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Review Article

Comprehensively Summarizing What Distracts Students from Online Learning: A Literature Review

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As online learning becomes an indispensable component of the current education system, students benefit from the advantages of online education. At the same time, students are also facing more challenges during online learning. Multitasking, mind-wandering, and using digital devices are the extensively discussed types of distractions that detriment students' learning performance by impairing their focused attention. However, the consensus on the definition of distraction and what represents distraction during online learning are still lacking. This literature review develops a comprehensive definition of distraction, summarizes three main types of distraction (multitasking, mind-wandering, and using digital devices), and proposes two new types of distraction (unexpected interruption and consistent interference). Since the detrimental effects of distraction on online learning are salient, more explorations on helping students to resist distractions and maintain focused attention are imperative for future studies.

1. Introduction

With the rapid development of online education, the number of enrollments, online courses, and online degrees has increased dramatically since 2012 [1–3]. More traditional institutions, instructors, and students started to adopt online teaching and learning voluntarily because of the advantages of online education [4, 5]. In 2020, the National Council for State Authorization Reciprocity Agreements (NC-SARA) published the annual data report on distance education enrollment in all of the U.S. states (except California), which was provided by a total of 2,088 institutions [3]. This report shows that the average increase rate of enrollment from 2015 to 2018 is 37.34%, and the total online education enrollment increased by 7.5% in 2019. The data provided by National Center for Education Statistics (NCES) in 2020 also indicates that 37.2% of all enrolled postsecondary students took at least one online course in the fall of 2019. Similar results can also be found in Distance Education Enrollment Report 2017 and the report of Grade Increase 2018 [6, 7]. Both reports indicate

that public institutions' online enrollment has increased significantly in recent years.

At the same time, the Massive Open Online Courses (MOOCs) platforms also show significant increases in the number of both enrollments and online courses. The edX 2021 annual impact report indicates the total number of enrollments reached 110 million by the end of 2020. Compared to the total number of enrollments, which was only 115 thousand when edX went through its first year in 2012, the Compound Annual Growth Rate (CAGR) reached 135.82%, an extraordinarily high growth rate. Similarly, the Coursera 2021 annual impact report also shows that the total number of enrollments reached 189 million by the end of 2021 and achieved the CAGR of 48.7% from 2016 to 2021. Besides the increasing total number of enrollments, MOOCs platforms offer more online courses, certificates, credentials, and degrees, which tremendously benefits online learners seeking higher degrees [2].

The unexpected COVID-19 pandemic catalyzed the development and adoption of online education in all schools

and institutions in all countries [8]. During the pandemic, numerous scholars from different countries unavoidably paid more attention to online learning and were dedicated to solving the unprecedented challenges of online education [9–11]. Since online education can effectively counter the outbreak of infectious diseases by minimizing the close contact between teachers and students, it is important and necessary for all schools and institutions to be prepared to transiting to online teaching at any time, even the transition from traditional classes to emergency online format is not ideal [12, 13]. Therefore, expectedly, online education will remain as an important component of the current education system, and more students will experience online learning in the foreseeable future.

Online education has been successful in both traditional institutions and online MOOCs platforms. However, as online education gradually becomes an indispensable component of the current education system instead of a simple supplement or alternative to traditional education, more educators and students have started to realize the challenges of online teaching and learning [14–16]. For example, students are frequently distracted by smartphones during online learning because of lacking instructor-student interactions. Therefore, students need to acquire higher self-regulation skills for maintaining focused attention and resisting distractions during online learning [17].

Although distraction has become the biggest issue that interferes and even impairs students' attention, especially when students are engaging in online learning, the consensus on the definition or what distraction represents still has not been reached, which inevitably impedes scholars from conducting distraction-related research [18]. Currently, scholars have different understandings of distraction and what distraction represents. For example, both Blasiman et al. [14] and Schmidt [18] considered multitasking as the manifestation of distraction, whereas both Unsworth and McMillan [19] and Forster [20] assumed mind-wandering is the representation of distraction. Meanwhile, Flanigan et al. [21] perceived digital devices as the main source of distraction, while Rusz et al. [22] believed the occurrence of distraction is closely related to reward. Additionally, Dontre [23] discussed academic distraction, which mainly refers to digital device-caused media multitasking that overlaps between digital distraction and multitasking. Although the above studies are all closely related to distraction, their understanding of distraction still conflicts with each other.

This literature review has contributed to the field of distraction in the following claims. At first, this literature review resolved the conflict between various understandings of distraction by thoroughly summarizing different definitions of distraction and proposing a comprehensive definition of distraction. Secondly, this literature review proposed a theoretical framework of distraction, which contributed to the theoretical foundation of distraction. Thirdly, this literature review unprecedentedly categorized distraction into five main types based on empirical studies and theoretical foundations, which provides valuable guidance to the future studies. At last, this literature review also provided an effective approach to improve students' learning efficiency in online learning, which is minimizing the occurrence of five main types of distraction.

For advancing future distraction-related studies, resolving current conflicts, and improving the quality of online learning, this literature review will answer the following questions by comprehensively reviewing empirical literature:

(1) How is distraction defined?

(2) What are the types of distractions students experience during online learning?

(3) Why does studying distraction benefit online learning?

2. How Is Distraction Defined

Various definitions of attention have been recognized by scholars in the field and supported by numerous attention-related studies and many attention theories. However, the concept of distraction has not received much attention, whether in the field of cognitive psychology or the field of educational psychology, until recent years [24–27]. Especially since the distraction-based theory has not been developed, defining distraction becomes even harder. Therefore, for developing a comprehensive definition of distraction that can be applied in all contexts, it is necessary to begin synthesizing various definitions of distraction from different perspectives and then propose the definition.

After reviewing the literature, distraction has been clearly defined under three main perspectives: attention theory-based definition of distraction, driver distraction, and digital distraction [28–30]. The definitions of distraction from each perspective have been analyzed and summarized to develop a comprehensive definition of distraction.

2.1. Attention Theory-Based Distraction. Distraction-based theories are extremely limited compared to many widely recognized attention theories, which heavily impedes the understanding of distraction. Therefore, inferring from attention theory-based definitions of attention is indispensable for understanding the mechanism of distraction and developing a comprehensive definition. James et al. [31] indicated the close relationship between attention and distraction by considering distraction as the opposite of focalization and concentration. In other words, distraction is the opposite of attention.

One of the most foundational and representative theories of attention is Broadbent's filter model of attention, which largely explains the mechanism of attention [24]. Broadbent [24] proposed that people can receive unlimited information in parallel ways with no capacity limitation. But, due to the limited information processing capacity, people have to actively allocate their attention by deciding what they want to focus on and what they prefer to ignore. Broadbent [24] metaphorically visualized this process as information going through a filter that keeps relevant or needed information by filtering out irrelevant or unwanted information. Broadbent's model not only vividly demonstrated the mechanism of attention but also inspired the understanding of distraction. Therefore, many definitions of distraction can be perfectly explained by Broadbent's filter model of attention.

Schumm and Post [29] defined distraction as "diverted attention from a desired area of focus and thereby blocking or diminishing the reception of desired information," and Regan et al. [32] provided a similar definition of distraction as "a form of inattention that shifts attention away from the task at hand." Both definitions stressed the process of shifting attention, which is compatible with Broadbent's filter model because it mentioned that distraction occurs when task-irrelevant information is wrongly going through the filter and being processed [24]. Meanwhile, distraction has been defined by Smiley [33] as "misallocated attention," which can also be interpreted as wrongly focusing on irrelevant information. Gazzaley and Rosen [34] concisely defined distraction as "task-irrelevant information," which can be interpreted as a precise separation of distraction from attention based on Broadbent's attention theory.

2.2. Driver Distraction.

Driving is a daily activity that frequently encounters distractions. The National Highway Traffic Safety Administration (NHTSA) conducted several studies on driver inattention and concluded that approximately 25% of police-reported car crashes were caused by driver inattention [35]. Since driver distraction is considered the main form of driver inattention, many studies focus on exploring the mechanism of driver distraction, which is accompanied by the development of various definitions [36].

Treat [30] defined driver distraction as "the event, activity, object or person within or outside the vehicle induces the driver's shifting attention away from the driving task." Similarly, Streff [37] proposed that driver distraction can be defined as "a shift in attention away from stimuli critical to safe driving toward stimuli that are not related to safe driving." Binder et al. [38], the US-EU bilateral task force, concluded the definition of driver distraction as "the diversion of attention from activities critical for safe driving to a competing activity," which was adopted by the World Health Organization (WHO) in 2011 [39, 40]. All three definitions indicated that driver distraction basically represents driving-unrelated activities, which shares large similarities with task-irrelevant information that wrongly goes through the filter [24, 34]. Therefore, the definitions of driver distraction can largely be explained by Broadbent's filter model of attention.

Driver distraction is not limited to shifting attention away from the driving task. Young et al. [35] indicated that the reason why driver distraction occurs is failing to allocate sufficient attentional resources to the driving task and further defined driver distraction as "occurring when a driver's attention is, voluntarily or involuntarily, diverted away from the driving task by an event or object to the extent that the driver is no longer able to perform the driving task adequately or safely." This definition is compatible with Kahneman's capacity model, which stresses the limited capacity of attention and the dynamic allocation of attentional resources [41, 42].

Additionally, the International Organization for Standardization (ISO) provided a relatively official definition of driver distraction as "attention given to a non-driving-related activity, typically to the detriment of driving performance" [43]. Besides perceiving the driving-unrelated activities as driver distraction, this definition also mentioned the detrimental effect of driver distraction on driving performance, which brought the consequence of distraction as a component of the definition.

According to these different definitions of driver distraction, it is obvious that the theoretical foundation of these definitions is still attention theories. Especially the core concept of driver distraction is diverting attention away from the driving task, which is compatible with both Broadbent's and Kahneman's models [24, 41]. Therefore, understanding driver distraction can be generalized and contribute to developing a comprehensive definition of distraction, which can be applied to all circumstances instead of just driving.

2.3. Digital Distraction.

As entering the digital age, digital devices (e.g., smartphones, tablets, and laptops) have been increasingly perceived as one of the most important sources of distraction. Flanigan and Kim [28] edited the first book that explores the effect of digital distraction on current college classrooms and defined digital distraction as "the misuse of mobile technology for leisure purposes while attending to academic tasks inside or outside of the classroom." This definition specifically indicated that the occurrence of distraction is triggered by mobile technology for task-irrelevant purposes while learning, which is still largely compatible with Broadbent's filter model of attention because these irrelevant purposes are wrongly passing through the filter [24]. Meanwhile, this definition can also be interpreted as digital devices attracting students' attention from learning, which stresses the process of shifting attention from task.

2.4. Defining Distraction.

After reviewing all definitions of distraction from these three main perspectives, the commonalities and dissimilarities have been discovered. At first, regardless of the environment, most definitions of distraction defined distraction as shifting or diverting attention from the primary task to secondary tasks. For example, Schumm and Post [29] defined distraction as "diverted attention from a desired area of focus," and Streff [37] also mentioned, "a shift in attention away from stimuli critical to safe driving" as part of the definition. This commonality is largely compatible with Broadbent's filter model of attention that distraction occurs when task-irrelevant information is wrongly passed through the filter and processed [24]. Secondly, although distraction has been defined under both driving and learning scenarios, the fundamental understanding of the mechanism of distraction is the same. The process of distraction was considered "toward to stimuli that are not related to safe driving" by Streff [37], and Flanigan and Kim [28] considered this process "misusing mobile technology for leisure purposes during learning." Both definitions express that the process of distraction is the capture of attention by a task-irrelevant stimulus which can be a message notification, smartphone, or irrelevant thoughts. [44–47].

Besides the commonalities among definitions, many dissimilarities also exist. ISO [43] brought the detrimental consequences of distraction into consideration while developing the definition by mentioning the detrimental effect of non-driving-related activity on driving performance. Due to distractions impairing focused attention, poorer performance on the

task is expected [48, 49]. Another dissimilarity is that Flanigan and Kim [28] introduced that the occurrence of distraction can accompany completing other tasks, such as listening to a lecture while using social media applications, which brought more attention to the role of multitasking in the definition of distraction. Since multitasking is basically referring to switching attention between two or more tasks [50], experiencing multitasking inevitably also impairs focused attention and academic performance because of the task-switching cost [51, 52].

Although these commonalities and dissimilarities have been successfully extracted from provided definitions, current definitions neglected the circumstance that only part of attention was occupied consistently by the interferences: for example, consistently playing background music while learning or the consistent presence of a smartphone in sight while learning. A classic social experiment conducted by Przybylski and Weinstein [53] found that the presence of a smartphone can interfere with the formation of relationships in a face-to-face social setting, which was explained by Alter [54] as the presence of a smartphone consistently occupying part of participants' attention, even they had face-to-face interactions. This study supports that the presence of distractions can partially occupy the attention and the detrimental effect on performance is inevitable. Therefore, considering the occupation of partial attention as a component of distraction is indispensable.

In summary, the comprehensive definition of distraction needs to contain the mechanism, the consequent, and the state of attention. Therefore, this literature review defines distraction as "diverting attention from primary task to secondary task or paying partial attention to task-irrelevant information with negative effects on task performance."

3. What Are the Types of Distractions Students Experience during Online Learning

After defining distraction, exploring what are the types of distractions that distract students from learning is the next imperative question. As mentioned earlier, one of the current problems of distraction is that scholars have different understandings about distraction, which inevitably brings confusion and misunderstandings. For example, Blasiman et al. [14] explored the effects of six distractions (folding laundry, playing a computer video game, texting, etc.) on students' learning performance while taking online lectures. Although Blasiman et al. [14] indicated that multitasking is only one type of distraction, using multitasking and distraction equivalently still caused confusion. Differently, Unsworth and McMillan [19] believed that mind-wandering is the best representation of distraction. To resolve the conflicts between the various understandings of distraction, this section comprehensively summarizes the mechanisms and online learning-related findings of three main types of distraction, using digital devices, multitasking, and mind-wandering. Two additional types of distraction, unexpected interruption and consistent interference, have been proposed and discussed to explain the distractive circumstances, which are different from using digital devices, multitasking, or mind-wandering. But due to studies on these two types

of distraction being extremely limited, further explorations are still required to support this categorization.

3.1. Using Digital Devices. Since Flanigan and Kim [28] published the first academic book on digital distractions in college classrooms, the concept of digital distraction has started to attract more attention. Although digital distraction is a new term, the studies on digital distractions started more than a decade ago. Nowadays, more educators and professionals start to realize the detrimental effects of using digital devices on students' learning performance and feel powerless about the increasing number of students becoming highly dependent, even addicted, to digital devices [54–59]. As this situation becomes more severe and prevalent globally, it is extremely important for educators and students to know how using digital devices distract them from learning and how their learning performance has been negatively impacted.

Digital devices refer to electronic devices that can be used for leisure purposes [28]. Currently, smartphones, laptops, tablets, and game consoles are the mainstream digital devices, but with the development of technology, more attention has been brought to wearable digital devices. The prevalent smartwatch (e.g., Apple Watch, Samsung Galaxy Watch, and Fitbit) and upcoming smart glass (e.g., Google Glass) are perceived as wearable digital devices, distracting students from learning. But most studies still consider smartphones as the representation of digital devices because of their prevalence and functions [60, 61]. Therefore, this literature review will use smartphones to represent all kinds of digital devices to explore the mechanism of how using digital devices distract students from online learning.

Flanigan et al. [62] comprehensively explained the mechanism of digital distraction by summarizing three sources of digital distraction that students experience during class: motivational interference, environmental contributors, and person-centered contributors. Motivational interference was proposed by Fries and Dietz [63] to explain the phenomenon of motivation decrease due to the presence of temptations. Fries et al. [64] indicated that the presence of leisure alternatives distracts students from learning by reminding them what interesting activities they are missing. Since most modern leisure activities are closely related to digital devices (e.g., scrolling social media on smartphones and watching videos on a laptop), resisting the temptation of leisure activities is basically the same as resisting the temptation of using digital devices [65]. Flanigan et al. [62] also stressed the importance of paying attention to environmental contributors: boredom, class size, and observing classmates using their devices for off-task purposes. The environmental contributors tend to summarize what from the external environment evokes the tendency of digital distraction. Pettijohn et al. [66] found that 40% of the 200 undergraduate students use a digital device to entertain themselves when they feel bored during class. Meanwhile, Flanigan et al. [62] indicated that students are distracted by digital devices more frequently when they study in a classroom with large enrollments and when they observe their classmates use digital devices for off-task activities [67, 68]. The person-centered contributors explain why

students are attracted by digital devices based on their characteristics, which include habitual mobile technology use and self-regulation [62]. Habitually using digital devices predicts a more frequent occurrence of distraction in the classroom because students automatically generate thoughts closely related to using digital devices [69]. At the same time, poor self-regulation capability unavoidably leads to poorer performance in resisting distractions triggered by digital devices [70]. According to Pintrich [71], self-regulation learning is an active and effortful process for students to regulate and control their cognition, motivation, and behavior while engaging in learning. The failure of self-regulation leads to more frequent use of digital devices, incapability of maintaining focused attention, and procrastination, which predicts poorer performance on academic tasks [72].

Besides the three sources of digital distraction proposed by Flanigan et al. [62], frequently using digital devices for entertainment can also be explained by the concept of behavioral addiction [73]. Alter [54] summarized that one of the most important ingredients of behavioral addiction is irresistible and unpredictable positive feedback, which largely explains the mechanism of why using digital devices constantly attract students. Accessing whatever students want by simply using their digital devices is a typical pleasant experience, which can lead from average use of digital devices to overuse, even addiction [56]. Since addictive behaviors are reinforced by consistently receiving rewards, unrestrictedly using digital devices inevitably leads to addiction, motivating students to use digital devices and prolonging the time they spend on using digital devices. For example, TikTok is an extremely successful social media application, but it is also an addictive short video-sharing application because it provides unlimited interesting videos to people [74]. Since watching interesting videos is always a pleasant experience, people unconsciously spend tremendous time on TikTok by simply scrolling the screen [75].

Although Flanigan and Kim [28] mainly explored the influence of digital distraction in the traditional classroom context, the findings can also be generalized to online learning. Since online learning mainly occurs in bedrooms or dormitories fulfilled with more distractive temptations and that have no restrictions on using digital devices compared to traditional classrooms, online students are more heavily impacted by using digital devices and find it harder to maintain focused attention during online learning [76]. For example, online students can spend hours scrolling on social media until they want to stop. Teachers and instructors also take active actions to prevent students from using digital devices for course-unrelated purposes during face-to-face lectures. In contrast, no one will stop online students when they are learning online in their bedroom or dormitory. Therefore, using digital devices play an indispensable distractive role in online learning. Removing digital devices from students' sight during online learning would be an effective approach to maintain focused attention.

3.2. Multitasking. The prevalence of advanced digital devices leads to the increasing occurrence of multitasking [77]. Mokhtari et al. [78] collected a survey from 935 undergraduate college students to explore students' multitasking habits while they were learning. The result showed that most students performed two or more tasks simultaneously, such as watching TV while reading books or listening to music while reading books. Meanwhile, almost half of the students reported that they were aware of the detrimental effects and interferences from off-task activities. These findings directly reflected that multitasking has gradually become an integral part of students' learning processes, and students are becoming more vulnerable to resist the temptations of using digital devices [78]. Moreover, Bowman et al. [79] found that students need to spend more time on completing their primary learning task when multitasking, which indicates the occurrence of interference effect while multitasking [80]. Therefore, exploring the mechanism of multitasking is necessary to minimize the negative effects of multitasking and prevent multitasking-caused distractions.

Cole et al. [52] provided a concise and accurate definition of multitasking as "doing two or more than two tasks simultaneously in a specific period of time." But the problem with this definition is that it fails to explain the hidden mechanism of multitasking, which makes it hard to be applied in studies. Monsell [50] concluded that multitasking shifts attention from one task to another in rapid succession instead of concurrently paying attention to two tasks, which explained the mechanism of multitasking and represented its compatibility with Broadbent's filter model [24]. So, multitasking also refers to "switching attention" in mainstream studies [81].

Although multitasking was considered a valuable working skill during the early age of digital technologies [82], many studies later found the detrimental effects of multitasking on both online learning performance and task performance [52, 83–85]. Task-switching cost is further considered responsible for the detrimental effects [51, 86, 87]. Meiran et al. [86] suggested two explanations for task-switching costs: preparatory reconfiguration and task set inertia [50]. The preparatory reconfiguration represents a process of configuring tasks before performing the task. Task set inertia is considered a reflection of the interference raised from completing the prior task [88, 89]. Similarly, Rosen et al. [51] also discussed three key issues of task-switching cost, primary task completion, secondary task completion, and resumption lag, which share large similarities with the explanations provided by Meiran et al. [86]. Even though the task-switching cost can be reduced by extending preparation time or adding more external cues, these strategies are still relatively impractical, and the positive effects can only be found in the laboratory settings [90, 91]. Therefore, both theoretically and practically, multitasking inevitably predicts impaired attention and poorer task performance.

Reading is a commonplace activity for people from all age groups. However, due to the development of technology and the prevalence of digital devices, paying full attention to reading is becoming harder for people to achieve [78, 92]. Current studies have found that more people multitask using digital devices while reading, which greatly prolongs reading time and detriments reading comprehension [93–95]. Bowman et al. [79] conducted an experiment to explore the effect of

instant messaging (IM) on reading by assigning students to IM before reading, IM during reading, and no IM conditions. The result showed that students spent significantly longer time on reading the passage when they were using IM during reading. A comprehensive meta-analysis was conducted by Clinton-Lisell [93] to analyze the effect of multitasking on reading performance and reading time. The result found that multitasking during reading is detrimental to reading comprehension, especially when the time is limited. Meanwhile, this study also supported that multitasking significantly prolongs reading time. Similar results can be found by Fox et al. [96] and Subrahmanyam et al. [97].

Media multitasking is a subtype of multitasking that specifically involves the use of digital devices for accessing social media [98] and is defined by Xu et al. [99] as "the simultaneous pursuit of two or more largely independent tasks where at least one of those tasks involves media." The Mobile Fact Sheet published by the Pew research center reported that the American smartphone ownership rate continued to increase and reached 85% in 2021, indicating the increasing likelihood of media multitasking. As media multitasking becomes an inseparable component of daily life, learning while using digital devices inevitably becomes a prevalent behavior. Junco and Cotten [83] explored the relationship between multitasking and academic performance by collecting web survey data from 1839 college students. The result showed that using Facebook and texting while completing schoolwork negatively associated with overall college grade point average (GPA), which supported that media multitasking impairs students' academic performance by distracting their attention from schoolwork to social media. Similarly, Patterson [100] found that preparing for an exam while multitasking with digital media technologies predicts poorer performance in the following exam. Meanwhile, a meta-analysis was conducted by Jeong and Hwang [101] to summarize the overall effect of media multitasking on cognitive outcomes. The result indicated that engaging in media multitasking predicts poorer cognitive performance, such as reading comprehension, learning, or memorizing.

Students are heavily engaging in media multitasking during class as well. McCoy [61] reported that students spent 19.4% of class time using digital devices for nonclass purposes during lectures. Survey data collected from 986 respondents revealed that students spend considerable time on media multitasking during class. Spending more time on media multitasking inevitably leads to spending less time on focused learning and poorer performance on tests or GPA [102, 103]. Junco [104] also reported similar results that students frequently use digital devices for texting and accessing social media during class, which significantly contributes to the detrimental effects on overall semester GPA. Skiera et al. [105] specifically studied the relationship between accessing Facebook during class and academic performance. The result found that Facebook activities during class negatively related to academic performance. Duncan et al. [60] perceived using digital devices and media multitasking as distractions by discovering the significant negative correlation between in-class smartphone use and final course grade. Besides using digital devices to access social media, Kraushaar and Novak [106] pointed out that stu-

dents spent 42% of class time on non-course-related software applications via laptops during class.

Since multitasking significantly detriments both in-class and off-class learning performance, predictably, multitasking also negatively impact students' online learning performance. Blasiman et al. [14] explored the impact of multitasking on students' posttest performance in the online learning environment. This experiment randomly assigned students to two of six experimental conditions (folding laundry, playing a computer video game, texting on a cell phone, engaging in conversation, watching a low-arousal video, and watching a high-arousal video while learning from online lectures) after completing the controlled baseline condition. Students were required to complete a posttest after multitasking. The result showed that the posttest scores of six distraction conditions were worse than the controlled baseline condition between 15% and 30%, which directly reflected the negative impact of multitasking on online learning. Dindar and Akbulut [107] also reported that responding to chat messages while watching video lectures led to poorer content retention performance.

Although multitasking can be productive when the secondary task is relevant to the primary task [106, 108], overall, multitasking detriments students' performance heavily on academic tasks by switching attention between the primary task and the secondary task [51]. As online learning is increasingly prevalent, multitasking gradually becomes one of the main reasons distracting students from learning [14]. However, due to extremely limited studies on multitasking and online learning, further explorations are imperatively needed to discover productive multitasking that benefits online learning.

3.3. Mind-Wandering.

Mind-wandering is a ubiquitous human experience that occupies a considerable part of people's daily life. Smallwood and Schooler [109] summarized that people spend between 25% and 50% of their waking hours on thoughts unrelated to their primary tasks. Such findings indicate that people's task performance is impaired by mind-wandering, which is common to all people. Pachai et al. [110] introduced that the mind naturally wanders, which means maintaining focused attention and resisting mind-wandering is extremely hard to achieve. Although the impact of mind-wandering on learning has been extensively studied in traditional classroom settings, studies on mind-wandering and online learning are extremely limited [16].

According to Smallwood and Schooler [111], mind-wandering was a relatively new concept and is defined as "executive control shifts away from a primary task to the processing of personal goals." Smallwood and Schooler [109] further updated their definition of mind-wandering as "attention drifts from its current train of thought to mental content generated by the individual rather than cued by the environment." Both definitions revealed the mechanism of mind-wandering: shifting attention from a primary task to personal preferred thoughts. Since multitasking refers to switching attention back and forth between primary tasks and secondary tasks, theoretically, mind-wandering can be perceived as the secondary task that diverts attention from

a primary task to task-irrelevant thoughts, which is supported by McVay and Kane [112] as providing a concise definition of mind-wandering as "off-task thoughts during an ongoing task or activity."

The definitions of mind-wandering reflect large similarity and compatibility with the proposed definition of distraction since both include shifting attention from a primary task to a secondary task [109]. Gazzaley and Rosen [34] perceived mind-wandering as the representation of internal distraction, which supports that mind-wandering is an important type of distraction. Similarly, Shinar [39] also revealed the relationship between mind-wandering and distraction by purposing the concept of "cognitive distraction," which includes mind-wandering, inattention, and task-irrelevant thought.

Extensive studies have found the distractive and detrimental effects of mind-wandering on learning in the context of reading and lectures [110]. Schooler et al. [113] conducted an experiment to explore the effect of mind-wandering on reading comprehension by controlling the intermittent zone-out experience-sampling probe between two groups of participants. All participants were required to complete a forced-choice comprehension test, and the result showed that test score-based performance is negatively correlated with both the frequency of self-caught zone-outs and the probe-catch ratio. Since increasing the difficulty level leads to mind-wandering more frequently, comparing the performance of reading difficult texts and easy texts is an important approach to estimating the impact of mind-wandering on reading comprehension [110]. Feng et al. [114] assigned participants to read eight difficult or easy passages and reported the frequency of mind-wandering by using the probe-caught method. Reading comprehension performance was measured by scoring the answers to comprehension questions. The result showed that mind-wandering occurred more frequently when participants were reading difficult texts and supported the hypothesis that mind-wandering negatively influenced participants' reading comprehension. A similar study was conducted by Soemer et al. [115], which recruited 125 eighth-graders to read an easy, moderately difficult, or difficult text and to complete several comprehension questions afterwards. The result also revealed that reading difficult texts leads to more frequent mind-wandering and worse reading comprehension.

Besides the detrimental effects of mind-wandering on reading comprehension, studies found that mind-wandering also negatively impacts learning in lectures [110]. Lindquist and McLean [116] investigated the relationship between task-unrelated images and thoughts and academic performance by analyzing the scores of an after-class test. Results indicated a significant negative correlation between mind-wandering and academic performance. Meanwhile, Wammes et al. [117] also collected data from 154 undergraduate students throughout a 12-week course. They found that mind-wandering during lectures is associated with a significant performance cost, including short-term performance (e.g., in-class quiz score) and long-term performance (e.g., course final exam). Therefore, even for students who are studying in face-to-face lectures, mind-wandering still impairs their learning performance by diverting their attention from learning to course-unrelated thoughts.

Mind-wandering not only negatively influences learning performance in the context of reading and lectures but also in the context of online learning [16]. Since watching recorded lecture videos is still recognized as the most prevalent format of online education, especially for MOOCs, completing tests after watching recorded lectures is perceived as an effective simulation of online learning [118]. Risko et al. [119] recruited sixty undergraduate students to watch a 60-minute recorded lecture and complete a test afterward. Probe-caught method was applied to recording the frequency of mind-wandering. The results revealed that mind-wandering occurred more frequently in the second half of the lecture and the test performance was worse for the questions drawn from the second half of the lecture, which indicated that mind-wandering negatively impacted learning performance. Szpunar et al. [120] studied the influence of mind-wandering on learning from a different perspective. Unlike investigating how more frequent mind-wandering impacts learning performance, they chose to reduce the frequency of mind-wandering by increasing the number of in-class tests. Thirty-two students were assigned equally to tested and nontested groups, and all watched the same 21-minute video lecture. But differently, the tested group took a test after watching one segment of the whole lecture (four segments in total), whereas the nontested group only took one test at the end. The result indicated that students from the tested group reported significantly fewer mind-wandering times than those from the nontested group. Meanwhile, compared to students from the nontested group, students from the tested group answered significantly more questions correctly, which reflected the positive effects of successfully reducing the frequency of mind-wandering.

3.4. Other Distractions. In addition to the distractions caused by using digital devices, multitasking, and mind-wandering, students also experience other types of distraction, which have not been comprehensively discussed. This review summarized two types of distraction, unexpected interruption and consistent interference, which are conceptually separated from using digital devices, multitasking, or mind-wandering. Unexpected interruption refers to the unexpected notifications that immediately occupy full attention and increase an individual's arousal level. For example, an unexpected visitor who rings the doorbell immediately distracts the house owner's attention from the current task. Consistent interference can be explained as part of the attention is consistently occupied by task-irrelevant interferences, such as the noise from a lawn mower or the background music. Both unexpected interruption and consistent interference impair attention and detriment task performance [121, 122].

3.4.1. Unexpected Interruption. Rose [123] indicated that people currently live in an age of interruption because any person or platform can send unlimited information anytime. Along with the increasing prevalence of digital devices, mobile phone rings or notification sounds have become representative examples of unexpected interruption. Gazzaley and Rosen [44] categorized the unexpected cellphone ring or message notification as an unexpected distraction that interrupts current primary work and impairs focused

attention. Furthermore, similar to multitasking, unexpected interruption is also accompanied by a task-switching cost which goes through the processes of disengaging the primary task, engaging the secondary task, and reengaging the primary task [51]. For example, when the smartphone rings, students' attention disengages from learning from the ringing smartphone and then reengages learning with the resumption lag. Brown and Medcalf-Bell [124] further summarized that the use of smartphone accompanies with experiencing uncertainty, which unavoidably increases the level of social anxiety and impairs focused attention.

Due to no study on unexpected interruption in an educational context has been found, exploring the influence of unexpected interruption is largely based on related studies in the workplace context. Iqbal and Horvitz [125] conducted a field study to explore the impact of unexpected notification cues generated by email clients and instant messaging applications on daily task performance. This study observed twenty-seven participants in their natural working settings for two weeks. The results revealed that participants spent around 10 minutes switching from daily tasks to received notifications and another 10 to 15 minutes for regaining focused attention to daily tasks, which indicated that unexpected interruption negatively impacts working efficiency. Sonnentag et al. [126] collected 870 daily surveys from 174 employees to investigate the relationship between online messages and task accomplishment. The result showed that being responsive to received online messages is negatively associated with task accomplishment, which reflects the distractive effects of receiving unexpected interruptions on work performance.

Besides how people are interrupted by smartphone rings and email notifications, Gazzaley and Rosen [44] further pointed out that people are becoming self-interrupters who interrupt themselves from focusing on their primary tasks. Hair et al. [127] reported that 34.3% of participants checked emails every 15 minutes or less, which indicates that people interrupt themselves even if no notification is received. Fear of missing out (FoMO) is a trending mental disorder that reflects people who are becoming increasingly worrying about missing out on messages [128]. Initially, people simply checked social media applications to avoid missing out on messages. But, with the development of social media and short video applications, nowadays, people are constantly worrying about missing out on important news, which leads them to a positive association with internet use and poorer performance on task [129, 130]. So, people use digital devices more frequently and spend more time on social media applications like Twitter and TikTok, which inevitably interrupt them from their current tasks [131].

Currently, unexpected interruption is not a widely recognized term, and its relationship with distraction lacks both theoretical and experimental support. Especially, the role of expectancy in interruption requires further investigation. So, this review is just tentatively proposing the term unexpected interruption and categorizing it as a type of distraction based on the understanding of its mechanism. However, compared to no study on unexpected interruption in educational settings has been found, several studies on unexpected interruption in the workplace have been found [126, 127]. Since unexpected interruption distracts employees' attention from work and leads to poorer task performance, predictably, unexpected interruption also distracts students' attention from learning and leads to poorer academic performance in both traditional classroom and online environment.

3.4.2. Consistent Interference. Unlike unexpected interruption presented by unexpected and interruptive notifications, consistent interference refers to the consistent presence of distractive visual information or auditory information, such as background music, web page advertisements, or a smartphone in sight. Conceptually, consistent interference is largely compatible with the concept of continuous partial attention, which represents continuously occupying partial attention [132]. Since the attentional resource is limited, consistently occupying partial attention by task-irrelevant interferences predicts poorer task performance and impaired attention [41, 133].

Driving with music or radio is a common situation that all drivers experience daily. However, most drivers are unaware that listening to music or radio is a consistent interference that occupies part of their attention. Febriandirza et al. [134] reported that listening to hard rock music while driving is accompanied by a higher level of distraction and the lower level of concentration compared to listening to natural sounds. Similarly, Brodsky and Slor [135] also found that young drivers violate traffic laws more frequently and severely when they listen to driver-preferred music while driving, which reflects the distractive role of preferred music on driving performance.

Besides driving, background music is also a consistent distraction for learning-related activities, such as reading comprehension and completing cognitive tasks. Anderson and Fuller [136] found that students' reading comprehension performance significantly declined when completing the test while listening to Billboard top hit singles compared to completing the test in a nonmusic environment. A similar study was conducted by Doyle and Furnham [137], which also examined the effect of background music on participants' performance of a reading comprehension task. The result reported that noncreative participants had better scores on the reading comprehension test when they were in silent condition. Moreover, Thompson et al. [138] found that participants' performance on reading comprehension was significantly worse while listening to fast and loud background instrumental music, which also supported consistent background music as a source of distraction that impairs task performance. Meanwhile, Cassidy and MacDonald [139] found participants performed poorer on all five cognitive tasks (immediate recall, free recall, numerical and delayed recall, and Stroop) when background music or natural noise is present compared to the silence conditions, which supported that background music and noise occupied part of attention and interfered with task performance. Additionally, the irrelevant-speech effect supports the detrimental effects of consistent interference on task performance because it refers to "the impaired recall performance in the presence of irrelevant auditory stimuli" [140, 141].

Although there is no direct evidence to support the detrimental effects of consistent interference on online learning, studies have already found the negative influence of consistent interference on driving and learning-related activities, which indirectly predicted the negative impact on students' online learning performance [134, 136]. Further explorations are imperative because of the rapidly increasing prevalence of online learning.

4. Why Does Studying Distraction Can Benefit Online Learning

The purpose of studying distraction is always to learn how to resist it. Eyal [142] stated that distraction only occurs when people are trying to focus on their tasks. When people enjoy entertainment, they cannot be distracted because they are not paying full attention to any task. Therefore, ultimately, people are seeking to minimize the influence of distraction and increase the level of focused attention when they have tasks on hand.

Since online students are frequently and heavily distracted by various types of distractions, studying distraction to more effectively resist distraction is extremely necessary. This section specifically discussed the important role of developing distraction theories, designing better learning environments, and developing learning strategies for resisting distraction during online learning. By obtaining a better understanding of distraction, educators and students can improve the quality and efficiency of online teaching and learning.

4.1. Developing Distraction Theories. Unlike many attention theories and models that are well-established, there is no widely recognized distraction or distraction-related theory or model available yet. Currently, the goal interference model proposed by Gazzaley and Rosen [34] is an emerging distraction-related model because it perceives distraction as a form of interference. Even though this goal interference model successfully explains how four types of interference (internal distraction, internal interruption, external distraction, and external interruption) hinder or impede the performance of the primary task, conceptually, goal interference is still different from distraction [34]. Therefore, the goal interference model only provides indirect theoretical support to the concept of distraction. Meanwhile, Eyal [142] proposed the concept of "traction," the opposite concept of distraction, for representing what facilitates goal completion. Eyal's model also contains internal triggers and external triggers for representing the promotion or distraction caused by internal thoughts or external cues [142]. For example, mindfulness can promote task performance, whereas frequent mind-wandering can detriment task performance, reflecting that internal trigger can be beneficial or detrimental. However, these two models are not developed for comprehensively explaining the concept or the mechanism of distraction. Therefore, one of the most important purposes of studying distraction is building its theoretical foundation. Since online education will become increasingly prevalent and indispensable in the foreseeable future, developing distraction-related theories and models is necessary for resolving current and future online learning-related challenges [15].

4.2. Designing Better Learning Environment. Summarizing all types of distractions helps to design a better learning environment. Contextual distraction is one of the distraction themes proposed by Brady et al. [143], which represents the distracting elements of students' surrounding environment, such as TV sounds, roommates talking, and noise from lawn mowers. Brady et al. [143] specifically indicated the distractive role of contextual distractions and stressed the importance of building a learning environment without contextual distractions to prevent students from getting distracted and improve students' academic performance. Environmental cue shares a similar meaning with contextual distraction, which is perceived as a trigger of task-irrelevant thoughts and mind-wandering [112]. McVay and Kane [112] also mentioned that involuntary autobiographical memories could be triggered by environmental cues, which supported the distractive role of the environmental cue. Przybylski and Weinstein [53] found the detrimental effects of the consistent presence of smartphones on building the interpersonal relationship, even when participants were having a face-to-face conversation. This finding directly supports that the presence of a smartphone, as an environmental cue or contextual distraction, impaired focused attention during the conversation and evoked conversation-unrelated thoughts. Alter [54] further indicated that a comfortable learning environment more likely cultivates bad learning habits and even accelerates the formation of behavioral addiction, emphasizing the severe consequences of indulging students in using digital devices as they want. Therefore, managing the learning environment is extremely important for preventing various types of distractions from occurring. Fries and Dietz [63] used the term "environmental control" for stressed the importance of reducing the possibilities for off-task behavior in the learning environment. Similarly, Schmidt [18] indicated that the best way to manage the surrounding distractions is to decrease accessibility to distractive sources, such as smartphones or tablets. Although Brady et al. [143] introduced technology management and environmental structuring as practical strategies for countering contextual distraction, designing the ideal online learning environment still requires further exploration. Predictably, removing contextual distractions from the learning environment can effectively improve students' online learning efficiency and academic performance.

4.3. Developing Learning Strategies. Studying distraction benefits the development of strategies that promotes focused attention and resists distraction in online learning settings. Unlike traditional classroom learning, where instructors and students actively interact, online students perceive more temptations and contextual distractions that divert their attention from learning [16]. Although the theoretical foundation of distraction is still lacking, many practical strategies have been proposed for promoting learning and resisting distraction. Eyal [142] provided a series of strategies that helps online students to improve self-control and resist external distractions, for example, scheduling specific times

for replying to emails instead of being constantly prepared for incoming emails. Brady et al. [143] also proposed several strategies that counter distraction during online learning, such as improving time management, seeking help, and promoting willpower. Schmidt [18] summarized that entering the state of flow is the most ideal approach to turning down distractions and immersing in learning. Even though distraction is the opposite concept of attention, considering how to resist and avoid distraction is still an indispensable component of developing learning strategies. The Pomodoro Technique is a practical and effective time management method that significantly increases productivity and prolongs focused attention by sticking with the schedule, minimizing foreseeable interruptions, and estimating the needed time for completing tasks [144]. Therefore, studying distraction will contribute to developing learning strategies like the Pomodoro Technique and increase students' online learning performance.

5. Discussion and Conclusion

5.1. The Definition of Distraction. After reviewing empirical literature, no distraction-related theories have been developed and only a few distraction-related models are available (e.g., Gazzaley and Rosen's goal interference model), which reflects that the understanding of the mechanism of distraction is still largely based on attention theories, especially based on Broadbent's filter model of attention [24]. Under this circumstance, the comprehensive definition of distraction has been proposed in the review, which explains the mechanism of distraction, considers the consequence of the task as an indispensable component, and fills the gap of the occupation of partial attention. Predictably, scholars interested in studying distraction will obtain a better understanding of distraction based on this definition. Meanwhile, this definition will also contribute to the development of distraction-related theories or models in the future.

5.2. The Problem of Digital Distraction. Since the studies on distraction are relatively limited, it is important to summarize the findings to guide future research. After reviewing the literature, another important finding is that using digital devices should not be considered an independent type of distraction, even if it is a widely recognized source of distraction. Although using digital devices has been categorized as a type of distraction by Flanigan and Kim [28], the problem is that it largely overlaps with all other types of distraction. For example, students can use their smartphones to check social media while watching a prerecorded online lecture, reflecting the overlap between smartphones and multitasking. Meanwhile, smartphones or other similar digital devices are also the main carrier of unexpected notifications and background music, which reveals the overlap. So, perceiving using digital devices as an independent type of distraction inevitably causes confusion and misunderstandings. To better classify the types of distraction, it would be better if using digital devices was applied to various types of distraction instead of being considered an independent type of distraction.

5.3. The Shift of Attention. The occurrence of any type of distraction can be directly explained as the shift of attention from the current task to another task. Basically, each type of distraction describes a set of circumstances. More specifically, multitasking represents when people are shifting attention back and forth rapidly between primary task and secondary task, like shifting attention between listening to a lecture and texting via smartphone [50]. Similarly, mind-wandering represents shifting attention from the current task to irrelevant thoughts, which still consists of distraction's core concept [109]. For example, students may think of where they will have dinner during class. Since unexpected interruption represents that attention is captured by unexpected notifications and shifts from the current task, it also consists of distraction's core definition [34]. For instance, students can be interrupted by email notifications sounds while learning. Therefore, all three types of distraction share the same mechanism of distraction in different circumstances.

5.4. The Uniqueness of Consistent Interference. Consistent interference differs from the other three types of distraction because it represents that part of the attention is consistently occupied by visual or auditory information instead of shifting attention between tasks. For example, the consistent presence of smartphones and continuously playing background music detriments the performance of building interpersonal relationships and reading comprehension, respectively [53, 136]. Consistent interference expanded the boundary of distraction by adding the occupation of partial attention as a circumstance of distraction. However, due to studies on consistent interference being even more limited, further explorations on the relationship between consistent interference and learning performance are still required.

5.5. Eliminating Distractions and Maintaining Focused Attention. Predictably, online education will continue to thrive in the foreseeable future and play an even more important role in the education system [15]. As more educators and students start to realize the severity of distractions in online learning, exploring practical and effective approaches to maintain focused attention and resist distractions becomes more imperative [18].

Removing perceivable distractions from the external environment is an easy and effective approach to preventing students from getting distracted during online learning. This review intends to help students be aware of what distracts them from online learning and how to minimize the negative effects. But, more importantly, students need to maintain their attention on the learning content, which requires a higher level of self-regulation capabilities to become indistractable and enter the state of flow [18, 142, 145]. Since the classic white bear experiment, conducted by Wegner [146], already revealed that simply suppressing unwanted thoughts only evokes more irrelevant thoughts, achieving the state of flow might be the ultimate solution to resist distraction. Therefore, besides paying attention to eliminating distractions, helping online students to enjoy the learning content and enter the state of flow is essential for future success in online education.

6. Future Directions

6.1. Designing Learning Environment. Unlike traditional face-to-face learning and classroom instruction, where learning occurs between students and instructors within a physical classroom, the learning environment of online learning commonly is a bedroom or dormitory where students' private space fulfilled with temptations [76, 147]. Students can freely access their smartphones or use their laptops to play games or watch videos, which are strong temptations, even for adults. The purposes of designing a learning environment are minimizing the presence of distractive things which might trigger task-irrelevant thoughts and blocking the notifications from any source. Studies have already found the distractive effect of smartphones on face-to-face interpersonal communication and the disruptive effect of the unexpected phone call at work [53, 125], but these effects have not been proved in the context of online learning. Therefore, designing the ideal external environment for online learning requires further explorations for promoting students' focused attention and minimizing the presence of potential distractions.

Additionally, students are also distracted by the presence of task-irrelevant things or information. For example, the browser's YouTube bookmark constantly reminds students that they can access YouTube and start watching videos with a simple click. Alter [54] summarized such behavior as behavioral addiction because clicking a YouTube bookmark is a positive reinforcement of gaining instant pleasure by watching YouTube videos. Although the purpose of saving bookmarks is quickly access favored websites, it still triggers task-irrelevant thoughts that divert attention from learning. Application logo and website advertisement are also representative examples. Since students normally engage in online learning via laptop or desktop [148], designing an ideal online learning environment on a laptop or desktop will also directly help students to stay focused and prevent them from getting distracted.

6.2. Interactive Online Lectures. Unlike traditional classroom learning, where instructors and students can actively interact with each other, most asynchronies online courses, especially courses from MOOC platforms, utilizes prerecorded lecture videos for delivering course content to online students, which leads to the problem of lacking both learner-content and instructor-student interactions [149]. The purpose of developing interactive online lectures is to minimize the occurrence of mind-wandering. So, students can better maintain their focused attention on the course content instead of generating task-irrelevant thoughts which distract them from learning.

Embedding interactive learning activities (ILAs) in online lectures is a promising future direction that increases student-content interaction and improves learning performance. Hung et al. [150] developed a customizable embodied interactive video lecture software, which added various features to recorded lectures. For example, students were required to type their own description of an activity under a 30-second countdown. Their study designed and embodied multiple ILAs in the software, and the result found that the participants in the embodied interactive group showed better performance on comprehension and retention of learning content than the participants from the conventional video lecture group, which reflected the effectiveness of ILAs on students' learning performance and implied that students could better maintain their attention on the learning content for a longer time. Since students frequently feel bored and face the temptations of using digital devices when watching long prerecorded lecture videos, utilizing ILAs is an effective and practical approach to occupy their attention and resist distraction [16, 151]. Therefore, future studies can develop interactive online lectures and evaluate the effect of resisting all types of distractions.

Data Availability

No data were used to support this study.

Conflicts of Interest

The author declares that they have no conflicts of interest.

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