicitly formulating a "netiquette" guideline that states what kind of online contributions are expected of students, as well as what students can expect in terms of student–teacher interaction (see also Katsarou & Chatzipanagiotou, 2021). Clear mutual expectations help to avoid frustrations and increase motivation (Farley & Burbules, 2022; Muljana & Luo, 2019).

3.2.2 Challenging, Authentic, and Inclusive Learning Activities and Content

Several reviews identified the need for *challenging*, high-quality online content to enhance students' engagement with the material (e.g., Castro & Tumibay, 2021; Rodrigues et al., 2019). The quality of the content is an important predictor of student outcomes (Cook et al., 2010; Katsarou & Chatzipanagiotou, 2021; Yunusa & Umar, 2021). Scaffolding techniques promote engagement because the material can be adapted to individual needs to make them challenging but not too challenging. Scaffolding can be done by either teachers themselves (Muljana & Luo, 2019) or through personalized e-learning systems (Mikić et al., 2022; O'Donnell et al., 2015). Using game-based learning activities can be an effective way to promote online students' engagement through challenging assignments (Wang et al., 2022).

Effective online education can also be promoted through *authentic* learning experiences. Students who feel that the learning activities are relevant and meaningful to their postgraduate career are more engaged (Ng, 2019; Sun & Chen, 2016), which leads to favorable cognitive (Rodrigues et al., 2019) and behavioral (Muljana & Luo, 2019) outcomes. This can be accomplished through, for example, technology-based environments that resemble real-life settings (Rodrigues et al., 2019), assessments that focus on skills and knowledge that transfer to situations outside the classroom (Gikandi et al., 2011), and learning systems that offer personalized content aligned with students' interests (Mikić et al., 2022).

Further, considering that students have different needs and expectations, online learning environments have to be *inclusive* (Fermín-González, 2019; Zhao et al., 2021), particularly when online courses attract a diverse student population. An effective learning space is one that is sensitive to cultural diversity (Farley & Burbules, 2022; O'Donnell et al., 2015; Regmi & Jones, 2020; Zhao & Frank, 2003) and, preferably, diversity in its broadest sense (Fermín-González, 2019). An online learning environment that appeals to a diverse student

population leads to favorable learning outcomes (O'Donnell et al., 2015; Stevens et al., 2021), whereas courses that inadequately address cultural diversity limit students' sense of belonging and lead to lower performance (Farley & Burbules, 2022).

3.2.3 Facilitating High-Quality Online (Social) Interaction

High-quality online (social) interaction is related to high engagement (Ng, 2019; Ogunyemi et al., 2022), high performance (Wei et al., 2021), and a positive overall learning experience (Katsarou & Chatzipanagiotou, 2021; Sun & Chen, 2016). By contrast, student dropout is often related to a poor sense of community due to a lack of interaction with their peers, feelings of isolation, and inadequate support (Farley & Burbules, 2022; Muljana & Luo, 2019).

Many reviews highlighted the importance of student collaboration to foster student interaction (e.g., Fermín-González, 2019; Money & Dean, 2019; Ng, 2019; Rodrigues et al., 2019; Sun & Chen, 2016). Collaboration promotes student connectedness (Hehir et al., 2021), increases performance and satisfaction (Thomas & Thorpe, 2019), and helps students to take more ownership over their learning process through collaborative learning (Regmi & Jones, 2020; Wang et al., 2022). Similarly, peer assessment may contribute to online learning as well (Topping, 2021). Teachers do need to closely monitor interaction between peers, since its effectiveness strongly depends on the efforts of all students (Muljana & Luo, 2019).

Another aspect to consider is whether online interaction is best facilitated synchronously or asynchronously. Synchronous interaction (e.g., via videoconferencing) can facilitate direct, real-time exchanges, but calls for strict moderating to keep the conversation comprehensible and often comes with technological difficulties (Al-Samarraie, 2019). Conversely, asynchronous interaction allows participants to respond at their convenience, but that makes the conversation more time-consuming. Effective asynchronous interaction can be facilitated through tools such as blogs, wikis, and social media platforms (Ogunyemi et al., 2022; Yadav et al., 2017). Gegenfurtner and Ebner (2019) found that synchronous interaction resulted in marginally higher student achievement than asynchronous or offline interaction, but Means et al. (2013) found no performance difference regarding synchronous or asynchronous interaction in a blended environment. Importantly, neither form of interaction is inherently favored over the other, and choosing between them should be done in accordance with the intended goal of the interaction (Farley & Burbules, 2022; Regmi & Jones, 2020; Sun & Chen, 2016).

3.2.4 Online Assessment Formats

Overall, student performance does not differ across online or on-site types of assessment (Butler-Henderson & Crawford, 2020); both are most effective if the outline and quality of the feedback helps students to further self-regulate their learning (Ogunyemi et al., 2022; Vo et al., 2017), if students have to call upon their (meta)cognitive skills (Ng, 2019), and if they are encouraging for students and transferable to contexts outside of the university (Gikandi et al., 2011). Online assessments differ, however, with respect to *how* students are assessed. The majority of students prefer online assessments over paper exams because of the ease of editing responses, and they find online assessments more trustworthy, although some report anxiety related to online assessment, such as fear of technical issues and unease with "proctoring" software (Butler-Henderson & Crawford, 2020).

Further, the empirical evidence is inconclusive as to whether cheating rates are higher for online assessment compared to on-site assessment, but it is often perceived to be easier to cheat during online assessment (Holden et al., 2021). This issue may be mitigated by using, among other things, identity verification and tracking software, personalized assessment, and invigilated assessment formats (Butler-Henderson & Crawford, 2020; Holden et al., 2021; Mikić et al., 2022).

Irrespective of attempts to mitigate cheating, using multiple assessment formats is a good practice because different types of learning outcomes require different assessment methods (Wei et al., 2021). For example, quizzes can be used to test factual knowledge, essays to test conceptual understanding, and oral exams to test metacognitive knowledge (Butler-Henderson & Crawford, 2020). Furthermore, summative assessment helps to assess students' current capabilities, whereas formative assessment provides insight into students' learning progress and generates feedback for improvement (Rowe et al., 2019; Wei et al., 2021).

3.3 Student Factors

The key findings related to student factors can be categorized into three main themes: background characteristics, cognitive and meta-cognitive skills, and affective attributes.

3.3.1 Student Background

Students' background characteristics predict their performance, satisfaction and retention rates (Hachey et al., 2022; Martin & Bolliger, 2022). For example, academic background is positively related to achievement (Money & Dean, 2019; Rodrigues et al., 2019) and completion rates (Delnoij et al., 2020; Muljana & Luo, 2019) in online education. Further, older students perform better than younger students and are less likely to drop out, while being employed and having a family status negatively affect performance and retention rates because students may prioritize work or family over educational duties (Chung et al., 2022; Farley & Burbules, 2022; Hachey et al., 2022). Personality traits also affect students' persistence and success in online learning (Chung et al., 2022; Ogunyemi et al., 2022).

3.3.2 Cognitive and Meta-Cognitive Skills

Students' learning outcomes are often defined by their cognitive and meta-cognitive skills (Anthonysamy et al., 2020; Broadbent & Poon, 2015; Muljana & Luo, 2019); in particular, self-regulation skills and digital literacy were frequently mentioned as important contributors to effective online education. *Self-regulation skills* (i.e., skills that allow students to self-direct their learning process) are particularly relevant for online students, as they are expected to work autonomously to a large extent. Students with high levels of self-regulation can positively impact their academic success by taking responsibility over their learning process through mindful planning, meaningful engagement with the material, and critical evaluation of their progress (Delnoij et al., 2020; Eggers et al., 2021; Ng, 2019; Regmi & Jones, 2020). Broadbent and Poon (2015) identified time management, critical thinking, metacognition, effort regulation, and peer learning as effective self-regulation strategies that increase students' performance. Anthonysamy et al. (2020) concluded that such self-regulation strategies also positively impact non-cognitive outcomes. In particular, peer learning was shown to be effective in online environments (see also Eggers et al., 2021),

arguably because peers become an essential source of assistance when student–teacher interaction is limited (Stevens et al., 2021). Thomas and Thorpe (2019) suggested peer-facilitated online groups as an effective way to promote self-regulated learning.

In addition, high levels of *digital literacy* (i.e., one's familiarity and confidence with accessing, using, and interacting via online environments) are positively related to performance and satisfaction with online education (Awan et al., 2021; Yunusa & Umar, 2021). By contrast, difficulties with technology use impede students' satisfaction with online education and lead to disengaged students (Hehir et al., 2021). Even though most students are accustomed to using digital environments nowadays, it should not be assumed that all students are able to use these environments effectively (Castro & Tumibay, 2021; Delnoij et al., 2020; Money & Dean, 2019; Muljana & Luo, 2019; Regmi & Jones, 2020).

3.3.3 Affective Attributes

Nearly all studies addressed the relation between the effectiveness of online education and students' affective attributes; that is, their attitudes, beliefs, and motivation regarding online learning in general or regarding particular programs, courses, instructors, and other students. Students' motivation to learn in an online setting affects their performance (Castro & Tumibay, 2021; Money & Dean, 2019) and persistence in continuing with an online course (Delnoij et al., 2020; Muljana & Luo, 2019). The personal confidence and self-belief of online students that they will achieve the expected outcomes (i.e., academic self-efficacy) is even more important in online education than in on-site education, and has been consistently positively linked to performance, satisfaction, perceived learning, and course completion (Delnoij et al., 2020; Farley & Burbules, 2022; Wang et al., 2022; Zhao et al., 2021).

Next to students' self-confidence, their motivation is also affected by their attitude towards online ways of learning and technology and their usefulness (Chung et al., 2022; Muljana & Luo, 2019; Rodrigues et al., 2019; Zhao et al., 2021). According to the review by Ng (2019), students with an internal locus of control (i.e., who feel that their own actions are responsible for their academic outcomes) tend to have higher motivation, be more self-regulated, and are less likely to drop out of online courses than students with an external locus of control (see also Delnoij et al., 2020; Money & Dean, 2019; Muljana & Luo, 2019). Delnoij et al. (2020) suggested that students' ability to adapt to new academic environments affects their motivation and persistence; students who (partially) transition to online learning environments are required to adapt to new forms of learning and must thus possess the adaptability skills to successfully make this transition (Rodrigues et al., 2019).

3.4 Teacher Factors

Two key themes associated with effective online teaching were identified: online teaching competencies and teacher professional development.

3.4.1 Online Teaching Competencies

The interaction between teachers, students, and the material changes in online education, requiring teachers to develop a set of competencies that is specific to online teaching (Farley & Burbules, 2022). Four domains of teacher knowledge and skills were identified that are particularly relevant to online teaching. First, teachers need to have good *interpersonal*

skills (Ng, 2019; Thomas & Thorpe, 2019). Thomas and Thorpe (2019) characterized effective online teachers as people-oriented, emphatic, having a desire to reach out to students, and being able to bridge communication gaps through deep listening and careful communication (see also Hehir et al., 2021). Second, when teaching online, teachers need to think about the structure and organization of courses in advance and to be explicit about their planning, which requires good *organizational skills*. In this regard, a well-organized course is one with clear guidelines in which the teacher communicates the information students need to successfully complete the course in a timely way. Third, in a review on personalized e-learning, O'Donnell et al. (2015) argued that effective online teachers should not only be proficient in technology use, but also need to know how to use these tools effectively to support meaningful learning, which is also referred to as *technological pedagogical content knowledge* (TPACK) skills (see also Koehler et al., 2013). Finally, some studies suggested that effective online teachers need to be able to flexibly cope with technical issues and adjust to new forms of digital communication and interaction (Rodrigues et al., 2019; Sun & Chen, 2016).

3.4.2 Teacher Professional Development for Online Education

Professional development opportunities should be directly relevant to teachers and address their needs concerning instructional design, online teaching strategies and technology use (Muljana & Luo, 2019; Sun & Chen, 2016; Thomas & Thorpe, 2019). Teachers should preferably have the opportunity to reflect on their role and gain first-hand experience in how to transfer the professional development experiences into their own teaching practice (Philipsen et al., 2019). Professional development programs should offer the opportunity to learn how to identify online students' needs and how to (re)design courses that address these diverse needs (Fermín-González, 2019; Muljana & Luo, 2019; O'Donnell et al., 2015). Professional development should also address how to effectively design and assess online courses, including using effective teaching strategies to promote online student collaboration, setting high expectations, and facilitating meaningful interaction (Sun & Chen, 2016; Thomas & Thorpe, 2019). In addition, Thomas and Thorpe (2019) argued that it is important for online teachers to develop the pedagogical awareness required to choose the appropriate learning methods based on their knowledge of (online) learning theories.

Further, as technology use is central to online teaching, teachers need adequate training in the technologies applicable to online teaching, and on how to troubleshoot technical problems when they arise (Deacon et al., 2023; Sun & Chen, 2016). A lack of basic technology skills has been commonly identified as a barrier to technology adoption (Liu et al., 2020); some teachers have concerns about using new technologies out of fear that they might fail and appear unprofessional (O'Donnell et al., 2015), or worry that students will be more adept with those technologies (Rodrigues et al., 2019). Moreover, teachers should also know how to use these tools *effectively,* meaning that they need to know how these technologies assist students to achieve the intended learning outcomes (O'Donnell et al., 2015). Teachers are more likely to adopt technologies when they believe these technologies will help them to analyze their courses for example, to increase student engagement (Wei et al., 2021), or when the technologies enable students to learn new skills, prepare for future careers, or encourage collaboration (Deacon et al., 2023; Liu et al., 2020).

Next to formal teacher professional development, more informal forms of collaborative learning which can occur online are advantageous as well. García-Martínez et al. (2022) highlighted that teachers who collaborate online (e.g., via forums, wiki-based platforms,

and virtual environments) improve their practice, develop trust in each other, and improve their professional performance, yet many teachers are reluctant to use existing opportunities for online collaboration. Teachers' involvement in (online) collaboration spaces can be promoted by scheduling regular meetings, funding the creation and use of online collaboration spaces, and offering training on how to use digital technology for collaboration purposes (García-Martínez et al., 2022).

3.5 Institutional Factors

Institutional factors may benefit or hinder effective online education (Delnoij et al., 2020; Ng, 2019; Regmi & Jones, 2020). Three key emerging themes were: an institution-wide vision on online education, providing adequate technological infrastructure, and offering support to students and teachers.

3.5.1 Institution-Wide Vision on Online Education

An institution-wide vision on online education assists in converging all initiatives towards a single goal and helps to unite stakeholders (Deacon et al., 2023). Effective implementation of this vision hinges on the extent to which staff members and students get involved in and accept these new ways of education (Awan et al., 2021; Castro & Tumibay, 2021; Deacon et al., 2023). Smooth adoption of online education is promoted by involving what are termed "referential leaders" (Deacon et al., 2023, p. 449), who consider the context in which online education is implemented and address specific disciplinary and pedagogical needs (Liu et al., 2020). Early involvement of teachers and students in the preparatory and implementation phases ensures that their expertise and understanding of the adoption context is incorporated, which, in turn, positively influences teachers' and students' attitude towards these new forms of education (Castro & Tumibay, 2021; Delnoij et al., 2020; Liu et al., 2020; Money & Dean, 2019).

3.5.2 Providing Adequate Technological Infrastructure

The available technological infrastructure, by and large, strongly affects whether teachers and students are willing and able to use the tools needed for effective online education (Bernard et al., 2014; Castro & Tumibay, 2021; Deacon et al., 2023; Regmi & Jones, 2020). Institutions thus need to consider what technologies and tools are needed to optimally support online learning. For example, resource sequencing can create individual learner paths, artificial intelligence can be used for adaptive feedback, and learning analytics can provide data-driven insights into students' learning progress (Mikić et al., 2022; O'Donnell et al., 2015). The amount of time students spend in learning management systems positively predicts performance (Chung et al., 2022). By contrast, technical issues (e.g., bandwidth issues and malfunctioning microphones and cameras) negatively impact the learning experience and make teachers and students less inclined to use new technologies (Awan et al., 2021). Such issues cannot always be obviated, but it is important that institutions aim to minimize (technical) issues by providing adequate technological infrastructure and sufficient support.

3.5.3 Student and Teacher Support

Accommodating institutional support that assists in effectively integrating online education positively impacts learning outcomes (Awan et al., 2021; Muljana & Luo, 2019; Ng, 2019; Regmi & Jones, 2020; Yunusa & Umar, 2021). Institutions can (and should) offer several types of support in order to address the needs of teachers and students related to the introduction of new technologies and new ways of education (Awan et al., 2021; Liu et al., 2020).

For students, offering institutional support is positively related to students' satisfaction (Martin & Bolliger, 2022) and retention rates (Delnoij et al., 2020). Institutions can set up student support programs by means of workshops, tutoring, remedial teaching, peer mentoring, motivational support, student support services, and technological support (Delnoij et al., 2020; Farley & Burbules, 2022; Money & Dean, 2019; Muljana & Luo, 2019). Online learning communities may be offered to enhance community-based motivation, where peer interaction may produce students who feel supported and develop a sense of belonging (Ng, 2019; Sun & Chen, 2016). Online peer groups can also alleviate the teachers' workload (Thomas & Thorpe, 2019). Student support programs can target the general population, or be tailored to specific groups by collecting relevant student data (e.g., through learning analytics or information from student councils) to identify and address the needs of these groups (O'Donnell et al., 2015; Wang et al., 2022), as in courses with high attrition rates (Muljana & Luo, 2019) or "at-risk" students (Delnoij et al., 2020; Money & Dean, 2019).

For teachers, it is important that institutions consider how teachers can best be supported to adopt new online forms of education (Awan et al., 2021; Sun & Chen, 2016). As discussed in Sect. 3.4.2, a teacher support structure may include professional development training, technical support, and facilitating collaboration. Another way to support teachers is by reducing teaching loads, for teachers to be able to make effective use of the support offered (Deacon et al., 2023).

4 Discussion

Research on online (forms of) education is rapidly expanding (Drysdale et al., 2013; Gao et al., 2022; Zhang et al., 2022), and the increase in publications on this topic further accelerated during the COVID-19 pandemic (Yavuz et al., 2021). In this meta-review, insights from reviews and meta-analyses were synthesized concerning factors that contribute to effective online education in HE at four levels: the course level, the student level, the teacher level, and the institutional level (see Fig. 3 for an overview).

At the *course* level, a clear course structure is crucial for effective online education. In online education, students are expected to learn more autonomously than in on-site education, and there is less room for teachers to make "on-the-fly" adjustments. Course developers thus need to consider how to structure the online activities and assessments and to explicitly formulate how these contribute to students' learning process. High-quality online interaction, whether synchronous or asynchronous, can be facilitated through meticulous course design and using netiquette guidelines to describe the kind of online interaction that is expected of students, as well as what students can expect of their teachers. At the *student* level, to learn effectively in an online setting requires students to have a positive attitude towards online education, high levels of self-regulation, and sufficient digital savviness to

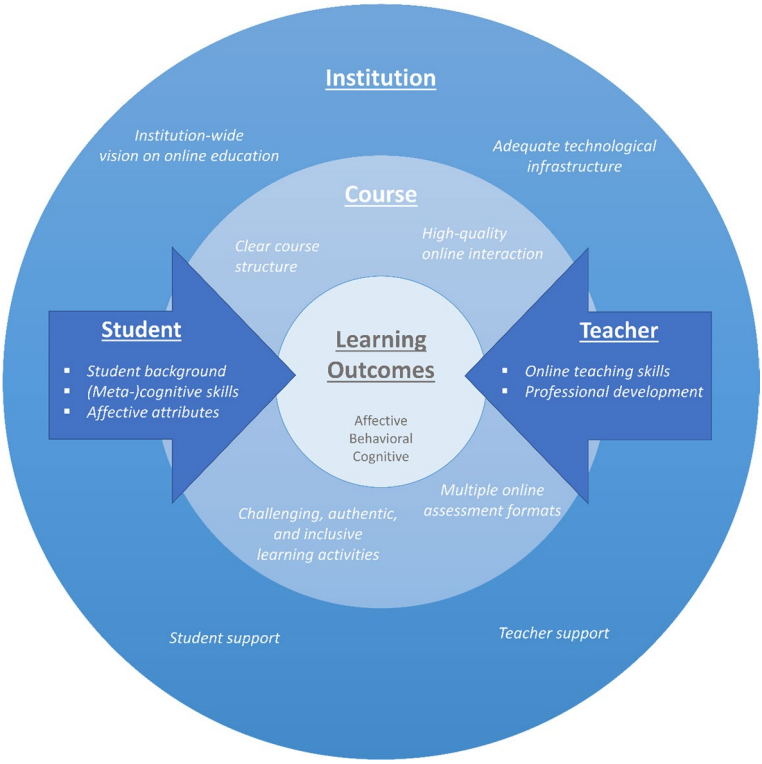


Fig. 3 Factors that contribute to effective online higher education

be able to use the provided tools effectively. At the *teacher* level, teachers need to possess teaching competences that are specific to online teaching (e.g., how to offer support remotely) and must believe in their own capabilities to teach online, both of which call for external support and professional development via formal training programs or informal learning communities. At the *institutional* level, institutions set the right conditions for effective online education by having a vision on online education that helps to converge all stakeholders toward a shared goal (viz., effective online education), providing adequate technological infrastructure, and actively involving and supporting teachers and students in adopting online forms of education that are new to most of them.

It is important to bear in mind that all the factors described are interconnected on all levels. This study underscores the reality that effective online education requires taking a holistic approach that pays attention to all the identified factors simultaneously; even the most self-regulated student will struggle to thrive in a poorly designed online course, the best-designed online course will fail if students are ill-equipped to learn effectively in an online setting, and professional development programs will offer feeble support if teachers do not complete them. These considerations illustrate that although the factors were described sequentially at four different levels, they represent parallel, interdependent processes. All factors inherently impact the effectiveness of the other factors, and what works in a certain context may fail in others (Scherer et al., 2021). Therefore, to better understand the mechanisms behind effective online HE, in line with Bernard et al. (2014), more insight

is needed concerning the interaction between these factors and how this interaction affects learning outcomes.

For example, future research may focus on the set of online teaching competences needed to optimally promote students' self-regulation skills, or on what institutional policies are needed for teachers to acquire such a skill set.

If institutions wish to keep online education, more effort is required to (re)design online courses to make them effective; online forms of education warrant a new way of thinking about education, and insights derived from face-to-face settings may not directly transfer to online settings (Redmond, 2011). To contribute to a more evidence-informed knowledge base on effective online education, this meta-review contains insights from multiple perspectives that can be used to inform online course development, assist the improvement of online teaching practices, set up advantageous institutional conditions, and inspire future research.

4.1 Limitations and Recommendations

Focusing on reviews and meta-analyses allowed for an efficient synthesis of generic insights, but limited our access to more fine-grained insights. Given the nature of literature reviews and meta-analyses, for example, we were unable to discuss the pros and cons of specific tools or address more specific pedagogical questions, such as how to promote self-regulation in a diverse online student population (e.g., Littlejohn et al., 2016), design culturally sensitive courses (e.g., Kahu & Nelson, 2018), and set up effective online professional development programs (e.g., Lay et al., 2020). Readers are advised to look at the specific studies for such insights.

Another limitation pertains to the diversity of the sample. In line with previous findings (Halverson et al., 2014), most studies focused on course and student factors; only a few primarily focused on teacher or institutional factors. Consequently, much is still unknown about the relation between outcomes (i.e., affective, behavioral, and cognitive) and teacher factors (e.g., how teacher self-efficacy relates to online learning performance; Corry & Stella, 2018) or institutional factors (e.g., how the quality of support relates to students' online learning acceptance; Lee, 2010). This limitation may have originated from the search strategy, in that searching for studies on *effective* online education may have excluded reviews that did not directly frame teacher and institutional factors in terms of their *effect* on the outcomes examined in this meta-review. For example, there are reviews that emphasize the importance of TPACK skills (Rosenberg & Koehler, 2015; Tseng et al., 2022) and the institutional culture (Ndibalema, 2022), but they were not explicitly related to affective, behavioral, and cognitive outcomes. Future research may consider to use search parameters that would identify such reviews.

Further, our findings primarily reflect the pre-COVID knowledge base on online education. The research on online education would greatly benefit from systematic reviews of the studies that were conducted during the pandemic (Shankar et al., 2023). Analyzing experiences with online teaching and learning during the pandemic can provide valuable insights that may be used to further develop sustainable online teaching and learning strategies (van Dorresteijn, forthcoming).

Finally, another limitation derives from the conceptual ambiguity of what constitutes online education. Many included studies lacked an explicit definition of online education or used different terms (e.g., *distance education, web-based education, e-learning*) that can refer to online education, but can also refer to conceptually different types of education (Graham, 2006); for example, all online education is distance education, but not all

distance education is online. It is thus important to be mindful that this review provides general principles that can inform and guide online course design, but these insights need to be contextualized; there are numerous possible configurations of online settings, and what works in one setting may be less effective in others (Margulieux et al., 2016; Theelen & van Breukelen, 2022). To advance the knowledge base on online education with more fine-grained insights, it is important for future researchers provide clear and detailed descriptions of the online education context that is being studied.

5 Conclusion

Online education has been placed high on the agenda of many HE institutions following the COVID-19 pandemic. To move online education beyond the emergency remote education that was provided during the pandemic, dozens of reviews and meta-analyses have been conducted to establish an evidence-informed knowledge base on online learning and teaching. Our review suggests that effective online education in HE requires: (1) at the course level: a clear course structure; challenging, authentic, and inclusive learning activities and content; facilitation of high-quality online social interaction; and meaningful assessments; (2) at the student level: high self-regulation skills, sufficient digital literacy, and a positive attitude towards online learning; (3) at the teacher level: online teaching competences, professional development for online education, and (online) teacher collaboration; and (4) at the institutional level: involvement of students and teachers when implementing online education, adequate technological infrastructure, and robust support structures for teachers and students. Our findings also suggest that effective online education requires attention to these multiple factors simultaneously, rather than in isolation.

Appendix A

Search String

TOPIC: (“higher education” OR university).

AND

TOPIC: (“blend* learn*” OR “blend* teach*” OR “blend* course*” OR “blend* instructi*” OR “blend* educat*” OR “hybrid learn*” OR “hybrid teach*” OR “hybrid course*” OR “hybrid instructi*” OR “hybrid educat*” OR “online learn*” OR “online teach*” OR “online course*” OR “online instructi*” OR “online educat*” OR “distance learn*” OR “distance teach*” OR “distance course*” OR “distance instructi*” OR “distance educat*” OR “web-based learn*” OR “web-based teach*” OR “web-based course*” OR “web-based instructi*” OR “web-based educat*” OR “e-learning”).

AND

TOPIC: (effect* OR efficacy OR success*).

Appendix B

See Table 2.

Table 2 Codebook

Code	Definition	Example
A—general information		
A1—author(s)	Author(s) of the article	- M. Fermín González - J. Broadbent & W.L. Poon
A2—title	Title of the article	- Factors contributing to student retention in online learning and recommended strategies for improvement: A systematic literature review - A meta-analysis of blended learning and technology use in higher education: from the general to the applied
A3—year	Year of publication	- 2010 - 2017
A4—journal	Journal in which the article appeared	- Internet and Higher Education - Computer & Education
B—Definitions		
B1—definition of online and/or blended learning	How the study defines or operationalizes online and/or blended learning	- Blended Learning is the combination of face-to-face and online learning outside of class, where the latter does not exceed 50% of the course time. Face-to-face classroom time therefore can be greater than 50%. (Bernard et al., 2014, p. 94) - We operationally define the flipped classroom instructional strategy as students learning with instructional videos and supporting materials before class and then engaging in interactive and collaborative learning activities that facilitate them to understand, apply, analyze, evaluate, and create during class. (Cheng et al., 2019, p. 795)

Table 2 (continued)

Code	Definition	Example
B2—definition of effectiveness	How the study defines or operationalizes effectiveness	- What is the impact of blended learning on the achievement of higher education students in formal education settings? How do course demographic features moderate the overall effect size? How do various pedagogical factors moderate this effect? How do various interaction treatments modify the overall treatment effect? Is there a difference between no technology as control condition and some technology in the control condition? (Bernard et al., 2014, p. 93) - How effective are webinars in promoting student achievement? (…) - When students participate in a webinar-based learning environment, the effectiveness of webinars can be assessed in several ways. First, it can be assessed in terms of participants' development from pretest to posttest, measuring their relative increase in knowledge and skills. Second, webinar effectiveness can be assessed as the difference in achievement outcomes between webinar and control participants at posttest. Third, and arguably the most relevant for determining the effectiveness of webinars in promoting student achievement, we can compare how much webinar and control participants gained in knowledge and skills from pretest to posttest, taking into account their levels of prior knowledge before the intervention started. (…) The meta-analytic review reported here compares webinar effectiveness on all three levels. (Gegenfurtner & Ebner, 2019, p. 3)

Table 2 (continued)

Code	Definition	Example
B3—Outcomes	Which type(s) of outcome(s) are investigated in the study	- Cognitive ('what one knows or learns'): knowledge, self-regulatory skills - Affective ('what one feels or experiences'): satisfaction, motivation - Behavioral ('what one does'): retention, non-completion - Not mentioned
C—research characteristics		
C1—Research question or main aim	Main research question and/or the main aim of the research	- The aim of this review was to understand how students could best apply self-regulated learning strategies to achieve academic success within the online environment. (Broadbent & Poon, 2015, p. 2) - 1. What are the factors—within the aforementioned internal aspects of the open systems framework—that contribute toward student retention within the online learning environments? 2. What are the recommended strategies for improving student retention in online learning environments? (Muljana & Luo, 2019, p. 24)
C2—theory/framework	Specific theory or framework applied	- Community of inquiry framework - (Open) systems theory - Self-determination theory
C3—research method	Research method used	- Systematic literature review - Meta-analysis - Questionnaires
C4—population	The population investigated	- Empirical articles on student self-regulation between 2010–2020 - Teachers in nursing education at the University of Amsterdam

Table 2 (continued)

Code	Definition	Example
C5—sampling method	How the authors collected their sample. If a review or meta-analysis: keywords, databases, inclusion and exclusion criteria	- Only studies with random-assignment or controlled quasi-experimental designs have been included to draw on the best available evidence. (Means et al., 2013, p. 12) - The following data sources and search tools were used: (1) electronic research databases, including ERIC, PsycINFO, PubMed, ABI/INFORM, and UMI ProQuest Digital Dissertations. (Means et al., 2013, p. 13)
C6—sample size	Number of included articles	- 105 articles
C7—time span	Years included	- Published after 1990
D—Results		
D1—main conclusion	Overall conclusion	- The overall finding of the meta-analysis is that online learning (the combination of studies of purely online and of blended learning) on average produces stronger student learning outcomes than learning solely through face-to-face instruction. (Means et al., 2013, p. 29)
D2—limitations	Important limitations to consider when interpreting the outcomes	- In addition, meta-analyses of effectiveness studies provide only limited guidance for instructional design and implementation. (Means et al., 2013, p. 38) - Lastly, although this review demonstrates that some individual SRL strategies are related to academic performance, the underlying processes responsible for this association remain unclear. (Broadbent & Poon, 2015, p. 12)
D3—future research	Recommendations for future research	- Researchers and designers (and instructors) must carefully consider why these forms of activity and/or mediated setups are desirable, and more importantly, how they can better facilitate learning based on theory, so that they are powerful and replicable. (Bernard et al., 2014, p. 117)

Table 2 (continued)

Code	Definition	Example
D4—recommendations	General pragmatic/policy-oriented recommendations	- Since factors within the open systems of online learning are interrelated, we recommend a collective effort from multiple stakeholders when addressing retention issues in online learning. (Muljana & Luo, 2019, p. 20) - Lastly, we argue that increased peer learning should be prioritised in the context of online learning and that further research is needed to determine an appropriate measure of this strategy. (Broadbent & Poon, 2015, p. 13)
E—course factors (related to the design/structure/content of the course—e.g., length, ratio between online and face-to-face, number of students, instructional strategies, pedagogical approach, "course in action")		
E1—course factor (general)	General comments about course factors that are not further specified or discussed in the article	- Course design plays an important moderating role on the final learning experience and achievement of learning objectives. (Castro & Tumibay, 2021)
E2—course subject	Subject taught in the course	- Methodological course(s) - Domain-specific course(s) - Discipline(s) of included sample
E3—course characteristics	Course characteristics mentioned	- Group size - Type of course (lecture, seminar, etc.) - Ratio of online and face-to-face activities - Asynchronous or synchronous
E4—instructional resources	Instructional resources used	- Use of (online) tools - Ease of software navigation
E5—instructional and assessment strategies	Instructional and assessment strategies integrated within the course	- Use of learning setting - (Formal) formative/summative feedback - Teaching presence
E6—interactional dynamics	Role interaction plays in the course	- Type of interaction (e.g., student–student and student–teacher) - (Informal) instructor feedback - Communication channels

Table 2 (continued)

Code	Definition	Example
F—institutional factors (institutional support that is not directly course-related—e.g., teacher development programs, student workshops, organizational culture, technological infrastructure)		
F1—structural (formal) institutional factors	Formal structure that affects the effectiveness of the (blended) learning process	- Technical infrastructure - Technological (ICT) support - Teacher professional development programs - Student helpdesk
F2—cultural (informal) institutional factors	Informal structure that affects the effectiveness of the (blended) learning process	- Collegial learning - Institutional culture - Student peer support
G—Student factors (current knowledge, skills, attitudes and/or beliefs of students concerning (elements of) online education—partly directly shaped by the institutional factors)		
G1—background characteristics	Characteristics that only indirectly affect the effectiveness of blended learning	- Age, gender, etc - Cultural background - Financial situation
G2—cognitive skills	("First-order") skills that pertain to direct hands-on (perceived) knowledge and abilities	- Technological knowledge - Writing skills
G3—metacognitive skills	("Second-order") skills that pertain to an awareness and understanding of one's own thoughts and actions	- Self-regulatory skills - Critical thinking - Analytical abilities
G4—affective characteristics	Characteristics that pertain to one's feelings and emotions	- Motivation - Attitude towards online/blended education - Attitude towards technology (in class)
H—teacher factors (current knowledge, skills, attitudes and/or beliefs of teachers concerning (elements of) online education—partly directly shaped by the institutional factors)		
H1—background characteristics	Characteristics that only indirectly affect the effectiveness of blended learning	- Age, gender, etc - Cultural background - (Online/blended) teaching experience
H2—cognitive skills	('First-order') skills that pertain to direct hands-on knowledge and abilities	- Technological knowledge - Pedagogical content knowledge

Table 2 (continued)

Code	Definition	Example
H3—metacognitive skills	('Second-order') skills that pertain to an awareness and understanding of one's own thoughts and actions	- Self-regulatory skills - Critical thinking - Analytical abilities
H4—affective characteristics	Characteristics that pertain to one's feelings and emotions	- Motivation - Attitude towards online/blended education - Attitude towards technology (in class)

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Data Availability The data that support the findings of this study are available from the corresponding author, CvD, upon reasonable request.

Declarations

Conflict of interest None.

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