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iPad vs. Music Glove Use in The Music Classroom: Differences in Children's Learning Performance, Ease of Use and Concentration

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Abstract. This study uses a mixed-methods approach to investigate the learning outcomes, student experiences, and concentrated-behavior patterns of two classes of elementary school music students (N = 42). The study examines the academic performance resulting from students using established music technology, the iPad, in comparison to using an experimental technology, a wearable Music Glove. The musical knowledge score improved significantly in both the iPad (W = 1, p < .001) and Glove (W = 28.5, p = .043) classes; however, the iPad class improved more than the glove class (d = 1.83 vs d = .48). Following this, we conducted a Mann-Whitney U test to assess whether the improvement in scores between the two groups from before to after the study was significant. Results show a significant difference in test score improvements during the learning process (p = <.01). Full contents of this study can be found in the primary author's doctoral dissertation.

Keywords. Music technology, music education, iPad, education

1 Introduction

In this study, our goal was to better understand the impact that established and experimental music technology has on children's musical academic performance, user experience and concentrated behavior. To do this, we used a mixed-method approach, analyzing both quantitative and qualitative data. The quantitative data came from a (1) student musical knowledge assessment, measuring the student's learning performance, (2) a user experience survey measuring student perceived ease of use of their assigned device and, (3) concentrated-related behavior as measured via qualitative video

analysis. The study consisted of two groups of students using either the iPad or the Music Glove, a wearable device that activates musical sound when its sensors are touched. Both devices were used over a 6-week period. The three primary research questions in this study are:

RQ1. What is the difference in musical knowledge before and after using the Music Glove between the two music classes?

RQ2. What are the students' ratings in perceived ease of use before and after using the iPad or the Music Glove?

RQ3. What is the difference in concentration-related behavior patterns of the student's while playing and using the iPad or Music Glove in the two music classes?

1.1 Technology Integration in the Music Classroom

In recent years, music classrooms have seen significant technological integration. These integrations involve using innovative devices to encourage hands-on interaction and touch-based feedback as part of the learning process. The most well-known of these devices is the iPad, a tablet computer made by Apple, which has become widely used in modern classrooms. Studies conducted by [1, 2, 3] have shown that iPad use in classrooms has a positive effect on learning outcomes.

1.2 The Music Glove

The Music Glove is a musical MIDI controller using touch sensors and an electronic unit to produce data. These touch sensors are arranged in multiple rows on the glove, forming a musical scale. To activate these sensors, the user presses them with a finger from their other hand. The touch sensors are positioned from the index finger to the little finger, with each fingertip corresponding to specific notes in the first octave, namely C, D, E, and F. Notably, the semitone E-F is positioned between the ring finger and the little finger. When a user touches the glove's sensors, it generates a data signal that is then transmitted to an external device, such as a MIDI device, a PC, or a computer tablet, for details see, e.g., [4, 5].



Fig. 1. A diagram of the Music Glove with a musical instrument digital interface (MIDI) and Bluetooth (BT) connected to a personal computer (PC). The numbers in the diagram refer to the hardware that the Music Glove implements: 10. A Glove device.
16. Touch sensors. 18. Central MIDI electronic unit. 21. Bluetooth transmitting MIDI code. 23. Bluetooth receiver. 25. Personal Computer (host device) (U.S. Patent No. 9,905,207, 2018).

1.3 Concentrated Behavior in the Music Classroom

Concentration is said to be achieved during genuine engagement in learning, as the student is cognitively and affectively attuned to acquiring requisite information during lesson time [6]. Concentration is noted to be a core component of educational endeavors, as [7] argue that the amount of time and effort spent in a classroom is wasted if students are not learning, and this happens exclusively within the concentration span of the learners.

1.4 Technology Acceptance in the Music Classroom

The Technology Acceptance Model (TAM), originally developed by [8], helps us understand why people choose to use technology and how they use it. TAM consists of two key factors that are crucial for understanding computer acceptance: perceived usefulness and perceived ease of use [9, 10, 11]. In a survey investigating musicians' uses and attitudes towards using technology in individual learning settings, these two aspects (perceived usefulness and perceived ease of use) were predictors of using technology in music learning [12]. We chose perceived ease of use from the TAM as a theoretical concept to investigate the degree of effort the students anticipated had to exert while interacting with technology in their class.



Fig. 2. Original Technology Acceptance Model (TAM) [8].

2 Methodology

We carried out a mixed-method research study in Central Finland, involving two elementary school classes. In one class, students were allocated iPads using a music production app (the Keyboard Touch Instrument app found in GarageBand) for their music lessons. The other class were allocated the Music Glove as their primary device for music lessons.

2.1 Participants

The study involved two classes, each consisting of 21 students, totaling 42 participants. These students, aged 8 to 9 years, were enrolled in regular music classes at Jyväskylän Normaalikoulu in Central Finland. Their average age was 8.3 years (SD = 0.5). To ensure the anonymity of the students, each child was allocated a number from #1 to #21 within their respective classes, allowing consistent identification throughout the data collection processes. Concurrent mixed-method sampling [13] was chosen as it aligned with the needs of both the quantitative and qualitative aspects of the study.

2.2 Apparatus: iPad and Music Glove

The iPad is a tablet with a multitouch screen interface, operating on the iOS platform. It has the capacity to function as a versatile platform for running various applications. Furthermore, we connected the Music Glove to an iPad via USB, with the iPad serving as the host device.

2.3 Familiarization with the Music Glove Device

We conducted two familiarization sessions before giving the students the pre-study knowledge test and the Week 1 user experience survey. These sessions served two purposes: (a) allowing the children to learn and experience the equipment before the actual study began and (b) helping the children and researchers get to know each other. This is crucial when conducting research with children as it builds trust and encourages them to express themselves as they normally would [14].

2.4 Learning Performance: Student Musical Knowledge Assessment

Both classes of students participated in a musical knowledge assessment as the study began (pre-), and at its conclusion (post-). These pre- and post-tests were used to evaluate the students' retention of musical knowledge and their learning progress before and after utilizing their allocated technologies.

2.5 User Experience Survey: Perceived Ease of Use

To assess how the two groups of students rated their ease of use about using their respective technologies during their music class, the students were asked to complete a subjective experience survey before and after using either their allocated iPad or Music Glove. The survey applied a Likert-type scale, which was visually represented in the form of thumb pictures. We conducted a reliability test of the survey during the familiarization sessions. We found no inconsistencies in their responses to the user experience survey after the familiarization session, indicating preliminary validity.

2.6 Video Analysis: Student Concentrated Behavior

To examine variations in students' behavior associated with their concentration levels

while using the two music technologies, we carried out a qualitative analysis of video recordings capturing students engaged with their allocated devices in the classroom. The two researchers selected lessons from Weeks 1, 3, and 6 for video analysis, covering the beginning, middle, and end of the study. They used a three-phased coding process to analyze the video recordings. After the three-phased coding process and independent analysis, they agreed on two categories to analyze student concentrated behavior: off-task behavior and on-task behavior.

2.7 Learning Outcomes

As previous literature suggests [15], when introducing technology in the classroom, the pedagogical practices, context, and purpose defined are significant to the potential effect any technology will have on students. Therefore, in the current study, the teacher supervised the integration of both technologies (iPad and the Music Gove) within both classes.

3 Results

3.1 Student Musical Knowledge Assessment

All students in both classes completed a Musical Knowledge Assessment. This test served as a baseline measurement of their understanding of the musical syllabus before they started using the devices. After using the technologies, the same test was given again to see if the use of these technologies had an impact on their musical knowledge. We used Pearson's correlation coefficient to analyze the relationship between the group that used only iPads for music learning (21 students) and the group that used the Music Glove (21 students) for the same purpose. We also compared the test scores at the beginning of the study (Week 1) with the scores at the end (Week 6) of the study. The analysis showed a moderate positive correlation between the initial and final test scores for both groups. The correlation coefficient was .73 for the iPad group and .77 for the Music Glove group.

The results of the knowledge test before and after using the technology are shown in Figure 3. First, we ran two Wilcoxon signed-rank tests to check whether the improvements of the post scores were significant. The MKS improved significantly in both the iPad (W = 1, p < .001) and Glove (W = 28.5, p = .043) classes; however, the iPad class improved more than the glove class (d = 1.83 vs d = .48). Furthermore, we conducted a Mann-Whitney U test to assess whether the improvement in scores between the two groups from before to after the study was significant. The Mann-

Whitney U test showed that there was a significant difference in the change of test scores between the students who used iPads (median change = 8) and those who used the Music Glove (median change = 1). The results were statistically significant (U = 115, p = .004 two-tailed), and the effect size was medium (d = .77).



Fig.

3. Violin plots comparing the pre- and post-learning academic test of knowledge results of the iPad and Music Glove class. The violin plot provides a visual representation of the distribution curve, with interquartile ranges (IQRs) and median values displayed using boxplots, denoted by black horizontal lines. Additionally, mean values are depicted as black rhombi. *Note.* Pre-test presents scores before using allocated technology in the class. Post-test presents scores after using allocated technology in the class. The total test score is out of 31.

3.2 Student Perceived Ease of Use

	Week 1	-		Week 3	_		Week 6	-	
Factor	Mean	Median	SD	Mean	Median	SD	Mean	Median	SD
I think the iPad will be easy to use today	3.84	4.00	1.12	3.50	4.00	1.43	3.76	4.00	1.25
Today I found the iPad easy to use	2.84	3.00	1.07	2.80	3.00	1.28	2.53	2.00	1.55
I think the glove will be easy to use today	4.30	4.50	0.95	3.95	4.00	0.95	3.70	4.00	1.17
Today I found the glove easy to use	2.80	3.00	1.06	2.35	2.00	1.82	2.10	1.50	1.21

 TABLE 1. Descriptive statistics showing the ease-of-use response ratings during weeks 1, 3 and 6, before and after classes for the iPad and Music Glove classes.

To analyze the change in perceived ease of use responses before and after the students used their allocated technologies, we used two Wilcoxon Signed-ranks tests to examine their perceived ease of use survey responses for both groups.

Before using the iPad at Week 1, the median perceived ease of use rating was 4.00. After using the iPad at Week 6, the median rating decreased to 2.00. Analysis showed a significant change (Z = -2.58, p = .009, d = .80). Before using the Music Glove at Week 1, the median perceived ease of use rating was 4.5. After using the Music Glove at Week 6, the median rating decreased to 1.5. Analysis revealed a significant change with a large effect size (Z = -3.42, p = .001, d = .80).

3.3 Concentrated Behavior Observations

Two researchers independently rated and coded the behavior of the selected students at each observation point. To ensure the accuracy of the collected data, we measured interrater reliability using Cohen's kappa (k). The kappa value was found to be k = .81, indicating a strong agreement between the researchers in their coding categories. Tables 2 and 3 present the researchers' analysis of the behavior of two representative students in both the iPad-using and Music Glove-using classes. In the iPad-using class,

students numbered #7 to #12 were chosen for video analysis, while in the Music Gloveusing class, students numbered #3 to #10 were selected for behavior analysis through video recordings.

Week	Student	Off-Task Behavior	On-Task Behavior	
1	#7	3	0	—
	#12	2	0	
3	#7	0	0	
	#12	0	0	
6	#7	1	0	
	#12	4	0	
TOTALS:		10	0	

TABLE 2	. Total	tallies	of the	researchers'	analysis of	^{behavior}	in the i	Pad class.

Note. Student indicates the number assigned to students in the class (categorized from #1 to #22). Students numbered #7 and #12 selected for analysis.

Week	Student	Off-Task Behavior	On-Task Behavior
1	#2	0	0
1	#3	0	0
	#10	0	0
3	#3	0	0
	#10	0	0
6	#3	0	3
	#10	0	3
TOTALS:		0	6

TABLE 3. Total tallies of the researchers' analysis of behavior in the Music Glove class.

Note. Student indicates the number assigned to students in the class (categorized from #1 to #22). Students numbered #3 and #10 selected for analysis.

4 Discussion

In this study, it was found that students improved more than the glove class (d = 1.83 vs d = .48) who used the iPad for music learning. As the change in perceived ease of use ratings is analyzed before using both technologies, statistically significant results are reported. The findings from the qualitative video analysis tentatively indicate that concentration-related behavior appeared to be more prominent in the two students who used the Music Glove compared to the two students using only the iPad.

RQ1. What is the difference in musical knowledge before and after using the Music Glove between the two music classes?

As evident from the analysis of post-test results, students who used the iPad displayed greater improvements in their musical knowledge over the 6-week learning period compared to those who used the Music Glove. When we compared the differences in post-test results related to the change between these two groups, we found the difference to be significant, with a medium effect size. These results suggest that the use of the iPad contributed more to enhanced learning compared to the Music Glove. These findings align with a previous study that utilized the same data [4] as well as a recent meta-analysis [3].

RQ2. What are the students' ratings in perceived ease of use before and after using the *iPad* or the Music Glove?

The results from the perceived ease of ratings indicate that both the iPad and the Music Glove were perceived as more difficult to use after six weeks of use, compared to their initial ratings at Week 1.

RQ3. What is the difference in concentration-related behavior patterns of the student's while playing and using the iPad or Music Glove in the two music classes?

The differences observed in concentration-related behavior between the two students from each group could be attributed to the students' varying levels of familiarity with the iPad and the Music Glove. It's worth noting that all participants in this study had previous experience using the iPad in their music classes before this experiment began. Therefore, their on-task and off-task behaviors might have been influenced or even caused by their familiarity (with the iPad) or lack of (the Music Glove) with their allocated technology.

4.1 Student Ease of Use Ratings, Concentration and Technology Acceptance in the Music Classroom

Curiously, the data shows that the students observed for concentration-related behavior while using only the iPad engaged in more off-task behavior than those using the Music Glove, suggesting that the former group was not as fully concentrated during the 6week study. In this context, higher perceived ease of use corresponded to lower interaction effort with the familiar technology (i.e., the iPad), leading to lower levels of concentration-related behavior. On the other hand, the increased concentration-related behavior observed in students using the Music Glove likely stemmed from their heightened effort in interacting with the technology. Therefore, applying the concept of perceived ease of use from TAM [8] illustrates that students had strong expectations about how user-friendly both device interfaces appeared before playing music, but their concentration-related behavior reflected the challenges these technologies presented in practice. One might also consider limitations of the original version of TAM [8] in this context due to its over-simplicity. Subsequent developments of the model, including TAM 2 [16], the Unified Theory of Acceptance and Use of Technology (or UTAUT) [17], and the e-commerce-oriented TAM 3 [18] each unpack and add detail to model elements. Additional testing and perhaps further development of the model will be necessary to ascertain the suitability of this general framework to the issues discussed in this paper.

5 Conclusions

In summary, the study revealed several key findings:

- Students who used the iPad showed greater improvement in their learning performance compared to those who used the Music Glove.
- Both groups of students initially rated the perceived ease of use of both technologies highly, but these ratings decreased after 6 weeks of use.
- We observed that both groups of students displayed high levels of concentratedrelated behavior while using their respective devices. However, students using the Music Glove exhibited even higher levels of concentration compared to those using the iPad alone.
- When considering the relationship between concentration and perceived ease of use (based on the TAM), we found that both technologies were expected to be easy to use for playing music. However, the iPad required less effort during use compared to the Music Glove. This difference in effort could be attributed to students' familiarity with the iPad in their music education.

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This book presents a collection of selected papers that present the current variety of all aspect of music research, development and education, at a high level. The respective chapters address a diverse range of theoretical, empirical and practical aspects underpinning the music science and teaching and learning, as well as their pedagogical implications. The book meets the growing demand of practitioners, researchers, scientists, educators and students for a comprehensive introduction to key topics in these fields. The volume focuses on easy-to-understand examples and a guide to additional literature.

Michele Della Ventura, editor **New Music Concepts and Inspired Education** Revised Selected Papers

