The Moment I Knew: Using Music and Encoding Specificity to Improve Learning

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The appropriate use of music during class may enhance student learning by positively impacting the students' mood and attitude towards learning, and increasing arousal. The presence of sensory stimulation (such as music) during content delivery has been shown to increase student learning if the input is present during testing due to an effect called encoding specificity. Currently, the effects of music on undergraduate student learning are not well understood, and although there is a body of literature dedicated to encoding specificity, it has not been researched in an engineering undergraduate environment.

In this study, the authors employ a two dimensional model to determine whether background music played during content delivery increases the achievement of learning objectives in a statistically significant way. Music was played during both content delivery and testing, and the variations in the presence or absence of it was studied to determine the impact of music on learning.

A statistically relevant link was found between the presence or absence of the environmental cue (music) and testing results. While music was found to improve content retention when present at both delivery and testing, it was found to have a negative effect on learning when present during only one of those periods. Although these are preliminary results, reproduction of this experiment on a larger scale could have a strong impact on the role of music as a pedagogical tool. Music could be deployed strategically during delivery of particularly difficult concepts to aid student learning, or during supplemental instruction to help the students with lower performance.

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Background

The impact of music on learning in an engineering classroom has not yet been adequately characterized. Many practicing teachers have their opinions about music and its pedagogical impact, and most have some degree of anecdotal evidence to support their claims. However, there is a lack of quantitative research to assess the real impact of music on the pedagogical process and achievement of learning objectives.

While some teachers may have thought that music had the potential to enhance learning, it wasn't until Rauscher et al[1] found that the spatial abilities of undergraduate students had improved after listening to music by Mozart that this idea gained wider awareness. The results of the study were widely reported in the media and initiated a flurry of research activity and of policy decisions, including providing every baby born in Georgia with a Mozart album[2].

While some researchers were enthused with the results and published recommendations to best obtain the benefits of music[3], these benefits were quickly theorized to come from increases in mood and arousal[4,5] of the subjects. If indeed, the increase in cognitive performance can be attributed to increases in mood and arousal, then the potential pedagogical effects of music could be replicated through any other positive upbeat activity, and were not due to an innate quality of the music itself. Other studies performed[2,6] seem to corroborate these

results. Listening to background music did not increase verbal learning[7]. It was also found that depending on the type of music, the only result may be a larger mobilization of brain resources through activation of different brain regions in response to the background music. The results of Jäncke and Sandmann[7] are of special interest as they contradict directly the results of Rauscher et al, but may still be explained through the increase in mood and arousal theory. If the music selected did not increase the mood and/or arousal of the subjects then no positive effect on learning should have taken place.

Although the original study[1] showing a link between music and improved learning had as subject a population of undergraduate students, most subsequent studies have been performed at other educational levels. In only one study[8] was the population undergraduate students enrolled in an engineering class. This leads the authors to believe that a research plan should be undertaken to correctly assess the potential benefits of music for engineering education. In addition to the potential cognitive benefits of music, it also promotes creativity in the students which has been recognized as a desirable trait[9].

In a previous study[8], the authors sought to understand whether the pre-class period (the period before a lecture is delivered, which is commonly used for student transit and setup of any equipment necessary to the lecture) could be leveraged to improve students' learning by playing music before a lecture starts. Three conditions were analyzed: playing music, chatting with students, and limiting student-instructor contact. While no statistical link between use of the pre-class period and results in achievement of learning outcomes, this again may be interpreted through the mood and arousal theory. By playing music before a lecture, the temporary benefits due to increased mood and arousal were present, but quickly dissipated and were insignificant throughout the length of the lecture. Differences in the sections of the class analyzed (such as the instructors) may have also played a role in the lack of results. However, increased rapport between the students and instructors was observed. This was seen as a valuable benefit for improving the classroom environment, which may indirectly lead to improved learning[10].

As the previous study had failed to yield definitive results, efforts to extract music's pedagogical benefits were made through the use of encoded specificity.

The encoded specificity hypothesis "assumes that salient elements of the context in which the learning of target information occurs are encoded along with the target information as part of the memory trace. These contextual components may then function as retrieval cues to the target information when the same context is reinstated at testing"[11]. This hypothesis, first postulated by Tulving and Thompson[12] would allow for music to become a salient element of the learning environment. Schab[11] found an increase in learning when the subjects were subjected to the same odor at the learning and testing stages. Schab finds odors specifically suited to this task, a position supported by anecdotal evidence and literary allusions, the authors are inclined to agree while proposing that music may present its own distinct advantages.

As learning occurs and information is stored in the memory, two processes affect the storage of information: encoding specificity and transfer appropriate processing. These two memory principles have found broad behavioral support[13]. Encoding specificity dictates that the operations at encoding affect storage which in turn affect the how memory retrieval cues work[12].Transfer appropriate processing is the theory that memory is enhanced if the environment during encoding operations is recapitulated at retrieval[14]. Thus, there is a predicted overlap between encoding and retrieval processes and "both theories predict that brain regions activated during encoding ought to be activated during retrieval"[13]. As Jäncke and Sandmann found that different brain regions were activated through the use of music, it seems like a specifically suited cue to activate both brain processes. As encoded specificity increases the strength of the memory match between the target information to be remembered and the environmental cue[15] the hypothesis that playing music while the delivery of instructional material may benefit learning outcomes seems reasonable.

Lastly, as memory is concerned, Tulving and Thomson[12] make a distinction between episodic and semantic memory. Semantic memory is defined as

"the system concerned with storage and utilization of knowledge about words and concepts, their properties, and interrelations" which is the memory engaged when learning engineering concepts. Thus, this paper will study the effects of using music as a retrieval cue during instructional delivery to improve achievement of learning objectives by improvement of semantic memory.

Methodology

The population used for this study was a class of seven undergraduate upperclass students, the majority of which are in their junior year. All the students were enrolled in a junior level Construction Management course which is required for civil engineering majors, and all the subjects were civil engineering majors. The course has for a prerequisite a Project Management class in which some basic management concepts as they relate to engineering are addressed, albeit not in the setting of the construction industry.

The study was performed by testing the achievement of individual learning objectives in a sequence of loosely related lectures. The learning objectives were displayed on the board and discussed prior to the beginning of the lecture. The lecture was delivered in two conditions (the presence or not of background music), at the end of which all material necessary to the achievement of the learning objectives had been delivered. The testing was performed at the subsequent class meeting, through a short (5 minutes in duration) quiz that restated the lesson objectives in question form. The two conditions used during material delivery (presence and absence of background music) were also used during testing to construct a two dimensional model.

The music used was the same playlist every time, played in the same order. Table 1 shows the playlist used. All songs were from the album[16]. When music was played, the playlist was played from the beginning until a time when either the delivery or testing of material was concluded; that is to say that the duration of the background music was variable and tied to the duration of the relevant part of either the lecture or the quiz. The playlist was started when the target material was approached, and the music was not played during class discussions unrelated to the target material (e.g. discussions related to homework and field trip scheduling).

Table 1- Songs used in this study

Song Name	Duration
Dime Store Cowgirl	3m 35s
Pageant Material	3m 56s
Biscuits	3m 18s
Die Fun	3m 29s
Good Ol' Boys Club	3m 18s
Cup of Tea	2m 42s
Fine	3m 55s
Are You Sure	3m 56s

Maintaining musical consistency was necessary for encoded specificity to take place. To improve the retrieval of the target information, the context during retrieval must match the context during learning as closely as possible[17]. The music was chosen by the instructor as, in his judgement, it possessed the upbeat qualities that would lead to the increase in mood and arousal necessary for the beneficial pedagogical impacts of music to occur. The artist (Kacey Musgraves) was chosen due to her relatively low exposure in mainstream media, which would reduce the possibilities of previous exposure to the subjects. As a positive change in mood is necessary, popular artists about which the subjects may have negative reactions would have nullified the positive pedagogical effects.

The learning objectives were formulated using verbs from Bloom's Taxonomy, and the quizzes were produced by asking students to fulfill the learning objectives. The learning objectives are presented in Table 2. The quizzes were graded on completion to reduce the effect of an unfamiliar condition during testing.

Student work was assessed using a rubric developed specifically for this purpose. The rubrics were developed by two evaluators who were not involved in the teaching or testing portions of the classes. The rubrics used were identical across all the surveys and objectives. The efficacy of the rubrics was evaluated prior to their deployment in this study using a different class exposed to similar teaching and testing conditions. Ten random quiz samples were collected from each class survey in order to

Table 2- List of target Learning Objectives that were assessed

	Lecture 1	Lecture 2	Lecture 3	Lecture 4
Objective 1	List issues encountered in a construction project that may delay completion	List the main 4 resources used in a construction project	Describe the bidding process timeline	Explain why bid bonds are used in the construction industry
Objective 2	Compare large and small construction firms	Contrast construction technology and construction management	Explain conditions under which a time extension is commonly granted	Distinguish between performance and payment bonds
Objective 3	List the main 4 types of ocnstruction projects	Differentiate between strategic and tactical plans	Describe how changes to a project are approved	Classify contracts based on bidding and negotiating process
Objective 4	Classify the 4 main types of construction projects based on the professionals involved and the project ownership	Identify 4 levels of hierarchy	Distinguish between liquidated damages and penalties	Contrast common fee structures for negotiated contracts

gauge the appropriateness of the rubrics and the consistency of grading between the two evaluators. Once finalized, the rubrics were applied by both evaluators to every student in the sample for all four surveys conducted in this study**.** Figure 1 shows a skeleton form of the rubric used for evaluation.

Paper scores were compiled electronically for all rubrics; no data was discarded at this point in the study. Individual question scores and total (cumulative) survey scores for each of the four assessments were compiled. Analysis of Variance (ANOVA) and multi-variable analysis of Variance (MANOVA) was used to examine the mixed effects of teaching, testing and condition (Music, or No Music). Interaction between the effects was also studied.

Analysis

Table 3 shows the results of the statistical analysis. Results indicated that participants, on average, showed a preference for matching conditions between playing music during teaching and the test, but not consistently across all learning objectives. There was a significant interaction between teaching and testing, across learning objectives, $F(1, 21) = 8.37$, $p < .05$. However, upon further investigation, we found that the significant effect was the result of the overall benefit of matching music during teaching with music during testing ($M = 3.27$, $SD = .724$) on objective 1. These were consistently higher than any other condition. Upon further reflection of the data, the results were far less consistent, although in almost every case, the matched conditions were higher, although not significantly, than the unmatched conditions.

Noting that significant differences were seen in terms of the individual learning objectives and to what extent they were successfully achieved, it is evident that further refinement and study of this aspect in needed. In particular, investigation is needed regarding the other learning objectives to determine if there are fundamental differences in the objectives that give rise to the different pattern of results. These differences may be expected as learning objectives may vary in terms of how they are addressed pedagogically by the instructor, the cognitive level required for their successful achievement, and the manner in which they are assessed. It is also possible that music (or lack thereof) may contribute in different ways depending on each situation. For example, music may work well in a laboratory or workshop environment while engaging students in a hands-on pedagogical approach. In other circumstances, as when engaging

Student Lesson Objective Rubric

Course: CER 360 Assignment: _____ Semester: Spring 2016

Student #: _____ Reviewer: _____ Date: _____

	Unsatisfactory 1	Developing 2	Satisfactory 3	Exemplary 4	Rating
Objective	**Student shows no ability/interest in achieving this skill**	**Student shows signs they are developing the skills we require**	**Student meets what we determine to be a minimum standard**	**Student Shows they have this skill beyond our minimum threshold**	**Score or N/A**
List objective/ question # here (1-5)	Student cannot answer the question in any part, misunderstands question, or provides a random guess that is in no part correct.	Student provides a significantly incomplete or incorrect answer (<50% correct). Several parts missing and incorrect terminology/nomenclature used.	Student provides a substantially correct answer (>50% correct). Answer may miss some details or use incorrect terminology.	Student can provide a correct and well-detailed answer using the terminology/ nomenclature demonstrated in class.	1-4
1					
2					
3					
4					

Figure 1- Rubric used to assess learning objectives for every survey considered in this study.

in activities more reflective in nature, it may prove counter-productive.

While the results of this study produced evidence consistent with the open literature, namely, that encoding specificity improves learning by using music as a retrieval cue, the effects of music on learning is an area that should be researched further. Future efforts will focus on increasing the scope, and in particular the sample size of the study. These studies should seek to further categorize the presented options (i.e. what type of music specifically was played, does the music relate to the topic, is it liked by the students, etc.). It is also possible that the effects of music on learning are not scalable, and can only be appreciated in a specific class size. Future research should strive to evaluate both smaller and larger class sizes.

Conclusions

A two dimensional model was used to assess the impact of music on the achievement of learning objectives. The conditions tested were the presence or absence of background music while both delivering and testing instructional material in a junior civil engineering course.

The results agree with what the authors expected to find based on the published literature. There was an increase in material retention when presented with matching conditions during teaching and testing. This effect was at its strongest when music was played, which is consistent with the mood and arousal theory found in the literature.

From the results of this study, it appears that the presence of music is an effective environmental cue that aids in the retrieval of information through encoding specificity. Further work should be undertaken to try to replicate the results presented here with a larger sample size. It would also be beneficial to continue performing research on any other potential uses of music in the classroom to increase cognitive performance of the students. In addition to the potential pedagogical effects of music. The authors have found an abundance of anecdotal evidence from instructors that indicates it is a topic of interest among the educational community.

Table 3- Results of statistical analysis comparing the use of music in teaching and testing environments.

Teaching	Objective #1	Objective #2	Objective #3	Objective #4
Music				
Mean	3.0833	2.7500	2.1667	2.0833
N	12	12	12	12
Std. Dev.	0.79296	1.12818	0.93744	0.90034
No Music				
Mean	2.4615	2.3846	2.7692	2.6154
N	13	13	13	13
Std. Dev.	1.19829	0.86972	1.36344	0.86972
Testing	**Objective #1**	**Objective #2**	**Objective #3**	**Objective #4**
Music				
Mean	3.4615	2.3007	2.8462	2.4615
N	13	13	13	13
Std. Dev.	0.66023	0.94733	1.28103	0.96742
No Music				
Mean	2.0000	2.8333	2.0833	2.2500
N	12	12	12	12
Std. Dev.	0.85280	1.02986	0.99620	0.86603
Total				
Mean	2.7600	2.5600	2.4800	2.3600
N	25	35	25	25
Std. Dev.	1.05198	1.00333	1.19443	0.90738

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