Journal of Music Theory Pedagogy

Volume 28 Article 9

1-1-2014

Computer-Assisted Instruction and Remedial Music Fundamentals

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By Mark Yeary

Music theory instructors in the United States, like the war-room generals in Stanley Kubrick's *Dr. Strangelove*, have for some time noted a large imbalance in resources between two populations: this imbalance is the *fundamentals gap*. The music theory curricula in many post-secondary institutions assume that incoming students possess a set of musical skills and knowledge—what we loosely term the fundamentals of music—that many matriculating high-school students today simply do not have. Two informal surveys of music theory instructors, both appearing in this journal—one from over a decade ago,[1] one more recent[2]—note both an increased need in remedial fundamentals instruction for incoming freshman music majors and an urgent desire on the part of instructors to help students better prepare for Theory 1 (the first course in the theory sequence).

The impact of this gap is frustrating, and this frustration is felt by students and instructors alike. Students whose remedial needs are identified may be placed in a fundamentals course that is designed to bring them up to speed in preparation for first-year theory, but with this move comes a curricular delay of up to a full academic year, which further strains their typically rigorous four-year plan. On the instructor's side, remedial instruction places increased demand on a school's instructor resources—both in the teaching of fundamentals and in the possible restructuring of the music theory core to accommodate trailing sections or courses. And should a student's remedial needs *not* be detected, they become likely candidates for failing first-year theory—giving rise to the notion of music theory as a weeder course that thins out a cohort of music majors.

Accordingly, music theory instructors often attempt to reach out to their incoming students during the summer, so that they might address their remedial needs *before* they set foot in the theory classroom.

[1] Jeff Gillespie, "Welcome to Theory Camp! More Than Simple Remediation," *Journal of Music Theory Pedagogy* 14 (2000): 47–62.

[2] Elizabeth West Marvin, "The Core Curricula in Music Theory: Developments and Pedagogical Trends," *Journal of Music Theory Pedagogy* 26 (2012): 255–64.

The music theory "boot camp," an intensive summer course with a specific focus on preparation for theory, has proven successful where implemented,[3] but its demand for additional student and instructor availability will not be equally appealing to every school. Without the possibility of a pre-semester course, we might appeal to our students to prepare for the theory core on their own during the summer—such efforts range from samples of music-theory coursework to the less directed "read this textbook, chapters one through five"—and yet without any means of instructing students or assessing their progress, only the most optimistic among us would expect a significant increase in preparedness across the incoming class.

Thankfully, advances in computer-assisted instruction (CAI) for music learning have reached the point where instructors may begin to proactively address the fundamentals gap. The computer's ability to combine verbal instruction, sound, notation, and student response in a self-paced learning environment makes it ideal for use in music learning, and CAI has been productively used in music schools since affordable workstations first appeared.[4] The increasing availability and affordability of electronic devices such as laptops, tablets, and smartphones, coupled with the development of internet-enabled or browser-based applications, has resulted in a wealth of music-learning resources: music theory students of the current generation, conditioned to turn to the internet as a primary means of acquiring information or skills, may choose from a number of websites that offer exercises designed to test one's music fundamentals. Many of today's theory students have turned at some time to a website such as *musictheory.net*, *teoria.com*, or *emusictheory.com*—perhaps suggested by a friend or colleague, perhaps simply found online—to brush up on their skills in anticipation of an exam or assessment. And as these online applications have become increasingly accessible, stable, and practical over the years, many instructors now endorse or turn to them as a way to address the

[3] Gillespie, "Welcome to Theory Camp! More Than Simple Remediation"; Melissa Hoag, "Seven Strategies for Enabling Student Success in the First-Year Music Theory Sequence," *Music Theory Pedagogy E Journal* 1 (2013), http://jmtp.ou.edu/ejournal/seven-strategies-enabling-student-success-first-year-music-theory-sequence.

[4] Wolfgang Kuhn, "Computer-Assisted Instruction in Music: Drill-and-practice in Dictation," *College Music Symposium* 14 (1974): 89–101; Dorothy Gross, "Computer Applications to Music Theory: A Retrospective," *Computer Music Journal* 8, no. 4 (1984): 35–42.

fundamentals gap—to reach students in their native environments, and to give them the learning tools that have previously been restricted to the classroom or the lab.

This review examines several current CAI applications that specifically offer training in music fundamentals to the student preparing for post-secondary education. A preparatory section identifies the topics that are typically considered to be prerequisites for Theory 1, followed by a look at the the effectiveness and requirements of CAI applications in teaching these topics; a concluding section lists the benefits and challenges that accompany their use. As with any written review of Internet-age technology, it is bound to be both incomplete and soon outdated, yet the concepts and issues addressed within should remain valid for as long as our current way of interacting with computers remains intact—in other words, until radically newer technologies render these applications obsolete.

Scope Of Fundamentals For CAI

Gillespie[5] offers a concise list of topics that are covered in his fundamentals diagnostic exam, and we may use this list as a working definition of fundamentals: "the basics of rhythm and meter; pitch notation in treble, bass, alto, and tenor clefs; scales (major and all three forms of minor); key signatures; intervals; and triads." We may choose to add or subtract a few elements from this list: some may leave topics such as C clefs or triads for Theory 1, whereas others may wish to include triadic inversions, chord symbols, and seventh chords. Each CAI application contains its own assortment of topics, of course, and in general they tend to include more than the topics listed above; the instructor wishing to omit one or more topics may customize the application to exclude them, or they may simply ask students to selectively complete topics from a given list.

Similarly, whereas the terminology and notation of fundamental concepts are not standardized, most CAI applications conform to commonly accepted practices. Because many CAI applications are developed in North America by, or with, music theory instructors, these practices are largely consistent with North American theory education: a stemmed, filled-in note without a flag is a quarter note, not a crotchet. Other topics are less standardized across institutions: scale degrees, for instance, may be identified functionally (tonic,

[5] "Welcome to Theory Camp! More Than Simple Remediation," 49.

supertonic, mediant), with moveable-*do* solfège syllables (*do*, *re*, *mi*), with scale-degree numbers ($\hat{1}$, $\hat{2}$, $\hat{3}$), or with some combination of these. Whereas some CAI applications allow the instructor to select one or more set of terms to be seen by the student, others are less flexible, and the instructor who adopts a fundamentals CAI may want to either offer a preemptive correction to students or give substitute concepts and terms once Theory 1 begins. For this reason, I recommend that the instructor adopting a CAI fundamentals application start with a small list of topics, with a concentration of widely agreed-upon fundamentals: pitch and rhythm reading, clefs, key signatures, scales, intervals, and triads.

Although this list of fundamentals topics is reasonably complete, it does not specify the role of sound in learning these topics. Even in institutions where there are separate sections for "written" and "aural" theory, many instructors would include basic sound identification tasks in a list of desired fundamentals: the ability to distinguish higher or lower pitches, the matching of basic pitch or rhythm patterns with given notation, and the recognition of common scales or intervals. Pairing sound and notation is a strength of CAI applications, and the opportunity for students to learn and develop sound-notation associations such as labeling, error detection, and transcription ("dictation") permits instructors to require a greater facility in this domain than is commonly assessed in many placement-test environments.

Similarly, many instructors would also ask that students develop basic sound-*making* skills simultaneously: such tasks might range from tactile (i.e., pressing a key on the computer keyboard) production of a given rhythm pattern to sight-singing basic melodic patterns into a microphone. In this area as well, a CAI application offers a potentially great advantage over self-directed study and in-class diagnostic exams: the student is given the same opportunity to drill-and-practice these skills as the notation and aural skills described above, and the immediate feedback and progress-tracking capabilities of a computer—not to mention its infinite patience—promise a more intensive and self-directed learning method than those offered in a textbook or the classroom. Unfortunately, whereas rhythm-tapping exercises fare reasonably well—the CAI application interprets the user's input within a quantization or "forgiveness" range of the notated rhythm pattern—sight-singing assessment is much more uneven, and assessing even the most basic pitch patterns is confounded by detection of noise or pitch wobble

as discrete note events. This lack of capability is not necessarily a limitation of computer technology, however—witness the recent advances in speech-recognition technology driven by the portable-device market—and we may hope that sight-singing assessment becomes more reliable in the near future.[6]

Suitability Of CAI For Fundamentals

Michael Rogers's outline of fundamentals study offers the following pithy assessment of the three stages of learning: "(1) understanding the concept behind a topic […]; (2), developing accuracy through practice; and (3) developing speed."[7] Fortunately, these stages of learning are highly appropriate to the use of CAI, which has been proven effective in addressing the lower levels of Bloom's revised learning taxonomy—the "remember" and "understand" levels.[8]

Two common uses of CAI are the *tutorial* paradigm, in which new material is introduced and student response is used to measure comprehension, and the *drill-and-practice* paradigm, in which familiar (previously taught) material is rehearsed by the student to develop speed and accuracy.[9] CAI offers tangible benefits in these uses: feedback is instantaneous, correct answers may be

[6] One notable exception to this lack of capability is an iOS (Apple device) application called "Sing That Note!", developed by Gil De Benedetti for G Major Music Theory (http://gmajormusictheory.org), which asks users to listen to a musical excerpt and sing back the tonic; the application works with acceptable, if not perfect, accuracy. The greater accuracy of this approach is likely due to the elimination of the temporal dimension: whereas assessing sight-singing measures a series of timed pitches, "Sing That Note!" requires only a single held pitch.

[7] Michael R. Rogers, *Teaching Approaches in Music Theory: An Overview of Pedagogical Philosophies*, 2nd ed (Carbondale; Edwardsville: Southern Illinois Press, 2004), 35.

[8] Lorin W. Anderson and David R. Krathwohl, *A Taxonomy for Learning, Teaching, and Assessing: A Revision of Bloom's Taxonomy of Educational Objectives* (Boston: Pearson, 2001).

[9] Chen-Lin C. Kulik and James A. Kulik, "Effectiveness of Computer-Based Instruction: An Updated Analysis," *Computers in Human Behavior* 7, no. 1–2 (1991): 75–94; Richard C. Forcier and Don E. Descy, *The Computer as an Educational Tool: Productivity and Problem Solving*, 3rd ed (Boston: Pearson, 2008), chap. 2.

encouraged or rewarded using a game paradigm, and (perhaps most importantly) the computer can produce an endless stream of examples at any time of day. Using CAI in these paradigms has proven to be effective in augmenting lower-level learning, and a meta-analysis of CAI applications confirms its positive effect.[10] Accordingly, an effective CAI for music fundamentals will include both a tutorial component, in which concepts are introduced through text, examples, and student feedback, and a drill-and-practice component, in which the student works to meet a threshold of speed and accuracy.

An additional component of CAI—threshold assessment—is essential to the college-prep scenario outlined earlier, in which instructors must assess student readiness without in-class feedback. Assessment in CAI includes record-keeping of times, scores, and completion percentages; it may occur at the level of an individual skill, such as note reading, or at an overall level across all exercises. For a music fundamentals CAI, we will want the ability to ensure that each major topic is sufficiently mastered; this may be accomplished by passing a number of units or lessons, or by above-threshold performance on each section of a larger diagnostic test.

Although basic assessment capabilities are found in many CAI environments—a web-based exercise will track the number of correct and incorrect responses, perhaps in conjunction with a threshold of success—the instructor wishing to ensure student readiness requires a reliable means of measuring student performance. Secure assessment and transmission of students' achievements is a significant difference between many theory-tutoring websites and the CAI applications discussed in this review. It is this capability that allows the fundamentals CAI to largely replace the typical in-class fundamentals assessment given during the initial meeting of a first-year theory course; instructors may use the results of the CAI to place students with those of similar skill levels.[11] And because the student

[10] James A. Kulik, "Meta-Analytic Studies of Findings on Computer-Based Instruction," in *Technology Assessment in Education and Training*, ed. Eva L. Baker and Harold F. O'Neil (San Diego: Psychology Press, 1994), 9–34.

[11] One obvious difficulty with using CAI as a replacement for in-class testing is academic honesty: an unskilled but ambitious student may hire a "ringer" to take (and pass) the assessment in their place. For this reason, I recommend that instructors adopting a CAI platform as a diagnostic measure place a clause in their syllabi stating that students found lacking in skills in the Theory 1 classroom may be directed to enroll in the fundamentals course.

is privy to these results as well, they may repeat the CAI until they have reached their desired goal—placement in Theory 1.

Music Fundamentals CAI Applications Reviewed

The three CAI platforms examined below are specifically designed to teach notation-based and sound-based music fundamentals; all include the tutorial, drill-and-practice, and secure assessment components. Each platform differs slightly in its design and origins: the first comes from a publisher of classroom music materials, the second from the designers of a well-known notation-and-ear-training CAI, and the third is a homegrown platform from a large music school. Instructors who already use CAI to supplement theory courses will likely find that their existing platform meets most of the criteria discussed above: long-standing applications such as Practica Musica[12], MacGamut[13], and Auralia/Musition[14] are known for their drill-and-practice application and secure recording of student performance, and whereas their included tutorial components may or may not be as robust as the platforms reviewed below, the ability to use a single platform from pre-theory to the later stages of the theory core may offset this shortcoming with both cost savings and interface consistency.

There are several computer-based learning platforms that are designed to address fundamentals, but do not meet both the content and component requirements listed above. Several well-known ear-training programs, such as EarMaster, offer some elements of tutorial, drill-and-practice, and secure assessment, but they deal

[12] Practica Musica, developed by Jeffrey C. Evans for Ars Nova Software (http://ars-nova.com), comes with an e-text, "Exploring Music Theory," which may be used as a tutorial; within the text, students are directed to drill-and-practice exercises that pertain to the concept being tutored.

[13] MacGamut, developed by Ann Blombach, lacks an integrated tutorial component; MacGAMUT Music Software International, the publisher (http://macgamut.com), has addressed this need with a separate platform, MFun: Music Fundamentals, that is included in this review.

[14] Rising Software's Auralia/Musition platform (http://risingsoftware.com) contains several courses—text-based tutorials linked with exercises—that cover topics found in placement tests such as the AP Music Theory exam.

only with sound-based skills. Preparatory online courses, such as Steven G. Laitz's "eTheory: Music Fundamentals in Four Weeks,"[15] deliver self-directed, online study of fundamentals with tutorials and exercises; although the scope and pace of these courses is inline with the demands of the theory sequence in highly regarded music programs, they lack the drill-and-practice component that lies at the core of a CAI fundamentals platform. Similarly, Leigh vanHandel's Music Theory Skill Builder platform[16] offers a robust suite of drill-and-practice exercises, but, because it was designed to supplement an existing music theory curriculum, it lacks an integrated tutorial component.

For each of the following applications I have described the following components:

- Scope: the included concepts
- Getting started: purchasing and installing the application
- Tutorial: the instruction component
- Assessment: the diagnostic component
- Reporting: the way diagnostic results are transmitted
- Summary

As all of the CAI platforms discussed here are available for instructor demo, I encourage interested instructors to try them for themselves; while I have in these reviews attempted to document the key aspects of student and instructor experiences, a text-only description is insufficient for making a decision for your institution or classroom.

[15] "eTheory: Music Fundamentals in Four Weeks" is published by the Eastman School of Music; it is available at http://www.esm.rochester.edu/iml/store/product/music-theory-fundamentals/.

[16] Music Theory Skill Builder is published by Oxford University Press; it is available at http://mtsb.oup.com/ .

Alfred's Essentials of Music Theory on the Web

- Authors: Andrew Surmani, Karen Farnum Surmani, and Morton Manus
- Publisher: Alfred Music, http://www.emtontheweb.com
- Software requirements: Flash-enabled web browser
- Video tutorial: http://alfred-music.com/EMT/EMT_Web_Trailer.mov
- Seven-day trial period available upon request

This all-in-one fundamentals CAI platform (hereafter called EMTW) was first offered in 2013; it is derived from Alfred's *Essentials of Music Theory* textbook, written by the same authors, that was published in 2004. EMTW is designed to be used by an instructor in a full-length online or hybrid fundamentals course, and creating an instructor account is required before any student accounts may be registered. Accordingly, EMTW lacks a few of the features found in CAI platforms designed for self-directed, preparatory study: exercises are not timed, and there is no summative diagnostic exam. However, the design and structure of this platform is very appealing, and its usability is so remarkable that it merits consideration as a preparatory platform.

Scope

The topics included in EMTW extend beyond the common notation-based and sound-based exercises in a manner that reflects its pedigree: advanced topics include harmonizing and composing a melody, spelling a blues scale, applying lead-sheet chord symbols (such as Am for an A-minor triad), and recognizing form in popular music. For instructors who typically include concepts and notations derived from popular music, this emphasis may be a welcome addition, and although not everyone would agree with Alfred's use of the term "keynote" in place of the term "tonic", these minor differences are easily offset by the well-written and interactive tutorial component that underlies this effective and engaging online platform.

Getting started

The application is launched from a browser; it, like many web-based applications, requires Adobe Flash to run, and for this reason it may not be used on an iPad or other Apple iOS device. Once

the student logs on, they are taken to a main menu, from which individual units or sub-units may be selected. The display changes when taken to a lesson or practice module, but there are three buttons available at all times—Main Menu, Logout, and Help—and this consistent interface allows the student to navigate the application quite easily. Selecting the help button brings up a "how to use" document, with in-document bookmarks to common topics such as administrative tasks; this is a bit clunky by modern standards, but as it's primarily intended for instructors/administrators, it does not hamper the student's experience.

Tutorial

EMTW's well-designed tutorial component is one of its strongest aspects; it alone makes this application worth a try, if only for a glimpse at the possibilities afforded in a multimedia environment. The application is structured in eighteen units, each focused on a single large topic such as clefs, scales, or meter; each unit is comprised of several subunits (treble clef, bass clef, alto clef, etc.), with aural identification ("ear training") exercises at the end of most units. All text is spoken as well as displayed; a "mute" button allows the student to turn off narration, but the combination of text and speech may be welcome to users accustomed to instructional videos from online learning sources. New terms appearing in the text are linked to a glossary: the glossary entry for a given term includes not just a definition, but audio and video examples where appropriate, and an audio pronunciation of the term—helpful to the musical novice who struggles not only to recognize an appoggiatura, but to pronounce it as well. Navigating between individual lessons is less intuitive: the user who wishes to skip around must navigate a lengthy list that contains nested folders by volume, unit, and lesson.

Another promising aspect of the tutorial is the ability to change or customize its content. An existing lesson may be copied and edited, and new lesson plans may be created to introduce topics and exercises in a different order. A lesson editor allows the instructor to control the visual and text content of each lesson, and this same editing capability applies to the glossary of terms as well.

Drill-and-Practice

Drill-and-practice exercises are located within each lesson; they include activities such as building a scale or triad, labeling musical events (pitch, key, etc.), and aural identification of rhythms or pitch combinations. Each drill-and-practice exercise is scored according to a simple threshold: the student must achieve a given percentage of correct answers, such as 8 out of 10, in order to pass the exercise, and exercises may be repeated as often as needed.

The user interface is responsive: drag-and-drop works well and without lag, buttons are intuitively labeled, and instructions are clearly presented. The application of accidentals to a note is simple: accidentals are clearly marked with buttons next to the staff, and they may be added before or after a note is placed. I've found that handling accidentals is one of the most variable aspects of CAI fundamentals platforms, and to some extent this functionality may be taken as a litmus test of usability; EMTW passes the test.

Although there are some customization options available for drill-and-practice activities; time is not one of them; for instructors who value a time-limited environment to for developing speed, this may be a significant drawback. Another notable shortcoming is the lack of constructive feedback for incorrect responses: the student hears an "uh-oh" sound, but the correct answer is not displayed, and there is no verbal component that explains how or why the student's answer is incorrect.

Assessment and Reporting

There is no separate summative assessment or overall threshold, so the instructor wishing to use EMTW as a preparatory course may devise their own system of determining overall success. Although each unit offers a "test" option, selecting this option generates a printable document with written questions—not the series of computer activities that one would expect from a CAI test.

The record-keeping found in EMTW is common to other CAI applications: each student is tracked according to scores achieved, time spent, and units completed. Because all student activity is recorded online, the instructor wishing to track or assess student activity has instantaneous access to activity reports; there are no files to be copied or sent. However, as these records are neither sortable nor exportable to a spreadsheet format, their utility is somewhat limited.

Summary

The video introduction for EMTW makes clear that this platform is intended for use as an online component in a fundamentals course, either in hybrid format or fully online. In this regard, its ability to meet many of the demands of a preparatory CAI is a testament to its flexible design and remarkable usability. Although the instructor considering EMTW may be discouraged by its lack of advanced assessment means, its excellent user interface and robust content make it worthy of consideration—perhaps in conjunction with a separate diagnostic exam, or as a CAI component of a fundamentals boot camp.

MFun: Music Fundamentals

- Author: Elizabeth Sayrs
- Publisher: MacGamut Music Software, Inc., http://www.macgamut.com/products/mfun/
- Hardware requirements: Windows XP, NT, Vista, 7, 8; Macintosh OS 10.5–10.10
- Demo version available upon request

MFun is published by the makers of the venerable CAI platform MacGamut, and although the two platforms share their love of musically-engaged cartoon characters, MFun is a separate application that does not require MacGamut. MFun's accompanying brochure clearly announces it is designed with the underskilled incoming music major in mind, and its thoughtful combination of tutorial and drill exercises make it appropriate for use as either a stand-alone preparatory course or an e-textbook for an on-campus fundamentals course.

Scope

MFun is organized into eleven chapters (units) that cover the fundamentals and beyond: later chapters include concepts such as seventh chords, part-writing, and melodic and harmonic cadence types. Instructors looking for a battery of fundamentals similar to that described above—just the basics, up to building triads—could ask students to skip the chapter on melody (listed as an "analytical interlude") and conclude their study with chapter 8 (Triads I). Alternatively, the entire course could be assigned for a more robust introduction to fundamentals; students who have practiced the basics of part-writing and melodic analysis should be well-positioned to tackle these subjects more comprehensively when they arise in Theory 1.

Getting Started

The MFun application must be installed on a Windows or Mac computer; although it is not a web-based application, it may be purchased and downloaded online. Launching the application is somewhat unintuitive: if one clicks on the MFun icon to launch it, they are asked to locate a "transcript file" and presented with a file directory, with no help button in sight. This is a rather archaic requirement in an era where application data and preferences are routinely shielded from user interaction; students expecting a click-and-go procedure may need additional instruction.

Once the transcript file is loaded, the student arrives at a main window, from which a row of menu buttons opens various aspects of the application: a table of contents, a glossary, an index, a report screen, and a virtual piano keyboard. From the table of contents, the student selects a chapter, and then either pages through the chapter or selectively skips around using the menu bar on the left. Whereas the contents and organization of each chapter are thoughtfully laid out—each chapter begins with a list of objectives and ends with a summary of the drills and quizzes within—navigating the content list requires the student to drag the scroll bar with the cursor (instead of using a scroll wheel or trackpad).

Tutorial

The text of the tutorial is well-written, and it is augmented with introductory concepts that go beyond the basics: the chapter on pitch, for instance, begins with an explanation of frequency using a vibrating string. The author takes an engaging tone throughout, and the text itself would be suitable as a paper-format textbook; accordingly, the amount of reading asked of the student is similar to that of a textbook, and students accustomed to multimedia tutorials that use smaller chunks of information may be less prepared to digest the information within.

Text and notated examples flow together, and all notated examples come with "play" and "stop" buttons for audio. Musical examples are not animated, which strikes me as underutilizing technology: many students with low music-reading skills would benefit from a "follow the bouncing ball" approach or a similar means of highlighting musical passages as they are heard. Hyperlinks to earlier materials are included within the text, so that

the student may return to a concept's first introduction for a quick review; the student must then press the "back" button from the top menu to return to their lesson.

Within a lesson, periodic "test yourself" screens appear; these are simple, untimed exercises, often answered with pull-down menus or radio buttons, that provide a safe (i.e., not graded) environment to check one's comprehension, so that the student may be prepared for the exercises that appear later in the lesson. Scored exercises appear at the end of a lesson: the chapter on intervals, for instance, offers exercises for interval quantity, perfect intervals, imperfect intervals, and dissonant intervals.

Drill-and-Practice

The drill-and-practice component of MFun is one of its strongest aspects. A set of exercises is typically presented in three components: drill, written, and quiz. The drill and quiz share the same topic and methods; the drill allows the student to prepare at their own pace before they begin the timed quiz. The written exercise—a generated worksheet that may be printed for use—provides another opportunity to practice, and although it is more suitable for an on-campus course than a remote self-study course, many instructors will appreciate the option to ask that students create notation with a pencil as well as with a mouse or trackpad.

When launching a drill or quiz, the student may choose to either go to an instruction screen or proceed directly to the exercise. The instruction screen is extremely well-designed: it presents the upcoming drill or quiz exactly as it will appear, while an annotated walkthrough guides the students through the steps required to complete the exercise. The interface in this mode is fully functional, and students may answer questions and test out the interface as if they were taking the actual drill or quiz.

The quiz, which is the graded component of the exercise, may be taken in practice or quiz mode; the two modes are identical in every regard except for record-keeping. This is yet another thoughtful feature of MFun's drill-and-practice component, and students will appreciate the opportunity to master both the response interface and the timed quiz environment before putting themselves to the test. Quiz performance is scored with a simple points mechanism (X out of Y correct), and time limits, if applicable, apply to the complete battery of questions, such that the student must complete all responses before the time limit is reached.

The administrative side of quizzes is equally appealing to instructors. For each quiz in the course, instructors may adjust several options: the option to exclude or include the quiz, the number of questions given, the time limit (a number of seconds, or unlimited), the number of attempts allowed, and the option for students to quit within a quiz. The options window also comes with two default settings that are appropriate for "music majors" and "non-majors"; for the instructor looking to fine-tune performance requirements, these settings offer a helpful baseline from which they may make adjustments as desired.

Assessment and Reporting

Student performance is available from the "my transcript" button found in the main window. Records are presented in an uncluttered format, arranged by chapter: for each drill or quiz, the student sees the activity dates, number of attempts, and best and average scores. Individual drill and quiz titles are hyperlinked, so that the student who sees a quiz score of 40 and wants to improve it can simply click the title and proceed directly to the quiz. As there are no built-in criteria for successfully completing a quiz, the instructor must communicate their performance expectations to the student before the course begins.

Reports of student performance are transmitted electronically: the student submits their transcript file via email or other electronic means to the instructor, who gathers and arranges the collection of transcripts using a separate application. Although this process feels somewhat outdated in the Web 2.0 era of instant data collection and retrieval, the instructor may use an online (cloud) file-sharing service to store and access students' transcript files; in this manner, the instructor may check on student progress as often as desired, without relying on students to send weekly email attachments. This service may be a basic shared-directory application such as Dropbox or Google Drive, or it may exist as a component of a learning management system (LMS). Accordingly, as of July 2014 MFun has begun to offer an online solution using the Moodle LMS platform.

Summary

MFun offers a lot to the instructor wishing to narrow the fundamentals gap: it works as both a standalone course and a component of a physical or hybrid course. Instructors will like its well-planned series of drills and the option to customize the quizzes as needed; students will appreciate the annotated instructions and detailed progress reports. Now that MFun has addressed its most notable issue—the need to send transcript files from student to instructor—with an LMS solution, it should serve well as a preparatory fundamentals course.

Music Fundamentals Online

- Author: a team of writers, designers, and developers led by Eric Isaacson
- Publisher: Indiana University, http://mfo.music.indiana.edu/
- Software requirements: Flash-enabled web browser
- Trial account available upon request

Music Fundamentals Online (MFO) is an in-house project that has been designed with a single goal in mind: reduce the number of incoming music students who must take Theory 109 (Fundamentals of Music) and delay their theory curriculum by one year. MFO was introduced at IU in 2012, at which time all incoming music students were required to either complete MFO during the summer or enroll in Theory 109 in the fall. In 2013, the completion rate for MFO was over 90%, and enrollment in Theory 109 has dropped drastically, such that the course has been repurposed as a hybrid course—using MFO in conjunction with a few in-class exams—for non-majors. The designers of MFO anticipate its general release for both individual and institutional use in the spring of 2015.

Scope

MFO offers six units that cover a fairly common gamut of fundamentals: pitch, rhythm, scales, key signatures, intervals, and chords. The unit on chords includes Roman numeral notation, seventh chords in all inversions, and continuo-style and chorale-style voicing, but does not include voice-leading. Most units contain a small aural-identification component; aural recognition of intervals is given more extensive coverage. The pitch and rhythm units contain modules on orthography, a topic that is often neglected in CAI music applications; students are tutored on the placement of staves, clefs, notes, rests, accidentals, and beams, and they are asked to identify orthographical errors within a notation example.

Getting Started

Unlike other CAI applications that use lessons and drill to build to an exam, MFO begins with a diagnostic exam; upon a student's first login (using a Flash-enabled web browser), they are taken to an instruction screen, and one button later the exam begins. The diagnostic exam consists of approximately 90 exercises, with content taken from all six units of the course; once begun, it may not be resumed or retaken later. The results of the exam are then used to determine which of the 30 total lesson modules must then be completed; a student who aces pitch and rhythm but struggles with intervals, for example, will find that the pitch and rhythm modules are marked as completed, leaving the more challenging modules (intervals) for the student to complete. This diagnostic paradigm allows more skilled students to get right to the areas in which they need work; exceptionally skilled students may pass the entire course with a successful exam. Because the exam may only be taken once, instructors adopting MFO may wish to recommend a pre-diagnostic reference that allows students to acclimate to the terms and concepts used within; even skilled students may not have been exposed to scientific pitch notation or all five C-clefs, for example.

Tutorial

Each module begins with a brief overview of topics and outcomes before proceeding to one or more tutorial lessons. The layout of the lesson emphasizes the notation or sound-producing component, which appears in a large frame in the center of the window. Displays are often animated and occasionally interactive; when learning interval inversion, for example, the student may click a button to invert an interval and see the results. The lesson text appears in a smaller, upper frame, alongside a navigation bar; the prose is straightforward and functional, with significant terms placed in a bold, red typeface. The tone of the text is review-like, and while the student wanting to work quickly may appreciate this direct approach, at times it eschews opportunities to use visual or mnemonic aids, such as those commonly used to learn lines and spaces in each clef. Audio is typically controlled with start/stop buttons, and repertory examples, while sparse, are effective and illustrative. Many lessons contain an interactive "test yourself" component, similar to that in MFun, that allows students to confirm their understanding of the lesson material.

Drill-and-Practice

A lesson is followed by one or more activities, in which the student works toward a success threshold; there is no separate, ungraded practice component aside from the in-lesson "test yourself" mentioned above. Each activity contains one or more levels, in which the current topic is broken down into smaller components; for example, when learning notes on the alto-clef staff, the level-one activity is restricted to recognizing F3, C4, and G4 only, with other notes added in later levels. There is no penalty for quitting or repeating an activity, but the student must eventually pass all of a module's activities for the module to be considered complete.

The student interface is responsive and clean. Notation-building exercises use drag-and-drop for notes, rests, clefs, and accidentals; it passes the CAI "add an accidental" test with high marks. Other interface components, such as labeling buttons and a small piano keyboard, always appear in the same place and offer the same functionality. Whereas this consistency allows the student to focus on content rather than mechanics, it does come at a slight cost in speed: a typical response may include one or two drag-and-drop operations and several clicked buttons, and some students may prefer keyboard input—such as typing "G4" instead of clicking buttons labelled G and 4.

Most activities combine speed and accuracy thresholds in an intuitive and somewhat forgiving format. A typical MFO activity assesses accuracy within a visually presented moving window of assessment, and the student is required to correctly answer (for example) 7 of 8 consecutive questions; they may continue to work until this success threshold is reached. Similarly, time limits are imposed as average response time over the same moving window: were the above example a timed activity, the 7-of-8 correct responses would require an average response time of (for example) 5 seconds or less. Correct and incorrect responses are shown within the moving window using checks and X's, and the correct answer is always shown for comparison. Feedback is brief; there are no sounds of joy or anguish, and text responses to incorrect answers are terse. Completing a level or an activity is sometimes (not always) accompanied by a brief tone pattern; the lack of clear visual indicators means that it's not always obvious when an activity has been successfully completed.

Assessment and Reporting

For the student, tracking progress is as simple as a visual scan of the modules remaining completion: a module is either exempted (because the student passed it in diagnostic exam), incomplete (empty checkbox), or complete (checkmark). Whereas a lack of sub-module progress indication may frustrate students who choose to hop from module to module, this approach may encourage working to completion on one module at a time. The student may continue to work on exempted or completed modules if they wish to do so.

Instructors visit a password-protected web page to view student performance. An individual student report lists the state (exempted, completed, incomplete) of each of the 30 modules; completed modules are date-stamped. A group report lists students alphabetically, showing the number of modules in each completion state, and a summary table groups students by their number of modules remaining. The reports appear as HTML tables, and instructors wishing to further manipulate the data—such as create an email list based on number of modules completed—could do so by copying the tables into a spreadsheet.

Summary

MFO is equal parts diagnostic and fundamentals course, and instructors looking for a robust placement exam component will be well served by this platform. The student interface is excellent, and modules are thoughtfully and economically designed; its purpose is to prepare students for Theory 1, not to explore the concepts behind these fundamentals, and in this regard it performs admirably. Instructors who want to narrow or change the topics covered may want to consider other platforms, as there are no options to customize or exclude modules at this time. But as a ready-to-go diagnostic exam and fundamentals course in one it makes an impressive package, and it's hard to argue with the results: more music majors are placing into Theory 1 thanks to MFO, and it has changed the nature and purpose of the remedial fundamentals course that it has replaced.

Discussion and Conclusion

As music fundamentals CAI applications continue to be developed over the coming years, one might ask if these applications might partially or completely remove the need for fundamentals instruction in a music-school setting—such that Theory 1 might begin with higher-level concepts from the start. Whereas CAI applications have been proven effective for use in conjunction with instructor interaction, the concept of a stand-alone CAI platform is relatively less mature, and any expansion beyond the rather limited role I have emphasized in this review—as a targeted, self-paced course in the basic concepts and tasks used in music theory—would be required to address the following three factors.

The first factor is what Rogers refers to as *fluency* in fundamentals. A student may use a CAI application to develop a high level of proficiency in a variety of tasks, but these proficiencies are procedural in nature: the student knows how to apply them, but not necessarily when or why. It is the role of the instructor to help students see the connections and interrelations among these concepts, and to situate them within real-world musical examples, so that students may apply them in a holistic manner—with an understanding that (for example) intervals, scales, and triads are all built of the same elements, and that musical context may dictate the most appropriate concept for use in a given situation. And whereas

the rapid accuracy gained from CAI drill-and-practice is a necessary first step, it is only a step: the goal of learning fundamentals is not "speed as an end in itself but as an aid to continuity."[17]

The second factor is the development of *strategies* for fundamental concepts. At its core, a CAI application is similar to a collection of electronic flash cards: it may be used to develop a *retrieval* strategy for responses, so that (for example) the student no longer has to solve 3+3 with their fingers or look up *le chien* in their French dictionary. However, many fundamentals tasks involve a vast number of possible problems or situations, and it is impractical to ask that a student memorize all possibilities—just as it would be impractical to memorize multiplication tables beyond a relatively small number. To come up with the correct response, the student must draw from a collection of known strategies. Leigh VanHandel[18] offers a fruitful example of strategy use in working with musical intervals: the student need not memorize that the interval C♯ up to G𝄪 is an augmented fifth in order to identify it as such. When we describe the idealized process for coming up with this correct response, we offer several complementary strategies which are themselves based on lower-level knowledge and procedures: C up to G is one of our known (memorized) white-key fifths; adding the same accidental to both pitch-classes (C♯ up to G𝄪) preserves its interval; raising the accidental of the higher tone in a dyad increases the interval quality by one step on the quality ladder; one step above a perfect interval is an augmented interval. Without this emphasis on navigating strategies, a student may reflexively revert to less optimal solutions, such as counting each semitone between C♯ up to G𝄪—the musical equivalent of doing addition on one's fingers—in response to this uncommon but musically conceivable event. For these reasons, I recommend that you select options (if available) in your CAI application to restrict pitch elements to those most commonly occurring: the student who knows by heart the qualities of all white-key seconds, thirds, and fourths is well positioned to learn how to quickly measure *all* intervals in the first weeks of Theory 1.

Lastly, a CAI application is unable to help students deal with conceptual roadblocks. To a large extent, the fundamentals applications described in this review go beyond the original

[17] Rogers, *Teaching Approaches in Music Theory*, 39.

[18] "What Can Music Theory Pedagogy Learn from Mathematics Pedagogy?" *Journal of Music Theory Pedagogy* 26 (2012): 191–214.

intent of CAI, in which the computer *assists* instruction rather than replaces it. This statement is not a strike against the use of CAI, and many instructors and researchers have acknowledged that CAI applications are significantly superior to unassisted instruction in the main aspects highlighted in this review: they offer drill-and-practice with immediate feedback, they faithfully present themselves for use whenever needed, and they can be counted on for a fair and instantaneous assessment of performance. However, CAI applications are currently unable to assess one of the most critical elements in learning—a student's learning capabilities and limitations—and this recognition must inform our use of CAI in two significant ways. First, student-instructor interaction, either in-person or electronic, must be made available to the fullest extent possible, particularly when introducing a new CAI application for use. Second, the concepts covered within the CAI application should be kept as low-level as possible: tasks that require a more conceptual or higher-level response are more susceptible to misinterpretation, confusion, and lack of student engagement.

Whereas these three factors afford a case for retaining the typical first-unit fundamentals review in Theory 1, the use of CAI for procedural learning helps to ensure that this unit actually serves as a review—not an introduction. In this regard, a combination of preparatory CAI and theory-course review is well equipped to replace the remedial fundamentals course as a prerequisite for Theory 1. As noted in the introduction, incoming music majors who do not place into first-year theory are perpetually behind their peers, and this trailing position complicates the music major's already full curriculum. Using a preparatory CAI fundamentals application allows students to work at their speed—not at the speed of a remedial course—so that the typically hard-working music student need not lose an entire semester or year because of a lack of rote fundamentals learning. Similarly, a CAI fundamentals application may be productively coupled with fundamentals boot camp; with procedural learning taking place in a CAI environment, student-instructor interaction may focus on the conceptual, higher-level elements of fundamentals described above. A CAI fundamentals application may similarly be used in a music theory course for non-majors: by offering a drill-and-practice fundamentals tool in the opening weeks of the course, the instructor frees up more course time for higher-level music-theory topics—the holistic concepts that are most rewarding for student and instructor alike.

The CAI platforms outlined above offer an effective and immediately available response that promises to narrow the fundamentals gap significantly, if not completely, and I strongly recommend that we as music theory instructors adopt this technology in its most useful roles—reaching and assisting students before they set foot in the theory classroom. And should we find one or more shortcomings with otherwise serviceable CAI applications that we're considering for use, I suggest that we contact the developers of these applications; in many cases, they are current or former music instructors like ourselves, and their dedication to develop these tools may be partially repaid by our suggestions and case studies. As these platforms continue to develop, and as our understanding and implementation of them improves with experience, we may begin to create an environment in which incoming students can address their skills needs individually and fully participate in the music classroom.