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TEACHING STUDENTS TO USE NOTATION SOFTWARE: EXPLORING THE INFLUENCE OF SEVERAL INDEPENDENT VARIABLES ON SUCCESS WITH A MUSIC TECHNOLOGY TASK

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The purpose of this study was to investigate the influence of individual learning styles, music experience, technology experience, music technology experience, and varied learning conditions on participants' success with a music technology task. Students from four Midwestern high schools ($N = 94$) were surveyed about their experiences and learning styles. The participants learned to operate music notation software (*Sibelius 5*) using one of two randomly assigned learning conditions, and then completed a timed task with the notation software. Data were analyzed using a five-way ANOVA in which the effects of the independent variables on the achievement score were measured. Analysis revealed that none of the main effects or interactions between variables reached statistical significance. Further analysis of sub-scores for a specific task did vary significantly among learning styles, with the Abstract Random learning style providing particularly disparate scores. Recommendations for greater variable control in further research are offered.

The ways that music teachers make use of technology are often dictated by the design, functionality, and limits of technological tools. These factors, coupled with the limited experience that most teachers have in integrating technology into music teaching, lead to the claim that enhancement of teaching methods is an important pursuit toward advancing the status of technology in music education. Some research into the uses of technology in music classrooms has shown that teachers do not feel comfortable enough with technology to make it a regular part of their teaching practice (Dorfman, 2009; Reese, 2003; Taylor & Deal, 2003). Materials and curricula in traditional music teaching and learning environments have been established by examining the ways in which students most effectively learn to perform, compose, listen, and participate in other musical activities. The relative youth of the practice of teaching music with technology leaves the field with an untested set of musical activities; that is, the experiences in which students participate within technology based music teaching have little research to support their effectiveness or the factors that may enhance or detract from those experiences. Examining student experiences in music, with general technology, and with music technology, along with their individual learning styles may provide evidence that these characteristics are mediating factors in the pursuit of the most effective methods for teaching music through technological means.

The purpose of this study was to investigate the influence of those factors on student achievement with a defined music technology task. The study was designed to provide information that may help to tailor curricula in technologically based music learning environments to better accommodate for the various learning styles and experiential characteristics that students bring to tasks. The study was limited due to the number of participants and the fact that there was only one type of technology addressed, and should therefore be treated as exploratory, rather than as a study that would be generalizable to wider populations.

Review of the Literature

Literature suggests that there exists a reasonably stable and universal set of beliefs about the content areas that are the typical components of music technology (Rudolph, 2004; Watson, 2005; Williams & Webster, 2006). Large scale curricular designs are few, but many teachers' curricula include the basic content areas of music production and sequencing, notation, multimedia, computer assisted instruction, communications and web design, and administration as their foundations.

Several meta-analyses have provided evidence that technology enhanced learning is effective, and that students generally feel positive about their learning experiences that make substantial use of technology (Bayraktar, 2001-2002; Christmann & Badgett, 1999, 2003). Though examples such as the study by Watkins (1998) can be found, studies that contradict these results are extremely rare, further supporting the value of using technology in teaching and learning across curricula.

In the present study, the interaction of students with technological tools was under direct investigation. Stauffer (2001) found that a student composer using technology became very involved in the compositional process, and that the student's compositions became more sophisticated over time. Savage (2005) suggested that student experiences in composing electronically may focus attention upon sound rather than compositional rules.

> Pupils enjoyed exploring the sounds within a pedagogical framework of exploration and discovery rather than in the context of right or wrong compositional choices. But more than this, the technologies themselves brought about a shift of emphasis in compositional enquiry, away from thinking about melody, rhythm or harmony towards an increasing focus on dealing with the sound itself, and its intrinsic value and place in a wider musical structure. (p. 171)

The present study was based on the hypothesis that variations in students' individual learning styles would bear a significant impact on their achievement on a music technology task. Some previous research has examined the interactions between learning styles and music related task achievement. Fortney (1993) examined the effectiveness of learning with a CD-ROM as a function of students' learning styles. He found that, using the hypermedia environment to teach factual content, students who exhibited different learning styles did not vary significantly in the amount they learned.

A survey of the literature related to learning style measurement and categorization was conducted, and models of learning styles were examined. These models included David Kolb's *Learning Styles Inventory* (1999), Dunn and Dunn's (1979) model of learning styles, the *Myers-Briggs Type Indicator* (Myers & Myers, 1980) and the *Gregorc Style Delineator* (1982b). For the purposes of this study, the *Gregorc Style Delineator* was chosen as the most appropriate measure of learning style for several reasons: (a) it is designed to be used with the age group of the participants that had been chosen; (b) it usually provides a single, easily interpretable and objective score; and (c) unlike some of the other instruments described above, its focus is on measurement of the self, rather than on prediction of performance in a job. The author of the *Style Delineator* tested the instrument to support claims of reliability and validity. Gregorc (1982b) lists reliability for the four domains ranging from 0.89 to 0.93, indicating strong internal consistency. The author also conducted studies to support the predictive validity of the *Style Delineator* and found that the results of the test were highly correlated with self-report labels. Though concerns have been raised in the learning styles literature regarding validity and reliability of this instrument, and in fact about the concept of learning styles in general (Coffield, Moseley, Hall, & Eccleston, 2004; Schmeck, 1988; Veenman, Prins, & Verheij, 2003), it was determined through comparison of available instruments and review of the above-noted characteristics that this test was the most appropriate of available measures for the present study.

The pedagogical sources by Herman (1994) and by Mixon (2004) describe efforts to modify music teaching approaches to account for learning styles. Learning styles have been linked in the literature to classroom management in ensemble settings (Bauer, 2001; Gordon, 2001; Merrion, 1991; Woody, 2001) in the sense that learning styles can serve as a foundation for the design of short-term and long-term lesson planning. Other than the Fortney (1993) study described above, little research exists on the effects of varying learning styles on achievement in music. Moore (1986) examined learning style, measured with the *Gregorc Style Delineator*, as it correlated with intuitive or rational musical ability. Moore found that there were significant correlations between varying learning styles, the methods by which students composed, and their abilities to do so successfully. Ester (1992) examined the efficacy of teaching vocal anatomy to college music majors of varying learning styles using a CD-ROM or a lecture. Abstract learners "learned more effectively via a lecture approach than they did when paired with the CAI" (Ester, 1992, pp. 99-100). Finally, Stuber (1997) studied the ways in which teachers' learning styles affect their classroom behaviors. Teachers varied significantly across learning styles for some specific classroom behaviors.

As will be described in the next section, one of the learning conditions to which students were exposed in the present study involved the use of a software tutorial. As such, it was necessary to explore foundational ideas related to educational software and the elements of effective design. The tutorial used in this study was created according to principles of constructivism (see von Glaserfeld, 1995) and the active learning theories of Papert (1980).

Since the tutorial made use of still images, animation, and sound, it is considered a multimedia artifact. An important source of guidance for the development of the tutorial was Mayer's (2001) theory of multimedia learning, which is based on three assumptions: (a) Humans possess discrete channels for visual and auditory learning; (b) Humans have limited capacity for the amount of information they can process through each modality; and (c) Humans engage in active learning by organizing incoming information. Mayer's work espouses several principles upon which multimedia designs may be based. For example, Mayer's Coherence Principle addresses decisions about inclusion or exclusion of material in multimedia artifacts. It states, "Students learn better when extraneous material is excluded rather than included" (p. 113). Mayer's Modality Principle states, "Students learn better from animation and narration than from animation and on-screen text; that is, students learn better when words in a multimedia message are presented as spoken text rather than as printed text" (p. 134). These principles, along with Mayer's other ideas, are based on the study and observation of human cognitive abilities.

Additional guidance for the development of the tutorial was obtained from similar projects in general education (Solomon, 1986) and science education (Edelson, 2001; Edelson, Gordin, & Pea, 1999). Several other recent studies have used multimedia tutorials as treatments in educational settings, and some have indicated significant positive effects of their use as opposed to other types of instruction (Gormley, 2005; Huh, 2007; Qui, 2003; Schmidt, 2005).

Two additional summarizing points were extracted from the review of literature, and guided the design of the present study. First, a large amount of the literature that addresses integration of technology into music teaching deals with individual instances of that integration, rather than addressing the goal of creating curricula that can be implemented for large numbers of students in varied learning environments. Second, prior attempts at researching the influence of learning styles on music learning with technology have fallen short of addressing the broader issue of the application of teaching methods to technologically enhanced learning environments.

Method

The participants underwent three phases of the research protocol. In Phase One, the participants completed a researcher-designed survey that measured their music experience, their general technology experience, and their music technology experience. In addition, the participants completed the *Gregorc Style Delineator*.

In Phase Two of the study, the participants were randomly assigned to one of two learning conditions. All participants were given printed notation for J. S. Bach's *Two-Part Invention No. 1* (BWV 772). In Condition A, the participants viewed an interactive tutorial that guided them through constructing the *Invention* score in the notation program *Sibelius* (version 5). The tutorial, which the researcher constructed in the Adobe application

Captivate, featured several interactive elements, and lasted for about twenty minutes. The tutorial was developed with the intention of explicitly instructing students to complete the tasks that would be required of them in the third phase of the study. The artifact was pilot tested with five college freshman with varying levels of experience with *Sibelius*, who supplied the researcher with feedback about its effectiveness.

In Condition B, the participants were given the same amount of time to explore freely the software and discover the tools necessary to build the notation for the Bach piece. At the conclusion of Phase Two, the *Invention No. 1* notation was collected.

In Phase Three, all participants received the printed musical notation for Bach's *Two-Part Invention No. 10* (BWV 781). They were given twenty minutes to use the techniques they had learned in Phase Two to re-create the *Invention No. 10* notation in the software as completely and accurately as possible. The files created by the participants were printed in hard copy and saved electronically, then the researcher scored them according to a predefined scale that accounted for both efficiency (as measured by the quantity of symbols entered in the allotted time) and effectiveness (as measured by the accuracy of entry of those symbols). Each notation symbol on the page was assigned a value of one point; that is, each note, accidental, rest, clef, time signature, text element, and all other symbols that the student entered correctly earned a point toward their total score. This score was the single dependent measure in the study.

Results

High school students from the Midwest (N = 94), all of whom were members of their schools' performing ensembles, served as participants for this study. Demographic and background data were collected using the researcher designed instrument.

General technology experience, as phrased in the data collection instrument, referred to the number of hours per week that participants spent using computer applications for tasks such as typing papers, emailing, instant messaging, browsing the Internet, and other nonmusic related activities. The mean number of hours participants reported that they spend on this type of activity was 13.32 hours per week. The six-point Likert-type scale that measured expertise in these types of technological activities resulted in a mean response of 4.45 (SD = 1.07). All Likert scales on the instrument appeared with the numbers 1 through 6, and were anchored by the terms "Novice" and "Expert." The analysis indicated that there was a moderate positive correlation between the number of hours spent engaged in nonmusic technology applications and self reported expertise with those types of tasks (rho = .385).

Music technology experience was measured by asking participants to indicate the number of hours per week spent using a computer to do music related tasks such as downloading music, recording or creating their own music, editing music, or making custom CDs. The mean number of hours spent on this type of activity was 4.42 hours per week. The six-point Likert-type scale that measured expertise in these types of music technology activities resulted in a mean response of 3.34 ($SD = 1.36$). The analysis indicated that there was a moderately strong positive correlation between the number of hours spent engaged in these types of music technology applications and self reported expertise with those types of tasks ($rho = .688$).

Learning styles were assessed using the *Gregorc Style Delineator*. The sample produced members of the four learning styles associated with the instrument: Concrete Sequential ($n = 32$), Abstract Sequential ($n = 7$), Abstract Random ($n = 18$), and Concrete Random ($n = 30$). In addition, a potentially confounding variable was the occurrence of "tie scores," or situations in which participants' scores demonstrated equal preference for two styles of learning. Seven of the 94 participants exhibited such preferences. Though this quality of the *Gregorc Style Delineator* calls its validity into question, it is an unavoidable characteristic of the test. In order to compensate for this phenomenon, participants who produced tie scores were excluded from statistical calculations in which learning style was a variable.

Based on previous administrations of the *Gregorc Style Delineator* and on its manuals (Gregorc, 1982a, 1982b, 2001), it was expected that the distribution of learning styles would be relatively even. The chi square goodness of fit test revealed significant deviation from this expectation ($X^2 = 18.61, p < .05$). This could be attributed to the relatively small N of 94, or to the homogeneity of the academic characteristics of the schools from which participants were chosen.

The majority of the participants (76.6%) were either 17 or 18 years old; the mean age of the participants was 17.03 years. The sample included students who listed as their primary instrument all of the instruments of typical school bands and orchestras, and vocalists from all voice parts. Music experience was measured by asking the participants the number of years they had been playing their primary instrument or singing. The mean number of years for the entire sample was 6.98 ($SD = 1.94$) with a minimum response of two years and a maximum of 13 years.

There were a total of 536 possible points to be earned for the Phase Three task. The range of scores resulting from the systematic evaluation of student work was between zero and 536 ($M = 211.14$; $SD = 132.012$). The group of scores approximated a normal distribution.

Continuous independent variables from the Phase One survey were each transformed into balanced categorical groups. The five way ANOVA statistic was employed to examine the effects of each independent variable on the achievement score. The appeal of this procedure lies in its ability to reveal both main effects for the independent variables in isolation and the interaction effects between these variables in all possible groupings. It should be noted, however, that the appropriateness of this statistic may be questioned due to the small sample size.

Given the five independent variables (Table 1), neither the main effects nor the interaction effects reached statistical significance. Since statistical significance was not achieved, post hoc tests often associated with the multiway ANOVA procedure were not necessary. Table 1 displays the results of the multiway ANOVA procedure. It is possible that these interactions were effected by the relatively limited sample size; cells in the multiway ANOVA that did not have adequate size were excluded from the table.

Table 1.

Main and Interaction Effects of the Independent Variables on the Dependent Variable

Independent Variable(s)	*df*	*F*	Significance
	Main Effects		
Learning Condition (LC)	1	2.356	.137
Dominant Learning Style (DLS)	3	.154	.926
Music Experience (ME)	2	1.557	.230
General Technology Experience (GTE)	2	.758	.479
Music Technology Experience (MTE)	2	1.431	.257
	Interaction Effects		
LC * DLS	1	.447	.510
LC * ME	1	.235	.632
DLS * ME	3	1.116	.361
LC * GTE	1	.368	.549
DLS * GTE	2	.481	.624
ME * GTE	1	.038	.848
LC * MTE	2	.140	.870
DLS * MTE	3	1.083	.374
ME * MTE	1	.002	.963
GTE * MTE	2	.375	.691

Additional analyses were conducted to determine if a component of the task, rather than the whole achievement score, demonstrated significant effects. Of the 536 available points, 36 were elements associated with score setup; these tasks included choosing a staff arrangement, selecting clefs, selecting a time signature, selecting a key signature, and entering initial text items such as the title, composer, and copyright information. A one way between groups ANOVA was conducted to examine the impact of learning condition on participant achievement with these "setup" tasks. The guided learning condition group produced a mean score of 16.95 ($SD = 4.75$), while the unguided group produced a score of 13.89 ($SD = 5.33$). The differences between these groups are significant at the *a priori* level of $a = .05$ [$F(1, 92) = 8.298$].

A similar one way analysis of variance was conducted to examine the impact of learning style on the setup score. The setup score measurement did not vary significantly across the four learning styles at the .05 level [$F(3, 83) = 1.319$]. Therefore, it can be concluded that while students' learning styles did not affect their achievement on setup-related tasks, exposure to a video tutorial did.

Plots of the interactions of several variables revealed some analytical trends. Though these claims did not reach statistical significance, visual analysis showed that participants categorized as "most experienced" in the music experience variable generally scored higher on the achievement task than did students designated "experienced," or "least experienced." Finally, it was concluded, based on visual analysis of the plots, that participants categorized as Abstract Random learners were more successful with the achievement task given the unguided learning condition than they were when exposed to the guided learning condition.

Discussion and Implications

The null hypotheses for this study predicted that there would be no significant effect for each of the independent variables on the achievement scores. Since no statistical significance was found for either the main effects or the interaction effects of these independent variables, none of the null hypotheses were rejected. Several limiting factors may have contributed to the lack of statistical significance. These include: (a) validity issues associated with the *Gregorc Style Delineator*; (b) the amount of exposure to each of the learning conditions was only twenty minutes—longer exposure may have resulted in greater impact on achievement; (c) random assignment to each of the learning conditions was present, but participants were not randomly selected; (d) demographic and socioeconomic descriptors of the four schools at which data were collected were fairly homogenous; (e) additional independent variables that were not measured, such as keyboard experience and notation experience, may have given certain participants an advantage; (f) technology based research is, as a rule, at the mercy of the speed of the hardware and software used in the measurement procedures. In the present study, computers used in data collection ranged from the most modern technology available to dated hardware that may have slowed student work; and (g) a pilot study was not conducted—doing so may have revealed some of the above-mentioned limitations and allowed for greater control.

In addition to the above factors, future research on the achievement of students in technology based music learning environments should carefully consider the design of the software used and the implications that software design may impose upon student success. Currently, music educators do not have a clear set of criteria with which to evaluate software. In their important work on the design and assessment of instructional software in general education, Walker and Hess (1984) stated:

> Although it is not easy to define precisely a universal set of criteria for evaluating educational software, the effort to make explicit the basis for our judgments and to provide for them a foundation that can be subjected to discussion, criticism, and possibly even empirical test is an important part of the overall task of improving educational software. (p. 204)

Though a complete discussion of educational software evaluation is beyond the scope of this study, music teachers would benefit from awareness of the principles by which software can be evaluated. These include, but are not limited to (a) adherence to a defined category of software such as drill and practice, simulation, game, or tutorial; (b) attention to clear, usable interface design that is aesthetically pleasing; (c) sensitivity to the culture(s) in which the application will be used; (d) appropriate balance between levels of interactivity, user control, and automated control for the intended audience; and (e) appeal to the needs of both students and teachers. Future research could include inquiry into each of these characteristics and the importance of each as an element of software design.

Teachers of technology based music should consider that definitions of what constitutes music technology are sparse. The activities examined in the survey instrument in the present study are undeniably technological, but some imply creative pursuits, and some more utilitarian. Technology assumes roles in both the creative work of musicians, and the pedagogical and preparatory work of professionals (such as teachers). Operational definitions of "music technology" should be established to help in examining interactions with those technologies that are most closely tied to creative activity, and those that may serve other functions.

The present study suggests that the design of *Sibelius*, the software used to gather the dependent scores, is appropriate for students of many learning styles, and with diverse levels of music, general technology, and music technology experience. In addition, the students in this sample were able to learn to use *Sibelius* as well without the sequential tutorial as they were with the guided multimedia learning artifact. This may imply that in selecting software for student use, across the many categories of music software, educators should seek robust, well-designed software in order to ensure that it will allow students to succeed. Software that is not designed to account for the ways in which students make use of it may yield less successful results for students who differ along learning style and experience variables, or who are taught to use the software in varying ways.

Future research on student interactions with music technology may capitalize on larger and more diverse samples of participants. A larger sample for this study would lend more credence to the results because of the questionable appropriateness of the five way ANOVA statistic for a relatively small sample. The students who participated in this study were from reasonably homogenous, suburban high schools. A larger sample would certainly lend greater validity to the analysis, but the study provides a baseline for comparison with future research This is an important consideration because so little research exists regarding learner interactions with technology in music education. Future investigations should also consider additional independent variables. Among the most pressing issues to be examined are (a) the effects of gender on technology usage; (b) the effects of lab structure, physical environment, and ergonomics of physical space on efficiency of technology-based music work; and (c) the effects of implementation of other software tools. The use of open ended applications such as sequencing programs for music production would add the ability to apply measures of creativity to the investigation of students' uses of technology.

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Footnote

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