Education Tech Research Dev (2020) 68:2817–2837
https://doi.org/10.1007/s11423-020-09783-4

RESEARCH ARTICLE

The effects of background music on learning: a systematic review of literature to guide future research and practice

Efren de la Mora Velasco[1] · **Atsusi Hirumi**[2]

Published online: 9 June 2020

Abstract
This review builds on prior reviews by synthesizing thirty studies that examined the effects of background music (BM) on learning from 2008 to 2018. Each study was coded based on key methodological features, BM's characteristics, and reported BM effects on learning (i.e., negative, neutral or positive). Frequencies and percentages were used to describe BM effects on learning across studies, methods used, and BM's characteristics manipulated in the selected studies. Results showed (a) inconclusive findings as noted in prior reviews, (b) the need for more rigorous research methods, (c) that not all BM interventions are the same, and (d) a dearth of studies exploring BM impacts in multimedia learning environments. Implications are discussed for primary researchers, synthesis researchers, faculty and instructional designers.

Keywords Background music · Music · Learning · Review of literature · Research synthesis · Multimedia learning · Cognitive performance · Cognition · Students · Learners

Introduction

As a primary stimulus source, music is used to provide entertainment, aesthetic or spiritual experiences. As a secondary stimulus source, music is used in the background. In films, music's structural elements (i.e., tempo, rhythm, volume, harmony and melody) are used to elicit moods and help people connect to the information that is being presented (Jaspers 1991). Social media platforms, such as *YouTube,* allow users to add background music (BM) to their videos, making them more attractive (Kuo et al. 2013). In videogames, BM fosters fun and game play (Linek et al. 2011), and augments action (Zhang and Gao 2014).

Other purposes of BM are improving concentration and evoking emotions. For instance, instrumental BM may positively affect attention in the workplace (Shih et al. 2012). Similarly, college students use music while studying to increase concentration on academic

✉ Efren de la Mora Velasco
efren@ucf.edu

[1] Rosen College of Hospitality Management, University of Central Florida, 9907 Universal Blvd, Orlando 32819, Florida, USA

[2] College of Community Innovation and Education, University of Central Florida, 12494 University Blvd, Orlando, Florida 32816, USA

tasks (Kotsopoulou and Hallam 2010). Individuals use self-selected BM to regulate their mood (Greasley and Lamont 2011), to be calmer and more relaxed while driving (Dibben and Williamson 2007), and to enhance their emotional state while traveling (Heye and Lamont 2010). Over the past 13 years, additional studies have also examined the effects of BM's on learning. The present review is focused on music and not sound (e.g., sounds effects and narration) and begins by summarizing findings reported in four prior reviews of literature and one content analysis. Limitations of prior reviews are explained.

Background

Waterhouse (2006) summarized ten studies analyzing the impact of listening to Mozart's music before conducting visual-spatial tasks. Her review identified contradictory findings across studies and proposed that BM's beneficial impacts may be due to the emotional arousal it induces, providing short-lasting improvements in learning. Waterhouse highlighted the lack of empirical evidence to support the notion that Mozart's music in the background improves the learning of spatial skills, and recommended future researchers consider potential mechanisms and contextual factors when examining the impact of BM on spatial skills.

Similarly, Črnčec et al. (2006) reviewed empirical evidence on the effects of classical music in cognitive visual-spatial functions, and noted four important shortcomings: (a) no studies examined BM's effects in learning outcomes other than spatial skills, (b) the existence of equivocal findings for the impacts of BM on adult learners, (c) lack of investigations exploring BM's effects on children, and (d) substantive methodological limitations in BM research, such as the lack of focus on normal populations, examination of relatively small samples, and the potential influence of teachers. Črnčec et al. recommended future researchers examine whether BM's effects in cognitive performance can be replicated in normal populations, and additional factors that could influence how BM affects learning (class size, teacher expertise, etc.).

Following Črnčec et al. (2006) review, Bishop et al. (2007) conducted a content analysis to delineate the role of BM in 12 educational software programs. By coding each software based on a framework that distinguishes instructional functions of sound, they found BM was used less frequently as compared to sound effects and narrations, and implemented in a limited manner (e.g., played during introductions, assessment activities, or major screen transitions). Additionally, Bishop et al. determined that BM was mostly used to organize information (e.g., to help learner differentiate among blocks of content), and argued instructional designers did not use systematic methods to incorporate BM into multimedia instruction. They encouraged instructional designers to explore BM's associative potential to provide learners cognitive support.

Hallam and MacDonald (2016) synthesized findings of primary research to identify methodological and theoretical issues when studying BM's impacts on learning. They analyzed a sample of studies from 1965 to 2008 and concluded that, in general, BM research has failed to consider differences in BM characteristics (e.g., genre, vocal versus instrumental), BM assessment methods (e.g., self-reported measures, assessment tests, physiological measures) and the subjectivity of BM perception (e.g., preference, musical training). To address the shortcomings, Hallam and MacDonald posed a framework illustrating potential factors that may influence the relationship between music and learning, including type of music, individuals' characteristics, an individual's current emotional arousal and

mood state, the testing environment, and learning task characteristics. They also suggest that future researchers should examine music's long-term learning effects, and to study the use of BM in different educational settings, not only in music lessons taught in schools.

Schwartz et al. (2017) summarized empirical research published between 1970 and 2014 that explored whether BM facilitates academic task engagement and performance in individuals with developmental disabilities. Their findings suggest that instrumental BM, or BM selected by participants provided the most beneficial performance effects. Swchwartz et al. recommended future researchers examine the potential lasting effects of BM over time, BM's influences on individuals without developmental disabilities, BM's impacts on diverse academic tasks, how a BM's genre affects performance, and whether the length of exposure to BM impacts learning.

Prior reviews of literature have led to number of conclusions and recommendations guiding future research and practice on the use of BM's to facilitate learning. This review addresses five specific limitations, including: (a) the equivocal impact of BM on learning and the need to include more recent studies; (b) the lack of systematic procedures to "reduce bias in accounts of the research, and to standardize and make explicit the procedures used to collect, catalog, and combine primary research " (Cooper 2017, p. 10); (c) the need to examine BM's impact on learning outcomes other than spatial skills; (d) failure to analyze BM studies' methodological features and BM's characteristics that could influence learning, and (e) the lack of theoretical frameworks to support the identification of factors that might be influential in the relationship between BM and learning.

The purpose of this systematic review is to synthesize recent studies examining BM's effects on learning to guide future research and practice. It includes studies from 2008 to 2018, examines the impact of BM on alternative human cognitive outcomes, and identifies methodological features and BM's characteristics potentially affecting learning, taking into account an existing theoretical framework (Hallam and MacDonald 2016).

The basic research question that guided this review is, does BM affect learning (across studies)? Two specific questions also directed the review:

(1) What methods (such as setting, type of learning outcome, sample size, etc.) have been used to study the effects of BM on learning?
(2) What BM characteristics have been manipulated to study the effects of BM on learning?

Method

The 14 databases included in the literature search (Table 1) covered research on education, training, music psychology, professional development, health sciences and social sciences. The term "background music" was used and an initial search yielded 25,471 results. The search was narrowed by retrieving resources including "background music" within abstracts only, yielding 7953 results. The results were reduced to 783 including only peer-reviewed journal articles, documents that appeared from 2008 through 2018, and documents published in English. The titles and abstracts of the 783 articles were screened to identify studies specifically exploring BM interventions on any explicit learning outcome, and identifying studies comparing subjects exposed to BM conditions versus no-BM conditions. Forty articles were identified after screening and applying inclusion and exclusion criteria.

Table 1 Articles identified and included in the review of literature by database

Database	Articles initially retrieved by database after applying first set of parameters	Articles identified after completing prescreening of titles and abstracts	Articles that met the inclusion criteria
ERIC	25	9	7
Academic search premier	139	6	4
PsycINFO	172	5	4
RILM abstracts of music literature	49	3	3
Science direct	40	3	3
Academic one file	110	2	2
Directory of open access journals	40	2	0
Education source	50	2	1
Professional development collection	11	2	1
Social Sciences Citation Index	3	2	1
Arts & Humanities Citation Index	5	1	1
IEEE xplore digital library	82	1	0
SPORTDiscus	14	1	1
Supplemental Index	43	1	1
	783	40	30

Full-text assessments were made of the 40 articles and only those using experimental and quasi-experimental research designs, measuring explicit cognitive learning outcomes by participants with no cognitive or physical disabilities, and whose contents were published in English (in addition to their titles and abstracts) were included. Studies using music interventions other than BM or that focused on therapies were excluded. After completing the full-text assessment, 30 articles were identified for review. Table 1 shows articles identified in the search and those selected for coding.

Coding scheme

The 30 research articles were coded using methodological features identified by Cooper (2017) and key methodological aspects and BM characteristic delineated in the *model of the effects of BM on behavior and learning* posited by Hallam and MacDonald (2016). Table 2 shows the coding categories.

BM effects on learning were coded negative, neutral or positive. First, *p*-values were used to determine if there was an effect. Non-significant *p*-values were coded as neutral effects. Then, significant *p*-values that included higher group means for experimental conditions (i.e., BM) were coded as positive effects, and significant *p*-values that included higher group means for control conditions (i.e., no BM) were coded as negative effects.

The selection criteria and coding process differed from prior studies to help address their limitations by recording selected studies' methodological features and BM' characteristics manipulated. The coding guide included items to analyze literature that examined

Table 2 Coding categories used in the selected studies

Coding categories
Type of BM effect on learning
Methodological feature
Type of learning outcome
Setting
Type of community
Sample size
Participants' age
Musical expertise
Selection of BM
Testing of participants
Modality of delivery
Type of measurement instrument
Reliability of measurement instruments
Characteristics of the BM intervention
Duration of the BM
Composition
Arousal
Valence
Inclusion of lyrics
Genre
Volume

participants in normal populations and children, as suggested by Črnčec et al. (2006) and allowed identifying associative and contextual factors that might influence BM's effects on learning, as suggested by Waterhouse (2006) and Hallam and MacDonald (2016). Studies exploring BM's effects on alternative academic tasks were also coded, as recommended by Schwartz et al (2017). Table 3 shows general characteristics of the 30 articles coded.

Results and discussion

Specific actions were taken to address the five limitations identified in prior reviews. First, studies from 2008 to 2018 were included in the search. Second, a systematic method (Cooper 2017) was followed by formulating questions, locating and gathering literature, judging about study rigor and instruments' reliability, and summarizing the collected data to identify patterns and trends. Third, studies that explored effect of BM on different learning taxonomies were included. Fourth, key methodological features and BM characteristics were coded and analyzed. Last, a conceptual framework (Hallam and MacDonald 2016) was used to inform the coding and analysis of studies' methods and BM characteristics.

Does BM affect learning across studies?

The results indicate that the effects of BM on learning remain inconclusive. Of the total studies, 11 reported positive effects, 10 reported neutral effects, 9 reported negative effects. These results are consistent with Waterhouse (2006) and Črnčec et al. (2006) in the sense that findings on the impact of BM on learning are still inconclusive. However, the results also show a substantial number of beneficial effects of BM on learning and provide insights into how BM may affect learning based on variation of the studies' methodological features and the different BM's characteristics employed in selected papers.

What methods have been used to study the effect of BM on learning?

Results showed BM was implemented by varied methods at different levels. Table 4 shows frequencies and percentages of methods used in the 30 reviewed studies based on type of learning outcome, setting, type of community, sample size, age of participants, participants' musical expertise, selection of BM, testing of participants, modality of delivery, type of measurement instruments, and reliability of the measurement instruments.

Type of learning outcome

Table 4 illustrates that most of the studies explored BM's impacts on memorization or recall of information ($n=18$), followed by reading comprehension ($n=6$), writing skills ($n=10$) and few studies measuring arithmetic skills, technical skills, or multiple cognitive tasks simultaneously. In terms of the effects reported by type of learning outcome, out of the 18 studies that examined the effects of BM on memory or recall, 6 reported negative result and 5 positive results. Two of the 6 effects that examined effects of BM on reading comprehension reported negative results and 2 positive results. For writing skills, 2 of the studies reported positive effects and 1 negative effects. The only available study on the effects of BM on arithmetic learning reported positive effects.

Table 3 General characteristics of the articles coded

No	Author(s) and year	Type of learning outcome	Sample size	Mean age of participants	BM effect on learning
1	Küssner et al. (2016)	Foreign word recall task	33	21	Neutral
2	Cho (2015)	Foreign language writing	28	24	Positive
3	Nguyen and Grahn (2017)	Memory recall	93	20	Neutral
4	Ferreri et al. (2015)	Retrieval of information	19	21.65	Neutral
5	Liu et al. (2012)	Recognition of Chinese characters	22	22.3	Negative
6	Reaves et al. (2016)	Associative memory	103	43.6	Negative
7	Kang and Williamson (2014)	Language learning	32	25	Positive
8	Langan and Sachs (2013)	Retention of literacy concepts	20	NR	Positive
9	Hallam and Godwin (2015)	Writing a story	54	10	Negative
10	Anyanwu (2015)	Dissection skills	60	NR	Positive
11	Richards et al. (2008)	Remembering facts of a story	72	24.2	Positive
12	Linek et al. (2011)	Recall of physics information	59	13.6	Neutral
13	de Groot and Smedinga (2014a, b)	Recall of foreign words	41	NR	Negative
14	Taylor and Rowe (2012)	Trigonometry activities	69	NR	Positive
15	Tze and Chou (2010)	Reading comprehension	133	31.8	Negative
16	Bloor (2009)	Reading comprehension	47	10	Positive
17	Batur (2016)	Writing essays	80	NR	Positive
18	Chew et al. (2016)	Reading, math and memorization of words	165	21.87	Neutral
19	Jäncke et al. (2014)	Recall performance	226	25.8	Neutral
20	Yang et al. (2016)	Delay response of visual patterns	94	25.5	Neutral
21	Bottiroli et al. (2014)	Processing speed	65	69	Positive
22	Patston and Tippett (2011)	Language comprehension and visual-spatial search	72	23.8	Neutral
23	Thompson et al. (2011)	Reading comprehension	25	19.7	Negative
24	Haning (2016)	Reading comprehension	50	NR	Neutral

Table 3 (continued)

No	Author(s) and year	Type of learning outcome	Sample size	Mean age of participants	BM effect on learning
25	Fassbender et al. (2012)	Remembering of facts	48	22.7	Neutral
26	Doyle and Furnham (2012)	Reading comprehension	56	27	Positive
27	Kasiri (2015)	Reading comprehension	60	21.5	Negative
28	Dobbs et al. (2011)	Verbal reasoning	111	14.5	Negative
29	Angel et al. (2010)	Spatial processing and linguistic processing	56	NR	Positive
30	Su and Wang (2010)	Memorization of words	40	NR	Negative

We recorded neutral effects in cases when more than two studies were reported in the same research article and each of them reported different effects for the same dependent variable either for dependent or independent samples

NR not reported

Table 4 Number of studies by methodological feature and reporting effects (percentages in parentheses)

Methodological feature	Number of studies ($n=30$)		Effects within subcategories		
			Negative	Non-significant	Positive
Type of learning outcome					
Memory or recall	18	(.60)	6 (.33)	7 (.39)	5 (.28)
Writing skills	3	(.10)	1 (.33)	0 (.00)	2 (.67)
Arithmetic skills	1	(.03)	0 (.00)	0 (.00)	1 (1.0)
Reading comprehension	6	(.20)	2 (.33)	2 (.33)	2 (.33)
Technical skills	1	(.03)	0 (.00)	0 (.00)	1 (1.0)
Multiple outcomes	1	(.03)	0 (.00)	1 (1.0)	0 (.00)
Setting					
Educational settings	26	(.87)	9 (.35)	9 (.35)	8 (.31)
NS	4	(.13)	0 (.00)	1 (.25)	3 (.75)
Type of community					
Urban	7	(.23)	4 (.57)	3 (.43)	0 (.00)
Suburban	1	(.03)	0 (.00)	0 (.00)	1 (1.0)
NS	22	(.73)	4 (.18)	7 (.32)	10 (.45)
Sample size					
0–25	5	(.17)	3 (.60)	1 (.20)	1 (.20)
26–50	8	(.27)	2 (.25)	3 (.38)	3 (.38)
51–75	10	(.33)	2 (.20)	2 (.20)	6 (.60)
76–100	3	(.01)	0 (.00)	2 (.67)	1 (.33)
100 or more	4	(.13)	2 (.50)	2 (.50)	0 (.00)
Participants age					
1–12	2	(.07)	1 (.50)	0 (.00)	1 (.50)
13–17	2	(.07)	1 (.50)	1 (.50)	0 (.00)
18–24	10	(.33)	3 (.30)	6 (.60)	1 (.10)
25–44	6	(.20)	2 (.33)	2 (.33)	2 (.33)
45–64	1	(.03)	0 (.00)	0 (.00)	1 (1.0)
NS	9	(.30)	2 (.22)	1 (.11)	5 (.56)
Musical expertise					
Non-musicians	2	(.07)	0 (.00)	1 (.50)	1 (.50)
Musicians and non-musicians	6	(.20)	1 (.17)	4 (.67)	1 (.17)
NS	22	(.73)	8 (.36)	5 (.23)	9 (.41)
Selection of BM					
Selected by investigators	24	(.80)	8 (.33)	8 (.33)	8 (.33)
Selected by participants	1	(.03)	0 (.00)	0 (.00)	1 (1.0)
NS	5	(.17)	1 (.20)	2 (.40)	2 (.40)
Testing or participants					
In group	17	(.57)	4 (.24)	6 (.35)	7 (.41)
Individually	8	(.27)	4 (.50)	3 (.38)	1 (.13)
NS	5	(.17)	1 (.20)	1 (.20)	3 (.60)
Modality of delivery					
Face-to-face	27	(.90)	8 (.30)	9 (.33)	9 (.33)
Multimedia	3	(.10)	0 (.00)	1 (.33)	2 (.67)
Type of measurement instruments					

Table 4 (continued)

Methodological feature	Number of studies ($n = 30$)		Effects within subcategories		
			Negative	Non-significant	Positive
Standardized	7	(.23)	3 (.43)	1 (.14)	3 (.43)
Teacher/investigator developed	21	(.70)	6 (.29)	8 (.38)	7 (.33)
Multiple measures combined	2	(.07)	0 (.00)	1 (.50)	1 (.50)
Reliability of measurement instruments					
Specified	6	(.20)	2 (.33)	2 (.33)	1 (.17)
NS	24	(.80)	7 (.29)	8 (.33)	10 (.42)

NS not specified

These findings stand as one indicator of progress in the BM literature, but also illustrate that most studies concentrate on the influence of BM on relatively simple cognitive tasks, such as retention of characters, words, images or facts. No studies were found that explored the impact of BM on more complex cognitive tasks (e.g., applying, analyzing, creating or evaluating knowledge). Together, these findings confirm that BM can affect learning outside of music lessons (as formulated by Hallam and Macdonald 2016), but there is still a lack of available studies for researchers to determine under which circumstances the effects of BM might be positive or negative for learning, and how BM might affect higher-order thinking skills.

Setting, type of community and sample size

The results depicted in Table 4 show that BM research is often conducted in narrow settings, does not clearly specify community types, and tests relatively small samples of participants. For instance, 26 studies were conducted in educational settings, mostly public higher education institutions, and no studies were conducted in companies, industrial or governmental organizations. Also, 22 studies did not define the type of community where the BM interventions were implemented; 7 specified that the study was implemented in urban communities, and 1 in a suburban community. Additionally, 23 studies examined samples equal or smaller than 75 participants, and 7 studies assessed samples larger than 76 participants. In terms of significant effects, out of the 26 studies that examined impacts of BM in educational settings, 9 reported negative results and 8 reported positive results. For the type of community, out of the 7 studies that examined effects of BM on urban communities, 4 reported negative results, and the only study conducted in a suburban community reported positive results.

Studies with smaller sample sizes reported more negative effects of BM compared to studies that examined larger samples (see Table 4, column 5). For instance, out of the 5 studies that examined samples between 1 and 25 subjects, 3 reported negative effects, while out of the 10 studies that examined samples between 51 and 75 students, 6 reported positive effects. However, given the relatively small number of studies, it is not possible to determine if sample size affects outcomes. Additionally, although there is not a specific standard for a sample size to be considered a threat to validity, a power analysis was conducted using one dependent variable (i.e., learning) and two independent groups (i.e., BM and non-BM) that identified 128 participants as the recommended sample size (Faul et al.

2007). Evidently, the ranges of sample sizes in the selected literature denote potential limitations to detect BM's effects on learning due to low statistical power. Together, the setting, type of community and sample size limit the generalizability of BM's effects on learning.

Age of participants

Črnčec et al. (2006) concluded there is a lack of findings on BM's affect on children's learning. Eleven years after Črnčec et al.'s (2006) study, only 4 of the studies explored these effects. Most studies included in the literature were young adults ($n=10$) followed by adults ($n=6$) teenagers ($n=2$) and only one study included elderly. Surprisingly, 9 the studies did not specify participant age. Differential significant effects of BM were reported in studies based on age. For example, 1 study that examined participants between 1 and 2 years old reported positive effects, while 1 study of the 10 articles that examined participants between 18 and 24 years reported positive effects (see Table 4, column 6). These findings suggest impacts of BM might be different depending on learner age. Although effects of BM on learning have been explored in different age groups since prior reviews, only a small number of studies reported age, making conclusions about age uncertain.

Musical expertise

Study participants' musical training was examined during the review. Table 4 shows that 22 studies did not specify participant musical expertise, followed by 6 that included participants with varied levels of musical expertise, and 2 that examined only musicians. For the studies that specified participant musical expertise, out of the 2 that explored effects of BM in musicians, 1 reported positive effects, and out of the 6 that examined musicians and non-musicians, 1 reported positive effects. Hallam and MacDonald (2016) noted participants' musical training as an essential factor, and the present review reveals that the majority of studies did not report it, so little is still known about BM differences between musicians versus non-musicians.

Selection of BM and testing of participants

According to Hallam and MacDonald (2016) the BM literature has ignored whether the selection of BM by participants, and how participants were tested (i.e., in groups or individually) affects on learning. Table 4 shows that after 9 years since the last study summarized by Hallam and MacDonald, 24 studies implemented music selected by researchers, and only 5 studies allowed participants to select their own. A probable rationale of using BM prescribed by the researcher might be that 17 of the studies tested participants in groups (e.g., classrooms) and only 8 tested participants individually.

Out of the 24 studies that used BM selected by the investigators, 8 reported positive effects and 8 negative effects. Only one study explored effects of BM selected by participants and it reported positive effects. Out of the 17 studies that tested subjects in groups, 7 reported positive effects and 4 negative effects. For the studies that examined participants individually, 4 reported negative effects and 1 positive effects.

Findings in terms of BM selection and testing of participants suggest that, (a) researchers still prefer to choose the BM and test participants in groups due to the technical and logistical difficulties involved in letting participants individually choose their own, (b) BM interventions delivered in groups are be more beneficial than those delivered individually

potentially due to internal validity issues (e.g. selection of subjects). Little is still known about the effects of allowing learners to select their own BM due to the small number of studies available.

Modality of delivery

A prior content analysis suggested the potential role of BM in alternative learning modalities, such as multimedia learning environments (Bishop et al. 2007). Modality of delivery in BM experiments was reviewed and 27 studies were conducted in face-to-face experiments (e.g., in classrooms or laboratories), and only 3 incorporated BM in multimedia. Likewise, out of the 27 studies conducted in face-to-face environments, 9 reported positive effects and 8 negative effects. Out of the 3 studies delivered with multimedia, 2 reported positive effects and no studies reported negative effects. For the BM experiments delivered in multimedia modalities, researchers used digital videogames (Linek et al. 2011), immersive virtual worlds (Richards et al. 2008) or interactive CD-based lessons (Kang and Williamson 2014) to examine BM learning impacts. These three experiments reported increases in student motivation (Linek et al. 2011), enhanced recall of facts (Richards et al. 2008) and improved foreign language learning (Kang and Williamson 2014).

The identified positive effects of BM on motivation and learning inform cognitive learning theory (CLT) and multimedia design theory (MDT). Both, the CLT and MDT discourage the use of BM in multimedia materials for its potential detrimental influences on learning. According to CLT, learners that see and hear several sources of information that are not related to the learning goal might experience cognitive overload. For instance, Sweller et al. (2011) suggest that BM "diverts working memory resources away from the task at hand, resulting in reduction of learning" (p. 152). Similarly, the MDT postulates that BM is not essential for instruction and might inhibit retention and transfer of knowledge (Mayer, 2014). However, three studies (i.e., Kang and Williamson 2014; Linek et al. 2011; Richards et al. 2008) suggested beneficial effects of BM on retention and motivation. Consequently, BM might be integrated into multimedia in ways not producing cognitive overload.

Type and reliability of measurement instruments

Types of measurement instruments and their reliability were not explored in the prior BM reviews. Two important findings emerged. First, the majority of studies ($n=21$) adopted measures created or adapted by the researchers, such as lists of symbols to be recalled (Nguyen and Grahn 2017; Ferreri et al. 2015; Liu et al. 2012; Jäncke et al. 2014), criterion-referenced tests (Fassbender et al. 2012; Anyanwu 2015), or performance-based tests (Hallam and Godwin 2015; Taylor and Rowe 2012). The least popular measures were standardized achievement batteries ($n=7$) such as TOEFL reading comprehension practice tests (e.g., Kasiri 2015; Tze and Chou 2010), GMAT reading portions (e.g., Doyle and Furnham 2012) and SAT reading and math portions (Bloor 2009). Second, 24 did not include information about reliability of their measures, such as internal consistency, test–retest or inter-rater indexes. Only 6 articles included information about reliability or used measures in which reliability was determined in separate studies.

When analyzing frequencies of significant effects reported by the selected literature in terms of measurement instruments, (as shown in Table 5, columns 4 and 6), out of the 7 studies that used standardized measures, 3 reported positive effects and 3 negative effects, while 7 of the 21 studies that implemented measurement instruments created by

Table 5 Number of studies by BM characteristic and reporting significant effects (percentages in parentheses)

Characteristic of the BM	Number of studies ($n=30$)		Effects within subcategories		
			Negative	Non-significant	Positive
Duration of the BM					
30 or less	18	(.60)	4 (.22)	9 (.50)	5 (.28)
31–60 min	4	(.13)	2 (.50)	1 (.25)	1 (.25)
61–90 min	3	(.10)	2 (.67)	0 (.00)	1 (.33)
91–120 min	2	(.07)	0 (.00)	0 (.00)	2 (1.0)
121 min or more	2	(.07)	0 (.00)	0 (.00)	2 (1.0)
Not specified	1	(.03)	1 (1.0)	0 (.00)	0 (.00)
Composition					
Existing music pieces	25	(.83)	9 (.36)	8 (.32)	8 (.32)
Composed for the intervention	2	(.07)	0 (.00)	1 (.50)	1 (.50)
Not specified	3	(.10)	0 (.00)	1 (.33)	2 (.67)
Arousal					
Stimulating	3	(.10)	1 (.33)	0 (.00)	2 (.67)
Relaxing	4	(.13)	2 (.50)	0 (.00)	2 (.50)
Stimulating and relaxing	6	(.20)	3 (.50)	1 (.17)	2 (.33)
Not specified	17	(.57)	3 (.18)	9 (.53)	5 (.29)
Valence					
Happy	1	(.23)	1 (1.0)	0 (.00)	0 (.00)
Sad	1	(.03)	0 (.00)	0 (.00)	1 (.00)
Multiple valence	11	(.10)	0 (.00)	6 (.55)	5 (.45)
Not specified	17	(.63)	8 (.47)	4 (.24)	5 (.29)
Inclusion of lyrics					
Instrumental	18	(.60)	6 (.33)	7 (.39)	5 (.28)
Non-instrumental	6	(.20)	2 (.33)	1 (.17)	3 (.50)
Instrumental & non-instrumental	2	(.07)	1 (.50)	1 (.50)	0 (.00)
Not specified	4	(.13)	0 (.00)	1 (.25)	3 (.75)
Genre					
Classical	8	(.27)	2 (.25)	3 (.38)	3 (.38)
Pop	5	(.17)	3 (.60)	1 (.20)	1 (.20)
Rock	1	(.03)	1 (1.0)	0 (.00)	0 (.00)
Jazz	1	(.03)	0 (.00)	1 (1.0)	0 (.00)
Others (e.g., blues, alternative, etc.)	3	(.10)	1 (.33)	1 (.33)	1 (.33)
Multiple genres	5	(.17)	2 (.40)	1 (.20)	2 (.40)
Not reported	7	(.23)	0 (.00)	3 (.43)	4 (.57)
Volume					
Low	3	(.10)	0 (.00)	1 (.33)	2 (.67)
Moderate	9	(.30)	3 (.33)	4 (.44)	2 (.22)
High	1	(.03)	1 (1.0)	0 (.00)	0 (.00)
Not specified	17	(.57)	5 (.29)	5 (.29)	7 (.41)

investigators reported positive influences and 6 negative influences on cognitive performance. For the two studies that combined multiple measures, 1 reported positive effects and no studies reported negative effects. In summary, the variety of measures and their questionable reliability may limit the ability to determine BM's effects.

What BM characteristics have been manipulated to study the effects of BM on learning?

The diversity and variation of BM characteristics manipulated in the selected studies is shown in Table 5. To build upon prior reviews, findings are presented based on the duration the BM, composition, arousal, valence, inclusion of lyrics, genre and volume.

Duration of the BM

The duration of BM played during studies could be a contextual factor influencing learning (Waterhouse 2006). This analysis showed relatively short BM interventions used by researchers. As can be seen in Table 5, 18 studies implemented BM interventions shorter than 30 min, 4 conducted BM interventions between 31 and 60 min, 3 lasted between 61 and 90 min, and 4 studies lasted longer than 91 min. A pattern indicating that significant effects of BM on learning might be present when participants' exposure to the music also increases. Out of the 18 studies that implemented BM interventions that lasted less than 30 min, 5 reported positive effects, the 4 that lasted more than 91 min all reported positive effects (See Table 5, column 6). Longer episodes of BM during learning might produce habituation, thus, making the influence of BM less intrusive. Although these findings suggest longer use of BM may be beneficial, there are only 4 studies assessing longer use. The findings do support the Swchwartz et al. (2017) recommendation that BM length be explored more.

Composition of the BM

Another characteristic analyzed was whether the BM was specifically composed for the instructional intervention, or if existing music was used. The findings show that most of the studies ($n=25$) used existing music (either entire musical pieces or portions) and only 2 implemented BM composed for the particular intervention. Three of the studies did not specify whether existing music or specially composed music was used. The findings of the studies based on BM's composition indicated that out of the 25 studies that used existing musical pieces, 9 reported negative effects in learning and 8 positive effects. Conversely, 1 article reported positive effects of composed music in learning and the other study within this subcategory did not find that composed music impaired learning.

The two studies that composed music either manipulated tonality to explore how it affected learning (Yang et al. 2016) or created BM that (a) used musical instruments with different tone ranges than the narrator's voice, (b) kept dynamics at the lowest, and (c) used minimal instrumentation to support the metric framework of the words narrated in the multimedia learning environment (Kang and Williamson 2014).

Few studies explored how composed BM might affect learning as compared to existing BM. Perhaps, the inconclusive findings on the effects of BM on learning across studies found in the present review, among other factors, are due to the addition of BM that was an incompatible auditory input not working as extra symbolic system that enhanced learning

(Moreno and Mayer 2000). Potentially, creating BM that is compatible with the visual events presented in the multimedia contents could be an effective way to promote emotional engagement and facilitate learning. However, the creation of BM also implies the use of musical and technological equipment, and involvement of experts (e.g., musicians, composers, music engineers, etc.) as compared to selecting or adapting existing music, or having learners select their own.

Arousal and valence

The results of this review revealed a dearth of studies examining the effects of varying the levl of BM arousal and valence on learning. Table 5 illustrates that 17 of the studies did not note whether the BM was stimulating and/or relaxing followed by 7 using stimulating, 4 using relaxing, and 6 using both stimulating and relaxing BM. Similarly, 17 did not report the valence (e.g., positive/happy or negative/sad) of BM, followed by 1 using happy BM, 1 using sad, and 11 using multiple valences (e.g., happy and sad music).

The results also suggest similar effects of stimulating, relaxing music, and differential effects for happy or sad music. Out of the 3 studies that used stimulating music, 2 reported positive effects on learning, while 2 of the 4 studies using relaxing BM found positive effects.

Analysis of the relatively few studies that examined arousal and valence suggest that such factors could be influential in the use of music while learning. Nine years after the theoretical framework posited by Hallam and Macdonald (2016), some advances have been seen in the consideration of valence and arousal by BM researchers, yet the majority of studies have not addressed them.

Inclusion of lyrics

Prior reviews suggested the existence of lyrics in BM might affect learning (c.f., Hallam and MacDonald 2016; Schwartz et al. 2017). The present review illustrates that 18 studies used instrumental music, 6 used existing songs, 2 used instrumental and non-instrumental music, and 4 did not specify whether the music was instrumental or not. Out of the 18 studies that used instrumental music, 6 reported negative effects and 5 positive effects; versus 3 that reported positive effects and 2 negative effects when using non-instrumental BM (i.e., BM with lyrics). Findings show that instrumental music might be the most common type used by researchers regardless its genre or particular characteristics, but lyrical music showed more positive influences on learning than instrumental music. Therefore, absence/inclusion of lyrics might be an important factor to consider when assessing the impact of BM in cognitive performance. However, additional comparisons of the effects of vocal and instrumental BM on learning are still needed.

Genre

Another important characteristic that has been noted in prior reviews is the BM's genre (Hallam and MacDonald 2016). This review found diverse genres utilized in the research literature, including classical ($n=8$), pop ($n=5$), rock ($n=1$), jazz ($n=1$), other genres ($n=3$), or multiple genres ($n=5$). Significant numbers of effects within BM genres suggested that classical was the music with more significant positive effects ($n=3$) and pop was the music with highest number of negative effects reported ($n=3$). Evidently, the most

popular genre used was classical, showing a possible influence of the well-known, yet controversial *Mozart effect* (Rauscher et al. 1993) that suggests classical music played before performing cognitive tasks benefits performance. This review shows important advances in utilizing differential music genres that may be further compared in terms of its impact on individuals' learning.

Volume

The last BM characteristic analyzed was volume-defined here as the sound's intensity. Reported level of BM intensity (i.e., low, moderate, or high) were used to code volume. In 9 of the studies researchers used moderate volume, 3 low volume, 1 high volume, and 17 did not report volume information. The results also show that volume might be a moderator factor on learning. Out of the 3 articles that used BM at a low volume, 2 reported positive effects on learning, 2 of 9 reported positive effects of moderate volumes on learning, and the only one study that used high volume of BM reported negative effects.

As shown in Table 5, the majority of studies omitted information about the BM's volume, as indicated in an earlier review (Hallam and Macdonald 2016). For the selected papers that reported the volume of the BM, the majority used moderate volumes, perhaps indicating that using moderate volume levels may be best. However, volume may be manipulated to improve learning due to its potential to isolate auditory distractors or decrease individuals' mental wandering (Greasley and Lamont 2011; Herbert 2011). BM's volume could also be a fundamental variable while learning from multimedia formats (Moreno and Mayer 2000) or different learning settings (e.g., classroom or laboratory). For instance, a low volume of BM in multimedia presentations might create a more pleasant auditory experience and facilitate learning, or volume could be increased at times to elicit specific emotions, provide attentional cues, and potentially enhance learning. In summary, volume can be an important moderator that needs to be reported more in the BM literature.

Conclusions and implications

The present systematic review has five conclusions informing future research and practice. First, overall, the results of the present review show that the reported effects of BM on learning are still equivocal, and while suggestive, there is no definitive conclusion about BM's role in learning until more empirical studies are available and further synthesis studies aggregate the findings.

Second, although the prior reviews' limitation of not analyzing BM methodological features was addressed, a need for more rigorous research methods was identified. Investigators could persistently strive to improve the reliability of their measurement instruments, include more participants to increase statistical power, conduct longer and sustained BM interventions, and conduct studies in other than educational settings. Otherwise, the findings on how BM affects learning will remain inconclusive.

Third, after dealing with the lack of examination of music characteristics on BM studies, the results demonstrate that not all BM interventions are the same. Future researchers should provide clearer descriptions of the BM characteristics manipulated, such duration of the BM intervention, levels of arousal and valence, whether the BM was instrumental or lyrical, whether the BM used was existing or composed, the BM's genre, and the BM's volume. Future research should also examine the potential impact on learning of individual

music preferences, individual temperament, and how habituated an individual may be with listening to music while learning. The availability of information about these BM's characteristics will facilitate future comparisons across studies and more accurate assessments of BM's impacts on human's cognitive performance.

Fourth, after addressing the third limitation related to the lack of reviews examining BM effects on different learning taxonomies, it was found the need of exploring higher-order thinking skills. Significant efforts have been invested in examining potential impacts of BM in low-level cognitive skills (e.g., remembering or recalling images, symbols, words, and facts). Few studies have explored BM effects on conceptual and procedural knowledge, and problem solving and metacognitive skills. Future studies could examine how BM impacts higher cognitive dimensions, such as applying, analyzing, evaluating, synthesizing and creating knowledge, using bi-dimensional taxonomy of education objectives posed by Anderson and Krathwohl (2001) to distinguish outcomes.

Lastly, although BM impacts have been mainly explored in face-to-face learning settings, the effects of BM in multimedia learning may be promising. Future scholarship should examine how BM can be selected, designed, incorporated, and improved for educational videogames, instructional videos, simulations, multimedia presentations, and other instructional resources. Furthermore, alternative research approaches such as design-based research (Cobb et al. 2003) could be used to (a) improve the BM based on students experiences and expert's evaluations, (b) enhance existing learning experiences or resources that do not include BM, and (c) explore to what extent BM enriches learners' engagement, motivation or learning.

The results of this study also show the need of comprehensive meta-analyses that synthesize BM's effects in learning. Such meta-analyses could address limitations of the present review by: (a) including non-published BM literature (e.g., doctoral dissertations, conference proceedings), (b) increasing inter-rater reliability, and (c) completing moderator analyses based on the factors identified in the present. Such meta-analyses could also inform and improve existing theoretical frameworks (Hallam and MacDonald 2016) and theoretical perspectives (Moreno and Mayer 2000; Thompson et al. 2001) explaining causal relationships between BM and cognitive performance.

This analysis is useful to distinguish among the range of applications of BM for instructional purposes. Collaborating with students, music experts, multimedia experts, and researchers could find innovative and better ways to incorporate music into instruction; the assessment of music's effectiveness in behavior, retention and transfer of knowledge; and the construction of evidence-based systematic methods to sustain instructional innovations that utilize the power of music to enhance the learning experience and students' academic performance.

Limitations

Three factors limit the results and conclusions found in this systematic review. First, some relevant studies might not have been retrieved. Although a complete an exhaustive review was attempted, the 30 articles analyzed might not be representative of the full body of research on the effect of BM on learning. Second, only empirical research published in refereed journals was reviewed. Conference proceedings and dissertations were not included. Third, only one coder gathered study information and assigned learning outcome categories. Although the articles were coded based on seminal literature recommendations and

theoretical frameworks, potential miscoding or misclassification of articles might have occurred for certain learning outcomes.

Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

References

Anderson, L. W., & Krathwohl, D. R. (2001). *A taxonomy for learning, teaching, and assessing* (Abridged ed.). Boston: Allyn and Bacon.

Angel, L. A., Polzella, D. J., & Elvers, G. C. (2010). Background music and cognitive performance. *Perceptual and Motor Skills, 3*, 1059–1064. https://doi.org/10.2466/04.11.22.PMS.110.C.1059-1064.

Anyanwu, E. G. (2015). Background music in the dissection laboratory: Impact on stress associated with the dissection experience. *Advances in Physiology Education, 39*, 96–101. https://doi.org/10.1152/advan.00057.2014.

Batur, Z. (2016). The contribution of music to the fluent writing skills: MAYAZ technique. *Education, 137*(1), 82–92.

Bishop, M. J., Amankwatia, T. B., & Cates, W. M. (2007). Sound's use in instructional software to enhance learning: A theory-to-practice content analysis. *Educational Technology Research and Development, 4*, 467. https://doi.org/10.1007/s11423-006-9032-3.

Bloor, A. J. (2009). The rhythm's gonna get ya'–background music in primary classrooms and its effect on behavior and attainment. *Emotional & Behavioral Difficulties, 14*(4), 261–274. https://doi.org/10.1080/13632750903303070.

Bottiroli, S., Rosi, A., Russo, R., Vecchi, T., & Cavallini, E. (2014). The cognitive effects of listening to background music on older adults: Processing speed improves with upbeat music, while memory seems to benefit from both upbeat and downbeat music. *Frontiers in Aging Neuroscience, 6*(2014), 1–7. https://doi.org/10.3389/fnagi.2014.00284.

Chew, A. S., Yu, Y., Chua, S., & Gan, S. K. (2016). The effects of familiarity and language of background music on working memory and language tasks in Singapore. *Psychology of Music, 44*(6), 1431–1438. https://doi.org/10.1177/0305735616636209.

Cho, H. (2015). Is background music a distraction or facilitator? An investigation on the influence of background music in L2 writing. *Multimedia-Assisted Language Learning, 18*(2), 37–58. https://doi.org/10.15702/mall.2015.18.2.37.

Cobb, P., Confrey, J., diSessa, A., Lehrer, R., & Schauble, L. (2003). Design Experiments in Educational Research. *Educational Researcher*, *32*(1), 9–13. Retrieved July 16, 2019, from https://journals.sagepub.com/home/edr

Cooper, H. M. (2017). *Research synthesis and meta-analysis: A step-by-step approach*. Los Angeles: SAGE.

Črnčec, R., Wilson, S. J., & Prior, M. (2006). The cognitive and academic benefits of music to children: Facts and fiction. *Educational Psychology, 26*(4), 579–594. https://doi.org/10.1080/01443410500342542.

De Groot, A. D., & Smedinga, H. E. (2014a). Let the music play! A short-term but no long-term detrimental effect of vocal background music with familiar language lyrics on foreign language vocabulary learning. *Studies in Second Language Acquisition, 36*(4), 681–707. https://doi.org/10.1017/S0272263114000059.

De Groot, A. M. B., & Smedinga, H. E. (2014b). LET the music play!: A short-term but no long-term detrimental effect of vocal background music with familiar language lyrics on foreign language vocabulary learning. *Studies in Second Language Acquisition, 36*(4), 681–707. https://doi.org/10.1017/S0272263114000059.

Dibben, N., & Williamson, V. J. (2007). An exploratory survey of in-vehicle music listening. *Psychology of Music, 35*(4), 571–589.

Dobbs, S., Furnham, A., & McClelland, A. (2011). The effect of background music and noise on the cognitive test performance of introverts and extraverts. *Applied Cognitive Psychology, 25*, 307–313. https://doi.org/10.1002/acp.1692.

Doyle, M., & Furnham, A. (2012). The distracting effects of music on the cognitive test performance of creative and non-creative individuals. *Thinking Skills And Creativity, 7*, 71–77. https://doi.org/10.1016/j.tsc.2011.09.002.

Fassbender, E., Richards, D., Bilgin, A., Thompson, W. F., & Heiden, W. (2012). VirSchool: The effect of background music and immersive display systems on memory for facts learned in an educational virtual environment. *Computers & Education, 58*, 490–500. https://doi.org/10.1016/j.compedu.2011.09.002.

Faul, F., Erdfelder, E., Lang, A.-G., & Buchner, A. (2007). G*Power 3: A flexible statistical power analysis program for the social, behavioral, and biomedical sciences. *Behavior Research Methods, 39*, 175–191.

Ferreri, L., Bigand, E., Bard, P., & Bugaiska, A. (2015). The influence of music on prefrontal cortex during episodic encoding and retrieval of verbal information: A multichannel fNIRS study. *Behavioral Neurology, 2015*, 1–11. https://doi.org/10.1155/2015/707625.

Greasley, A. E., & Lamont, A. (2011). Exploring engagement with music in everyday life using experience sampling methodology. *Musicæ Scientiæ: The Journal of the European Society for the Cognitive Sciences of Music, 15*(1), 45–71. https://doi.org/10.1177/1029864910393417.

Hallam, S., & Godwin, C. (2015). Actual and perceived effects of background music on creative writing in the primary classroom. *Psychology of Education Review, 39*(2), 15–21.

Hallam, S., & MacDonald, R. (2016). The effects of music in community and educational settings. In S. Hallam, I. Cross, M. Thaut, S. Hallam, I. Cross, & M. Thaut (Eds.), *The Oxford handbook of music psychology* (pp. 775–788). New York: Oxford University Press.

Haning, M. (2016). The association between music training, background music, and adult reading comprehension. *Contributions to Music Education, 41*, 131–143.

Herbert, R. (2011). An empirical study of normative dissociation in musical and non-musical everyday life experiences. *Psychology of Music, 41*(3), 372–394. https://doi.org/10.1177/0305735611430080.

Heye, A., & Lamont, A. (2010). Mobile listening situations in everyday life: The use of MP3 players while traveling. *Musicæ Scientiæ: The Journal Of The European Society For The Cognitive Sciences Of Music, 14*(1), 95–120.

Jäncke, L., Brügger, E., Brummer, M., Scherrer, S., & Alahmadi, N. (2014). Verbal learning in the context of background music: No influence of vocals and instrumentals on verbal learning. *Behavioral and Brain Functions*. https://doi.org/10.1186/1744-9081-10-10.

Jaspers, F. (1991). Music in audio-visual materials. *Journal of Educational Television, 17*(1), 45.

Kang, H. J., & Williamson, V. J. (2014). Background music can aid second language learning. *Psychology of Music, 42*(5), 728–747.

Kasiri, F. (2015). The impact of non-lyrical Iranian traditional music on reading comprehension performance of Iranian EFL learners: The case of gender, attitude, and familiarity. *Procedia Social and Behavioral Sciences, 199*, 157–162. https://doi.org/10.1016/j.sbspro.2015.07.500.

Kotsopoulou, A., & Hallam, S. (2010). The perceived impact of playing music while studying: Age and cultural differences. *Educational Studies, 36*(4), 431–440. https://doi.org/10.1080/03055690903424774.

Kuo, F., Shan, M., & Lee, S. (2013). Background music recommendation for video based on multimodal latent semantic analysis. *2013 IEEE International Conference on Multimedia and Expo (ICME)*. https://doi.org/10.1109/ICME.2013.6607444.

Küssner, M. B., de Groot, A. M. B., Hofman, W. F., & Hillen, M. A. (2016). EEG beta power but not background music predicts the recall scores in a foreign-vocabulary learning task. *PLoS ONE, 11*(8), 1–16. https://doi.org/10.1371/journal.pone.0161387.

Langan, K. A., & Sachs, D. E. (2013). Opening pandora's stream: Piping music into the information literacy classroom. *Public Services Quarterly, 9*(2), 89–109.

Linek, S. B., Marte, B., & Albert, D. (2011). Background music in educational games: Motivational appeal and cognitive impact. In J. Bishop & J. Bishop (Eds.), *Gamification for human factors integration Social education and psychological issues* (pp. 259–271). Hershey: Information Science Reference/IGI Global. https://doi.org/10.4018/978-1-4666-5071-8.ch016

Liu, B., Huang, Y., Wang, Z., & Wu, G. (2012). The influence of background music on recognition processes of Chinese characters: An ERP study. *Neuroscience Letters, 518*(2), 80–85.

Mayer, R. E. (2014). Principles based on social cues in multimedia learning: Personalization, voice, image, and embodiment principles. In R. E. Mayer (Ed.), *The Cambridge handbook of multimedia learning* (pp. 345–368). New York: Cambridge University Press.

Moreno, R., & Mayer, R. E. (2000). A coherence effect in multimedia learning: The case for minimizing irrelevant sounds in the design of multimedia instructional messages. *Journal of Educational Psychology, 92*(1), 117–125.
Nguyen, T., & Grahn, J. A. (2017). Mind your music: The effects of music-induced mood and arousal across different memory tasks. *Psychomusicology: Music, Mind, and Brain, 27*(2), 81–94. https://doi.org/10.1037/pmu0000178.
Patston, L. M., & Tippett, L. J. (2011). The effect of background music on cognitive performance in musicians and nonmusicians. *Music Perception: An Interdisciplinary Journal, 29*(2), 173–183. https://doi.org/10.1525/mp.2011.29.2.173.
Rauscher, F., Shaw, G., & Ky, C. (1993). Music and spatial task performance. *Nature, 365*, 611.
Reaves, S., Graham, B., Grahn, J., Rabannifard, P., & Duarte, A. (2016). Turn off the music! music impairs visual associative memory performance in older adults. *The Gerontologist, 56*(3), 569–577. https://doi.org/10.1093/geront/gnu113.
Richards, D., Fassbender, E., Bilgin, A., & William, F. T. (2008). An investigation of the role of background music in IVWs for learning. *Research on Learning Technology, 16*(3), 231–244. https://doi.org/10.3402/rlt.v16i3.10901.
Schwartz, R. W., Ayres, K. M., & Douglas, K. H. (2017). Effects of music on task performance, engagement, and behavior: A literature review. *Psychology of Music, 45*(5), 611–627. https://doi.org/10.1177/0305735617691118.
Shih, Y., Huang, R., & Chiang, H. (2012). Background music: Effects on attention performance. *Work, 42*(4), 573–578.
Su, Q., & Wang, F. (2010). Study the effect of background music on cognitive memory. *Applied Mechanics and Materials, 37*(1), 1368–1371.
Sweller, J., Ayres, P., & Kalyuga, S. (2011). *Cognitive load theory*. New York: Springer.
Taylor, J. M., & Rowe, B. J. (2012). The "Mozart effect" and the mathematical connection. *Journal of College Reading and Learning, 42*(2), 51–66.
Thompson, W. F., Schellenberg, E. G., & Husain, G. (2001). Arousal, mood, and the mozart effect. *Psychological Science, 12*(3), 248–251.
Thompson, W. F., Schellenberg, E. G., & Letnic, A. K. (2011). Fast and loud background music disrupts reading comprehension. *Psychology of Music, 40*(6), 700–708.
Tze, P., & Chou, P. T. (2010). Attention drainage effect: How background music effects concentration in Taiwanese college students. *Journal of the Scholarship of Teaching and Learning, 10*(1), 36–46.
Waterhouse, L. (2006). Multiple intelligence, the mozart effect, and emotional intelligence: A Critical Review. *Educational Psychologist, 41*(4), 207–225. https://doi.org/10.1207/s15326985ep4104_1.
Yang, H., Lu, J., Gong, D., & Yao, D. (2016). How do musical tonality and experience affect visual working memory? *NeuroReport: For Rapid Communication of Neuroscience Research, 27*(2), 94–98. https://doi.org/10.1097/WNR.0000000000000503.
Zhang, J., & Gao, X. (2014). Background music matters: Why video games lead to increased aggressive behavior? *Entertainment Computing, 5*(2), 91–100. https://doi.org/10.1016/j.entcom.2014.01.002.

Efren de la Mora Velasco Dr. de la Mora Velasco is a post-doctoral scholar at the Rosen College of Hospitality Management at the University of Central Florida. He received his B.S. in information systems and his M.A. in Learning Technologies from the University of Guadalajara, Jalisco, Mexico. He was an associate professor of educational technology and multimedia programming and design at the University of Guadalajara for 8 years. For the past 4 years, Dr. De la Mora Velascoinvestigated the implementation of technologies to facilitate motivation, engagement and learning, as well as factors related to higher education students' academic achievements. Dr. De la Mora Velasco's research now focuses on information systems, consumer behavior, and learning technologies. Awards include: the Desirable Profile for Associate Professors by the Secretariat of Public Education of Mexico and the Latin American Academy Fellowship by the State University of New York.

Atsusi Hirumi Dr. Hirumi is a Professor of Instructional Design & Technology the University of Central Florida (UCF). He currently holds a joint appointment with the Dept. of Learning Sciences in the College of Community Innovation and Education, and the Dept. of Medical Education in the College of Medicine at UCF. For the past 25 years, Dr. Hirumi has centered his teaching, research and service on the design of

online and hybrid learning experiences. He has worked with faculty, staff, students and administrators in K12 and higher education, medical centers, and the military across North and South America, Asia, and the Middle East to improve eLearning. Dr. Hirumi's research now focuses on advancing medical education and fostering transdisciplinary collaboration among instructional designers and educators in the health professions. Awards include: The David H. Jonassen Excellence in Research Award presented by the Association for Educational Communication and Technology for long-term record of excellence in research and impact in ID&T, the US Army Training Maverick Award for leadership in distance learning, and the Texas Distance Learning Association Award for commitment to excellence and innovation.