HUMAN TECHNOLOGY

ISSN: 1795-6889

www.humantechnology.jyu.fi

Volume 17(1), June 2021, 81–112

NOVEL AND EXPERIMENTAL MUSIC TECHNOLOGY USE IN THE MUSIC CLASSROOM: LEARNING PERFORMANCE, EXPERIENCE AND CONCENTRATED BEHAVIOR

Andrew Danso
Department of Music, Art and Culture Studies
University of Jyväskylä
Finland

Rebekah Rousi
Cognitive Science,
Department of Computer Science and Information Systems,
University of Jyväskylä
Finland

Marc Thompson
Department of Music, Art and Culture Studies,
University of Jyväskylä
Finland

Abstract: *In recent years, music technology in the classroom has relied on general devices such as the iPad. In the current study, we used a mixed-methods approach to examine the learning performance, learning experience, and behavior of two class groups of primary school music students (*N = 42*), using established music technology (i.e., the iPad with the Keyboard Touch Instrument app) and novel music technology (KAiKU Music Glove). Results show a significant difference of change in test scores during learning (*p = <.01*) and a medium effect-size is found (*d = .75*), indicating use of the iPad and Keyboard Touch Instrument app contributed to increased learning when compared to the KAiKU Music Glove. Perceived ease of use ratings of both technologies and observable levels of concentration exhibited by the students are also discussed in the paper. Implications provide insights into the usage and development of embodied music technology in the music classroom.*

Keywords: *music education, music technology, learning experience, learning.*

https://doi.org/10.17011/ht/urn.202106223979

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INTRODUCTION

The creative use of information technology (IT) in the music classroom rarely is associated with concepts found in human–computer interaction (HCI) research. Thus, HCI, IT, and music education are peripheral disciplines that have not been bound together adequately to understand student behavior when engaged with embodied music technology. This represents a missed opportunity for understanding the phenomenon. In the present study, we sought to investigate the research gap among these peripheral disciplines by using HCI and IT research to understand children's behavior in the music classroom while students used embodied music technology as part of their music class. IT is a widely integrated aspect of teaching and learning in today's Nordic childhood music class. For the students, IT affects their learning performance and, crucially, their experience of music. For the teacher, IT can support the teaching of music education with technology's advanced technical capabilities (e.g., data storage, access to the Internet, variety of applications, gamification), enabling activities that are engaging to children. IT can also help the teacher to manage the students' learning performance.

In this study, we aimed to understand better novel and experimental music technology use and interactions in childhood music education. For this, we employed a mixed-method approach to examine quantitative and qualitative data. The quantitative data derived from learning performance tests and the qualitative data emerged from subjective experience surveys and behavioral observations. A mixed-methods approach appropriately supported the purpose of this study, which was to understand established and experimental embodied digital music technology usage in childhood music education. We achieved this by examining students' learning performance, their experience of using the technology in the context of music learning, and their behavior while using either the iPad with the Keyboard Touch Instrument app or the KAiKU Music Glove, a tactile wearable device that activates musical notes via touch. The three research questions directed this study:

RQ1. What is the difference in musical knowledge before and after using the iPad with the Keyboard Touch Instrument app and the KAiKU Music Glove connected to the iPad in children's music classes?

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

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

Within this paper, a review of related literature will be presented first, which discusses concepts in embodiment and cognitive concentration in particular. Having established a theoretical background for this research, an empirical investigation of two student groups assigned either the iPad or the KAiKU Music Glove as the primary device for music learning is carried out. These devices were used in the music classes over a 6-week period

PRIOR AND RELATED RESEARCH

Historically, technology use in the music classroom has been associated with IT from broader society, as computers and, in particular, MIDI (musical instrument digital interface) sequencing stimulated a musical revolution (Gall & Breeze, 2007). Accordingly, the following section looks at tablet computer use in education, specifically how tablet computer integration has impacted childhood music education. The subsequent section provides an overview of experimental hand-sensor music technology included and used in this study, KAiKU Music Glove, and then placing it into a HCI theoretical paradigm we have called human music technology interaction. Play and concentration in childhood music education are discussed, in addition to a theoretical concept from the original technology acceptance model (TAM; Davis, 1985) reviewed and used in the study.

The Tablet Computer in Education

As a result of the physical properties of tablet computers in terms of their screen size, lightweight design, multimedia support, ease of use, and long battery life, they can serve as optimal devices for encouraging student engagement in multiple actions and activities in many classroom subjects and learning situations (Churchill, Fox, & King, 2012; Henderson & Yeow, 2012). Studies have shown that tablet usage in learning situations encourages high levels of student productivity, creativity, engagement, autonomy, and self-regulation in class situations (Clark & Luckin, 2013; Henderson & Yeow, 2012).

Over recent years, substantial technological developments in music classrooms have involved integrating innovative devices as part of the learning process in order to encourage interaction through tactile input and haptic feedback. The most established of these innovations is the iPad, a tablet computer manufactured by Apple. The iPad has been widely integrated into contemporary classrooms. Burnett, Merchant, Simpson, and Walsh (2017) stated that the iPad's integration into the classroom has been less problematic than other similar devices, past and present. Studies by Wario, Ireri, and De Wet (2016), Wang, Teng, and Chen (2015), and Heinrich (2012) demonstrated that iPad use in classroom settings has a positive impact on learning. Rowe, Triantafyllaki, and Pachet (2016) reported that the creative utilization of the iPad, as well as its playfulness, transfers seamlessly into the experimentation involved in the creation of music. Flewitt, Kucirkova, and Messer (2014) found evidence that the iPad was useful to children in the classroom, reporting that children were motivated to use the technology and held concentration for longer periods of time when using the technology. In addition, a diverse range of music apps (for the iOS and Android operating systems), often readily available on tablet computers and iPads, allows the teacher and student access to creative music educational experiences (Hillier, Greher, Queenan, Marshall, & Kopec, 2016). The sensory interface of the tablet computer's touch screen facilitates student interaction with the digital interface of its apps in an intuitive way, (e.g., pressing on a piano key shown via the user interface or enabling gestures during music creation). To that end, Burton and Pearsall (2015) found that children as young as 4 years old preferred playing music in apps that required very little musical manipulation—meaning the apps were mostly open-ended in user interaction and allowed the children freedom in music making. Consequently, the 4-year olds preferred music-making apps that made them the source of music making rather than the apps' output. With this in mind, Burton and Pearsall (2015) claimed that apps used in childhood music education should have qualities that enable play and open music creation.

However, evidence is inconclusive regarding usage of tablet computers in the childhood music classroom, as Hutchison, Beschorner, and Schmidt-Crawford (2012), Ruismäki, Juvonen, and Lehtonen (2013), and Stretton, Cochrane, and Narayan (2018) stated. They reported that research on tablet computer technology in childhood music education is relatively unexplored.

Observations of tablet computer use show overuse in the classroom, misuse, and lack of user confidence. In addition, Heinrich (2012) found that young students using tablets as part of their learning curriculum may require support or familiarization with the device's features and functionality before actively using them.

The KAiKU Music Glove Device

The KAiKU Music Glove is a musical MIDI controller with touch sensors (see Figure 1). The glove fits on one's hand, while the sensors embedded within the glove's fingers are pressed with the other/opposite hand. The manufacturer, Taction Enterprises Inc., has organized the sensors within a practical and ergonomic perspective, and the devices are produced specifically for pedagogical use in teaching music theory (see, Danso, 2019; U.S. Patent No. 9,905,207, 2018).

The positioning of two rows of touch sensors is presented as a potentially effective method for teaching the musical scale. It also is effective in the teaching interval and chord structures when both the teacher and students are wearing the glove. This approach is an attempt to optimize the process of music teaching and learning (Paule-Ruiz, Álvarez-García, Pérez-Pérez, Álvarez-Sierra, & Trespalacios-Menéndez, 2017) based on the Kodály method (Harrison, 2021) that emphasizes the use of the hand during singing lessons. A theoretical premise behind the KAiKU Music Glove is that the glove encourages the embodied learning of music (Myllykoski, Tuuri, Viiret, & Louhivuori, 2015). Children can learn music utilizing different modalities (visually, auditorily, and kinaesthetically, or by combinations of these; Burton & Taggart, 2011; Persellin, 1992). Acknowledging the integration of multimodality into the embodied learning of music through the hands is a design principle of the KAiKU Music Glove device (Myllykoski et al., 2015). Targeting

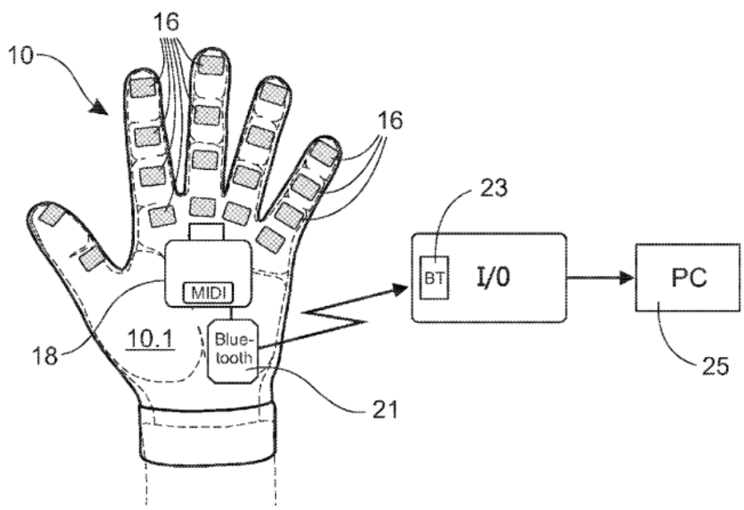

Figure 1. A diagram of the KAiKU Music Glove with a musical instrument digital interface (MIDI) and Bluetooth (BT) connected to a personal computer (PC). The KAiKU Music Glove generates musical data through a glove embedded with touch sensors and electronic units. It connects via Bluetooth or Universal Serial Bus (USB) to a host device (i.e., laptop or personal computer) to produce musical sound.

The numbers in the diagram correspond to the hardware that the KAiKU 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).

the hands for musical knowledge and instrument development is not exclusive to the KAiKU Music Glove device (Voustinas, 2017). Other technologies recently developed also focus on the hands for use in a performance setting.

Human Music Technology Interaction: Placing KAiKU in Paradigm

User interfaces may be seen as embodiments, or "skins," of technological systems (Sampson, 2019). At this level of design, the user encounters, affects, and is affected by the system. Moreover, the interface represents how data is made meaningful to the user through design (O'Brien & Toms, 2008). From a phenomenological perspective, how the user encounters these designs is always through the body and its senses (Höök, 2009; Höök & Löwgren, 2012; Rousi & Silvennoinen, 2018). This is furthered by how the body connects the sensory design of the technological interface to human action (Bødker, 1989; Dewey, 1934/2005; Gayler, Sas, & Kalnikaite, 2019). Music is intrinsically connected not only to the evolution of human cultural activities but also is tightly coupled with the development of language—the most permeating and fundamentally cognitively defining communication technology there is (Justus & Hutsler, 2005). Thus, the multitechnological layering of music and its associated instruments or tools are connected with human action and interaction. From this perspective, music can be understood as linguistic and/or expressive communication technology. Musical instruments are tools facilitating music expression, and IT-enabled devices may serve as instruments in their own right or extend (augment) the capabilities of traditional instruments, such as the electronic violin or piano, to name a few. Furthermore, in addition to being one of the most embedded technologies throughout human evolution, music and its instruments have always been fully embodied and multisensory (Lee & Noppeney, 2011, 2014; Zimmerman & Lahav, 2012), involving several human sensory channels simultaneously.

Both the tablet computer and the KAiKU Music Glove, for instance, integrate the tactile and haptic experience of music making with IT. These directly connect multiple senses (touch, sound, sight, perhaps even smell, depending on the device materials) to digital interaction, strengthening the link between the mind (thought) and the body (physical movement, control, and sensations) within digitally facilitated music production. Although embodied multisensory experience always has been one of the main characteristics of the body–music experience (production and consumption), IT extends the traditions and nature of tool/instrument-assisted music making through its informational layering. This informational layering refers to the nature of IT where form does not always follow function and, through informational manipulation, some sensory characteristics of the devices (i.e., sound and haptic feedback) may change entirely. When considering the connection between people and technology, or people and musical instruments, one may ponder the augmented nature of the tool. We use *tool* here to highlight the characteristic of instruments and technologies as enablers for human action, while simultaneously alluding to Heidegger's (1927/1962) ideas of tools (i.e., technologies are "ready-to-hand") as augmentations of the human body and cognition (see also Harman, 2011). Furthermore, musical instruments may be seen as augmented human capacities to act and affect: Engagement with a musical instrument also is an embodied interactive activity among multiple human actors (Leman, 2008; Yu, 2013). In other words, music and its instruments can be seen as tools for social experience and collective cognition, linking the embodied consciousness of multiple individuals through sound and other sensory effects (Himberg & Thompson, 2009). Leman (2008) supported a premise called "transparent technology," a means of musician-based technology integration whereby the instrument/technology becomes seamless in its use and experience from the perspective of the music maker. Thus, conscious cognition of the instrument and its properties gradually become embodied and automatized in the musician's practice, transferring the coupling of musician and instrument from thought to feeling (emotional and sensory–motoric).

Play and Concentration in Childhood Music Education

Play provides experiences and opportunities for learning. This has formed a much-discussed basis for research in the context of educational technology (Said, 2004). Moreover, from an HCI perspective, the concept of play has been associated with increased frequency of and satisfaction in system use (Atkinson & Kydd, 1997). Additionally, researchers have attributed play to increased motivation, challenge, and positive affect (e.g., Woszczynski, Roth, & Segars, 2002). Other studies have shown that playing increases players' concentration in their experience of the activity (Huizinga, 2004). "Play has a deep biological, evolutionarily important, function, which has to do specifically with learning…. Many scientists think of much of their work as play, often linking the idea of play with high creativity" (Prensky, 2001, pp. 5–6).

People learn from experience, and learned matter influences how individuals subsequently experience phenomena (see constructivist views on learning, e.g., Steffe & Gale, 1995; see also Helfenstein & Saariluoma, 2006; Putnam, 2012; Rousi, 2013; Saariluoma, 2003; Symeonidis & Schwartz, 2016, regarding apperception). "An experience" in terms of an event (see, e.g., Batterbee & Koskinen, 2005) may be understood as a narrative with a beginning, middle, and end. How this experience unfolds, however, is determined by how the minds of those involved (or observing) make meaning. The engagement with devices and software for the purposes of producing something new—whether music, a performance, and/or an interactional engagement—can be likened to play. It is a constructive process in which creative expression or representation is produced (McArdle & Wright, 2014).

Through play, new literacies are realized and involvement in the process encourages concentration (Koo, 2009). Concentration refers to a sustained period of attention. From the perspective of concentration, meaningful learning can be achieved, as long as one of three forms of interaction (i.e., student–teacher, student–student, student–content; Tsang, Kwan, & Fox, 2007) is of a high level. Concentration derives from genuine engagement in learning as the student cognitively and affectively is attuned to acquiring, integrating, assimilating, and applying the information and other content presented within the lesson time (Dansereau, 1985). Bester and Brand (2013) argued that the amount of time and effort spent in a classroom is worthless unless the students are learning, and this process happens within the concentration span of learners.

Ready-to-learn: A Tool View to Information Technology in Musical Education

The theory of reasoned action (TRA) is a model developed to represent the reasons people behave in an intentional way (Davis, Bagozzi, & Warshaw, 1989; Fishbein & Ajzen, 1975). An adaptation of TRA is the TAM (Davis, 1985). TAM provides the general reasons for technology acceptance, clarifying the user behavior involved in choosing to use and then using a technology. Davis (1989) argued that not only was TAM originally designed to predict user acceptance behavior but also to explain it. Thus, TAM fundamentally helps researchers and those working in the IT industry understand why a particular system may be either acceptable or unacceptable to the user. Such information then could be used as a basis to pursue corrective development action.

TAM contains two factors critically relevant for computer acceptance behaviors: perceived usefulness and perceived ease of use (Davis, 1985, 1989; Davis et al., 1989; Venkatesh, 2000). Perceived usefulness is the user's own perception that using technology improves task performance. This may indeed be likened to what social psychologist James Gibson (1977) referred to as "affordance," whereby designs and their qualities are understood for what they may afford the user—that is, how they assist in the attainment of goals that align with intention. Perceived ease of use is the degree of effort that the user expects to place into interaction while using the technology (Davis et al., 1989). Behavioral intention represents a person's attitude toward and perceived usefulness of a system. This makes the concept slightly different within TAM than in TRA. An attitude and behavioral relationship implies that a person may form the intention to carry out behaviors that have a positive affect (Davis et al., 1989). TRA and TAM have been used widely in the social sciences and information systems research communities and include extended versions, such as TAM 2 (Venkatesh & Davis, 2000), TAM 3 (Venkatesh & Bala, 2008), the unified theory of acceptance and use of technology (UTAUT; Venkatesh, Morris, Davis, & Davis, 2003), and UTAUT2 (Venkatesh, Thong, & Xu, 2012). The latter models expand on the dimensions of affect and emotion, adding detail to the expectational components of technological engagement (i.e., performance expectancy and social influence) in addition to greater importance placed on the role of context (i.e., facilitating conditions).

Theoretical Concept: Perceived Ease of Use

We chose perceived ease of use from the original TAM as a theoretical concept to examine the degree of effort the students expected to place into technology interaction within the music classroom. Accordingly, perceived ease of use as a concept is a good fit for providing theoretical and practical insights relative to this study's purpose and research questions. We applied perceived ease of use to the analysis of the study's results to capture the relationship between the participants' behavior, learning performance, and report of their experiences with their assigned technologies. Figure 2 presents the original TAM theoretical framework (Davis, 1985).

METHODS

We conducted an exploratory, descriptive mixed-method study involving two elementary school classes in Central Finland. One class was assigned only the iPad with a music-producing app as the device to use within their music class. The other class was assigned the KAiKU Music Glove as a device, but also used the iPad with the app as an apparatus to generate sounds only.

Participants

Participants comprised two classes of 21 students each (*N* = 42). All participants were students, aged 8 to 9 years, enrolled at Jyväskylän Normaalikoulu in Central Finland and participating in regular music classes. The average age of students was 8.3 years (*SD* = 0.5). To protect the students'

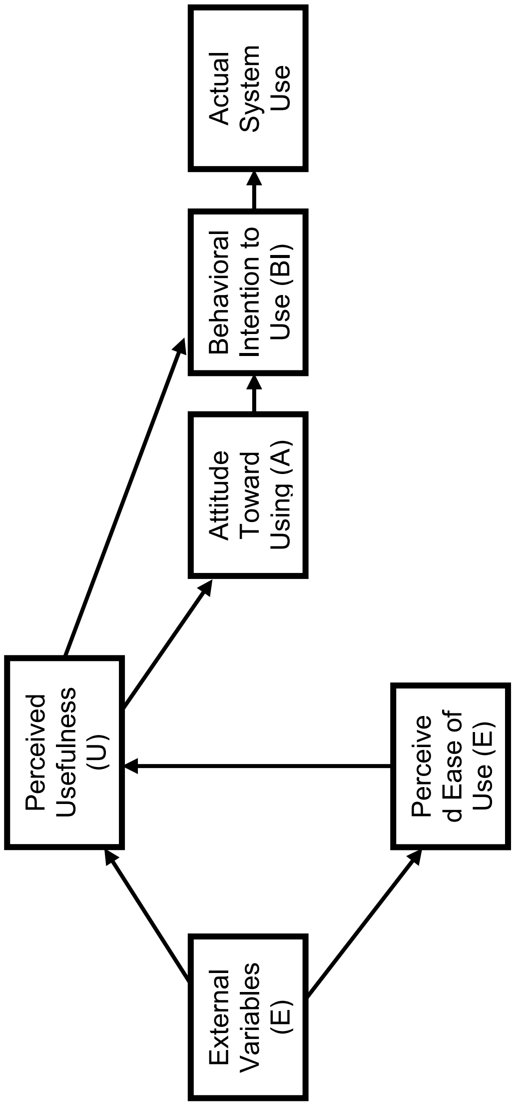

Figure 2. The technology acceptance model (TAM; Davis, 1985). The use of technology is determined by the person's behavioral intention to use (BI) the system, which is influenced by the user's attitude (A), described as an emotional response or a positive/negative experience when using the technology. Feeding into A is the perceived usefulness (U) and perceived ease of use (E). U also directly influences the user's BI. External variables may include social norms, such as an institution's access to technology and infiltration of use (Davis, 1985; Davis et al., 1989).

anonymity, each child received a number from 1 to 21 (each class separately) so that he or she could be identified consistently across the three data gathering processes.

Convenience sampling was used to address the specific aims related to our research questions. Specifically, the sampling method used in the current study is referred to as concurrent mixed method sampling (Teddlie & Yu, 2007) in that our sample serviced the requirements of our quantitative and qualitative strands of data. The quantitative and qualitative data were collected simultaneously, and the analysis of the quantitative data informed the analysis of the qualitative data (and vice versa). The procedure was convenient in that gaining access to the school to study both classes was made readily available by the existing common collaboration between the University of Jyväskylä and the Jyväskylän Normaalikoulu. Serving as a teacher training school for the University of Jyväskylä's Faculty of Education students, the Jyväskylän Normaalikoulu also collaborates with various departments at the university as an accessible location to conduct research. In addition, all of the subjects were willing to participate.

We obtained ethical clearance to conduct this research with children prior to commencing the study by receiving signed parental consent forms for each child that granted us permission to video record and use any data produced by the minor students in this study. Following the completion of the study, we researchers destroyed all video recordings.

Context

The study was carried out in two music classrooms at the Jyväskylän Normaalikoulu based in Jyväskylä, Finland. The school is responsible for educating students enrolled in Grades 1 to 9. Parents of the students attending the school typically permit their children to participate in associated research as well as work with student teachers.

Materials

iPad

The iPad is a multitouch screen tablet that runs on the iOS operating system. The device can serve as a platform for a variety of programs. In the case of this study, it was fitted with a music-producing app; the iPad created the audio output from the app. Students used headsets to hear the output.

Keyboard Touch Instrument App (iPadOS)

The Keyboard Touch Instrument app provides access to various MIDI-based keyboard instruments. For this specific music class—and thus this study—the app was set to the grand piano keyboard instrument, which was accessed via the iPad. The range of keys on the MIDI-based grand piano keyboard on the app was similar to the physical piano used in class by the teacher as well as emulates a standard piano sound. Thus, this digital instrument was deemed practical by the classroom teacher for the students to use. Tactile input from the both the iPad's screen and KAiKU Music Glove's sensors (see below) triggered the Keyboard Touch Instrument app to generate specific sounds.

KAiKU Music Glove

The KAiKU Music Glove device is a musical MIDI controller, fitted with touch sensors and an electronic unit. On the glove, touch sensors form more than two rows to format a musical scale (see Figure 3). To work the sensors, the user presses them with a finger from the other hand. The sensors are connected to an electronic unit that produces musical data.

The touch sensors are arranged from the index finger to the little finger. The tips of the fingers correspond to the notes of a first octave, C, D, E, F, so that semitone E-F is located between the ring finger and the little finger. The data signal created by touch on the glove transfers an output

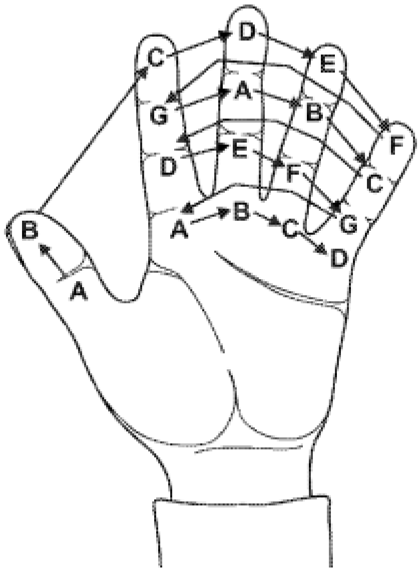

Figure 3. The progression of the music scale on the hand via the KAiKU Music Glove. The arrows show the position of the notes in relation to the fingers (U.S. Patent No. 9,905,207, 2018).

to a selected external device, for example, a MIDI device, a PC, or a computer tablet. In the current study, the glove's output was facilitated by a USB-connected iPad. The iPad functioned as a host device to the glove, decoding MIDI-information and producing sound accessed by headphones.

Study Design

This exploratory, descriptive mixed-method study involved two elementary school music classes. One class was assigned only the iPad as the device to use, which allowed students to play music from the Keyboard Touch Instrument app accessed via the iPad. The other class was assigned the KAiKU Music Glove as the primary music-creating device. However, this class also used the iPad with the Keyboard Touch Instrument app, but only as an apparatus to generate sounds. Because we compared the outcomes of the students using the KAiKU Music Glove device to the students using the iPad for learning, this quantitative aspect of the study can be considered quasiexperimental.

This mixed-methods approach served to address the multiple research questions. First, we worked with the music teacher to create a pre- and posttest assessment tool to measure any growth related to the participants' knowledge of music and musical listening abilities. This provided quantitative data on all students participating in this study and addressed RQ1. We also created an instrument to determine the participants' user experience associated with their assigned technology, employing a Likert-type scale. Students were asked to undertake these tests daily, before commencing use of their assigned devices and then once again after they used them. The responses to these user surveys were analyzed to answer RQ2. Thus, this survey provided both quantitative and qualitative information. Finally, we video recorded the 6 weeks of lessons so that we could analyze the behaviors of selected students regarding their concentration behavior, the analysis of which would address RQ3. These data were analyzed in light of perceived ease of use data results to draw inferences to generate a better understanding of the implications of utilizing established and experimental embodied digital music technology in childhood music education. This process provided our qualitative data. Figure 4 provides a visual summary of the research design. Each of the processes and materials are described more fully below.

Familiarization with KAiKU Music Glove and Researcher Integration Sessions

Two researchers were present in the classroom during the data collection phase of this study. Cozby and Rawn (2012) explained this allows the researchers to immerse themselves fully within the research setting, while Bogdan (1983) proposed this approach allows researchers to develop an understanding of complex social situations. Using the participatory observation method raises the problem of participant reactivity to being observed, known as the Hawthorne effect (Croucher & Conn-Mills, 2014). To account for this, we conducted familiarization sessions for each class so that we were able to integrate ourselves into the environment and introduce the KAiKU Music Glove technology into the experimental classroom. These pre-experiment sessions also allowed the researchers to pilot the data collection processes (i.e., test the Likert-type user experience survey questions and responses with the students and test the video recording process).

We researchers held two familiarization sessions before the prestudy test of knowledge was given to the students as well as Week 1's user experience survey. These sessions fulfilled a two-fold purpose: (a) to allow the children to learn and experience the equipment before the actual study, and (b) to allow children and researchers to become acquainted with one another. This important aspect of conducting research with children develops a trust relationship in which children are more willing to express themselves in the ways they normally would (Barley & Bath, 2014).

We structured the familiarization sessions similarly. The sessions started with the researchers introducing themselves. One class was given five KAiKU Music Gloves connected via USB to an iPad (with the Keyboard Touch Instrument app used on a iPad to generate sounds only) to interact and play music with, and the other class only used iPads with the Keyboard Touch Instrument app to interact and play music with. The class assigned the KAiKU Music Glove had five students at a time using the technology. This was timed closely by the class teacher, with four groups of students in total using the technology for approximately 10 minutes (total = 40 minutes). Five KAiKU

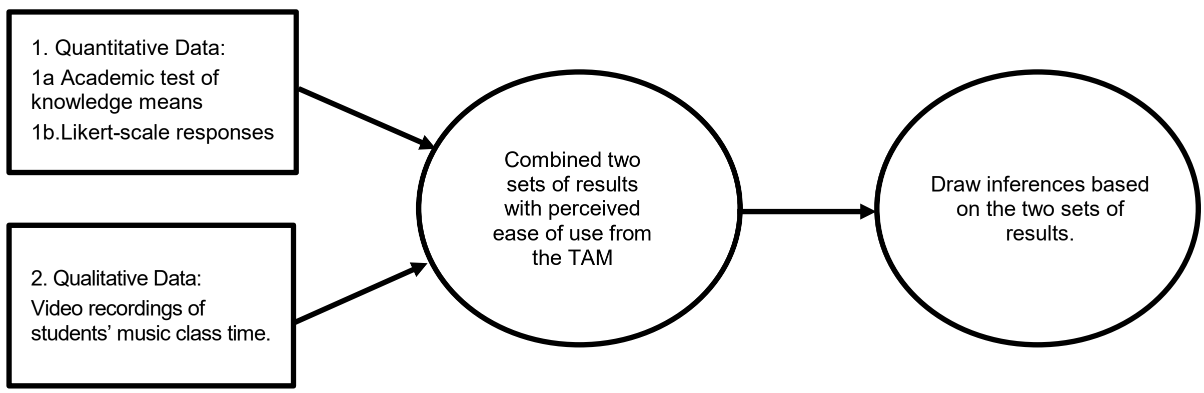

Figure 4. Mixed method study design of qualitative and quantitative data.

Music Gloves were deemed ready for use by their manufacturer before the study commenced, which is why we choose to use a limited number of them during these familiarization sessions. The students interacted and played with their KAiKU Music Gloves by touching the sensors of the glove to trigger and generate sounds in the Keyboard Touch Instrument app. When the students were not using the KAiKU Music Glove for their 10 minutes, they were instructed by the classroom teacher to complete musical exercises using an assigned iPad with the Keyboard Touch Instrument app. In the class assigned only the iPads, students played music by touching the iPad's screen to activate the sounds in the Keyboard Touch Instrument app for the entire class period. In both groups, the audio generated from the Keyboard Touch Instrument app played back through headphones plugged into the iPad and worn by each student. The familiarization sessions included small amounts of content, such as students playing four-bar simple rhythms, whole notes, half notes, quarter notes, and whole rests using one note.

After these familiarization sessions were completed, the KAiKU Music Glove manufacturer provided 22 of the gloves to the experimental class for the study's 6-week data collection period: 21 for all the students and one for the teacher to use. Additionally, in the week following the final familiarization session, the 6-week data collection period began with the following measures: the test of knowledge, the user experience survey to assess the students' perceived ease of use, and the qualitative video analysis.

Measures

Test of Knowledge

The students in both classes completed a test of musical knowledge at the beginning and end of the study. The pre- and posttests examined the students' musical knowledge retention and learning growth before and after using their assigned technologies. The classroom teacher (i.e., the teacher of all the students' subjects) and researchers discussed the nature of the test of musical knowledge, and the teacher developed the instrument. We researchers considered the teacher an expert at determining the validity of the content of the test because the teacher had taught primary and childhood music education classes at the Jyväskylän Normaalikoulu since 2012. The teacher designed the content of the test based on a Finnish childhood music education curriculum and teaching syllabus. The curriculum and syllabus integrates theoretical and practice-based music learning (Ruismäki & Ruokonen, 2006).

The development of the test of knowledge encompassed three stages. The first stage involved the researchers planning and discussing with the teacher the structure of the test and defining the content of the test. Following this, the teacher designed five open-ended questions in the Finnish language (see Table 1; these questions were answered by the participants in Finnish language and, for the purposes of this paper, have been translated by the classroom teacher from Finnish to English) based on the music class syllabus to examine theoretical (e.g., an examination of musical notation names) and practical questions (e.g., an examination of music listening skills). The test of musical knowledge consisted of five questions: one each testing the children's aural skill, pitch identification (these two were achieved by the teacher playing a musical notation by using a piano; the subjects listened to the notation and answered questions related to aural recognition of rhythm and pitch identification of melody), remembering musical notation names, and identifying piano keys and rhythmical markings. The second stage established face validity

Table 1. The Five Questions and Maximum Points from the Test of Knowledge.

Question	Maximum Points
What is the correct rhythm listened to?	1
In what order do you learn to play these melodies?	4
Name the piano keys.	8
Name the note names on the stave.	8
Identify the musical symbols from listening and match them to the phrase.	10

Note. The maximum points from the test are 31 and the minimum points are 0. The questions here were translated from Finnish to English by the music teacher.

of the test with the researchers. The researchers agreed that the test appeared to examine theoretical and practical questions. During the third stage, the teacher assembled the test in paper form. The students would complete their tests by using a pencil. The test—created in the Finnish language, one of two main official languages of Finland, which students of the age of the participants typically are able to read and write sufficiently—was administered by the music teacher before and at the completion of the 6-week study. The teacher also assessed the students' responses to the tests at both collection points and provided the results to us researchers.

User Experience Survey: Perceived Ease of Use

To examine how the two classes of students experienced using their respective technologies during their music class, the students completed a subjective experience survey each class, before and after using their assigned iPad or KAiKU Music Glove (see the Appendix for the survey in English). This user experience survey included one question on perceived ease of use; the balance of the survey presented questions not related to the scope of this paper and thus we focus only on Question 2 during the analysis in this paper.

We developed the questions for this user experience survey instrument thematically, based on Gasparini and Culén (2012), who explained that the perceived usefulness and ease of use of the iPad in the classroom are important factors for their acceptance. The Likert-type scale was designed pictorially in line with Kano, Horton, and Read (2010), who found that a thumb-scale employed for children's self-reporting on computer experience was effective with children as young as 7 years old. As a result, the students' responses to the statements on user experience required them to circle Likert-like scale thumb pictures (two thumbs down = *Not at all* to two thumbs up = *Very much*) to reflect their perspectives.We created this user experience survey employing the thumb scale in English, which the teacher then translated into the Finnish language. Again, all the participants were sufficiently skilled in Finnish.

We piloted the survey for reliability during the familiarization sessions (see below). Students responded to the test statements by circling thumb pictures. We then reviewed the initial responses between the familiarization sessions and at the start of the experiment to identify any inconsistencies in the intended response. For instance, we could determine if students from either class was responding incorrectly to statements (i.e., by writing numbers instead of circling thumb pictures to indicate their response, per instructions, or by drawing on the page arbitrarily). We did not find such inconsistencies in their responses to the user experience survey, indicating preliminary validity.

Qualitative Video Analysis

To observe the differences in students' concentration-related behavior patterns while using both music technologies, we conducted a qualitative video analysis of the recordings of the students using their assigned technologies in class. These data were collected and analyzed by two researchers (the first author of this paper and a master's graduate who is a classroom teacher), qualitatively observing the students using the technologies in the form of qualitative video analysis. To record each of the six classes, we set up a stationary video camera in the classroom in a position to capture the widest angle and the largest number of students possible. The camera setup recorded both audio and video. From the audio data, we could determine the students' verbal communications (i.e., a discussion with his/her peers related or unrelated to the music class activities, see Figure 5, or asking the teacher for help). We started the camera recording as the students entered the classroom and left the device to record without any action for the duration of the class. The qualitative video analysis was completed after the 6-week study was complete.

The general inductive approach for qualitative data analysis involves a research methodology suited for many research purposes. In the current study, we extended the approach to analyze video recordings of participant behavior. The primary goal of the inductive analysis was to allow research findings to emerge from the recurrent and prevailing themes in the data (Thomas, 2006). In inductive analysis, an iterative process, the raw data is read multiple times with codes, themes, and categories continually defined, refined, clarified, and amended (Braun & Clarke, 2006). The inductive analysis was driven by our interest in determining any differences in the concentration level of students using each of the devices, as articulated in RQ3. Thus, in our study, because our data comprised video recordings, we employed the iterative process by repeatedly viewing video clips containing behavior of interest.

We analyzed the behavior of four participants, two from each study condition, to identify concentration-related behavior patterns as the students' played and learned with their assigned technology during each lesson. The restricted camera angle used in the study and the quality of video that could be observed consistently for analysis limited our ability to expand beyond the four students. We focused our analysis on the four participants' nonverbal behaviors, such as looking around the classroom, and verbal communications, such as asking for help from the teacher or asking for help from another student. Criteria for selecting the four study participants involved (a) the student must be within the video frame consistently throughout the class, (b) the student must be present in class for the entire duration of the study, and (c) one student in each class scored high in learning performance (above median in the pre- and postlearning test of knowledge) and the other low on the same measure. Students 7 and 12 from the iPad class and Students 3 and 10 from the KAiKU Music Glove class were selected for observation via the videotaped data. However, both students selected for video analysis from the KAiKU Music Glove class scored below the median in the prelearning test of knowledge. Considering the limitations apparent in both the technical and selection challenges and because both students fully met the first two selection criteria and Student 3 scored above the median in the postlearning test of knowledge, the researchers agreed to modify the requirement of the third criterion and observe these students for the video analysis. In this instance, the high quality of behavioral observation that could be made via the videotaped data was considered of primary importance. We acknowledge this exemption in the study's limitations.

The two researchers chose lessons from Weeks 1, 3, and 6 for video analysis (as these lessons represented a beginning, middle and end point of the study for analysis), employing a three-stage process for the analysis of the video recordings. The first stage of analysis involved a first-pass inductive coding of the data to place identified data into preliminary analytic categories. In the first stage, the two researchers worked independently to identify segments of the video recordings with occurrences of student verbal and nonverbal behaviors suggesting a lack of concentration. Following this, the researchers negotiated and agreed on the following codes: boredom, no attention, task focus, and raising hand for help. In the second stage, the researchers concurred on a subset of the video recording sections where specific student verbal and nonverbal behavior was observed. The results of the second stage were lists of segmented descriptions, along with time codes; these were identified individually and entered into a shared spreadsheet. This stage of analysis led to the refinement of the previous identified codes. From this second stage, four themes emerged: looking away from technology, looking around the classroom, teacher–student interaction, and students discussing the task with fellow students. In the third stage, classifications for student verbal and nonverbal behaviors regarding their concentration-related behavior in the classroom were further revised. After independent analysis, we agreed upon two classifications at this selective coding stage: off-task behavior and on-task behavior (see Table 2). Patterns in off-task and on-task behavior have been the focus of much research (see, e.g., Baker, Corbett, Koedinger, & Wagner, 2004; Baker, D'Mello, Rodrigo, & Graesser, 2010; Cozby & Rawn, 2012; Ziemek, 2006).

Off-task behavior relates to the users' cognitive–affective states as they interact with technology. These include boredom (Csikszentmihalyi, 1990; Miserandino, 1996) and engaged concentration. Engaged concentration is a state of engagement with a task that is intense. During this state, attention is focused and involvement is complete. However, it does not involve the various task-related aspects that Csikszentmihalyi associated with flow (e.g., clear goals, balanced challenge, direct and immediate feedback). Baker et al. (2010) identified these cognitive–affective states as looking at or away from the object or looking around the room for something other than the user interface. Meanwhile, Ziemek (2006) associated off-task actions with disruptive behaviors, such as talking about things not related to the activity and disrupting their classmates. On-task behavior is identified by Baker et al. (2004) as asking for help from the teacher or another student and commenting on achievements. For our study, the frequencies of the occurrences of the students' nonverbal responses and verbal communications were considered indicators of their concentration during class.

Classroom Activities

The process of the music instruction conducted was typical for this teacher and this age group of students, other than the introduction of an experimental condition in form of the KAiKU Music

Table 2. Actions of On-Task and Off-Task Behaviors.

Off-Task Behavior	On-Task Behavior
Looking away from, the screen	Asking for help from the teacher
Looking around for something other than the user interface	Asking for help from others
Talking about things unrelated to the activity or disrupting others.	Commenting on achievements

Note. Based on the research of, e.g., Baker et al., 2004; Baker et al., 2010; Cozby & Rawn, 2012; Ziemek, 2006.

Glove and the data collection processes (i.e., measurement instruments and video recording). This 6-week period of time was blocked off during the students' academic semester, and as such the students had music education with this classroom teacher prior to our study. This classroom teacher is specifically a music teacher in this school and thus teaches music subjects only. All 42 students participating in this study have specific teachers in the following subjects: special needs teachers, language teachers, craft teachers, physical education teachers, class teachers, music teachers, and religion teachers. The class assigned the iPad had class on a Monday; the class assigned the KAiKU Music Glove had class on a Thursday. The teacher was the same for both music classes; the same classroom activities were assigned to the iPad and the KAiKU Music Glove classes. The teacher integrated both technologies into the existing curriculum of the lesson plans, ensuring students who participated in this study did not fall behind in the level of education they received. As the technology was incorporated into the lessons, the students were able to participate in the study without sacrificing the amount of material covered. Figure 5 briefly provides information on the content of the weekly lessons. The weekly classes followed the same procedure, as shown in Figure 6.

Week 1	The teacher instructed the class about incorporating three notes, C-D-E, into four-bar melodies. The teacher then demonstrated the location of the musical note positions, C-D-E, on the keyboard (or, in the class assigned the KAiKU Music Glove, on the device). The students incorporated three notes, C-D-E, as part of four-bar melodies while using and playing their iPad or KAiKU Music Glove.
Week 2	The teacher instructs the class about different note names found on the musical stave. Following the new instruction, the students then continued practicing playing three notes, C-D-E, as part of four-bar melodies while playing their iPad or KAiKU Music Glove.
Week 3	The teacher instructed the class on the location of the musical note positions found on the keyboard (or the KAiKU Music Glove) as well as the note names of *Twinkle, Twinkle Little Star*. The students learned, and practice playing the melody of *Twinkle, Twinkle, Little Star* while using their iPad or KAiKU Music Glove. The classroom teacher accompanied the students' by playing *Twinkle, Twinkle, Little Star* on the electric keyboard or on the KAiKU Music Glove.
Week 4	The teacher instructed the class on the note positions found on the keyboard or on the KAiKU Music Glove as well as the note names of a traditional Finnish Christmas carol (*Joulu on taas; It's Christmas Again*). The students learned and practiced the melody of *Joulu on taas* using their iPad or KAiKU Music Glove. The students sang to accompany the melody and harmony of the Christmas carol. This was the first-time students accompanied the use of their technologies with singing.
Week 5	The teacher instructed the class on the theoretical background of time signatures and ¾ time. The students learned about time signatures, and ¾ time playing. The students continued to practice the *Joulu on taas* using their iPad or KAiKU Music Glove. Also, the students sang *Joulu on taas* while playing it simultaneously on their technologies.
Week 6	The students continued to practice *Joulu on taas* using their iPad or KAiKU Music Glove. At times, the young musicians were accompanied by the classroom teacher on the electric keyboard, no matter which technology they were using.

Figure 5. An Overview of Activities in Both Music Classes.

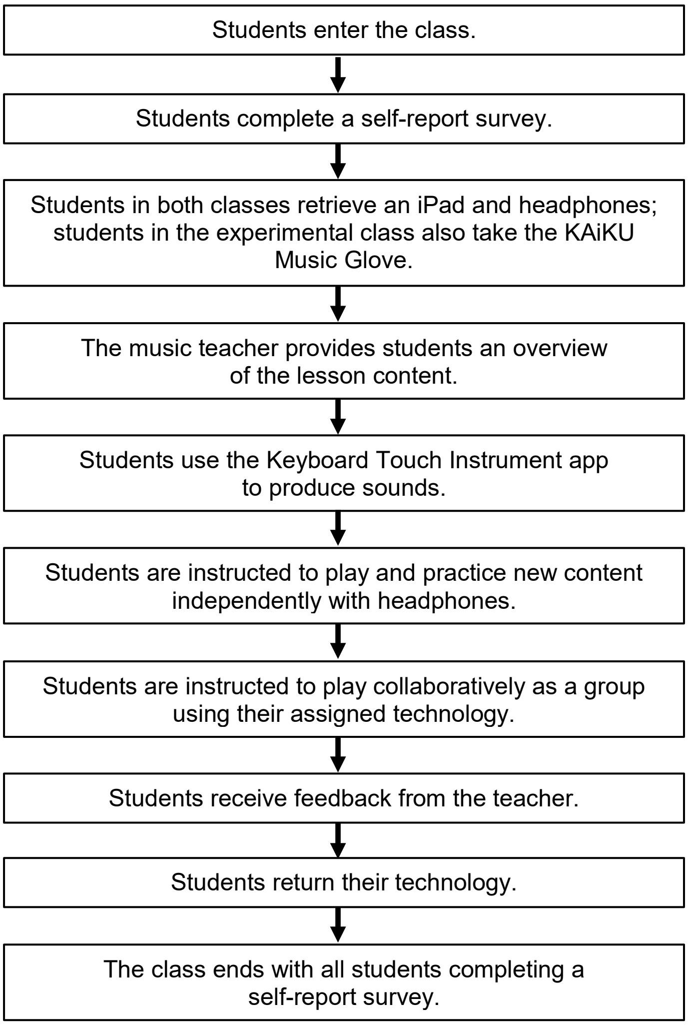

Figure 6. The session procedure during the 6-week-long experiment. Each box represents an essential component in the organization of each music lesson, observed and agreed on by researchers. The weekly lessons maintained a regular schedule and were held in the same room.

RESULTS

The results from the test of knowledge are presented first, followed by the responses on the perceived ease of use question of the user experience survey, and finally, qualitative observation tallies. The results report and compare learning outcomes between the iPad and KAiKU Music Glove classes and perceived ease of use responses before and after each time the students used their assigned technologies. Statistical analysis in the form of a Mann-Whitney U test was used to examine whether or not the difference in change in test scores between the student groups is significantly different after using their assigned technologies during the study's duration. To analyze the change in perceived ease of use responses before and after the students used their assigned technologies, we used a Wilcoxon Signed-ranks test to examine their perceived ease of use survey responses. The qualitative observation tallies were made by the researchers viewing video recordings of the classroom lessons. The observation tallies were the result of behaviors coded by both researchers. Observation tallies were made by both the researchers. Following the comparison of tally totals, both researchers negotiated and agreed upon final codes for behaviors and the total instances of each observed behavior.

The test of knowledge was completed by all students in both classes. Before the students used their devices, the test of knowledge established a baseline measurement of the students' knowledge regarding the musical syllabus. After using the technologies, the same test of knowledge was completed by the students to examine whether the use of the technologies had increased or decreased their musical knowledge.

Pearson's correlation coefficient was carried out to assess the relationship between the group of students using only the iPad for music learning (n = 21) and the group of students using the KAiKU Music Glove ($n = 21$) for the same purpose. We also computed test of knowledge scores at the beginning of the experiment (Week 1) and retest scores (Week 6). The Pearson's r data analysis revealed a moderate positive correlation between the test and retest scores for both groups, with an r of .73 (iPad only group) and an r of .77 (KAiKU Music Glove group). Results from the test of knowledge before and after using the technology are in Figure 7.

We performed a statistical analysis of the posttest of knowledge scores using a Mann-Whitney U test. The purpose was to compare whether the change between the two groups from pre- to posttest scores was significant. The Mann-Whitney U test indicated that the difference in change in test scores between the students after using their assigned iPad (Mdn = 7) and KAiKU Music Glove (Mdn = 0) technologies is significant, U = 115, z = 2.641, p = .008 two-tailed, and a medium effect-size was found d = .75.

As shown in Table 3, results from the daily survey indicate the technologies were rated similarly before they were used in perceived ease of use, as Week 1, Week 3 and Week 6 report median results of between 4 and 4.50, and a small effect size (d = .20) was found. After the technologies were used, the daily survey results indicate that both technologies were rated lower in perceived ease of use, as Week 1, Week 3, and Week 6 report median results of between 3 and 1.50, and a small effect size (d = .20) was found. In addition, results from the daily survey indicate that both devices were rated similarly in perceived ease of use, post-use, at Week 6 (iPad, Mdn = 2.00, KAiKU Music Glove Mdn = 1.50) and a small effect size (d = .31) was found.

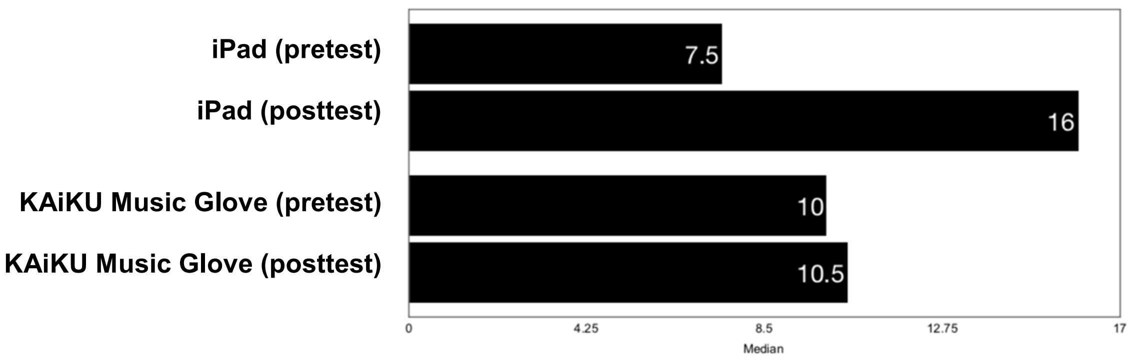

Figure 7. Medians comparing the pre- and postlearning test of knowledge results from the iPad and KAiKU Music Glove classes. The maximum test score is 31.

Table 3. Descriptive Statistics of the Perceived Ease of Use Responses During Weeks 1, 3, and 6 for the iPad and KAiKU Music Glove Classes.

	Week 1			Week 3			Week 6		
Item	Mean	Median	SD	Mean	Median	SD	Mean	Median	SD
I think the iPad will be easy to use today (iPad)	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 (iPad)	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 (KAiKU Music Glove)	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 (KAiKU Music Glove)	2.80	3.00	1.06	2.35	2.00	1.82	2.10	1.50	1.21

We performed a Wilcoxon Signed-ranks test on the change in perceived ease of use ratings. The Wilcoxon Signed-ranks test indicated the change in perceived ease of use rating before using the iPad at Week 1 ($Mdn = 4.00$) and after using the iPad at Week 6 ($Mdn = 2.00$) is significant, $T = 118$, $z = -2.5854$, $p = .009$; a large effect-size was found, $d = .80$. The Wilcoxon Signed-ranks test indicated the change in perceived ease of use rating before using the KAiKU Music Glove at Week 1 ($Mdn = 4.5$) and after using the KAiKU Music Glove at Week 6 ($Mdn = 1.5$) was significant, $T = 214$, $z = -3.4236$, $p = .001$, and a large effect-size ($d = .80$) was found.

To analyze the difference in change between the students' ratings in perceived ease of use of both the devices from Week 1 to Week 6, a Mann-Whitney U test on the ratings was performed. The Mann-Whitney U test indicated the difference in change of perceived ease of use ratings between the students who used the iPad ($Mdn = 0$) and the students who used the KAiKU Music Glove ($Mdn = 2$) across the 6 weeks of study was not significant, $U = 165$, $z = -1.384$, $p = .168$ two-tailed; a small effect size ($d = .40$) was found.

To analyze the difference in perceived ease of use ratings of both the devices between the two groups of students, after rating their devices at Week 6, we performed a Mann-Whitney U test on the ratings. The Mann-Whitney U test indicated the difference in the two groups of students perceived ease of use rating after using the iPad ($Mdn = 2$) and after using the KAiKU Music Glove ($Mdn = 1.5$) at Week 6 is not significant, $U = 217$, $z = -0.07547$, $p = .936$ two-tailed, and a small effect size ($d = .31$) was found.

We conducted a video analysis to understand the students' behaviors while using their assigned technologies. Video of the classes was recorded at 2-week intervals during the survey period (i.e., Weeks 1, 3, & 6), and the observations were of two students from each class, selected by specific conditions. The students' coded behaviors refer to their concentrated-related behavior while using their assigned technologies. These were labeled as Off-task Behavior and On-task Behavior.

Two researchers rated and coded behavior of the selected students at each observation point independently. Interrater reliability was measured to ensure that the data collected in the study were represented correctly. We completed statistical analysis in the form of Cohen's kappa (k)

to examine the reliability between the observed scores of the researchers. The results of the kappa were $k = .81$, indicating strong agreement between the researchers on their coded categories.

Tables 4 and 5 display the tallies of the researchers' analysis of the two representative students' behavior in the iPad-using and KAiKU Music Glove-using classes. Each student in both the classes were designated a number (from 1 to 21). Within the iPad-using class, students numbered 7 to 12 were selected for video analysis of their behavior, and within the KAiKU Music Glove-using class, students numbered 3 to 10 were selected for video analysis of their behavior.

Table 4. Tallies of the Researchers' Analysis of Two Representative Students' Behavior in the iPad Class.

Week	Student Number	Instances of Off-Task Behavior	Instances of On-Task Behavior
1	7	3	0
	12	2	0
3	7	0	0
	12	0	0
6	7	1	0
	12	4	0
Total		10	0

Note. Each student in the iPad-using class was designated by a number (from 1 to 21). Students 7 and 12 were selected for video analysis of their behavior.

Table 5. Tallies of the Researchers' Analysis of Two Representative Students' Behavior in the KAiKU Music Glove Class.

Week	Student Number	Instances of Off-Task Behavior	Instances of On-Task Behavior
1	3	0	0
	10	0	0
3	3	0	0
	10	0	0
6	3	0	3
	10	0	3
Total		0	6

Note. Each student in the KAiKU Music Glove-using class was designated by a number (from 1 to 21). Students 3 and 10 were selected for video analysis of their behavior.

DISCUSSION

The current study found that the students using, playing, and learning music with the iPad-only scored higher in their test of knowledge posttest result. When analyzing the difference in change between the students' posttest results during the 6 weeks of lessons, a Mann-Whitney U test showed a statistically significant result. When the change in perceived ease of use responses is analyzed before using both technologies, statistically significant results were found. The results of the qualitative video analysis tentatively suggest that concentration-related behavior may have been observed to be higher in the two students using, playing, and learning with the KAiKU Music Glove, than the two students using the iPad-only. The results above provide evidence for discussion of the study in terms of the three research questions.

RQ1. What is the difference in musical knowledge before and after using the iPad with the Keyboard Touch Instrument app and the KAiKU Music Glove connected to the iPad in children's music classes?

As indicated in the analysis of the posttest differences, the students who used the iPad with the Keyboard Touch Instrument app improved more in their musical knowledge after using the technology over the 6 weeks of lessons as compared to the students who used the KAiKU Music Glove. When the posttest results comparing the difference in change are compared to one another, the difference was significant and the effect size was medium. These findings suggest that use of the iPad with the Keyboard Touch Instrument app contributed to increased learning more so than the KAiKU Music Glove. The findings in this study are in line with a previous research that also used these data (Danso, 2019). However, a distinct difference in this study's use of the data is the analysis of change in posttest score after the students used their technologies, which highlights the potential significance of the iPad with the Keyboard Touch Instrument app's contribution to the students' increased learning. In addition, the increased learning of the students who used the iPad with the Keyboard Touch Instrument app supports the literature of Wario et al. (2016), Wang, et al. (2015), and Heinrich (2012), who found interacting with the iPad in the classroom may have a positive impact on learning. On the other hand, the difference may have resulted from students being more familiar with the iPad device and thus able to use its touch screen more efficiently, helping their learning performance.

Moreover, the students using the iPad as their music-education platform learned with the piano keys presented via the Keyboard Touch app. Touching the piano keys presented in the app may have supported the students' learning better than the students assigned the KAiKU Music Glove due to familiarity from prior lessons in understanding how notes are positioned on a keyboard. In addition, the Keyboard Touch Instrument app has a wider range of musical notes (27 keys in total) available for the students to play compared to the KAiKU Music Glove (17 sensors in total). This may have encouraged more freedom for the students in the iPad group to express themselves musically. The KAiKU Music Glove has a fixed mapping system placing notes across the fingers (see Figure 3), which may have presented a practical challenge for the students playing music and their subsequent learning. In this instance, the Keyboard Touch Instrument app used by the student group assigned the iPad could be seen as unrestrictive to the students' musical expression while supporting their learning outcomes. The unrestrictive nature of the app as the primary learning tool supports the findings of Burton and Pearsall (2015), who stated that apps used in childhood music education should allow children freedom in music making. To achieve a similar positive learning outcome, the KAiKU Music Glove may benefit from future development in placing additional sensors on the device and allowing users similar access to the range of musical notes the Keyboard Touch Instrument app provides, both which may encourage freedom in music making.

Consequently, the KAiKU Music Glove may have been a hindrance to learning in the music class. This could be due to the fact that it was too unfamiliar, thus diverting attention from the music learning in general. We had identified this potential obstacle already before the study's implementation and attempted to mitigate it with the familiarization sessions. Despite two familiarization sessions, we must acknowledge that the children assigned to the KAiKU Music Glove condition already had prior experience in using the iPad with the Keyboard Touch app that mirrored the piano keyboard and thus were presented with a significantly different musical interface when we entered the classroom. Although the question about how prior experience with iPads (or other tablet computers) and specific software programs may have contributed to the lower test scores for the KAiKU Music Glove condition is an important issue to explore more deeply, it is out of the scope of this current study.

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

We asked the students at the start and conclusion of each lesson about their anticipated and post-use perceived ease of use for their assigned technology. The students' rated both technologies higher in perceived ease of use across Week 1, Week 3 and Week 6 before using the devices, and rated them lower after they were used across Week 1, Week 3, and Week 6. This is indicated by two sets of results. First, the descriptive statistics reporting medians of between 4 (iPad-only pre-use Week 1) and 4.50 (KAiKU Music Glove pre-use Week 1) before the technology were used, and medians of between 3 (iPad-only Week 1, and Week 3 post-use) and 1.50 (KAiKU Music Glove Week 6 post-use) after they were used. Second, the analysis of the change of score between the students' rating their anticipated ease of use of the iPad and KAiKU Music Glove use at Week 1 and the final rating at Week 6 are statistically significant, in part due to their higher ratings before use at Week 1, and lower final ratings post-use at Week 6.We speculate the higher ratings before using the iPad-only may have been due to the familiarity of using the device prior to the study, and the lower ratings after they used the device may have been due to having to play music by using the Keyboard Touch Instrument app interface while completing the lesson content. On the other hand, the students rating the KAiKU Music Glove high before using it in perceived ease of use may have been due to the novel design of the KAiKU Music Glove, as it places musical notation across the hand in the form of sensors. Consequently, the children anticipating playing music on their hand may have influenced these responses in a positive manner. However, the lower ratings in overall perceived ease of use after the KAiKU Music Glove is used show that the device may have impeded playing music while completing the lesson content.

In line with Davis et al.'s (1989) conception of perceived ease of use, we can observe that students may have anticipated less effort in engaging the technology before using their assigned devices at Week 1 but then perceiving more effort was necessary in using them after the course at Week 6. Regarding the iPad, some of the students' high ratings in perceived ease of use before and after its use is in line with the works of Henderson and Yeow, (2012), Churchill et al. (2012), and Clark and Luckin, (2013), who indicated that tablet computers are supportive for use in classroom settings. Regarding the KAiKU Music Glove, some of the students' high scores before use suggest that novel hand-sensor technology is seen as easy to play music with.

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

Several explanations are possible in analyzing the difference in the concentration-related behavior of the students while using, playing, and interacting with their assigned iPad or KAiKU Music Glove. The teacher interacted more frequently with the two observed students who used the KAiKU Music Glove, as requested by these students. This was coded in the observation tallies as on-task behavior, in line with Baker et al. (2004). Thus, a tentative association with KAiKU Music Glove usage encouraging the students' to remain on-task might be identifiable, as they were asking for support from the teacher. Crucially, these data must be interpreted with caution because the students using the KAiKU Music Glove may have found the instructions from the teacher needed clarification, prompting a request for help and corrective guidance about the lesson content and how the lesson content was associated with playing on the KAiKU Music Glove.

It follows that the students using the KAiKU Music Glove may have needed additional help and support from the teacher because of the novelty of the technology and the technical difficulties students experienced while using it. Evidence of this can be seen from the results discussed in RQ2, where the KAiKU Music Glove was rated lower in perceived ease of use. But these circumstances also were noted clearly in the observations of the researchers. For example, the researchers observed that both students using the KAiKU Music Glove experienced practical difficulty in strapping the device to their wrists, making the glove properly cover their hands. In these cases, the wrist strap was slightly too large and the students requested the teacher's help in tightening the wrist strap appropriately. These difficulties can be seen to impede the embodied learning experience of the children by preventing—or at least delaying—them from engaging in the immersion of the music-making interactions. As the user interface skin (Sampson, 2019) of the KAiKU Music Glove did not always fit the students' hands easily, the sensory design of the technology prompted the students to interact more with the teacher instead of playing music with the sensory aspects of their hand (Höök, 2009; Höök & Löwgren, 2012; Rousi & Silvennoinen, 2018). This observed difficulty in usability of the KAiKU Music Glove also may have been embodied in the students' actions, as the improperly fitted technological design prompted the request for help (Bødker, 1989; Dewey, 1934/2005; Gayler, et al., 2019). Naturally, from this arises the importance of social interaction and experience from not only the perspective of music but also those of educational (music) instruction and technological usage. These are issues that deserve full attention in their own right.

In addition, the differences in observed concentration-related behavior of the two students from each group may have been due to the students observed being more familiar with the iPad and less familiar with the KAiKU Music Glove. As noted above, all participants in this study had used the iPad with the Keyboard Touch Instrument app in their music classes before we initiated this experiment. Thus, on-task and off-task behaviors could have been complicated—or perhaps even caused—by the students' struggle or unfamiliarity with their assigned technology.

The comparatively high off-task behavior of the students using the iPad only that we observed may have relevance to the evidence in RQ2. Because the iPad device and software were easier to use and more familiar than the KAiKU Music Glove, the off-task behavior may reflect that these students were freer to interact with one another more often (peer-to-peer) and provided opportunities for them to play with one another. This freedom in play and social interaction may have encouraged the students to concentrate more in the process of the lesson (Koo, 2009), which contributed to genuine engagement with the classroom activities and educational content (Dansenreau, 1985). As an effect of the iPad's design, the technology may have enabled the iPad-only students more opportunity for a social experience with the learning content. This social experience is described as coexperience by Batterbee and Koskinen (2005), who noted that children experienced music while using and playing with the technology together, as well as being engaged in play and social experience with one another. Hence, the iPad may have enabled a creative (McArdle & Wright, 2014) coexperience of playing music for these students to be occupied completely in.

This corresponds to a simultaneous creative coexperience of music enabled through design of the iPad, perhaps evidenced by its high ratings in perceived ease of use by the students and their familiarity with the device from prior use. In this class, this could be viewed as a benefit in using the iPad further, as it fostered coexperience between the students while maintaining their concentration on classroom activities. The familiarity of technology and coexperience may go hand in hand, and having the students become more familiar with the KAiKU Music Glove may have enhanced this. In addition, the KAiKU Music Glove's slightly lower ratings in perceived ease of use compared to the iPad-only after it was used, suggest it was practically difficult to use, somewhat hindering interaction with others. For this reason, the role of social learning in relation to the introduction of both established and new technologies in the music classroom should be explored in greater detail in future studies.

Moreover, concentration-related behavior was quite similar across both classes of students' using their assigned technology as evidenced by their overall low off-task behavior tallies. Speculatively, the respective low off-task behavior recorded by both classes of students' using their assigned technologies may associate with literature by Huizinga (2004), who suggested that students can be engaged in classroom task activity while using, playing, and interacting with their devices during class even if this involves peer interaction and other behaviors that might reflect loss of concentration.

As the students used their assigned devices, one must remember that they were engaged in an embodied music experience. Thus, the experience itself may be seen to extend beyond the human−device interaction toward the larger scope of the musical engagement per se. Because of the overall respective high concentration-related behavior, these findings resonate with findings by Huizinga (2004) by reporting that play supports children in concentrating on learning when engaged with the interaction of objects.

Associating perceived ease of use data with the current observation data indicates that the students' expectations of the studied technologies may have affected concentration-related behavior, which in turn resulted in their actual system use. It follows that the higher performing class in the test of knowledge (the class who only used the iPad with the Keyboard Touch Instrument app) may have perceived their technology as easy to use, which resulted in less effort invested in interaction while using the technology. Indeed, the data show the students observed for concentration-related behavior while using the iPad only engaged in more off-task behavior than the students using the KAiKU Music Glove, suggesting the students using the former technology were not concentrating as fully as the students using the latter during the 6-week study. We suggest that, in the current study, higher perceived ease of use corresponded to less interaction effort while using the familiar technology (i.e., the iPad), resulting in lower levels of concentration-related behavior. On the other hand, the higher concentration-related behavior recorded by the students using the KAiKU Music Glove most likely is linked to their increased effort toward interaction while using the technology. Consequently, applying the perceived ease of use conception from TAM (Davis, 1985) illustrates the students' strong intentions to anticipate how easy to use both device interfaces appeared before playing music, while their concentration-related behavior may be an instance of how challenging these technologies are in action.

LIMITATIONS AND FUTURE STUDY

The current study found practical information about novel and experimental technology use in the music classroom, particularly the strengths of the iPad regarding academic performance and overall ease of use during interaction. The current study also provides new insights into the use of experimental hand-based sensor technology in the childhood music classroom, finding the students had strong intentions about using it to play music throughout the duration of the class. Both technologies helped the students' learning performance, and the observed students appeared to concentrate in class. However, several limitations with the study design and implementation are apparent and thus the results should be considered preliminary and used with caution.

The current test of knowledge did not control for the effects of the students' history, maturation, and familiarity with the iPad device (see, e.g., Dimitrov & Rumrill, 2003); these aspects of student knowledge should be built into the development of any future iterations of the test of knowledge. Additionally, more sophisticated quantitative measures (such as ANCOVA) on the pre- and posttest data may produce a truer analysis of the scores than what was used in this study. Finally, the current study's duration was quite short. The 6 weeks represented a short component within a larger, ongoing class. A longer study period with both technologies, and particularly more time for the students to use the KAiKU Music Glove and practice with the technology in advance of research measurements, may provide more reliable interpretations about student usage of their respective technologies in their childhood music class.

Regarding the perceived ease of use items (adapted from TAM; Davis, 1985), we see a threat to the internal validity within the current study. Although the use of the perceived ease of use investigation was used only descriptively in this study, the current study's findings cannot provide distinct evidence that perceived ease of use was accurately measured as this has been determined less subjectively using construct validity scales. To provide clear evidence of TAM concepts in our data (such as those sought through our perceived ease of use survey), construct validity tests should be completed to ensure that the instrument is measuring the associated trait accurately.

In addition, the study itself is limited in its measurement of student concentration-related behavior. The qualitative video analysis used to analyze concentration-related behavior was problematically influenced by a fixed video camera angle. More video angles or a wider angled device is necessary to repeat a similar analysis, which would have helped us to adhere to our conditions for selecting subjects for observation. A larger population (or sample) of observed participants would also be beneficial. To further increase the reliability of the study, stratified sampling could be used to represent a larger swath of the population for analysis (e.g., test of knowledge scores). Moreover, we believe that the students' familiarity—or lack thereof— with the devices used in this study may have skewed the observation data. Thus, having students' equal familiarity of their respective devised would be important for future study. Furthermore, testing and analysis of a sample that uses KAiKU Music Gloves of the same physical size is necessary to draw more precise conclusions about its usage in the music classroom.

Other factors affecting learning experience, particularly in the music education context, were not accounted for during this study, such as the role of social experience and social learning in relation to music learning and technology usage. One worthwhile theory to investigate in relation to the function of the devices within the learning process would be Albert Bandura's (1977a) social learning theory (SLT). This theory significantly relates to behaviorist traditions in which researchers understand or investigate how people behave in specific ways to achieve specific outcomes (e.g., attain direct reward—e.g., financial, food, etc.—or achieve social acceptance). SLT is a complex construct in that it helps researchers understand not only how humans behave in ways to influence specific social outcomes but also to attain states of influence and agency within themselves. For instance, self-efficacy alludes to one's own experience of being able to do (capabilities) and affect (agency) in various circumstances (Bandura, 1977b). According to Bandura, these social and intrapersonal outcomes may be exercised through media and objects in relation to group dynamics. Thus, the social learning dimension of an iPad or KAiKU glove study could open interesting perspectives to examine in further studies. Within these further studies, attention could be placed on the devices as, for instance, boundary objects within the facilitation of music education and social interaction in the classroom.

CONCLUSIONS

The purpose of this study was to explore established (e.g., iPad) and experimental (e.g., KAiKU Music Glove) embodied digital music technology usage in childhood music education. We pursued this by examining students' learning performance, their experiences of using the technology in the context of the music classroom, and their behaviors while using either the iPad only or the KAiKU Music Glove. Concepts such as concentration, experience, and play while learning music through technology in childhood music education were discussed. Overall, we found in the current study that the student group who used the iPad with the Keyboard Touch Instrument app improved more in their learning performance compared with the student group who used the KAiKU Music Glove with the iPad and Keyboard Touch Instrument app (for sound output). In addition, the study found that students using both technologies rated higher perceived ease of use before they engaged the devices and lower ratings after 6 weeks of use. Furthermore, the study found that both devices were rated similarly in perceived ease of use toward the end of the study period. We observed concentration-related behavior to be respectively high in both groups of students using their devices. Specifically, concentration-related behavior was found to be higher in the two students using the KAiKU Music Glove compared with the students who used the iPad only. When the concentration data is associated with perceived ease of use (from the TAM; Davis, 1985), it explains that both technologies were anticipated strongly in their ease of use to play music, yet the iPad required less effort during play compared with the KAiKU Music Glove. Specifically, less effort may have been exerted by the students using the iPad only as compared with the KAiKU Music Glove, primarily because of their familiarity with the iPad in their music education. As IT is a widely integrated aspect of teaching and learning in today's Nordic childhood music classes (Christophersen & Gullberg, 2017), the current study provides practical insights into the creative use of music technology in the childhood music classroom.

IMPLICATIONS FOR RESEARCH, APPLICATION, OR POLICY

As technologies, particularly tablet devices, are becoming more prevalent in childhood education, and particularly in music learning, this research provides a foundation for future research as well as application considerations. Our finding that unfamiliarity with a technology may impede learning will help future researchers and teachers think through their introductions of new technologies and take the necessary steps needed to avoid any negative impact of the actual device on their evaluations of technology-enhanced learning. The same is true in regard to perceived ease of use and its impact on successful use of a learning technology. Finally, although our results are somewhat preliminary, our research contributes important considerations regarding what constitutes on-task task and off-task behaviors during the introduction of unfamiliar technologies.

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Authors’ Note

All correspondence should be addressed to

Andrew Danso
Department of Music, Art & Culture Studies (MACS)
University of Jyväskylä,
PO Box 35 (M), FI-40014, University of Jyväskylä, Finland
andrew.a.dansoadu[at]jyu.fi

Human Technology
ISSN 1795-6889
www.humantechnology.jyu.fi

Appendix: Likert-type Scale for Student Self-Report on User Experience

(BEFORE THE LESSON)

Student Name: ______________________________ Date: ______________________

Assigned Student Number: ______________

1. I am very excited to use the iPad/Glove today.

   not at all | no | maybe | yes | very much

2. I think the iPad/Glove will be easy to use today.

   not at all | no | maybe | yes | very much

3. I view the iPad/Glove as a musical instrument.
   just like the recorder and piano.

   not at all | no | maybe | yes | very much

(AFTER THE LESSON)

Student Name: ______________________________ Date: ______________________

Assigned Student Number: ______________

1. Today, I found the iPad/Glove easy to use.

   not at all | no | maybe | yes | very much

2. Making music on the iPad/Glove today was easy.

   not at all | no | maybe | yes | very much

3. Today I viewed the iPad/Glove as a musical instrument
   Just like the recorder and piano.

   not at all | no | maybe | yes | very much

4. I think I could teach my friends to play the iPad/Glove.

   not at all | no | maybe | yes | very much