MASTER'S THESIS

The soundscapes of study places and their effect on students' concentration and academic performance.

A scoping review exploring the influence of study environments and other factors on students' concentration and academic performance.

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Abstract

Many students study in environments with varying soundscapes, which can affect their concentration and academic performance. While research on soundscapes exists, research on the specific effects of different study soundscapes remains limited. This scoping review refines the focus by systematically examining existing literature to answer the research question: *"What are the effects of the soundscapes of study places on students' concentration and academic performance?"*

A scoping review was conducted across multiple academic databases, selecting studies based on methodological transparency and relevance. The included studies examined different sound sources (e.g., human-made, nature, traffic/mechanical, and music) and factors such as acoustic quality, noise sensitivity, and study places.

The findings suggest that no single soundscape optimally enhances concentration and academic performance. Instead, the effects depend on task complexity, acoustic quality, and individual preferences. Human-made sound, particularly background speech, was most disruptive, though some students found moderate noise beneficial. Nature sounds and instrumental music improved concentration by reducing cognitive load, while music with lyrics impaired performance due to attentional conflict. A key distinction emerged between the objective effects of soundscape—measured through task performance—and subjective perceptions, indicating that perceived noise disturbance does not always align with actual cognitive impairment.

This review contributes to the understanding of study soundscapes and offers practical strategies for optimizing study environments, such as selecting appropriate study places, using noise-cancelling headphones, and integrating beneficial auditory stimuli. Future research should explore long-term adaptations to soundscapes, the role of personal control over study environments, and the effects of curated study music.

Keywords: Study soundscapes, concentration, academic performance, noise sensitivity, cognitive load, arousal, human-made sound, nature sound, traffic/mechanical sound.

Samenvatting

Veel studenten studeren in omgevingen met uiteenlopende geluidslandschappen, wat hun concentratie en academische prestaties kan beïnvloeden. Hoewel er onderzoek bestaat naar soundscapes, is de specifieke invloed van studie-soundscapes nog beperkt onderzocht. Deze scoping review verfijnt de focus door systematisch bestaande literatuur te analyseren om de onderzoeksvraag te beantwoorden: *"Wat zijn de effecten van de soundscapes van studieplekken op de concentratie en academische prestaties van studenten?"*

Een scoping review werd uitgevoerd met zoekopdrachten in meerdere academische databases, waarbij studies werden geselecteerd op methodologische transparantie en relevantie. De geïncludeerde studies onderzochten verschillende geluidsbronnen (bijv. menselijke geluiden, natuurgeluiden, verkeer/mechanische geluiden en muziek) en factoren zoals akoestische kwaliteit, geluidsgevoeligheid en studielocatie.

De resultaten tonen aan dat er geen universeel optimale soundscape bestaat. De effecten hangen af van taakcomplexiteit, akoestische kwaliteit en individuele voorkeuren. Menselijke geluiden, vooral achtergrondspraak, waren het meest storend, hoewel sommige studenten matige achtergrondgeluiden als positief ervoeren. Natuurgeluiden en instrumentale muziek verbeterden de concentratie door cognitieve belasting te verminderen, terwijl muziek met songteksten prestaties verslechterde door aandachtconflicten. Een belangrijk onderscheid werd gevonden tussen objectieve effecten (gemeten prestaties) en subjectieve percepties, waarbij ervaren geluidshinder niet altijd overeenkwam met daadwerkelijke cognitieve beperkingen.

Deze review draagt bij aan het begrip van studie-soundscapes en biedt praktische strategieën om studielocaties te optimaliseren, zoals het kiezen van geschikte studieruimtes, het gebruik van noise-cancelling koptelefoons en het integreren van ondersteunende auditieve stimuli. Toekomstig onderzoek zou zich moeten richten op langetermijneffecten, persoonlijke controle over geluidsomgevingen en de invloed van gestructureerde studiemuziek.

Trefwoorden: Studie-soundscapes, concentratie, academische prestaties, geluidsgevoeligheid, cognitieve belasting, alertheid, menselijke geluiden, natuurgeluiden, verkeer/mechanische geluiden.

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1. Introduction

Students spend a considerable amount of their time studying at study places, such as at home, at the university, or at a café. While studying, students are continuously exposed to the sounds of their surroundings, whether it is people whispering, typing, sounds of the street, or the music they choose to listen. These sounds altogether are the soundscapes of students' study places. A soundscape exists of a combination of different sound sources such as human-made sound, nature sound, traffic sound or mechanical sound (Mascolo et al, 2024). A soundscape is the acoustic environment of a place, as perceived by people (Kang et al., 2016). The character of this soundscape is the result of the action and interaction of natural and human factors. It is a perceptual construct and therefore focuses on the experience of the acoustic environment by people, rather than the physical measurements of sound (Kang et al., 2016).

While acoustic environment and soundscape are interconnected concepts, they significantly differ in their scope and emphasis. Both refer to sound, but their distinctions lie in the focus on physical characteristics versus human perception. The acoustical environment refers to the characteristics of a space or environment that influence the acoustic experience, such as clarity, reverberation, and sound insulation (Kang et al., 2016). On the other hand, a soundscape is often used to describe how well an acoustic environment is suited for certain activities based on how sound behaves within it and how it is experienced by the users of the space (Kang et al., 2016; Hamida et al., 2024a; Hamida et al., 2024b). A high-quality acoustic environment is typically characterized by clarity, optimal reverberation times, and low background noise, achieved through effective sound insulation (Kang et al., 2016). Such an environment is highly desirable in study spaces, as it promotes focus and minimizes distractions. For example, environments with low levels of background sound can promote optimal concentration and the ability to process information (Yadav et al., 2023).

Exposure to natural, calm sounds can reduce annoyance and have a beneficial effect on people's mood, sleep quality and blood pressure (Kang et al., 2016). When students are exposed to these sounds while studying, they have a positive effect on concentration and academic performance. On the other hand, different studies have shown that noise has a negative effect on concentration and academic performance (Hamida et al., 2024a; Renaud et al., 2024). Sound is perceived as noise when it is considered unwanted by the one experiencing it in a certain context (Scannell et al., 2015). In the context of studying, human-made or mechanical sounds are often perceived as noise.

However, in certain contexts like social spaces (e.g., pubs or football stadiums), a high acoustic quality is not necessarily beneficial or even appropriate. Instead, these environments are valued for their soundscape, which creates an atmosphere suited to their purpose, even if the acoustic quality is technically poor. Coffee shops are an example of this. While they are frequently used as study spaces, their acoustic quality is often suboptimal due to background noises such as chatting and coffee machines. These sounds are considered distracting, increasing cognitive load and reducing focus and performance. Nevertheless, some perceive these soundscapes as beneficial for concentration, citing the ambient noise and atmosphere as supportive factors (Purwadi & Manurung, 2020; Umme, 2024). Moreover, this variability is shaped by individual characteristics, including gender, age, and personality (Scannell et al., 2015). For example, some students seem highly affected noise and struggle to filter it out, while others find it easier to concentrate in noisier environments. This personal characteristic is called noise sensitivity. Sound is perceived as noise when it is considered unwanted by the one experiencing it in a certain context (Scannell et al., 2015).

Research has shown that soundscapes affect students' physical health, performance, and well-being (Hamida et al., 2024a; Renaud et al., 2024), making the soundscape of study places important to their for concentration and academic performance. Suboptimal study environments can negatively impact both health and learning outcomes. Despite the growing recognition of the impact of soundscapes on cognitive performance, the effects of study environments on students' concentration and academic performance remain underexplored. Given that suboptimal soundscapes can impair focus, increase cognitive load, and negatively affect well-being, it is crucial to investigate how study soundscapes can be optimized to support learning and academic achievement. Understanding these effects will provide valuable insights for students, educators, and institutions in designing study environments that enhance productivity and academic outcomes.

1.1. Students' study places

Students have all kinds of different preferences and needs regarding their soundscape while studying, such as music, quietness, or background sounds. These aspects play a role in the choice of the study place. But where do students study? Three main study places will now be discussed in detail, though other study environments may also be relevant.

First of all, institutions of higher education, including universities, require informal learning spaces (ILS) for self-learning with no formal academic instruction (Zhang et al., 2023). Those ILSs are designed for various study tasks, such as reading, writing, memorization, and problem-solving (Scannell et al., 2015). However, ILSs are also intended for informal learning activities with more flexibility, collaboration, or recreational activities in addition to learning (Zhang et al., 2023). While these environments are equipped with mediating acoustic qualities that contribute to maximizing students' concentration and optimizing their academic performance, there are no strict rules to control the sound environment, as students are allowed to conduct non-learning activities (Thoutenhoofd et al., 2015; Zhang et al., 2024).

Secondly, students study at home. During COVID-19, students spent most of their (study) time at their homes which have different (less suitable) soundscapes for studying, which led to a decline in students' physical health, performance, and well-being (Hamida et al., 2024a). At home, they were more frequently exposed to distracting sounds, such as traffic, loud devices, or construction, because there is no sufficient sound insulation of windows or external walls (Hamida et al., 2024b). This significantly impaired concentration, as the brain is highly sensitive to interruptions, requiring effort to refocus after each distraction. Non-relevant sounds complicate information processing and reduce task efficiency. Due to this noise exposure, the brain continuously must filter sounds, leading to fatigue and affecting core cognitive functions, including attention, memory, problem solving, and reading comprehension ultimately reducing academic performance (Erdélyi et al., 2019). Altogether, this is why homes are less suitable for studying. Quiet environments minimize these effects, fostering better concentration and academic performance.

Finally, students study at cafés. The popularity of cafés being used as a study place is growing (Purwadi & Manurung, 2020). Students are meeting up to study while enjoying a cup of coffee. Different sources point out the positive effects such as the motivation to study harder and being productive while enjoying the ambiance (Purwadi & Manurung, 2020; Umme, 2024). It is even stated that cafés can help focus and improve recollection power. The brain uses contextual cues to recall information, and those cues, such as sights, sounds and smells, provided by the café trigger memory of everything we learned there (Umme, 2024). Therefore, any detail from the study session can trigger what needs to be recollected. Another positive aspect about studying at a café is that all aspects of the soundscape such as speech, teaspoons and cups clattering, and the coffee machine creates a kind of white noise eliminating distraction and facilitating attention and productivity (Umme, 2024). However, this is paradoxical to what is commonly understood about the effect of certain soundscapes on concentration. Theoretically, the suitability of the soundscape of a café for studying can be compared to the soundscape of a home: there are a lot of (unwanted) sounds present which lead to distraction and ultimately reducing academic performance. This contradiction illustrates the difference between measurable acoustic quality and the perception of acoustic quality and the role of personal preference.

1.2. Aim and research question

Altogether, students prefer different study places with their own distinct soundscapes, and those soundscapes seem to have different effects on concentration and academic performance. This is all context dependent, which means that the effect of sound depends on the location, preferences, timing and desirability (Scannell et al., 2015; Hamida et al., 2024b). We now understand where students study and the soundscapes to which they are exposed while studying. The aim of this research is therefore to examine the impact of the soundscapes of study places on students' concentration and academic performance through a scoping review. The following research question has been formulated: *"What are the effects of the soundscapes of study places on students' concentration and academic performance?"*

2. Methodology

Initially, the aim was to answer the research question through a systematic review. However, during the search procedure there were some difficulties with the development of the search string and the results thereof. In order to overcome these difficulties many different options of the search string were tested, each one with different problems. The original search string is presented below. The search string was adjusted often, by differentiation in words, asterisks, quotation marks, Boolean operators or leaving out part of the search strings. There are three reasons that caused these problems. First, the topic of soundscape is highly interdisciplinary, and therefore it was inevitable to perform the search in different databases (ERIC, SocIndex, PsychInfo, Medline, Scopus, and Web of Science). This resulted in getting barely any (relevant) results in one database (e.g., PsychInfo), and too many (often irrelevant) results in the other (e.g., Scopus). Because of the interdisciplinarity of the topic, leaving a database out was not an option. Second, there are a lot of relevant search terms that have a general or dual meaning, such as acoustic, noise, focus and perform. This resulted in a large number of irrelevant articles. The third and last reason why the search string did not perform as expected is because soundscape research, and this topic specifically, remains relatively unexplored. As a result, there is limited existing knowledge about this topic.

Therefore, it has been decided to perform a scoping review. This approach provides an overview of existing literature on the broader topic of the soundscape of study places, while striving for a systematic and thorough analysis. It qualitatively summarizes evidence on soundscape research regarding students and their study places. There is not one single search string, but different search strings and searches were used to obtain all relevant articles in order to answer the research question. Appendix A includes all performed searches and the retrieved articles.

The original search string:
(soundscape* OR sound* OR acoustic* OR "acoustic environment" OR "auditory environment" OR noise*)
AND (student* OR adolescent*)
AND ("study place*" OR "study space*" OR "study environment" OR "learning space*" OR "learning environment")
AND (concentration OR focus OR productivity OR "academic performance" OR "cognitive performance" OR "cognitive task performance" OR "study performance" OR perform*)

2.1. Search and selection procedure

Before performing the search, the search string was created. The related terms of the main concepts used in soundscape research were obtained through preliminary research. There are five main concepts identified in the research question. Each of these concepts has related terms that are considered in the search for relevant literature, since different terminology is used for the same concepts in different literature. Table 1 shows these main concepts and their related terms.

Table 1. Search terms of the scoping review

Concepts	Related terms
Soundscape	Sound
	Acoustic
	Acoustic environment
	Auditory environment
	Noise
Student	Adolescent
Study place	Study space
	Study environment
	Learning space
	Learning environment
Concentration	Focus
	Productivity
Academic performance	Cognitive performance
	Study performance
	Academic performance

Different searches were performed in different databases (ERIC, Scopus and Web of Science), since soundscape research is interdisciplinary. See Appendix A for a detailed explanation of how the search procedure led to the selection of articles.

Table 2. Inclusion and exclusion criteria for the literature search.

Inclusion criteria	Exclusion criteria
Research is based on higher/tertiary education	Research is based on primary or secondary school
Research is based on study/learning places	Research is based on teaching or lectures
Soundscapes of study/learning/work places	Soundscapes of other environments
The article is written between 2014 and now	The article is written before 2014
The article is written in English or Dutch	The article is written in a different language than English or Dutch
The article is peer reviewed	The article is not peer reviewed

Table 2 shows the inclusion and exclusion criteria for the search procedure. While retrieving data, these criteria were taken into account. This research focuses on higher education, so only articles about higher education are included. Since this research only targets study or learning places, soundscapes of environments not related to studying are excluded (e.g., streets, shopping mall, etc.). Furthermore, to account for current advancements in soundscape research, only literature between 2014 and now are included. Only articles written in English or Dutch are included because these are the languages I master. Finally, only peer-reviewed articles are included to ensure reliability and validity.

The articles were obtained through three ways. First, through the (6) performed searches in different databases as described above. Second, all articles used for the preliminary research have been included for the selection procedure. Third, the supervisor of this thesis shared articles that could be used for this study. The articles were screened by title and included for the selection procedure. Appendix A and Figure 1 represent the distribution of the data. The articles were collected in ZOTERO (n = 71). Subsequently, all articles were uploaded into Rayyan, where the remainder of the selection procedure took place. First, all articles (n = 71) were screened by abstract and labelled include, exclude or maybe. In cases of doubt (labelled 'maybe'), the introduction and conclusion were read before making a decision. After this screening procedure, 29 articles were full-text screened. Finally, there are 24 articles included in this scoping review.

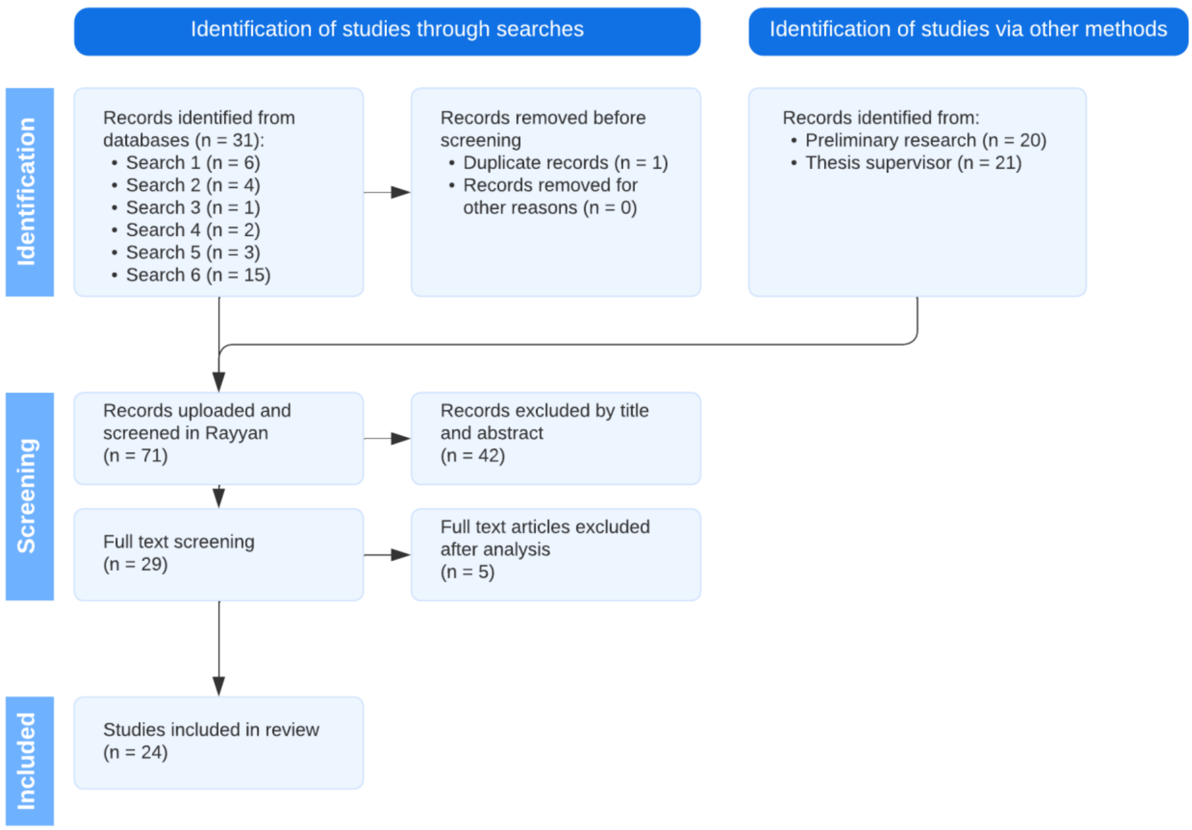

Figure 1. PRISMA-ScR flowchart.

2.2. Analysis procedure

After the articles were selected, they were thoroughly read and analyzed. Within these 24 articles, different methodologies were used to measure the influence of soundscapes (Figure 1). This reflects the multidisciplinary nature of research on soundscapes. This scoping review integrates findings across these methods to explore the effects of soundscapes on concentration and academic performance. All data that was relevant to answer the research question was thematically and systematically extracted in ZOTERO by labelling (color-coded), using tags, and documenting relevant findings in the notes of each article. Appendix C shows a summary of the articles in this review containing the basic information (author(s), year, goal, keywords, methodology, sample), the results and conclusion, and their position/opinion. This summary table presents an overview that clearly shows the different studies and their conclusions regarding soundscape research.

2.3. Quality analysis

In order to assess the transparency of the 24 included studies, a quality assessment was conducted based on the CASP checklist. The CASP checklist is an instrument designed to evaluate the quality of studies. This assessment is an adapted version of the CASP checklist, so that it could be used for this qualitative study (Langeloo et al., 2019). Appendix B presents the transparency checklist, which was completed for each article. This checklist includes seven yes/no questions on the clarity of the aims, methods, and results of each study. When four or more questions were answered with ‘yes’, the study was classified as transparent.

In order to assess the relevance of the 24 included studies, the aim of this study was compared to the aim of each included study. A study was judged relevant when the aim of the included study corresponded to the aim of this study (Langeloo et al., 2019). As a result of this assessment, all included articles were divided in four categories, representing their transparency and relevance (Table 3). Articles in category A are both transparent and relevant for this study. Articles in category B are less transparent but relevant. Articles in category C are transparent but less relevant. Finally, articles in category D are less transparent and less relevant.

3. Results

In total, 24 studies were included in this scoping review. These 24 studies represent diverse methodologies, outcomes, study places, sound sources, acoustic quality and mediating factors. Altogether they create a broad view on the influence of students' study soundscapes on concentration and academic performance.

The 24 included studies employed a variety of methodologies to examine the effects of soundscapes on concentration and academic performance, including experimental designs, questionnaires, sound measurements, field studies, and literature reviews. See Figure 1 for the distribution of these methodologies. These methods were often combined to provide a comprehensive analysis. For instance, some studies paired experimental observations of performance with questionnaires to capture students' perceptions and experiences (n = 7).

The 24 included studies focused on different outcomes. Ten studies focused on the effect of soundscapes on performance outcomes. These performance outcomes included reading tasks, writing tasks, reaction time, or verbal reasoning. These studies were primarily experimental studies where such student tasks were performed while being exposed to different sound conditions, while measuring the difference in task performance. Eleven studies examined the impact of soundscapes on concentration. In these studies, the terms 'disturbance' and 'distraction' were also interpreted as indicators of concentration or its interruption. The effects of soundscapes on concentration were assessed through both neurobehavioral tests and self-report questionnaires, allowing students to share their experiences with concentration and distraction.

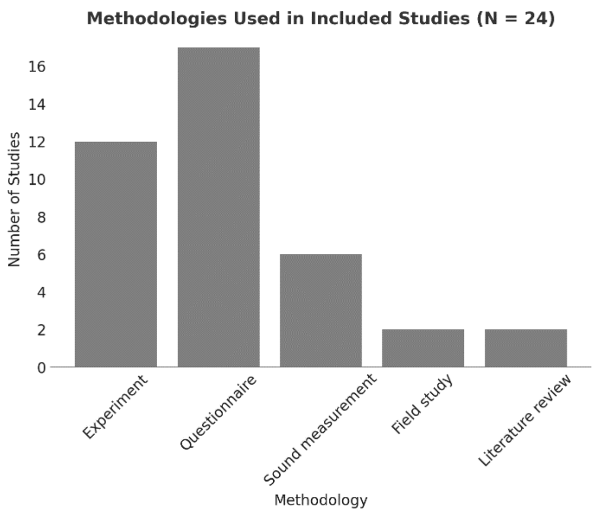

Figure 2. Distribution of used methodologies in included studies.

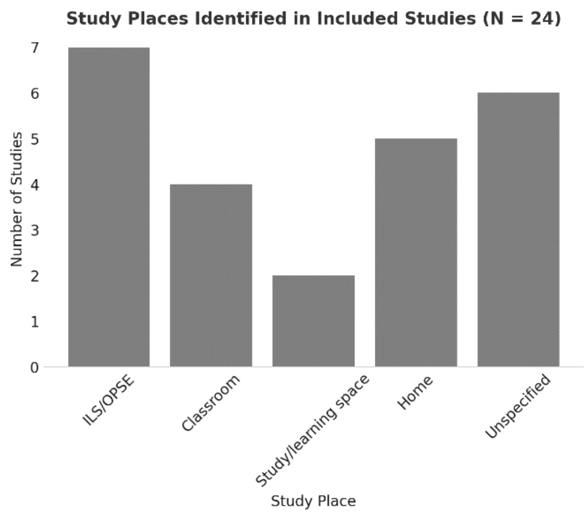

Figure 3. Distribution of identified study places in includes studies.

The included studies examined various environments where students prefer to study. These environments include Informal Learning Spaces (ILSs)/Open-Plan Study Environments (OPSEs), homes, and classrooms. There were also two studies who researched study/learning spaces in general, with no specific definition. See Figure 3 for the distribution of these study places. While both ILSs and OPSEs are often designed with mediating acoustic qualities, there are no strict rules controlling the sound environment, as students are allowed to collaborate or engage in non-learning activities (Thoutenhoofd et al., 2015; Zhang et al., 2024). In this study they are examined together (n = 7), as both share similar characteristics resulting in similar soundscapes and effects on students' concentration and academic performance. Four studies examined the soundscape of classrooms, which has a different purpose than study places. However, their results are relevant as their purpose relates to learning and academic performance. Furthermore, five studies examined the soundscapes of students' home study places. There were also studies that did not particularly researched a study place (n = 6). These were all experimental studies focusing on sound and not the place.

3.1. Quality assessment

The results of the quality assessment are presented in Table 3, where transparency and relevance are labeled as '+' or '–'. All included studies were found to be transparent (n = 24), meaning none were classified as category B or D. The majority of the studies were categorized as category A (n = 16), indicating both transparency and high relevancy to this study. The remaining studies were categorized as category C (n = 8), as they were transparent but less directly relevant. Their lower relevance stemmed from a focus on outcome measures such as preference, disturbance, experience, or emotion rather than on measures directly related to concentration or academic performance. However, these studies were included as they offer valuable insights to this topic.

Table 3. Overview of methodologies, sound sources, and study places identified in included studies.

Author (year)	Informational value			Study characteristics		
	Category	Transparency	Relevance	Methodology	Sound source	Study place
Braat-Eggen et al. (2017)	C	+	-	Questionnaire/interview Sound measurements	Human-made	ILS/OPSE
Braat-Eggen et al. (2020)	A	+	+	Experiment Questionnaire/interview	Human-made	ILS/OPSE
Braat-Eggen et al. (2021)	A	+	+	Experiment Questionnaire/interview	Human-made	ILS/OPSE
Chan et al. (2021)	A	+	+	Questionnaire/interview Sound measurements	Human-made Nature Mechanical	Classroom
Dadi Zhang et al. (2024)	A	+	+	Questionnaire/interview Sound measurements	-	Study/learning space
Gonzalez & Aiello (2019)	A	+	+	Experiment Questionnaire/interview	Music	-
Hamida et al. (2024a)	C	+	-	Questionnaire/interview Sound measurements Field study	Human-made Nature Music	Home
Hamida et al. (2024b)	C	+	-	Questionnaire/interview Sound measurements	Human-made Traffic	Home
Juan & Chen (2022)	A	+	+	Experiment	Traffic sound Music	Classroom
Lin et al. (2024)	A	+	+	Questionnaire/interview Field study	Human-made Nature Traffic Mechanical	Home
Liu et al. (2021)	A	+	+	Experiment Questionnaire/interview Sound measurements	Human-made Mechanical Music	ILS/OPSE
Liu et al. (2023)	A	+	+	Literature review	Human-made Nature Traffic Music	Study/learning space
Luo et al. (2021)	A	+	+	Experiment Questionnaire	Nature	-
Luo et al. (2022)	A	+	+	Experiment Questionnaire	Nature	-
Minelli et al. (2022)	A	+	+	Literature review	Human-made	Classroom
Pellegatti et al. (2024)	A	+	+	Experiment Questionnaire	Human-made Nature	Classroom
Puyana-Romero et al. (2023)	C	+	-	Questionnaire	Human-made Music Traffic Mechanical	Home
Rau et al. (2020)	C	+	-	Experiment	Music	Home
Scannell et al. (2015)	C	+	-	Questionnaire	Human-made	ILS/OPSE
Sun et al. (2024)	A	+	+	Experiment	Music	-
Zhang et al. (2023)	A	+	+	Questionnaire	-	ILS/OPSE
Zhang et al. (2024)	A	+	+	Questionnaire	Human-made	ILS/OPSE
Zhang et al. (2025a)	C	+	-	Experiment	Traffic	-
Zhang et al. (2025b)	C	+	-	Experiment	Nature	-

Note. Category A: transparent and relevant; B: less transparent, relevant; C: transparent, less relevant; D: less transparent and less relevant. + indicates more focused/relevant studies; - indicates less relevant/transparent studies.

3.2. Sound source

Because each soundscape exists of a combination of sound sources, the results are organized based on different sound sources identified in the literature. The most common sound source of study places, and the most disturbing, is human-made sound (Braat-Eggen et al., 2017; Chan et al., 2021). Other sound sources include nature sound, traffic and mechanical sound, and music. See Figure 4 for the distribution of these sound sources across the included studies. Each sound source has a different effect on concentration and academic performance, and is discussed in detail below, highlighting the number of studies, their main findings, and emerging trends or inconsistencies. This approach allows for a systematic exploration of how different sound sources influence concentration and academic performance.

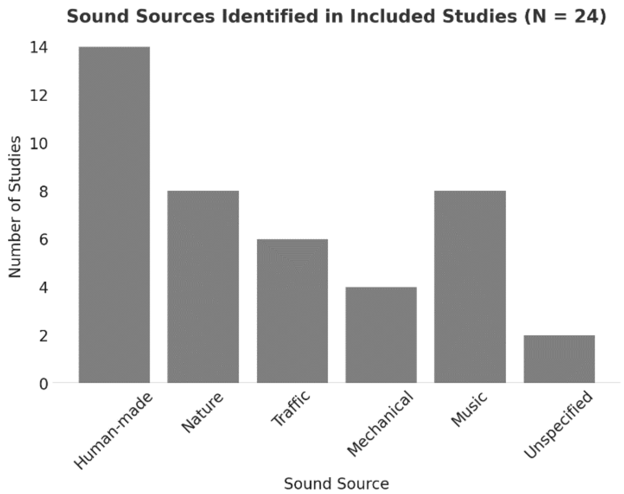

Figure 4. Distribution of identified sound sources in included studies.

3.2.1. Human-made sound

Within the context of studying or study places (e.g., ILSs or OPSEs), students are mostly exposed to human-made sound, such as background speech or footsteps (Chan et al., 2021; Hamida et al., 2024a). Most studies found that students are bothered by background speech (Braat-Eggen et al., 2017; Braat-Eggen et al., 2020; Chan et al., 2021; Lin et al., 2024; Pellegati et al., 2024). Braat-Eggen et al. (2017) found that human-made sound leads to disturbance, especially with language-based tasks such as reading and writing. Additionally, this negative effect is more significant when the background speech is meaningful or intelligible (Braat-Eggen et al., 2020; Liu et al., 2023; Lin et al., 2024). For example, speech is most intelligible in a room with short reverberation time (0,6s) when there are few people (n = 3) talking (Braat-Eggen et al., 2020). Besides causing noise annoyance, human-made sound also leads to poorer concentration levels as cognitive load increases, distracting attention to the student task (Rau et al., 2020; Braat-Eggen et al., 2021; Liu et al., 2023). However, Scannell et al. (2015) found that background speech is perceived as appropriate within certain contexts, such as ILSs, OPSEs, or cafés where speech is expected and socially accepted.

On the other hand, there are also reasons why students prefer human-made sound to be present (Hamida et al., 2024a; Zhang et al., 2024). Zhang et al. (2024) found that students experience a more relaxed feeling in study spaces where human-made sound is present. They do not feel the pressure of having to work hard and can work at their own pace. In addition to that, the sound masking effect is present within study places where there is human-made sound. Students' own sounds and conversations are masked by the background noise which also provides a safer feeling. Zhang et al. (2024) also found that the presence of other students (and its noise) motivates students to study as well.

3.2.2. Nature sound

Nature sounds, such as the sounds of spring water, birds, wind, or rain, have been found to offer several advantages within the context of concentration and academic performance. They are generally perceived as pleasant (Chan et al., 2021; Lin et al., 2024; Pellegati et al., 2024). Zhang et al. (2025b) conducted an EEG study examining the effects of spring water sounds on psychophysiological responses in college students. This study found that spring water sounds stimulate emotional responses and aid in recovering from negative emotions. These effects contribute to improved mood and perceptual quality. Luo et al. (2021, 2022) conducted two studies using a nature-sound mobile application to investigate psychological well-being and cognitive performance among university students. Exposure to nature sounds while studying was found to enhance concentration by masking other auditory distractions, ultimately fostering deeper engagement in deep learning and improving academic performance (Luo et al., 2022). Additionally, it helps students achieve a flow state while studying. This flow state can lead to decreased reaction time, improved alertness, minimized environmental distractions, reduced academic procrastination, and increased productivity (Luo et al., 2021, 2022).

3.2.3. Traffic and mechanical sound

Similar to human-made sound, traffic sound was perceived as both unpleasant and disruptive by students (Chan et al., 2021). Zhang et al. (2025a) found that traffic sound leads to mood disturbance and induces stress responses. Liu et al. (2023) found that traffic noise also negatively affects several study tasks such as learning efficiency. Mechanical sound, such as road construction from outside or home appliances indoors, has a similar effect on concentration and performance as traffic sound. Both types of sound are perceived as unpleasant and distracting, primarily due to their sudden fluctuations and unpredictability, which students find disruptive (Chan et al., 2021). Traffic and mechanical sound increase the cognitive load, which reduces concentration and academic performance (Rau et al., 2020). However, Liu et al. (2023) also found that traffic noise can shorten reaction time of search memory and promote visual cognitive work due to resistance to noise interference.

3.2.4. Music

Studies that examined the effects of listening to music while studying show mixed results regarding its impact on concentration and academic performance. Some studies suggest that music can improve task performance, while others indicate that it can reduce performance. In addition, while some studies suggest that music can have a greater effect on performance than a quiet environment (Chan et al., 2021; Juan & Chen, 2022; Dadi Zhang et al., 2024), other research highlights that quiet conditions lead to better performance compared to listening to music (Braat-Eggen et al., 2021; Pellegati et al., 2024). These mixed findings can be explained by the characteristics of the music, the presence of lyrics, the type of task being performed, individual differences among students, and emotional responses to the music.

The characteristics of the music play a central role in these differing effects. Gonzalez and Aiello (2019) found that music's impact on performance depends on its volume and complexity. Listening to music at a moderate volume can promote performance during simple tasks by occupying attentional resources and canceling out other auditory distractions, which reduces the likelihood of mind-wandering or getting distracted. In contrast, louder or more complex music increases cognitive workload, which has a negative effect on performance, especially for complex tasks like reading comprehension (Gonzalez & Aiello, 2019; Rau et al., 2020). Liu et al. (2021) found that this negative effect of background music is similarly to the negative effect that background noise has on academic performance. However, the negative impact of background music was consistently found to be weaker than that of general background noise, indicating that listening to music is less detrimental to concentration compared to environmental noise (Liu et al., 2021; Juan & Chen, 2022). Research by Dadi Zhang et al. (2024) adds to this by highlighting the importance of background noise levels: a sound level of 50 dB shows no adverse effects on performance (moderately quiet, comparable to a library, or soft background conversation). This volume is neither too high to cause noise annoyance (≥ 60 dB) nor too low to result in brain inactivity and a lack of stimuli (≤ 40 dB), both of which can negatively affect academic performance.

The presence of lyrics also significantly impacts how music influences performance. The effect of lyrics can be compared to the effect of background speech (Rau et al., 2020). Studies show that music with lyrics, regardless of genre, has a more negative effect on academic performance compared to music without lyrics (Sun et al., 2024). This indicates that the lyrics have the same negative effects as background speech. It increases cognitive load, reducing students' concentration and academic performance (Rau et al., 2020). This effect is even stronger when the lyrics are in the same language as the task, as they compete for linguistic resources required to focus on the task.

The type of task being performed is another factor that explains the mixed results regarding the influence of music on concentration and academic performance. Listening to music can enhance performance during simple tasks (e.g., reaction tasks) by providing a stable acoustic environment that minimizes external distractions, thereby improving task efficiency (Gonzalez & Aiello, 2019). However, for complex tasks (e.g., problem-solving, logical reasoning) music tends to increase mental workload, leading to performance deterioration. In such cases, silence is the more effective condition for maintaining focus and optimizing academic outcomes (Braat-Eggen et al., 2021).

Individual differences play a mediating role in how music affects performance. Students who are accustomed to listening to music while studying experience weaker effects compared to students who usually do not listen to music while studying (Sun et al., 2024). Another personal characteristic that mediates the effect is a person's preference for external stimulation. Gonzalez and Aiello (2019) found that individuals who are easily distracted perform better without music, as its presence increases the likelihood of distraction.

Emotional responses to music also play a key role in the effect of music on concentration and academic performance. Music that makes you feel good enhances performance, as it promotes positive emotions and supports cognitive recognition (Gonzalez & Aiello, 2019; Liu et al., 2023; Sun et al., 2024). The melody of the music influences how it makes you feel: positive music arouses positive emotions and improves attention, promoting performance, whereas negative or sad music arouses negative emotions, leading to distraction and reduced performance (Rau et al., 2020; Liu et al., 2023).

3.3. Acoustic quality

In addition to different sound sources, several studies have examined the acoustic qualities of study spaces. Minelli et al. (2022) conducted a literature review to determine the optimal acoustic conditions for learning performance in classrooms, describing sound level (dB), Signal-to-Noise Ratio (dB), reverberation time, and Speech Transmission Index

Optimal sound levels for study tasks appear to vary depending on the study setting. Sound level is expressed in decibels (dB). Minelli et al. (2022) found that an optimal sound level ranges between 35 and 40 dB, comparable to a quiet library or bedroom. However, Liu et al. (2021) identified 50 dB as the ideal level, stimulating brain activity and enhancing performance compared to lower (40 dB) and higher (60 dB) levels, both of which negatively affected performance. This aligns with findings from Dadi Zhang et al. (2024), who reported that lower sound levels (<40 dB) result in brain inactivity due to insufficient stimuli, while higher sound levels (>60 dB) cause auditory fatigue and increased cognitive load. This discrepancy can be explained by differences in study environments. Liu et al. (2021) examined OPSEs, where human-made sound is commonly present and discussion is permitted. In contrast, Minelli et al. (2022) focused on classroom settings, where silence is typically expected among students. As a result, the optimal sound level threshold was lower in Minelli et al. (2022) compared to Liu et al. (2021), reflecting the different acoustic expectations and noise tolerance levels in these environments.

Another crucial factor is the Signal-to-Noise Ratio (SNR), which measures the balance between useful signals (e.g., speech or music) and background noise, expressed in dB. A high SNR indicates that the signal is stronger than the background noise, making it clearer and easier to understand, whereas a low SNR means that the sound is masked by background noise, making comprehension more difficult. Minelli et al. (2022) found that an optimal SNR for academic performance ranges between 10 and 12 dB, particularly in quiet areas, as individual background sounds blend into the overall background noise, making them less distinguishable and reducing potential distractions.

Reverberation time (RT), referring to the time it takes for the sound level in a room to decrease by 60 dB after the noise source stops, also influences learning performance.

According to Minelli et al. (2022), the ideal RT for learning performance is between 0.6 and 0.7 seconds, balancing speech clarity with natural reverberation. This range minimizes cognitive load by making speech more distinguishable. A lower RT may make sound too dry or unnatural, potentially leading to distraction, whereas a higher RT can cause echoing and unwanted sound overlap, also impairing concentration.

Finally, speech intelligibility, measured by the Speech Transmission Index (STI), plays a role in study environments with background speech. STI values vary from 0 (very poor) to 1 (excellent). Minelli et al. (2022) determined that an STI of 0.6 or higher ensures better student performance. However, both lower and higher STI values can increase cognitive load, as students either perceive excessive auditory details or must exert significant effort to understand speech.

A total of four studies examined the home study environment, focusing on students' satisfaction, preferences, and acoustic qualities. All four studies used questionnaires or interviews to assess satisfaction and preferences, while two also conducted sound measurements to evaluate acoustic conditions. Puyana-Romero et al. (2023) found that home environments are generally less suitable for studying, as homes are not designed for sound isolation. Consequently, students are more exposed to external noise sources, such as traffic and construction, as well as internal noise from home appliances, television, or conversations (Puyana-Romero et al., 2023; Lin et al., 2024). Students reported that sudden fluctuations in volume or changes in sound sources were particularly distracting, significantly impairing their concentration (Chan et al., 2021). These environmental sounds have been shown to negatively affect students' concentration and academic performance by increasing cognitive load and noise annoyance (Puyana-Romero et al., 2023; Hamida et al., 2024b). The acoustic qualities of home environments do not meet the optimal conditions identified by Minelli et al. (2022), exposing students to louder and more frequent disturbances, which in turn reduces concentration and academic performance (Juan & Chen, 2022; Dadi Zhang et al., 2024).

3.4. Mediating factors

Several mediating factors were found within the effect of soundscapes on students' concentration and academic performance, including mood or feeling, noise sensitivity, age and academic performance, and the use of headphones or earbuds.

3.4.1. Mood or feeling

Some studies did not directly measure the impact of soundscapes on concentration or academic performance but focused on their effects on mood, pleasantness, well-being, or feelings. Consequently, this was one of the reasons why some studies were not classified as directly relevant in the quality assessment (Table 3). However, their outcomes are important, as they play a mediating role in the relationship between soundscapes, concentration, and academic performance, which can be explained by the arousal-mood hypothesis (Chee et al., 2024). This theory hypothesizes that changes in arousal and mood when exposed to auditory stimulation (music or noise) underlie the detrimental effects or improvements in cognitive performance.

Research has shown that certain sounds evoke specific emotional states. For example, Dadi Zhang et al. (2024) found that background sound levels influence students' satisfaction and mood; higher sound levels are associated with greater noise annoyance and negatively impact mood and satisfaction. Many studies have concluded that human-made sounds, such as background speech, are considered the most unpleasant and can lead to mood disturbances (Braat-Eggen et al., 2017; Chan et al., 2021; Lin et al., 2024; Pellegati et al., 2024). Additionally, Chan et al. (2021) and Zhang et al. (2025a) found that traffic and mechanical sounds (e.g., construction noise or home appliances) induce stress responses and contribute to mood disturbances. In contrast, these studies also reported that nature sounds are perceived as pleasant and foster a positive mood. For music, Gonzalez and Aiello (2019) found that positive or familiar music at a moderate volume (50 dB) can induce positive emotions, whereas sad or negative music induces negative emotions.

According to the arousal-mood hypothesis, these emotions and mood states have a positive statistical relationship with concentration and academic performance, meaning that positive emotions enhance concentration and performance, while negative emotions are associated with decreased outcomes. Sounds which induce negative emotions are considered as negative arousal. This negative arousal can lead to poorer performance because cognitive resources are distracted by negative emotions. Sounds that induce positive emotions are considered as positive arousal. This positive arousal contributes to a certain level of arousal which stimulates, motivates, inspires, and reduces stress, which improves academic performance (Chee et al., 2024). Therefore, sounds that induce negative emotions can have a negative effect on academic performance, and sounds that induce positive emotions can have a positive effect on academic performance.

3.4.2. Noise sensitivity

Three studies have identified noise sensitivity as a mediator of the effects of environmental sound on students' concentration and academic performance. Noise sensitivity refers to an individual's perceptual response to noise, reflecting the extent to which they are affected by environmental sound (Braat-Eggen et al., 2017; 2020; 2021). It is associated with increased annoyance, disturbance, stress responses, and negative impacts on concentration and cognitive performance. Students with high noise sensitivity experience a greater negative impact on concentration and performance when exposed to environmental sound (Braat-Eggen et al., 2020). In contrast, students who are less sensitive to noise are less disturbed by environmental sound, resulting in a smaller negative effect on their concentration and academic performance. However, Braat-Eggen et al. (2021) found no significant influence of noise sensitivity on students' performance and perceived disturbance. Furthermore, Braat-Eggen et al. (2017) suggested that the noise sensitivity of students in OPSEs is likely lower than that of the general student population, as some students choose to study in OPSEs due to their greater resilience to environmental sound. This finding indicates that noise sensitivity is an important factor in selecting an appropriate study environment.

3.4.3. Age (and academic level)

Zhang et al. (2023) found that younger students adapt more easily to varying sound environments, whereas older students report higher noise sensitivity levels and distraction. Additionally, students further along in their studies reported a stronger preference for quieter study environments compared to freshmen or sophomore students. This indicates that as students' progress in their academic journey, their need for a quieter sound environment increases, likely due to the increasing complexity and intensity of academic tasks, which requires more cognitive resources. Another explanation is the development of metacognitive skills as students progress in their academic journey, enabling them to better understand how external factors, such as noise, affect their concentration and academic performance (Efklides, 2011). As they gain experience with studying in different study places, they become aware of how background noise influences their focus and productivity, which allows them to make more deliberate choices regarding their study environments performance (Efklides, 2011).

3.4.3. Headphones or earbuds

Another key mediating factor influencing the relationship between soundscapes and students' concentration and academic performance is the use of headphones or earbuds. Braat-Eggen et al. (2017) and Hamida et al. (2024a) found that over 50% of students uses headphones or earbuds to minimize unwanted noise, both at home and in ILSs or OPSEs. The use of such devices can mitigate many of the negative effects associated with soundscapes by providing a controlled acoustic environment.

4. Conclusion

This scoping review aimed to answer the research question: *"What are the effects of the soundscapes of study places on students' concentration and academic performance?"*. The findings reveal that there is no singular or universal answer to this question, but the effects are instead influenced by a combination of sound source, acoustic quality, and mediating factors.

Human-made sound was the most prevalent in study environment, particularly in ILSs and OPSEs. It was generally perceived as disruptive, negatively affecting reading, writing, and cognitive tasks, especially when speech was intelligible. However, some students found human-made sound beneficial, as it created a sense of social presence, motivation, and sound masking. Nature sound had a generally positive effect on concentration and academic performance. These sounds, such as water flow, wind, or birdsong, were reported to enhance mood, reduce cognitive overload, and support deep learning. Exposure to nature sounds also facilitated a flow state, improving engagement and reducing academic procrastination. Traffic and mechanical sound were consistently perceived as unpleasant and distracting. These sounds, which include road traffic, construction, and home appliances, contributed to mood disturbance, increased cognitive load, and reduced learning efficiency. Their unpredictability made them particularly disruptive to concentration. Music had mixed effects, depending on its characteristics, presence of lyrics, task type, individual differences, and emotional responses. Simple instrumental music at a moderate volume (50 dB) was found to be beneficial, as it masked distractions and stabilized attention. However, music with lyrics negatively affected language-based tasks due to competition for linguistic processing.

Acoustical quality played a role in shaping the impact of soundscapes. Optimal sound levels ranged between 40-50 dB, with both excessively low and high levels impairing concentration. Additionally, signal-to-noise ratio (SNR), reverberation time (RT), and speech intelligibility influenced the effectiveness of study environments. Well-regulated acoustic conditions—balanced sound levels, controlled reverberation, optimal SNR, and clear speech transmission—were found to enhance concentration and academic performance. These findings emphasize the importance of designing study spaces that align with students' cognitive needs.

According to the mood-arousal hypothesis, students' mood and emotional responses mediated the effects of soundscapes. Human-made and traffic noise often led to negative arousal and stress responses, impairing concentration and academic performance. Conversely, nature sounds and positive music enhanced mood and motivation, thereby supporting concentration and academic performance. Noise sensitivity was a key individual characteristic, with highly noise sensitive students experiencing greater disruption from background noise. However, some studies found no significant effect of noise sensitivity on performance, suggesting that task complexity and engagement may override its influence.

To conclude, these findings suggest that study soundscapes influence concentration and academic performance through a complex interplay of external and individual factors. Human-made and traffic or mechanical noise generally impair concentration, while nature sound and controlled music can enhance focus. Better acoustic quality, positive emotional responses, lower noise sensitivity, and self-regulating strategies lead to better concentration and academic performance.

5. Discussion

The findings of this study confirm that study soundscapes do not have a uniform effect on students' concentration and academic performance. Any background sound, regardless of its type or intensity, influences concentration to varying degrees, while tasks of different complexity require different levels of cognitive resources (Liu et al., 2021). However, this study identified several general trends, discrepancies, and implications related to study soundscapes, which will now be further explored.

A key finding relevant to all results, is that personal preferences play a significant mediating role. Each student has specific preferences related to personal characteristics regarding their study soundscape, which influence their concentration and academic performance, such as the presence or absence of background speech or music. These preferences consistently shape the impact of soundscapes on learning outcomes. Consequently, these effects are subjective and can vary from person to person.

One of the personal characteristics that mediates the relationship between sound, concentration, and academic performance is noise sensitivity. However, Braat-Eggen et al. (2021) did not find a significant effect of noise sensitivity of the student performance. One possible explanation for this non-significant effect is that the importance of background noise decreases as task engagement and difficulty increase (Braat-Eggen et al., 2021). These factors overrule the impact of noise, reducing the influence of noise sensitivity. This suggests that multiple interacting factors shape students' concentration and academic performance, meaning that not all factors carry the same weight in every context. Additionally, when one factor changes, the relative importance of other factors may also shift.

Through various methodologies across studies, a distinction has been identified between the objective effects of sound (measured performance or sound measurements) and the subjective effects (students' experiences) on concentration and academic performance (Braat-Eggen et al., 2020; Liu et al., 2021; Zhang et al., 2023). A certain level of performance impairment (e.g., lower reading speed) may be perceived as more or less disruptive, depending on the individual student. Similarly, the same sound can be perceived as more disruptive than its actual impact on performance, or vice versa. While these measurements provide valuable insights, they do not always align with students' subjective experiences (Liu et al., 2021; Zhang et al., 2023). One explanation for this discrepancy is the perceived suitability of sounds within a certain context. For instance, a soundscape that meets acceptable thresholds for noise level and reverberation time might still be perceived as distracting or inappropriate depending on the context and the individual preferences. A clicking pen or chewing noises in a quiet study place, despite their low objective intensity, can be more disruptive than louder background sounds as they do not fit students' expectations for the environment. Conversely, some sounds that might objectively hinder concentration can be perceived as acceptable within certain contexts, thereby reducing their negative impact (Scannell et al., 2015; Lin et al., 2024). For example, background speech in an OPSE is typically seen as one of the most distracting sounds. However, in OPSEs, background speech is expected and socially accepted, making it less disruptive than it would be in a traditionally quiet study space. This finding aligns with Haapakangas et al. (2017), who examined both the objective effects on work performance and the subjective perception of noise disturbance in an open-plan environment. They found that there is not always a direct correlation between the measured performance impairments and self-reported noise annoyance, suggesting that subjective experiences of noise disturbance do not necessarily align with the objective impact of noise on task performance. This highlights the importance of distinguishing between objective cognitive effects and subjective noise annoyance in study environments (Haapakangas et al., 2017).

This study found that students are primarily exposed to human-made sound while studying in various study places (Chan et al., 2021; Hamida et al., 2024a). While most studies indicate that human-made sound is perceived as a disturbance, some have identified reasons why students might actually prefer its presence. Van den Bosch et al. (2018) explain this discrepancy through evolutionary psychology and the concept of audible safety. From an evolutionary perspective, the presence of human-made sound signals a familiar and socially rich environment, which can be comforting rather than distracting. Extremely quiet environments may feel isolating or even unsafe, leading some individuals to prefer moderate background noise as an indicator of social activity and safety. In such environments, where human-made sound is present, individuals experience a sense of pleasantness and security, allowing them to thrive, become fully engaged in their activities, and ultimately enhance their performance. Thus, the interpretation of human-made sound—whether as distracting or comforting—determines its effect on concentration and academic performance. This aligns with the introduction, which stated that studying in cafés can be beneficial for certain students, despite the generally negative effects of such noise (Umme, 2024). This also aligns with perceived suitability and socially accepted sounds. Human-made sound is perceived suitable in certain contexts or for some students, which clarifies the distinction between objective and subjective effects.

Finally, the impact of music on students' concentration and academic performance remains inconsistent, with studies showing both positive and negative effects on students' concentration and academic performance. This contradiction can be explained by the distraction-conflict theory, developed by Sanders (1982), which describes how the presence of external stimuli influences task performance. Distraction creates attentional conflict, as individuals must divide their cognitive resources between task-relevant processing (their study task), and task-irrelevant stimuli (music). This conflict increases arousal, which can have two opposing effects; for simple tasks, it can enhance performance, by reinforcing dominant responses such as focus, effort, and automatic processing. For complex tasks, it can impair performance by overloading cognitive resources, as distraction interferes with information processing (Sanders, 1981). The presence of lyrics, particularly when they are in the same language as the tasks, intensifies attentional conflict, further overloading cognitive resources. This aligns with findings that music can enhance academic performance for simple tasks, but becomes detrimental with complex tasks (Sanders, 1981).

5.1. Strengths and limitations

To provide a comprehensive evaluation of this study, its strengths, limitations, and implications for future research will be discussed starting with the strengths of this study. This scoping review offers a comprehensive and transparent overview of the existing literature on the effects of soundscapes on students' concentration and academic performance. The quality of the included studies was assessed by using the transparency checklist by Langeloo et al. (2019), with all studies classified as transparent and most as relevant. Additionally, the review includes a variety of methodological approaches. The consistency of findings across these diverse methodologies enhances the generalizability of results. Another strength is that most included studies specifically focus on students, making the findings directly generalizable to the total student population. Furthermore, the studies originate from various geographical regions, reflecting different educational systems, cultural norms, and societal values, thereby increasing external validity of the findings. Lastly, the broad scope of this review ensures that the complex interplay of external and individual factors between soundscapes and academic performance is considered. Despite differences in study settings and contexts, similar effects were found across different environments, strengthening the reliability and applicability of the findings.

Despite its strengths, this review has several limitations. First, due to methodological constraints a fully systematic approach was not feasible and a scoping review was conducted instead to provide a broad and exploratory overview of the literature. As a result, some relevant studies may not have been included, potentially affecting the completeness of the review. While efforts were made to ensure a comprehensive selection of articles, the absence of a fully systematic approach may have introduced selection bias. Specifically, studies were included based on their transparency and methodological quality, leading to all selected articles being classified as transparent according to the transparency checklist. As a result, this may have led to an overrepresentation of studies with strong designs, potentially creating an overly positive impression of the relationship between study soundscapes, concentration, and academic performance, as less transparent or contradictory findings may have been excluded. Consequently, this selection bias could also explain the prevalence of expected and unremarkable findings, as studies with more surprising or contradictory findings may have been underrepresented. Additionally, variability in search strings across databases makes the review difficult to reproduce, potentially affecting replicability. Another limitation is the absence of longitudinal studies in the included research. As a result, no conclusions can be drawn about long-term effects of soundscapes on students' concentration or academic performance changes. It remains unclear whether prolonged exposure to certain sound environments leads to adaptation, cognitive fatigue, or long-term changes in performance. Although the diversity of study methodologies strengthens the generalizability of the findings by demonstrating similar effects across different contexts and methodologies, it also limits direct comparisons. The reviewed studies vary significantly in study locations, sound sources, and measured outcomes, making it difficult to draw universal conclusions or establish causal relationships. Finally, Regarding the samples, some studies had relatively small sample sizes (e.g., $n = 23$), while others lacked diversity, consisting solely of senior students or students from a single university. Additionally, several studies relied on self-report measures, which could introduce bias. However, since many studies employed a combination of methodologies, and their findings were largely consistent, these limitations are unlikely to have introduced significant bias in the overall results.

5.2. Implications for future research

Future research should address several knowledge gaps identified in this review. First, future research should investigate long-term effects of different soundscapes on concentration and academic performance. This would provide valuable insights into whether students adapt to specific acoustic environments over time and how these effects persist or change.

One of the key findings of this study is the strong influence of personal preferences and individual characteristics on the effects of study soundscapes. Research has shown that factors such as noise sensitivity, personality traits, study habits, and sound/music preferences significantly impact how students perceive and respond to their acoustic environment. As a result, even when similar sound conditions are present, their effects on concentration and academic performance can vary widely across individuals. This variability highlights the need for future research to conduct more personalized or subgroup-based analyses to better understand how individual differences moderate the relationship between soundscapes and academic performance. Investigating these moderating factors could enhance the generalizability of findings and lead to more adapted recommendations for optimizing study environments. Moreover, exploring whether students actively adapt their study soundscapes over time could provide further insight into the long-term effects of different acoustic environments on academic performance.

Furthermore, experimental studies should control for key variables, such as individual noise sensitivity, task complexity, and sound familiarity, to better isolate the mechanism underlying the effects of soundscapes.

Another important direction for research is the role of personal control over soundscapes. Given that some students actively seek background noise, while others require silence to concentrate, future studies should explore whether the negative or positive effects of background noise identified in this study persist when students have actively selected their preferred soundscape, such as noise-cancelling headphones or studying in an environment that aligns with their personal preferences.

A final important direction for future research concerns the effects of different types of study music. While existing playlists for studying—including classical, piano, and electronic genres—are widely available, little is known about their actual effectiveness in enhancing concentration and academic performance. Future studies could examine whether certain types of music are more beneficial than others, and whether individual differences, such as task complexity or personal music preferences, influence these effects. Although this was not a primary focus of the present review, the absence of studies explicitly comparing different genres of study music highlights a possible gap in the existing literature.

5.3. Implications for practice

This study identified several factors that students can actively control to create their optimal soundscape for studying, thereby enhancing concentration and academic performance.

First, this study found that human-made sound is perceived as the most disturbing sound source and has the most detrimental impact on concentration and academic performance. However, it is also the most prevalent in OPSEs, as these environments are designed to facilitate collaboration and discussion. This creates a fundamental conflict: while OPSEs support interactive learning, the background speech and activity they encourage are also the primary sources of distraction while studying. Consequently, students in OPSEs have limited control over their soundscape, making it more difficult to create an optimal environment for focused study. Therefore, ducational institutions should consider these findings when designing study spaces, ensuring that acoustic qualities support both collaboration and individual studying. Potential solutions include dedicated quiet zones, improved sound insulation, separated discussion areas from silent study spaces, and the promotion of noise-reducing tools such as noise-cancelling headphones or sound-masking systems. By integrating these considerations into design and policy, institutions can create study environments that accommodate diverse learning needs and improve concentration and academic performance.

One of the key factors that students can actively control is their choice of study location. As discussed in the introduction, students select from various study environments, each characterized by distinct soundscapes and acoustic qualities, which influence concentration and performance. Given the importance of individual differences, students should choose their study place based on the task they need to perform, and their personal preferences and characteristics (Scannell et al., 2015; Braat-Eggen et al., 2017). For instance, students performing complex tasks or those who are easily distracted should seek quiet study spaces. Students who benefit from background speech or other auditory stimuli can study in OPSEs or cafés. By selecting their study place, students can actively shape their soundscape. As metacognitive skills develop over time, they can make more deliberate choices regarding their study environments (Efklides, 2011).

Another way students can manage their soundscape is by using (noise cancelling) headphones or earbuds, which eliminates unwanted sounds (Braat-Eggen et al., 2017; Hamida et al., 2024a). Additionally, they can intentionally listen to specific sounds that support concentration, such as nature sounds or positive, familiar music played at a moderate volume (50 dB), both of which have been shown to enhance focus and academic performance.

While writing this thesis, I applied some of these insights to my own study practices. My optimal study environment consisted of a quiet university study space, noise-cancelling headphones, and a Spotify playlist called 'House Focus,' which features calm, repetitive music without lyrics. This personal experience reflects the broader findings of this study: the best soundscape is not universal but is shaped by individual preferences, task requirements, and cognitive needs.

Ultimately, this scoping review pointed out that soundscapes have no uniform effect on students' concentration and academic performance, which was expected based on the preliminary research outlined in the introduction. Their impact is shaped by a complex interplay of variables, including study environment, sound source, task complexity, and personal preferences and characteristics. Future research should continue to explore these relationships, particularly the long-term effects of study soundscapes, the role of personal control in acoustic environments, and the potential benefits of structured study music. By acknowledging the nuanced nature of soundscapes, students and educators can create study environments that maximize both concentration and academic performance. In doing so, future designs of study spaces should take into account both objective acoustic principles and students' subjective preferences to enhance learning outcomes.

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Appendix A: Data Retrieval Distribution

In this appendix, it will be clearly outlined what articles were retrieved from each search. All articles from search 2, 3, and 4 were eliminated in the selection procedure.

Articles from prior research (n=10)

Braat-Eggen et al. (2017)

Chan et al., (2021)

Dadi Zhang et al. (2024)

Gonzalez & Aiello (2019)

Hamida et al. (2024b)

Minelli et al. (2022)

Scannell et al. (2015)

Sun et al. (2024)

Zhang et al. (2025a)

Zhang et al. (2025b)

Shared articles from supervisor (n=2)

Hamida et al. (2024a)

Pellegati et al. (2024)

Articles from search 1: Web of Science (n=4)

Sounds* AND university AND (performance or concentration) NOT (absor* OR insulat*)

Liu et al. (2021)

Luo et al. (2021)

Luo et al. (2022)

Zhang et al. (2024)

Articles from search 5: ERIC (n=2)

(soundscape* OR sound* OR acoustic* OR "acoustic environment" or "auditory environment") AND (student* OR adolescent*) AND ("study place*" OR "learning space*" OR "study environment" OR "educational environment") AND ("sound preference" OR "music preference")

Lin et al. (2024)

Puyana-Romero et al. (2023)

Articles from search 6: Web of Science (n=6)

Search 6 is a combination of two saved searches. The performed search strings are not retrievable, as they were not systematically recorded during the search process and can no longer be recalled.

Braat-Eggen et al. (2020)

Braat-Eggen et al (2021)

Juan & Chen (2022)

Liu et al. (2023)

Rau et al. (2020)

Zhang et al. (2023)

The search strings and databases form the eliminated searches

Search 2 in Web of Science.

(soundscape* OR sound* OR acoustic* OR "acoustic environment" OR "auditory environment" OR noise*) AND ("study place*" OR "study space*" OR "study environment" OR "learning space*" OR "learning environment") AND (concentration OR focus OR productivity OR "academic performance" OR "cognitive performance" OR "cognitive task performance" OR "study performance" OR "academic performance" OR perform*)

Search 3 in Academic Search Premier

TI (soundscape* OR sound* OR acoustic* OR "acoustic environment" OR "auditory environment" OR noise*) AND (concentrat* OR productivity OR "academic performance" OR "cognitive performance" OR "cognitive task performance" OR "study performance" OR perform*)
AND SU (soundscape* OR sound* OR acoustic* OR "acoustic environment" OR "auditory environment" OR noise*) AND (concentrat* OR productivity OR "academic performance" OR "cognitive performance" OR "cognitive task performance" OR "study performance" OR perform*)

Search 4 in Web of Science.

Sounds AND university AND (performance or concentration) NOT (absor* OR insulat*)

Appendix B: Transparency Checklist

Transparency checklist (Langeloo et al., 2019).

	Yes	No	Comments
Aims			
Is there a clear statement of the aims and/research questions of the study?			
Methods			
Is there sufficient information on the participants of the study?			
Data collection: is the research explicit on how data were collected?			
What is being measured with the collected data?			
What is the procedure followed for data collection?			
Analysis: is there an in-depth description of the analysis process?			
Results			
Is there a clear statement of the findings?			

Note. Every time a question is answered with a *no*, an explanation should be written down in the comment section

Explanation checklist (Langeloo et al., 2019).

Aims
Was there a clear statement of the aims and/or research questions of the research?
HINT: Consider the following:

- What was the goal of the research?
- Why it was thought important?
- Its relevance?

Methods
Is there sufficient information on the participants of the study?
HINT:

- Is the research explicit on the characteristics of the participants involved in this study (e.g., age, grade, language background, teacher information, N)?
- Does the research give enough information to replicate the study?

Data collection: Is the research explicit on

a. how data were collected?

HINT:

- In the case of a quantitative study: Is the research explicit on with which instruments variables were measured?
- In the case of a qualitative study: Is it explicitly mentioned what data were collected and how they were coded?

b. What was measured with the collected data?

HINT:

- Is the research explicit on what they are aiming to measure with the collected data (i.e., variables)?

c. the procedure followed for data collection?

HINT:

- Does the research describe what steps have been taken to collect and code the data?

- Does the research make explicit in what context data have been collected (e.g., how often, the role of the researcher, in what situation/type of activity)?

Analysis: Is there an in-depth description of the analysis process?
HINT: Consider the following:

- If sufficient data are presented to support the findings
- If the research is explicit on the analysis steps that have been taken; that is, how did the research get from data to results?

Results
Is there a clear statement of the findings?
HINT: Consider the following:

- If the findings are explicit
- If there is adequate discussion of the evidence both for and against the researcher's arguments
- If the findings are discussed in relation to the original research question

Appendix C: Data Summary

This appendix shows a descriptive summary of the includes articles. It provides an overview of the key characteristics and relevant information of the 24 included studies.

Author (year)	Title	Research question (RQ), aim (A) or hypothesis (H)	Topics and relevance	Methodology (Design, sample)	Findings and conclusions
Braat-Eggen et al. (2017)	Noise disturbance in open-plan study environments: a field study on noise sources, student tasks and room acoustic parameters.	A: Gain more insight into the assessment of noise in open-plan study environments.	Higher education Open-plan Student task Noise sensitivity Human-made sound Students' perception Disturbance Performance	Field study Questionnaire 496 students of 5 Dutch universities (322 male, 174 female)	38% was disturbed by noise. Noise sensitivity as a mediator. Speech is the most disturbing sound source. Students select their study place based on their needs and task, so students who study in an open-plan environment are more likely to be less disturbed by the noise.
Braat-Eggen et al. (2020)	The influence of background speech on a writing task in an open-plan study environment.	H: An increase of intelligibility of background speech, due to varying a realistic sound environment, will decrease writing performance and increase disturbance.	Higher education Open-plan Student task Noise sensitivity Human-made sound Students' perception	Experiment Questionnaire 74 Dutch students (29 male, 18 female)	Difference between measured influence of background speech on performance and students' perception of disturbance. The more intelligible the background speech, the bigger the negative influence.
Braat-Eggen et al. (2021)	The effect of background noise on a "studying for an exam" task in an open-plan study environment: a laboratory study.	H: A realistic sound environment with background speech will have a negative effect on performance and perceived disturbance will studying for an exam.	Higher education Open-plan Student task Noise sensitivity Human-made sound Students' perception	Experiment Questionnaire 66 Dutch students (42 male, 24 female)	Compared to background noise, a silent environment is best for performance according to student's perception. No significant effects were found except for background sound on logical reasoning.
Chan et al. (2021)	Influence on classroom soundscape on learning attitude.	RQ 1: What are the sound levels, loudness, and fluctuation strengths of sounds experienced by Hong Kong's higher education students in classrooms? RQ 2: What are the factors influencing students' learning attitude?	Higher education Classroom Learning attitude Nature sound Human-made sound Students' perception	Sound measurements Questionnaire 9 classrooms in 3 Hong Kong's higher education institutions	Nature sound is pleasant. Human-made sound is most present and most disturbing. Mechanical sound is also unpleasant. Regardless the sound source, a sudden change in the soundscape is most influential.
Dadi Zhang et al. (2024)	Interaction effects between mood state and background sound level on students' sound perceptions and concentration levels in study spaces.	RQ 1: What are the current situations regarding the acoustic quality, students' mood states, and concentration levels in the investigated study rooms? RQ 2: What are the impacts of the background sound level and mood states, separately, on students' acoustic satisfaction and concentration performance? RQ 3: What are the interaction effects between the background sound level and mood states on students' acoustic comfort and concentration performance?	Higher education Background sound Acoustic quality Students' perception Noise sensitivity	Sound measurements Questionnaire 4 study rooms in a university library in Hong Kong 257 students (117 males, 140 females)	The higher the background sound level, the greater the negative influence on students' mood and satisfaction. Too loud background sound (> 60 Db) negatively influences performance due to auditory fatigue, and too soft background sound negatively influences performance due to brain inactivity. Students' mood positively influences satisfaction and concentration

(continued)

Author (year)	Title	Research question (RQ), aim (A) or hypothesis (H)	Topics and relevance	Method (Design, sample)	Findings and conclusions
Gonzalez & Aiello (2019)	More than meets the ear: investigating how music affects cognitive task performance.	RQ: How will music (regardless of music complexity or volume), music complexity, and music volume moderate the relationship between preference for external stimulation and simple task performance?	Music preference Distraction Student task	Experiment Questionnaire 150 students (38 male, 112 female)	The effect of music on performance depends on music type, task type, and personal characteristics. Music positively affects the performance of a simple task. Music negatively affects the performance of a complex task
Hamida et al. (2024a)	Assessing the indoor soundscape approach among university students' home study places.	RQ: To what extent can the soundscape approach be used to assess the sound environment experience of each student at their home study place?	Higher education Home Students' perception Sound environment Human-made sound	Field study Interview 23 university students	Students are mostly exposed to human-made sounds. Some students prefer the present of human-made sounds and others are bothered by it. >50% uses headphones or earbuds do eliminate unwanted sounds.
Hamida et al. (2024b)	Profiling university students based on their acoustical and psychosocial preferences and characteristics of their home study places.	RQ 1: Can university students be clustered based on their acoustical and psychosocial preferences of their home study places? RQ 2: Can interviews with selected students from each cluster, building inspection of their home study places, and sound level measurements help to verify their acoustical preferences and their related aspects?	Higher education Home Students' preferences	Sound measurements Questionnaire: 451 students (275 female, 176 male) Field study: 23 students (15 female, 8 male)	Noise sensitivity is an important mediator for the effect of the home study soundscapes on students' concentration and performance. Sounds of the surroundings negatively affect concentration and performance.
Juan & Chen (2022)	The influence of indoor environmental factors on learning: an experiment combining physiological and psychological measurements.	H 1: Different environmental interference factors have significant influences on learners' concentration. H 2: Different environmental interference factors have significant influences on learners' anxiety. H 3: There is a significant relationship between learners' concentration and anxiety during learning.	Classroom Learning efficiency Traffic sound Music	Experiment 3 classrooms, different conditions 68 senior students (26 males, 42 females)	Environmental noise causes learners stress and anxiety. It interferes with their tasks. It has a significant effect on learning and concentration. Music has the same effect as environmental sounds, but this effect is weaker. Appropriate noise can positively affect learning, as quietness can result in insufficient brain activity.
Lin et al. (2024)	Semantic differential analysis of effects of indoor soundscapes on learning efficiency during online home-based classes.	RQ 1: Do the physical properties, personal and social attributes, and educational attributes of indoor soundscapes have an impact on students' learning efficiency during online home learning? RQ 2: Which key factors of indoor soundscapes will affect the efficiency during online home-based classes? And how does this differ from semantic differential analysis of other soundscapes? RQ 3: How to effectively improve learning efficiency during online home-based classes?	Home Learning efficiency Online classes Acoustic environment Students' perception Human-made sound Nature sound Traffic sound	Questionnaire, field study 951 Chinese students (511 male, 440 female)	Students prefer nature sounds over human-made sounds. Mechanical sounds and traffic sounds are also undesirable. Sounds that are considered suitable within the context of education are somewhat accepted. Language based sounds (television, conversations) are most distracting (especially with language-based learning) because of the intelligibility
Liu et al. (2021)	Does background sounds distort concentration and verbal reasoning performance in open-plan office?	RQ 1: Does an obvious difference exist between the effect of background music and background noise on individual concentration and verbal reasoning performance? RQ 2: What is the interaction between background sound types and sound intensities on the accuracy and efficiency of concentration and verbal reasoning tasks as well as individual activation and annoyance?	Office Open-plan Background sounds Concentration Performance Music	Laboratory experiment Objective and subjective measurement 82 employees (37 male, 45 female)	The effect of background music is always weaker than the effect of background sounds. The higher the background sound level the more annoyance and distraction, the stronger the negative effect on task performance. Low levels of background music can improve concentration and task performance.

(continued)

Author (year)	Title	Research question (RQ), aim (A) or hypothesis (H)	Topics and relevance	Method (Design, sample)	Findings and conclusions
Liu et al. (2023)	The effect of the acoustic environment of learning spaces on students' learning efficiency: a review.	A: Explore the effects of different acoustic environments on students' learning efficiency;	Learning spaces Learning efficiency Acoustic quality Human-made sound Nature sound Traffic sound Music Student task	Literature review 67 articles	Traffic noise negatively affects learning efficiency. However, traffic noise can shorten reaction time of search memory and promote visual cognitive work due to resistance to noise interference. Irrelevant speech negatively affects several study tasks. Intelligible speech affects language-based tasks. Music can negatively and positively affect performance of study tasks. Familiar music inhibits cognitive recognition, positively affecting performance. Music with no lyrics is preferable to music with lyrics. Positive music improves performance and negative music distracts.
Luo et al. (2021)	The effects of using a nature-sound mobile application on psychological well-being and cognitive performance among university students.	RQ 1: Does exposure to nature sounds through a mobile application in daily life impact on psychological well-being among university students? RQ 2: Does exposure to nature sounds through a mobile application in daily life impact on cognitive performance among university students?	Higher education Nature sound Student task	Experiment (pre- and post-test) Questionnaire Mobile app 71 Chinese students (28 male, 43 female)	The exposure to nature sounds through a mobile app reduces reaction time and improves alertness and working memory, improving students' academic performance.
Luo et al. (2022)	Exposure to nature sounds through a mobile application in daily life: effects on learning performance among university students.	RQ 1: Does exposure to nature sounds through a mobile application in daily life impact students' engagement in deep learning? RQ 2: Does exposure to nature sounds through a mobile application in daily life impact students' academic procrastination? RQ 3: Does exposure to nature sounds through a mobile application in daily life impact students' academic self-efficacy?	Higher education Nature sound Student task	Experiment Questionnaire Mobile app 4 weeks, 30 mins per day 71 Chinese students (28 males, 43 females)	The exposure to nature sounds through a mobile app improves the engagement in deep learning and decreases distraction. Nature sounds help students get into a flow state during studying. There is less academic procrastination and more productivity. Nature sounds improve self-efficacy. Nature sounds eliminate other environmental distractions.
Minelli et al. (2022)	Acoustical parameters for learning in classroom: a review.	A: Summarize 19 years of research about the effect of classroom acoustics on students' learning attainments, and identify acoustical parameters and their values, which have the greatest influence on students' performance at different ages	Classroom Acoustic quality Sound measurements Students' perception	Literature review 38 articles Ages 5-40 years	Optimal acoustical parameters for students' performance: - RT of 0,6 ÷ 0,7 (balanced clarity) - SNR ≥ 12 dB (low intelligibility) - Sound level 35 – 40 dB (soft but simulating) - STI ≥ 0,6 (optimal for comprehension)
Pellegatti et al. (2024)	Soundscape and indoor air quality in naturally ventilated educational environments: a multi-domain study.	A: Analyze the effect of indoor air quality and acoustic on students' performance on a math task, and the effect on soundscape perception.	Classroom Observed impact Students' performance Students' perception Nature sound Human-made sound	Laboratory experiment Questionnaire 192 students (12-14 years) 2 classroom, different conditions	Playground sounds (human-made sound) are perceived most annoying and disturbing. Quiet soundscapes or soundscapes that include birdsongs (nature sound) are perceived most pleasant. Playground noise resulted in a slower response time.
Puyana-Romero et al. (2023)	The acoustic environment and university students' satisfaction with online education method during the COVID-19 lockdown.	A: Evaluate the influence of the acoustic environment at home on students' satisfaction with the online learning modality.	Higher education Home Acoustic environment Noise interference Students' performance Students' satisfaction	Questionnaire 2477 students from a university in Ecuador (1103 male, 1371, female, 3 uncategorized)	>50% of the students says that music doesn't negatively affect academic tasks. Voice noises (human-made sound) highly interfere with student tasks. Studying at home is less suitable because such spaces are not designed for sound insulation, leading to increased exposure to both external and internal noise.

(continued)

Author (year)	Title	Research question (RQ), aim (A) or hypothesis (H)	Topics and relevance	Method (design, sample)	Findings and conclusions
Rau et al. (2020)	Distractive effect of multimodal information in multisensory learning.	A: Reveal which modality has the most distractive effect, and what the effect of their combination is.	Higher education Home Distraction Students' perception Music	2 experiments, reading task, answer questions 32 Chinese students (13 male, 19 female)	Auditory distraction (music) increases workload, deteriorating reading performance. Music lyrics has the same effect on performance as background speech. It reduces cognitive performance. The melody of music influences emotion and mood, indirectly affecting performance.
Scannell et al. (2015)	The role of acoustics in the perceived suitability of, and well-being in, informal learning spaces	A: Explore the relations between key acoustical characteristics of ILS and psychological outcomes. Other non-acoustical features were also assessed, given their expected impact on learning and well-being.	Higher education ILS Sound measurements Human-made sound Learning efficiency Students' perception	Questionnaire 850 students from a Canadian university (323 male, 527 female)	Speech is perceived as appropriate within the certain contexts (café's or open-plan environments), it is considered less disruptive and no annoyance. Therefore, it has a reduced impact on concentration and performance. Students select their study place based on their needs and task type.
Sun et al. (2024)	Impact of background music on reading comprehension: influence of lyrics language and study habits.	RQ 1: Would the accuracy rates in music conditions be significantly lower than the accuracy rates with no music for college students? RQ 2: Would Chinese/English reading comprehension accuracy rates when listening to music in the same language be significantly lower than that in different languages or no music? RQ 3: Would non-listeners have lower L1 and L2 reading comprehension accuracy rates than listeners when music was present? RQ 4: Would average reading comprehension accuracy rates be the lowest in the condition of Mandarin music compared with the English/no music condition?	Higher education Background music Student task	Experiment, reading task 90 Chinese students (40 males, 50 females)	Music with lyrics reduces reading performance compared to no music, regardless the language. Music in the same language as the reading task, compared to music in a different language, is more distracting and therefore has a greater negative impact on reading performance. Students accustomed to listening to music while studying experience less distraction from it compared to those who typically do not listen to music during study sessions.
Zhang et al. (2023)	Students' sound environment perceptions in informal learning spaces: a case study on a university campus in Australia.	H 1: Students' individual characteristics affect their sound environment perceptions. H 2: Students' sensitivities to the sound environments in ILS affect their preferences	Higher education ILS Sound environment Noise sensitivity Students' perception Students' preferences	Questionnaire 219 students at a university in Australia (93 male, 126 female)	Soundscape perception is influenced by personal characteristics. Older students or those further along in their studies are more sensitive to noise and more likely to be disturbed by it. Task difficulty also plays a role, with noise having a greater negative impact on performance in complex tasks. Students who are easily distracted tend to choose quiet study spaces, whereas those less prone to distraction often prefer ILS.
Zhang et al. (2024)	Human-made sounds in informal learning spaces on a university campus.	H 1: Human-made sounds have significantly different effects on students based on student's individual characteristics H 2: The auditory sensations brought by human-made sounds can provide students with positive experiences, such as relaxation, sound-masking effect and increased learning motivation.	Higher education ILS Human-made sound Students' performance Students' perception Individual characteristics	Questionnaire 219 students at a university in Australia (93 male, 126 female)	Human-made sounds in interactive learning spaces (ILS) have positive effects. The soundscape creates a relaxed atmosphere, reducing the pressure to perform in silence. The sound masking effect conceals individual noises, promoting comfort, while the presence of others motivates students to stay focused and study.

(continued)

Author (year)	Title	Research question (RQ), aim (A) or hypothesis (H)	Topics and relevance	Method (design, sample)	Findings and conclusions
Zhang et al. (2025a)	Effects of traffic noise on the psychophysiological responses of college students: an EEG study.	A: explore what the effect of traffic noise is on the psychophysiological responses of college students.	Higher education Traffic sound Observed impact Acoustic environment	Experiment 38 Chinese students (19 male, 19 female)	Traffic noise leads to mood disturbance and induces stress responses. Negative emotions rise. Short time exposure leads to dysfunction due to unnecessary brain energy expenditure through negative emotions such as anger and annoyance.
Zhang et al. (2025b)	Effects of spring water sounds on the psychophysiological responses of college students: an EEG study.	A: explore what the effect of spring water sounds are on the psychophysiological responses of college students.	Higher education Nature sound Observed impact Acoustic environment	Experiment 38 Chinese students (19 male, 19 female)	Spring water sounds can evoke positive emotional responses and aid in recovering from negative emotions. They enhance mood and perceptual quality, promote activity, and reduce stress, thereby facilitating a calm and relaxed state.

Appendix D: AI Use Statement

This appendix provides a declaration regarding the use of AI tools in the development of this thesis. ChatGPT was used as a tool in any phase of the research process within the guidelines of the faculty of BSS of the University of Groningen.

I acknowledge the use of ChatGPT to generate materials for inspiration at times when I got stuck (during the introduction or discussion). I confirmed all output before deciding whether to use it or further research on the output. I never used ChatGPT as a primary source as I am aware that it is prohibited and the correctness cannot be ensured.

I acknowledge the use of ChatGPT for advice on textual matters. It helped me rephrase certain sentences or words, regarding grammar or language (translation of certain words). It answered my questions about certain APA rules, and helped me restructure some sections. I always reflected on the output and suggestions and rephrased or adjusted as I wanted everything I presented in this thesis to be my work.

I acknowledge the use of ChatGPT for practical matters about how to use or perform certain actions in the programs I used such as Word, Rayyan or Zotero.