The Use of Binary Logic and Processing to Enhance Learning and Instruction in the Undergraduate Theory Classroom

Rudy Marcozzi

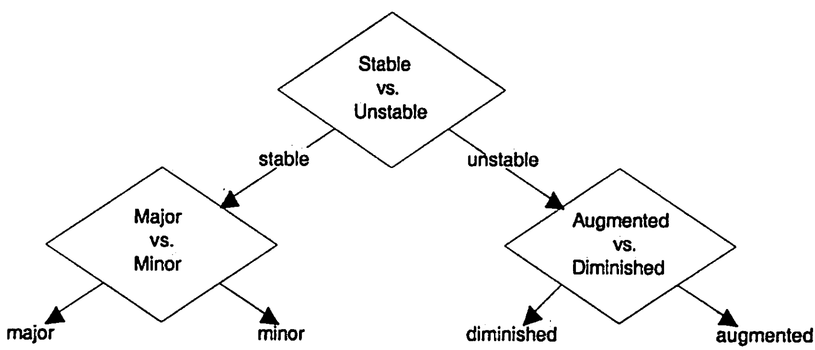
The ubiquitous personal computer, nowadays complete with full-color monitors, interactive CD-ROM drives, and lightning-fast internal modems, has revolutionized nearly every facet of our lives, including the way we teach and learn. Yet hidden beneath all the high-tech wizardry, the computer offers us a simple model that can enhance our learning and teaching, a background paradigm that is usually taken for granted, no doubt because it is overshadowed by the alluring sparkle and shine of the foreground technology.

I am referring to the fact that the computer's speed and efficiency is due to the way in which it breaks down every task into a series of binary questions or decisions. Since there are only two states (yes/no or on/off), the processing is extremely rapid, even when many thousands of such decisions are arranged in lengthy sequences. I call this "binary processing," and have used it as a successful problem-solving approach in the undergraduate theory classroom with both written and aural topics. In this article, I will first present binary process models for a few very basic topics and comment on the many advantages this type of approach brings to the learner. Next, I will present two hypothetical models of binary processing for an advanced topic and use them to compare aural and visual (or cognitive) approaches to the same problem. Here, I will show how models of binary sequences can help teachers discover the most effective pedagogical approaches to a given topic, and will argue for the early incorporation of aural processing into all instructional sequences. I will conclude with a critique of the ideas that have been presented and a summary of the advantages they bring to learning and instruction.

HELPING LEARNERS: SIMPLE BINARY PROCESSING AND ITS BENEFITS

Let's begin with a very rudimentary example, relevant to the early weeks of a beginning aural skills class when students are typically required to be able to identify the four common types of triads, discriminating them one from the other. A diagram that illustrates the possible binary processing involved for this problem can be seen in Figure 1.

FIGURE 1: Aural Discrimination of Four Basic Triad Types



Each diamond of the diagram requires a decision involving only two choices. In the highest diamond, the student is actually creating two broad families from the four possible choices by deciding if the triad sound is comparatively stable (major or minor) or unstable (diminished or augmented). Once that decision is made, the process follows the appropriate branch to the next level of decisions. Following the stable branch, the student must next distinguish a major triad from a minor one; following the unstable branch, the student must next distinguish an augmented triad from a diminished one. Teaching these discriminations can usually be accomplished fairly quickly using a student's inner hearing and imaginative association (for example, major is brighter or lighter than the darker sound of minor; an augmented triad might sound eerie, while a diminished triad sounds tense) without having to arpeggiate the triad or break it down into component intervals.

At first, breaking such a rudimentary task down in this manner may seem cumbersome or unnecessarily complex, but those who have taught ear training for any length of time know that it is not at all uncommon for some students to have trouble with this kind of basic problem. More important for our purposes, even the simple binary processing involved in this example—limited to only two decisions and two possible branches— illustrates many of its pedagogical advantages.

Of primary importance is that the processing is comparative. Similarities and differences among sounds that are familiar are used to learn about sounds that are not. As students compare sounds to one another, they discover and articulate relationships among them. Since music is a network of relationships and not a series of isolated events, it is the ability to process relationships rather than isolated events that will later lead to more musical performance and analysis. As Michael Rogers notes, "Developing an appreciation for discriminating and articulated comparisons is a habit worth cultivating for all aspects of theoretical study."[1]

Another crucial advantage of the approach is that it relies on the aural imagination of each student, hence focusing the task from the very beginning on the real goal of all ear training: the development of the inner ear. Class discussion of associative possibilities will allow students to understand that the range of potential associations is very broad and choices of meaningful associations vary from student to student. This will enable them to capitalize on the idiosyncratic nature of their inner ear and develop reliable individual strategies. The process also focuses on the musically salient feature of the triad, its harmonic quality, while avoiding mechanical dissection into component intervals (melodic events). Such parsing is a necessary skill, but it is often impossible for beginners; even when it is achieved, it usually remains a very time-consuming (and, there-

---

[1]Michael Rogers, *Teaching Approaches in Music Theory: An Overview of Pedagogical Philosophies* (Carbondale IL: Southern Illinois University Press, 1984), 43.

fore, musically impractical) task. More significant, this kind of processing does not transfer well to subsequent activities when the same triad qualities are encountered in different inversions and voicings.

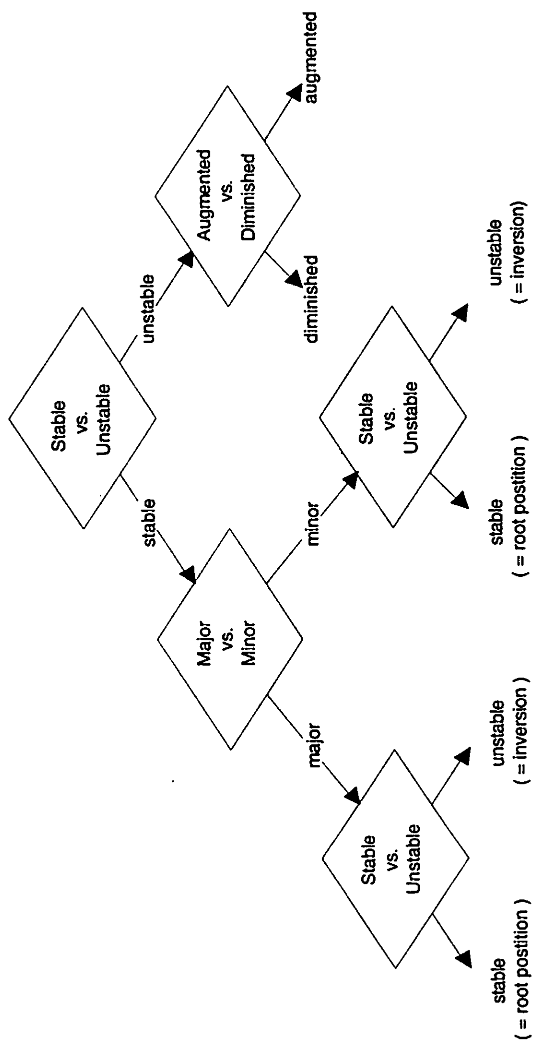
The binary model offers further advantages to students because it fosters early success. While it is typical for some students to confuse augmented and diminished triads, most students usually can negotiate the earlier decision diamond (stable vs. unstable) or even the parallel one (major vs. minor) with relative ease. Hence, even those students who are encountering difficulties with later decision diamonds can see at least partial success with earlier ones. This early partial success lessens the despair that often sets in as some students encounter difficulty with an activity that seems to pose no problems to others in the class. More significant, the initial success, even though incomplete, motivates further practice and proficiency, and leads ultimately to total mastery of the entire process.

Perhaps most important, the use of binary processing allows students and teachers to accurately diagnose and isolate problems so that efficient practice prescriptions can be formulated. Once students identify a decision diamond that presents difficulty, they can focus on practice activities that address that particular diamond using a variety of resources (practice partners, CAI programs, tapes, etc.). When the troublesome diamonds are mastered, they can be re-incorporated into the whole process.

Telling students that they should "practice more" is almost always unhelpful because students in trouble usually don't know how to practice. For them, more practice often means only more wasted time, more frustration, less success, and ultimately less belief and interest in further practice. Using binary processing, teachers can design and students can discover the kind of directed practice that is most likely to achieve the best results. Tangible intermediate success encourages further practice, and promotes attention to and refinement of practice habits. In other words, binary processing can teach students how to practice smarter so they don't have to practice longer. Students who invest time in mastering this valuable lesson reap dividends that reach well beyond the theory classroom into all other aspects of their musical training.

Finally, by establishing this kind of practice and problem-solving, the binary model can lay the foundation for future topics so that advancing through a semester or even a curriculum is achieved smoothly and efficiently. As an example, let us move to the point when students begin to encounter first-inversion major and minor triads. (We will assume that the unstable triads will remain in root position.) The number of possible answers has now increased from four to six chords. A possible binary processing model is illustrated in Figure 2.

FIGURE 2: Expansion of Processing to Include First-Inversion Triads



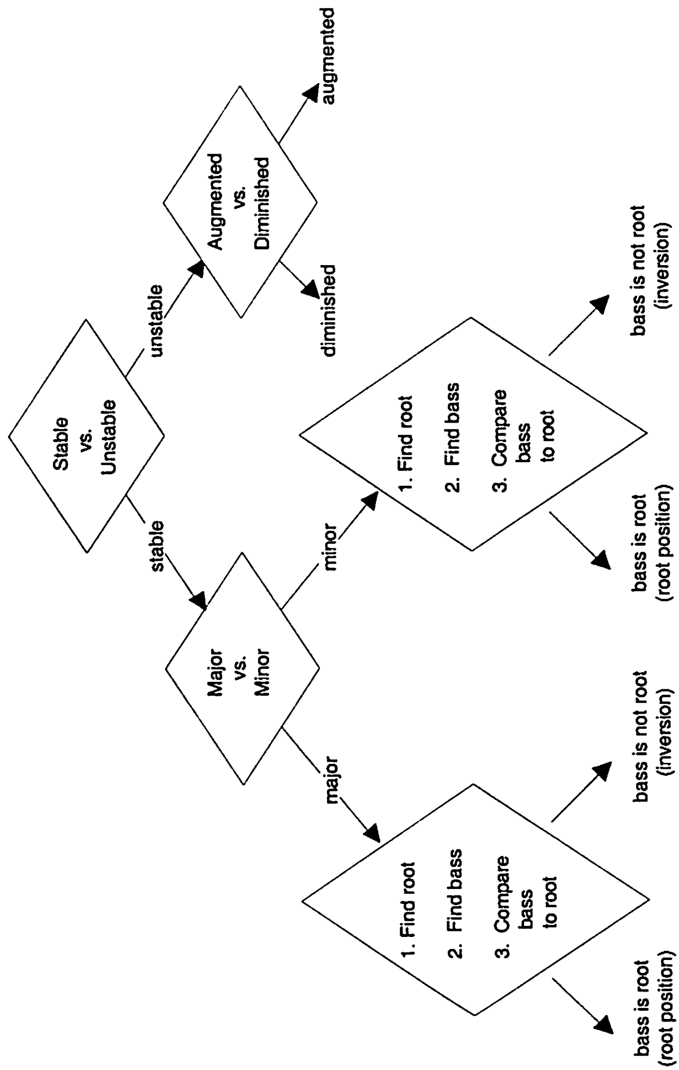
It is at once apparent that the earlier model serves as the foundation for the later one. The first and second layers of decisions are identical, but additional branching occurs on the left side of the model to create a third layer of decisions to discriminate between root position and first-inversion. Here, the earlier strategy of stable vs. unstable can be used again, but this time to compare an inverted triad with its root-position counterpart. Like the earlier theme, this variation avoids dissection of a harmonic event into melodic segments that may vary according to voicing.

At this point, it is possible to introduce other processing strategies which involve manipulation of the triad's component pitches. The fundamental task common to these strategies is the comparison of root and bass factors, a highly valuable skill that can be transferred and used in the solutions of many other subsequent problems. Sequentially, it is best introduced here, after students have established a solid foundation using less involved inner ear processing. A revision of the model that includes this kind of strategy might look like the one illustrated in Figure 3.

The third layer of decision diamonds in Figure 2 has been replaced with a vertically oriented process diamond. This is, in effect, a subroutine that is needed to arrive at the identification of the position. The numbered steps once again help students practice efficiently by allowing them to precisely identify what they are unable to do. Most students who encounter difficulty will typically engage in futile repetition that is focused on comparing the bass and the root (step 3). But the real source of the problem is that they can't accurately find the root (step 1) or the bass note (step 2) in the first place. Hence, the comparison involved in the final step is rendered impossible by the inability to perform the earlier two. Focused practice on these initial steps using a drill partner or teacher-student conferences usually leads to quick mastery of the entire subroutine.

Regardless of which strategy is used to discriminate between inverted and root-position triads, a comparison of Figure 1 with either Figure 2 or 3 suggests that the use of binary processing can assure effective sequencing that continually relates new problems to old solutions. Such sequencing should occur throughout the semester as new concepts are introduced. The flow charts of Figure 3 can be easily expanded to include second inversion triads, all posi-

FIGURE 3: Alternative Processing of Inversion



tions of common seventh chord types (when introduced in a gradual and systematic way), and typical sonorities from more recent repertoire (quartal chords, or common tri-chords and other pitch sets) Rogers observes that this kind of teaching is "almost painless, since the additional doses of truly new material are always relatively tiny. . . . Almost never is it necessary to start a 'new' topic from square one. . . . Each new[ly] achieved goal becomes a springboard for additional study."[2]

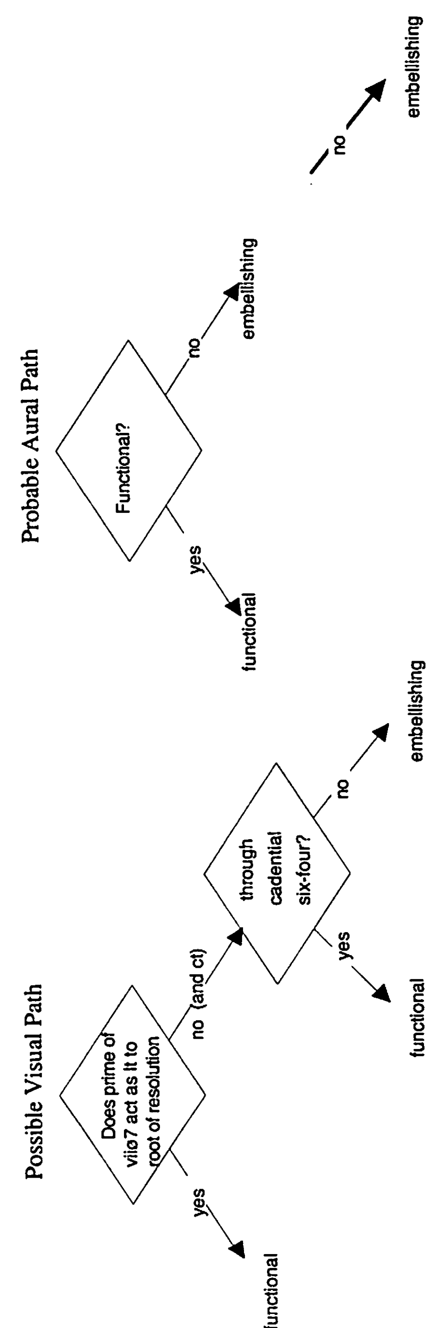
HELPING TEACHERS: COMPARING BINARY MODELS, OR, TROMPE-L'OEIL MA TRIOMPHE DE L'OREILLE

When I taught aural and written skills as separate classes, I often found myself developing different binary models for the same topic in an attempt to maintain some coordination between the two strands that had been unraveled by the curriculum . In the process, I discovered how the development of multiple binary process models for a single topic often reveals pedagogical strengths and liabilities of a given instructional approach. Figure 4 is an attempt to represent both an aural and written (or cognitive) approach to that most serpentine of chromatic topics: the diminished seventh chord. Let's assume that students have mastered the use of chromatic fully-diminished seventh chords used as functional secondary dominants, and are now being introduced to the idea of the diminished seventh as an embellishing sonority.[3] For pedagogical efficacy, let us also assume that our examples will be restricted to those that do not involve "incorrect" (i.e., enharmonic) spellings.

[2]Rogers, *Teaching Approaches,* 6.

[3]In textbooks that treat these chords separately, this is the usual order of presentation. For examples, see Stefan Kostka and Dorothy Payne, *Tonal Harmony,* 3rd ed. (New York: McGraw-Hill, 1995) or Robert Ottman, *Advanced Harmony,* 4th ed. (Englewood Cliffs NJ: Prentice-Hall, 1992). The distinction is made more clearly in Kostka/Payne. In Ottman, the presentation is nearly contiguous and seems flawed by the assignment of functional Roman numerals to both the functional and embellishing sevenths.

FIGURE 4: Two Processes for Distinguishing Secondary and Embellishing Diminished Sevenths



Aurally, only a single discrimination must be made: Is the relationship of the diminished seventh and chord that follows decorative or functional? If the relationship is decorative, an accurate label can be immediately assigned. If a functional relationship is perceived, then the analysis symbol is assigned based on the function of the resolution chord.

Compare this to the more complex branching in the visual path. Once the chromaticism is identified as a diminished seventh, we must determine if the prime of the seventh is acting as the leading tone to the root of the resolution chord. If it does, we can once again assign an analysis symbol based on the resolution chord. If not, a commonly prescribed strategy is to use the presence of a common tone or tones as a visual clue for an embellishing seventh.[4] Nonetheless, even if a common tone is present, one more decision or check is required to eliminate a very prevalent fly-in-the-common-tone ointment: vii°7/V moving through the cadential six before arriving at the dominant.

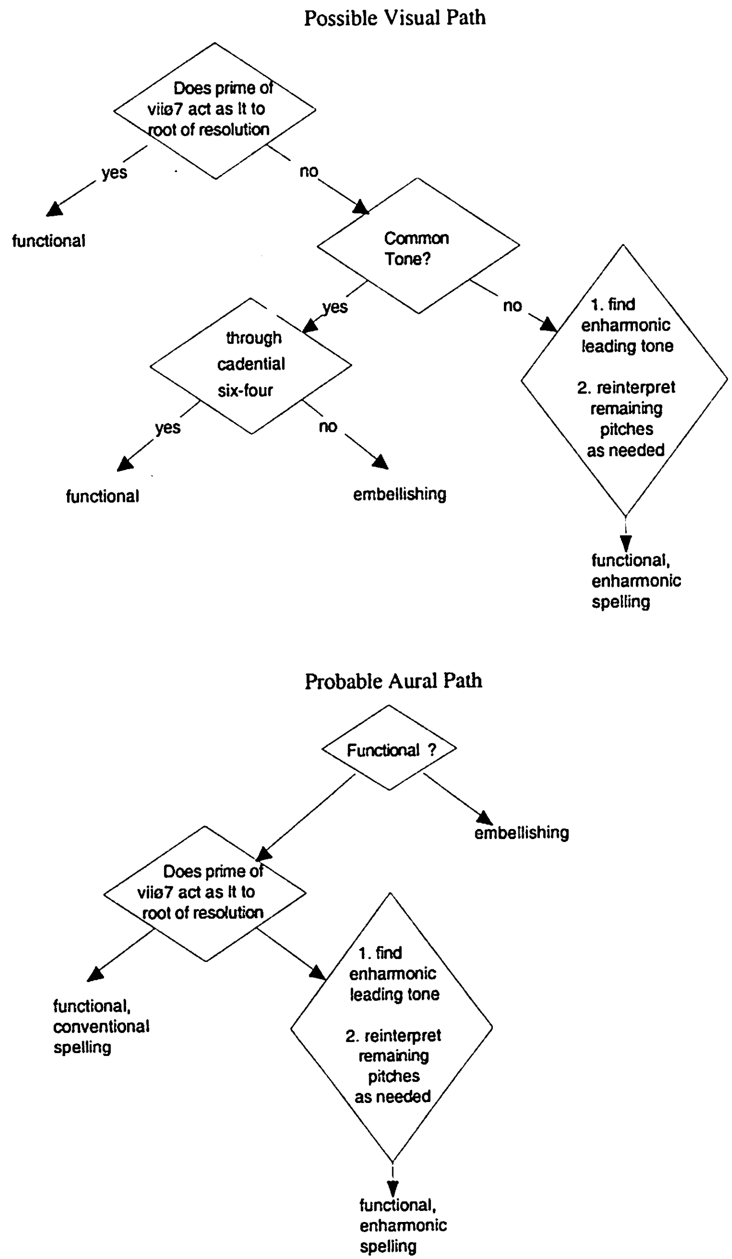
The model devoid of sound clearly involves more branching and decisions and, therefore, more potential for problems. As the number of discriminations in any paradigm increases, the efficiency and tempo of the processing decreases, accompanied by far greater potential for inaccuracy. On the other hand, the aural path is streamlined, relying solely on the most appealing dimension of the music—its sound, and remaining totally unencumbered by confusion generated either by notation (including especially the "enharmonic misspellings" that will soon be encountered) or the artistic inconsistencies of the music (such as incomplete voicings or delayed resolutions).

It is possible that as a given topic becomes more developed and complex, the efficiency of aural processing (and the inefficiency of visual processing) actually increases. For example, consider the next variation of the diminished seventh theme that usually occurs: enharmonic re-interpretation. An expansion of the early paradigms to include this possibility can be found in Figure 5.

---

[4]See Kostka and Payne, *Tonal Harmony*, 433-436, where the embellishing seventh chord is called a common-tone diminished seventh.

FIGURE 5: Secondary vs. Embellishing Diminished Seventh with Enharmonicism



Multiple additions to the visual path are necessary before it is possible to arrive at an accurate musical analysis. In the aural path, the identity of the chord is known far earlier; the additions to the process are actually visual/cognitive ones necessitated by the inconsistencies of the notation. A more serious pedagogical problem with the visual paradigm is that it undoes prior learning. It is now impossible to find the expected leading tone resolution, and students will have to alter or even unlearn a technique that up until now was reliable. This is a task as arduous and time-consuming as unlearning wrong notes that have been practiced into kinesthetic and aural memory over many months.

Figure 5 demonstrates that as the chromatic and notational complexity of tonal music increases, all processing will become more intricate, but those that rely on aural operations will always be simpler than those relying on visual or cognitive ones. These binary models show that even as the eye is fooled, the ear will triumph, since the number of functional sounds will always be less than the number of visual ways that can be used to represent them.

In reality, it is probably impossible to separate aural and visual processing; the models above using isolated modalities are therefore, to some degree, artificial and contrived. Nonetheless, the moral of the story told by the paradigms is that the ear should be involved from the very beginning in every task that students undertake. After all, they have been listening to music far more longer than they have been looking at it. As the music studied becomes more and more complex, the ear remains the analyst's best tool. Though often perceived by students to be the analytic tortoise, the ear always beats the visual hare who must stop to (w)rest(le) in the inconsistencies and inadequacies of notation. The integration of sight and sound must be done early and often; those wedded to reliance on visual analysis will be doomed to plodding and inaccuracy.

HELPING EVERYONE: A CRITICAL CONCLUSION

What are the drawbacks of these instructional strategies? Many will argue that is an artificial attempt to order something that is inherently unordered. While this may be true, the paradigms do allow students to become comfortable with the disorder as they work through it systematically, rather than be continually overwhelmed by it. Even though I know that you can teach a baby to swim by throwing her into a swimming pool, I am still reluctant to use that technique with my own child. I am far more comfortable with a safe and organized progression of smaller steps.

It can also be argued that this kind of aural skills pedagogy trains students to reason deductively rather than truly hear. While this might be true in the initial stages, the deductive reasoning is soon replaced by actual hearing. Like any other reference system, it is discarded as mastery occurs with repetition and practice. In the meantime, the deductive reasoning serves as an important motivating tool and strategy for problems that are difficult to practice in a focused manner. Students are not likely to practice anything when they have been given no suggestions about how to practice, or when practice fails to yield tangible improvements. Techniques based in binary logic overcome both these obstacles.

Mastery itself is another issue. The flow charts may suggest to students a very cumbersome and unnecessarily complex thought process, filled with a confounding number of steps which can each take an infinite amount of time. In reality each of the decision diamonds must be practiced in isolation until it can occur almost subconsciously, measured not in minutes but in nanoseconds. Most students will already be able to operate with this kind of fluency in at least a few of the earliest diamonds, and the speed requirement must be an insistent goal of the practice. Unmastered material will come back to haunt students in an exponential way.

Finally, it might be argued that the methodology attempts to impose uniformity on thinking and reasoning patterns that are highly idiosyncratic. In fact, even after a cursory examination of the models above, many readers might already have objections or alternatives to the content and ordering of the decision diamonds. Perhaps so, but it is precisely as students discover the ways in which their own listening, thinking, and hearing differ from a given model that the greatest amount and most exciting kind of learning occurs. Students report back with intense excitement that "this really worked," or "for me, it only works if I change x to y." They begin not only to help themselves, but to teach each other. This change from learning to teaching mode is a sure sign of thorough understanding and accomplishment.

I often help individual students encountering a particularly vexing problem unique to them to design their own flow charts. The process never fails to help me develop further insights and refined strategies for a wide variety of perennial problems. I am more and more convinced that successful teaching, particularly skills teaching, is about presenting as many different solutions as possible to the same problem so that students can develop their own hybrid approach as they practice.

While no technique is perfect, I maintain that binary logic may be used to achieve greater teaching and learning efficacy with a wide variety of theory topics, especially when they include the early incorporation of an aural dimension. Binary paradigms provide a systematic practice routine that fosters early success and motivates continued practice. With such instructional design, the skills learned build on past learning, transfer well to future learning, and can have immediate relevance in everyday musical situations encountered in the practice room and rehearsal hall. Most importantly, we move beyond music, theory, and the immediate task at hand, as we teach our students to think independently and develop problem-solving skills and habits.