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THE EFFECTS OF THE DIGITAL MUSIC STAND ON MIDDLE SCHOOL INSTRUMENTAL MUSIC SIGHT-READING

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The purpose of this study was to compare the effects of the digital music stand on middle school instrumental music sight-reading. The study was based on previous research comparing text reading on paper and video display unit (VDU). Subjects consisted of 25 seventh and eighth-grade music students from one Oahu intermediate school. The Watkins-Farnum Performance Scale was utilized as the sight-reading criteria. Form A of the Watkins-Farnum Performance Scale was displayed on a modified music stand in its original print format. Form B was displayed on a modified music stand using the *Freehand Systems MusicPad Pro* digital music stand. The author hypothesized that there would be no significant differences between the sight-reading scores of instrumental students when presenting music on a digital music stand verses printed music. Based on the data obtained, the null hypothesis was accepted ($t = -1.70$, $df = 24$, $p = 0.10$). Specific correlations between the use of computer screens for reading music and reading words were not established, but results of this study suggest that such a correlation might exist.

The purpose of this study was to compare the effects of the digital music stand on middle school instrumental music sight-reading. The ubiquitous integration of computers and computer displays in monitors, cell phones, and console video games has made these devices an integral part of many people's lives, especially young adults of the modern digital era. Video displays are now capable of replicating the colors, depth, and resolution of books, music and other visual media at a highly accurate level. This author proposes that given these advancements in technology, music displayed on a computer screen designed specifically for music notation will be viewed and performed as accurately as similar music viewed on traditional paper.

Digital music stands are emerging as a vehicle for the display of music notation for performance and rehearsal. Digital music stands are capable of displaying music notation files from popular software programs, as well any type of file that can be translated into a picture file, such as PNG and TIFF. Some of these devices allow musicians to mark music notation directly on the computer screen and have those markings stored for future reference.

There is a need to test empirically new technologies for their possible integration into music education. Research is needed to show how accurately students perform when reading music from a digital music stand as compared to reading from traditional paper notation. Results of this research may assist further development of digital music stand technology and its educational applications.

Tests have been performed in the past to determine the effectiveness of reading music from screens versus paper (Picking, 1997). These tests were based on reading music from original paper versus Cathode Ray Tube (CRT). Past studies on reading comparisons between paper and screen focused on the deficiencies of the CRT in terms of brightness, resolution, and speed (Askwall, 1985; Gould & Grischowsky, 1984; Switchenko, 1984). These former studies are outdated in light of current technologies. Given the improved capabilities and readability of the Liquid Crystal Display (LCD), new testing is needed to compare accuracy between the two current media, paper and Digital Music Stand (DMS).

There are several different versions of digital music stands available. *eStand* (2005) advertises the *eStand Mobile Tablet*, a *Gateway* Tablet PC with a fourteen-inch touchscreen. USB Footswitches are also available for hands-free page turning. In addition, *eStand* offers a software-only solution for use on a portable or tablet computer.

Two other companies also have digital music notation software for personal computers. Like *eStand*, these two companies, *MuseBook* and *Espresso* (2006), designed their products for use on a PC tablet, portable or desktop computer. *MuseBook*, of South Korea, features pitch-to-midi conversion that allows the music displayed on the screen to be played by the computer. It also allows the music to turn pages automatically when the musician has reached the end of a page (MuseBook, 2006).

Espresso, of New Zealand, is similar to *MuseBook* software. Bell, Blizzard, Green and Bainbridge (2005) describe *Espresso* as a digital music library that combines score retrieval and organization with their display and usage. It features the ability to download music directly from both retail and freeware sheet music websites. *Espresso*, like other digital music stand software, displays images of music notation in the PDF file format.

The major manufacturer of digital music stand hardware is *Freehand*, producer of the *MusicPad Pro*. The *MusicPad Pro* is a portable computer and display enclosed in a plastic case (13.3 in x 9.9 in x 1.8 in), weighing four pounds four ounces. The *MusicPad Pro* features a 13 in TFT LCD backlit touchscreen display, with an XGA resolution (1024 x 768). Because it employs backlighting, no other light source is needed to read the screen (Freehand Systems, 2005).

Research on screen versus paper reading has focused on factors involving the physical and psychological properties of traditional print versus computer screen print. The bulk of research results appeared in the early to mid 1980s, when the personal computer was in its developmental period. This period also marks the transition of computer displays from light text on dark background using monochrome monitors, to dark text on light background using monochrome and colored monitors. The limited viewable area of the Visual Display Unit (VDU) screen area was also an issue in the 1980s as many VDUs were 14 inches diagonal or less. Smaller screens presented less information, and were not capable of replicating the layout of paper text.

By the mid-1990s, research efforts comparing screen versus paper reading declined, possibly due to the improvement in VDU technology. Gould, Alfaro, Barnes, Finn, Grischkowsky and Minuto (1987) concluded that improvements in VDU quality were responsible for equality in reading speed differences, whereas reading from paper was faster than reading from screen just three years prior. Gould suggested that no single variable was attributable to this improvement. Mills and Weldon (1986) also concluded that there is a lack of clarity in the factors that lead to a reduction in screen reading performance. Dillon (1992) concluded that the variables of greatest interest to ergonomic and human factor researchers included reading speed, reading accuracy, and comprehension. Dillon, in his review of empirical literature, stated that drawing conclusions from available literature comparing screen and paper reading is difficult due to the fact that there was a lack of "scientific rigor" applied to experimental design and selection of subjects (p. 1298).

All previous literature focuses on differences between CRTs and paper. There is no available research on the comparison of LCD, the type of display in the digital music stand, and paper. Regardless of this fact, some factors involved in reading from CRT may also apply to reading from LCD.

Dillon (1992) remarked that measuring reading is a difficult task, and drew a distinction between assessing reading in terms of outcome and process measures. Outcome measures concern what a reader gets from text, and consider variables such as the "amount of information retrieved, accuracy of recall, time taken to read the text, and so forth" (p. 1299). Process measures concern how a reader uses the text and include "such variables as where the reader looks in the text and how he/she manipulates it" (p. 1299).

Early research on the difference in reading speed concluded that reading from screens was slower than reading from paper (Gould, Alfaro, Barnes, Finn, Grischkowsky & Minuto, 1987; Gould & Grischkowsky, 1984; Kak, 1981; Muter, Latremouille, Treurniet, and Beam, 1982; Wright & Lickorish, 1988). Results of these early experiments found a performance difference of about twenty to thirty percent between screen and paper reading (Dillon, 1992). Conditions for these experiments varied.

Other studies contradict the findings of differences in reading speed. Studies published after 1983 (Askwall, 1985; Cushman, 1986; Switchenko, 1984) found that there is no difference in screen versus paper reading speed. The primary reason for the equality of reading speed may be attributed to the improved quality of the VDU. Muter and Marutto (1991) concluded that high quality VDUs allowed for equivalent speeds in reading between paper and screen.

Whether these early studies definitively reflected inequalities in reading speed is still debatable. Dillon (1992) concluded that the evidence to support any deficiency in speed is inconclusive. He stated that a number of weaknesses including a large number of variables, poor methodology, and contamination of results are consistently evident in studies affirming and rebutting reading speed deficiencies. However, Dillon was not specific on the details of the aforementioned problems.

The only published research comparing music reading on VDU versus paper comes from Picking (1997). Picking's goal was to report a difference in music proofreading accuracy, with an emphasis on animated presentation style. Animated presentation style involved the movement of either the music or a music marker on the screen while audible music was played.

Picking concluded that computer animated music offers a powerful reading assistance. He cautioned that the computer display may cause ergonomic problems, but visual aids may cancel out these problems. Picking was not specific as to the types of ergonomic problems, nor to what visual aids might eradicate these problems. Paper, he concluded, has advantages in manipulation, annotation, and fatigue factors. Computerized display of music text might be a benefit in a library environment, aiding in access, security, and durability.

Bell, Church, McPherson and Bainbridge (2005) concluded that small music scores could be read accurately on a computer screen. No significant difference was found in error identification between large and small music scores. The authors also concluded that musicians prefer to use large scores with frequent page turns when practicing, but smaller scores with fewer page turns are more suitable for performance.

Method

The subjects for the present study were 25 volunteer students from one Oahu public middle school. The school chosen had an established music program, employing state certified instructors. School choice was determined by availability to the researcher, and willingness of the school and administration to participate.

The subjects were middle school instrumental students, seventh and eighth grade. Each student studied instrumental music for a minimum of one year as of the testing month of January 2006. The subjects of this study were wind players only, and included all instruments contained in the Watkins-Farnum Performance Scale. The Watkins-Farnum Performance Scale is an objective test that determines a student's ability to utilize music that increases in difficulty. Players are scored on their accuracy, and continue to play until they perform most of the bars in a specific piece incorrectly. Clarinets and horns were included in this methodology although there have been issues in the past concerning the reliability of testing scores with these two instruments (Stivers, 1972). According to Stivers, percussionists have the lowest known reliability on the Watkins-Farnum ($r = .63$). Therefore, percussionists were exempt from testing in the present study.

It was the goal of the researcher to include as many different students as possible. Previous studies by Gould, Alfaro, Barnes, Finn, Grischkowsky, and Minuto (1987) have concluded that individual dynamics such as computer usage, age, and gender are not a factor in screen versus paper reading studies. Other variables, such as visual acuity and academic performance, are not a factor in this study because a subject's scores are not compared to other subjects' scores.

Procedure

The hypothesis of this study is that music displayed on a computer screen designed specifically for music notation will be performed as accurately as similar music viewed on traditional paper. To test this hypothesis, a comparison was made of the mean scores of the 25 subjects' performance on Forms A and B of the Watkins-Farnum Performance Scale. Form A was displayed in the original paper format, and Form B was displayed on the *MusicPad Pro*. Subjects performed a short warm-up selection composed by the researcher based on the musical format of the first study in the Watkins-Farnum Performance Scale. Subjects were informed that this selection was for warm-up purposes and would not be graded. The warm-up procedure was used to allow the student to become acquainted with the acoustics and set-up of the testing room. The warm-up lasted no more than two minutes.

Subjects sat while performing the test. Music stands initially were placed one hundred thirty two centimeters from the front of the subject's chair. Stand A held the paper version of the test, and Stand B held the digital music stand version. Subjects were allowed to move the stand, known as Stand A, for personal preference. Stand B was placed at the same distance as Stand A.

Stands A and B were adjusted to a 48 degree angle to the subject's eyes. Subjects were allowed to adjust the angle of the stand. Neither distance nor angle changed between Stand A and Stand B. During the testing no student adjusted the angle of Stand A or B.

The method of music reading assessment used in this study was the Watkins-Farnum Performance Scale, developed by John Watkins and Stephen Farnum. It was first developed as an adaptation of cornet rating scales, and later applied to common band instruments and snare drum (Watkins & Farnum, 1954). The test comes in two forms, with material in Form A adapted from material in Form B. Watkins found "in his study that the reliability coefficient between Form A and Form B was .95" (Watkins & Farnum, 1954, p. 5).

The Watkins-Farnum Performance Scale has been used to test beginning band students (Edwards, 1978; Jacobs, 1985; Morehouse, 1981), and middle school instrumentalists (Zdzinski, 1992). The test was validated in studies by Stivers (1972) and Haley (1999).

Both forms of the Watkins-Farnum Performance Scale, A and B, were used in this study. Form A was used to test paper notation, and form B to test the digital music stand. The choice of the first testing Form was randomly determined.

Form B of the Watkins-Farnum Performance Scale was scanned and adjusted to meet the quality of scans available from Sunhawk.com, the online publishers of music for the *MusicPad Pro*. Music was scanned at 300 dpi (dots per inch) in a pilot study, and judged by expert musicians.

The TIFF files were then corrected in Adobe *Photoshop CS*. Each TIFF file was adjusted with a brightness of plus twenty, and a contrast of plus fifteen. TIFFs were sharpened, and corrected with "Auto Level." Images were rotated if necessary to assure straightness of ledger lines. The image size was changed to a resolution of 200 dpi, and a width of 766 dpi. All TIFFs were converted to PNG, and imported into the *MusicPad Pro.*

Data generated from the assessment resulted in a standardized mean score for Form A (paper) and Form B (digital music stand) of the Watkins-Farnum Performance Scale. A two-tailed, correlated paired *t*-test was utilized to compare the differences in performance achievement between the two presentation types.

Twenty-five students were tested on Forms A and B of the Watkins-Farnum Performance Scale. Judging of the Watkins-Farnum Performance Scale was completed in the week following the end of the testing period. Judges were three expert music education specialists from the University of Hawaii. The researcher trained all three judges in the use of the Watkins-Farnum Performance Scale using recordings of two random students from the subject sample. Interjudge reliability was calculated using a Pearson r and established to be high for both Form A ($r = 0.99$) and for Form B ($r = 0.99$).

Data collection for this study included information about subjects' age, gender, instrumental experience (the number of years they had played their tested instrument), and approximate daily use in hours of a computer and/or video game, either on a console or handheld device. The sample ($N = 25$) consisted of ten females and fifteen males. Ten subjects played brass instruments and fifteen played woodwind instruments. Background data for age, years of playing experience, and daily computer hours are indicated in Table 1. Background data for age, years of experience, and daily computer hours by gender are indicated in Table 2. Three independent judges scored the performances of Forms A and B of the Watkins-Farnum Performance Scale. Means for Forms A and B of the Watkins-Farnum Performance Scale were calculated for all subjects.

Table 1

Subject Background Data

N	Age	Years of experience*	Computer hours**
25	13.2	2.4	2.5

Note. Age, years of experience, and computer hours are indicated in means.
*Instrumental performance experience
**Daily computer and video use

Table 2

Subject Background Data by Gender

Gender	No. of Students	Age	Years of Experience*	Computer Hours**
F	10	13	2.6	2.4
M	15	13.3	2.1	2.5

Note. Years of experience and computer hours are indicated in means.
*Instrumental performance experience
**Daily computer and video use

Table 3

Mean, Standard Error, and Standard Deviation for All Subjects on the Watkins-Farnum Performance Scale (WFPS) Forms A and B

WFPS Form	*N*	*Mean*	*SE*	*SD*
Form A (Paper)	25	29.60	2.89	14.07
Form B (Digital)	25	32.43	2.67	12.89

Table 4

Mean, Standard Error, and Standard Deviation for Girls on the Watkins-Farnum Performance Scale (WFPS) Forms A and B

WFPS Form	*N*	Mean	*SE*	*SD*
Form A (Paper)	10	37.23	4.45	14.18

Table 5

Mean, Standard Error, and Standard Deviation for Boys on the Watkins-Farnum Performance Scale (WFPS) Forms A and B

WFPS Form	*N*	*Mean*	*SE*	*SD*
Form A (Paper)	15	24.51	3.29	12.74
Form B (Digital)	15	28.22	3.56	13.78

Results

In spite of finding that the Form A (paper presentation) mean scores were lower than Form B (digital presentation) mean scores, the correlated paired *t*-test indicated that the difference between the two means was not significant ($t = -1.70$, $df = 24$, $p = 0.10$; see Table 3). These results support the central hypothesis of this study, and further analyses of gender based correlations provide additional supporting evidence. For both genders, mean scores were higher when reading from Form B (digital).

There was no statistically significant difference in scores for girls when comparing Form A (paper) with Form B (digital), $t = -0.51$, $df = 9$, $p = 0.62$; see Table 4. Likewise, there was no statistically significant difference in scores for boys when comparing Form A (paper) with Form B (digital), $t = -3.71$, $df = 14$, $p = 0.09$; see Table 5.

Discussion

There was no significant difference between the sight-reading scores on the Watkins-Farnum Performance Scale for middle school students when the music is presented via a digital music stand and when presented on traditional paper sheet music. In addition, there was no significant difference between the reading scores for either gender, thus supporting the research presented by Gould, Alfaro, Barnes, Finn, Grischkowsky and Minuto (1987).

Results of this study are consistent with previous research in which general reading skills were compared when presented on paper versus being presented on the computer screen (Askwall, 1985; Conklin, 2000; Cushman, 1986; Garland & Noyes, 2004; Gould, Alfaro, Finn, Haupt and Minuto, 1987; Mayes, Sims, and Koonce, 2001; Muter & Marutto, 1991; Muter *et al.* 1982; Switchenko, 1984). Additional research is needed to investigate the possibility of specific correlations between the use of computer screens for reading music and reading words.

The Watkins-Farnum Performance Scale is the only published standardized test for instrumental sight-reading. Although at least one previous researcher (Stivers, 1972) reported problems with reliability measures using this instrument, the three independent judges in this study exhibited high interjudge reliability. Additional research might address this potential problem by using computerized scoring, thereby eliminating any human bias in the judging process.

The Watkins-Farnum Performance Scale is a time consuming measurement tool. Administering both forms of the scale in one performance may lead to fatigue among performers, especially those of advanced music skills whose exams are more extensive.

Time constraints also limited the sample in this study to only a convenience sample of 25 students from one middle school. The study may have had greater validity with a larger, randomly selected sample representing a variety of school music programs, student ages and geographic locations.

This study suggests there is no difference in music reading skills when using a computer display. The results of early studies, showing such differences, may have been drastically altered by our technological evolution from cathode ray tube to liquid crystal displays. Previous problems with screen colors, brightness, size of display, resolution, refresh rates, and angle visibility appear to have been solved. Information displayed on an LCD today can often appear, to the casual viewer, to be an exact replica of the information on the original media, such as paper or canvas. It is also likely that extensive use of computers by today's students has increased research participants' comfort levels with reading music delivered via digital technology.

As newer technologies in the future subsequently replace the LCD, it is important that we continue to research any possible impact on the readability of music or other materials presented via these new tools. Many of these devices are evolutionary tools. Menoche (2004), in an extensive review of the *MusicPad Pro*, found the quality of the display compromised by the screen resolution and size. Since his 2004 review, the *MusicPad Pro* has upgraded its screen to a higher display resolution. He noted that he became more comfortable with the device the more he worked with it. He stated the he "found the unit to be one of the most reliable new pieces of digital technology with which I have worked. The interface was straightforward and easy to learn" (p. 519). This statement suggests the possibility that users become more readily accustomed to new technology that strives to maintain a traditional look, feel and interface. As Menoche noted, the future is hard to predict, and the employment of a device like the MusicPad Pro may be the first wave of many 21st technological innovations contributing to the widespread acceptance of digital music stands.

Several problems with the readability of computer displays remain and include:

(a) brightness, especially outside, and (b) screen glare, especially indoors and under fluorescent lights. Digital music stands, reliant on the same materials as any laptop or tablet computer, are heavier, costlier, and more delicate than paper. Paper is bright outdoors but glare is not an issue, and paper does not break when dropped off a music stand. Future tools should be designed to be durable enough to withstand rough handling by young students.

As the cost of computer processors and display technology continues to decline, digital music stands may eventually become a viable option for the average musician or school music program. At present, however, digital music hardware devices cost over nine hundred dollars. There are only a few organizations reported to currently use digital music stands. In order for digital music stands to compete with traditional stands and paper notation, cost and ease of use must become equal to traditional methods.

Another issue critical to the widespread employment of digital music stands is copyright. The copying and distribution of music is much easier and quicker when one only needs to download or electronically transfer it from one user to another. Bell, Blizzard, Green and Bainbridge (2005) stated that Digital Rights Management (DRM) software might be an effective solution to the issues of copyright and royalty distribution. However, while the catalog of digital music is growing for sheet music and other individual genres of music, it is still miniscule in regard to band, choir, and orchestral music. It appears that publishers and copyright holders are less inclined to make these catalogs readily available in digital form.

Finally, the acceptance of the digital music stand requires a fundamental change in the attitude and technical skill level of the average musician and music director. Use of digital music requires that a musician has achieved a sufficient technical proficiency with a computer and related peripheral devices. In order to accomplish the tasks needed to fulfill this study, the researcher had to demonstrate advanced capabilities in the following areas:

1. General computer use
2. Freehand *Music Pad Pro* digital music stand operations
3. Internet browsing for downloading of digital music
4. Scanning of music for use on the *Music Pad Pro*
5. Adobe *Photoshop* for the correction of scans to accurately match printed music
6. File transfer between media including computers, hard drives, and flash drives

Many of these capabilities are currently beyond the grasp of the traditionally trained music educator or musician. Musicians who are generally not as skilled with computers may be less inclined to learn an entirely new method of music presentation. The current generation of school musicians may be more open to the technological change. Students now use highly technical devices everyday in their school and home use, including computers, cellphones, portable music players, and handheld/console video games; therefore, present day students may more easily facilitate the migration to digital music notation devices.

However, the greatest barrier to wide-spread use of digital music stands is the tradition of paper music. The culture of paper music is thousands of years old. Paper is extremely easy to use, is inexpensive, and has a tactile quality with which musicians are familiar.

Based on the results of this study, the following recommendations are suggested.

1. Replication of this study to include a larger randomly-selected sample chosen from a variety of school types and age levels
2. Replication to include musicians of all age groups
3. Examination of the difference between group means that includes delineation for gender, age, instrumental group family, instrumental experience level, and computer experience
4. Replication of the study when new video display technology reaches practical application, especially when specifically designed for the display of digital notation
5. Examination of the copyright issues that may deter the advancement of digital music distribution and use with digital music stands

New technologies are not always easily adopted. Until the per unit cost of digital music stands is reduced, music teachers and students are well-trained in technology, and publishers provide copyright release for the digitalization of existing music libraries, the music stands in our future classrooms and concert halls may continue to hold only paper.

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