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The Case of the Tic Tac Toe-Playing Chicken: Programed Instruction and Behaviorism in Music Theory Pedagogy

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The Case of the Tic Tac Toe-Playing Chicken: Programed Instruction and Behaviorism in Music Theory Pedagogy

Harmonic Materials in Tonal Music: A Programed Course, parts I-II
by Greg A. Steinke, based on material originally created by Paul O. Harder.
Tenth Edition. Upper Saddle River: Prentice Hall, 2010.

reviewed by ANNA GAWBOY

The year 2018 marks the fiftieth anniversary of the first publication of Paul O. Harder's *Harmonic Materials in Tonal Music*. The past half-century has witnessed the professionalization and expansion of the field of music theory, several shifts in pedagogical philosophies and methods, and a radical disruption in how people access, interact with, and store information via the internet and electronic devices. The tenth edition of *Harmonic Materials in Tonal Music*, revised by Greg Steinke and released in 2010, is a time capsule of pedagogical thinking about music theory. It simultaneously inspires wonder at discarded relics of the past and reveals the persistence of issues we are still grappling with today.[1]

Programed instruction and B. F. Skinner's Teaching Machines

Steinke and Harder's *Harmonic Materials*, in two volumes, is preceded by a fundamentals text, *Basic Materials of Tonal Music* (12th edition, 2009). Together, they form a trilogy that covers the basics of notation through chromatic harmony and modulation. The most unique aspect of the series is its use of a programed method of instruction. When the book first appeared in 1968, programed instruction had been in vogue for nearly a decade, and was becoming increasingly popular in music education.[2] The textbooks present concepts in small, easy-to-understand chunks or "frames," which are followed immediately by comprehension exercises and feedback.

1 Harder was single author through the 5th edition. The 6th edition was the first to include Steinke as co-author. It was released in 1985, the year before Harder passed away. Steinke is listed as "author" of the 7-10th editions, but with the caveat, "based on materials originally created by Paul O. Harder." In my comparison of the first and 10th editions, much of Harder's original text remains. His voice is primary throughout the editions. The gist of Steinke's revisions seem to be the inclusion of more examples and prompts in music notation.

2 See Rogers and Almond (1970).

The accumulation of knowledge is meant to be almost effortless, a natural outcome of the use of the minutely graduated material. This organic approach to content is reflected by the cover art of the series, which features a hen sitting on her eggs for *Basic Materials*. The chicks hatch on the cover of volume I of *Harmonic Materials*, and several older chicks with budding pinfeathers walk around and peck corn under the gaze of their proud mother on the cover of volume II. These scenes featuring humble domestic fowl may seem like a strange artistic choice for the cover of a music textbook, but they suggest an intriguing double metaphor for the book's aims. The nurturing presence of the hen is perhaps a symbol of the text, which gently guides the learner through formative stages of knowledge acquisition. The chicks' gestation, birth, and young life allude to the learning process itself, which progresses through instinct rather than with conscious, concerted effort. But the hen also might remind those who know the history of programed instruction of B.F. Skinner's extensive and astonishing experiments in animal training. Skinner taught pigeons to choose the correct suit in a deck of cards, play ping-pong, and peck out simple tunes on the piano. His laboratory also produced chickens capable of winning consistently at tic tac toe—but only if the chicken got the first move.[3] Skinner's work led directly to his development of teaching machines for humans and contributed significantly to the philosophy and methods of programed instruction.

Skinner's teaching methods involved breaking a complex task down into tiny, manageable units, then positively reinforcing any behavior that approximated the desired result. For example, if the goal was to teach a dog to get the mail, the dog would receive a reward for any small movement toward the mailbox. The dog's subsequent movements would then be further "shaped" through positive reinforcement so that each iteration more closely resembled the desired action.[4] Skinner's methods were based on several core principles: the atomization of knowledge, the minimization of learner's effort, instantaneous positive reinforcement for desired behavior, and continued practice until the achievement of mastery. In the 1950s, Skinner developed several programs for teaching machines used at Harvard University (Example 1). The machine revealed a chunk of information to the students in a small window and immediately presented a comprehension question. The students would compose a response to the question and then turn a knob to reveal the correct answer and check their work. If the student responded correctly, he or she could dismiss the question.

3 Skinner (1951). Several films of Skinner's performing animals are available on YouTube.

4 Ibid.

If the student responded incorrectly, the question would be presented again later in the sequence. The program was complete once the student answered all questions correctly.

Example 1
One of the teaching machines invented by B. F. Skinner. Photograph courtesy of Wikimedia Commons, CC BY 3.0, https://commons.wikimedia.org/w/index.php?curid=3806150.

Skinner maintained that that his teaching machine alleviated the pitfalls of mass lecture-based instruction and produced a similar quality of instruction as that of an individual human tutor.[5] He pointed out that the student was constantly engaged with the material through answering comprehension questions instead of drowsing off listening to a lecturer. The teaching machine required that students learn all the material at one level before they progressed to the next, instead of allowing them to pass a class only having shown a certain percentage of understanding. The machine allowed the student to work at his or her own pace, spending more time with concepts that were challenging and quickly moving through easier material. Instead of waiting for an instructor's judgment handed down as a grade on homework or an exam, students received instant feedback about their learning and could modify their study accordingly.

If some of this rhetoric sounds familiar, it is because much of the philosophy associated with teaching machines and programed instruction transferred directly to computer-assisted instruction (CAI) and online learning.[6] Like Skinner's programed

5 Skinner (1958, 971).

6 Skinner himself saw CAI as a technical improvement on his basic educational philosophy. See Skinner (1986, 103-110). For a more critical view of the relationship between programed instruction, CAI and

courses, Steinke and Harder's *Harmonic Materials* is organized into frames containing a paragraph of material or a short musical example. Each new topic is introduced by an "expository frame," which outlines a basic concept. "Learning frames" provide additional information on the topic, and are followed by a question, usually fill-in-the blank. The end of the chapter includes a summary, followed by several "mastery frames" that test remembering and understanding of the key concepts. The frames run down the right column of each page, and answers to the comprehension questions are printed directly opposite the question in the left column in order to facilitate quick feedback. Skinner's teaching machines withheld answers to comprehension questions until immediately after the student had made his or her response, but Harder and Steinke instruct students to use the tear-out card that is included with the book to cover the left column while working and to quickly uncovering the printed answers as needed to check their responses.

This layout, with answers printed directly opposite the question, might tempt students to use the text in a manner other than intended, perhaps simply reading the answers without putting effort into thinking about the question. However, in learning frames, the answer to the question is usually embedded in the question and highlighted in such a way to attract notice, so not much effort is needed in the first place. Example 2 shows the expository frame and the first learning frame for a segment on chromatically altered harmonies.

The learning frame designated 3.16 states that "tones that are foreign to the prevailing tonality often are absorbed into the harmony to produce ALTERED CHORDS," and then one sentence later, the student is asked to fill in the blank: "A chord that contains a tone foreign to the prevailing tonality is call a(n)_____ chord." This style of presentation comes from Skinner himself, who believed that traditional textbooks were overly entertaining, discursive, and sometimes misleading by design.[7] Skinner stressed that programed instructional materials must be written to guarantee success, helping the student learn through hinting, prompting, and suggesting the correct answer. In keeping with this objective, *Harmonic Materials* doles out tiny chunks of information over a long series of frames. Students learn that the use of altered chords is associated with a chromatic harmonic idiom in Frame 3.17; they learn that there are several different types of altered harmonies and identify one in a sequence of diatonic chords in Frame 3.18; and then they delve into the function, spelling, and analysis

online learning, see McDonald, Yanchar and Osguthorpe (2005).

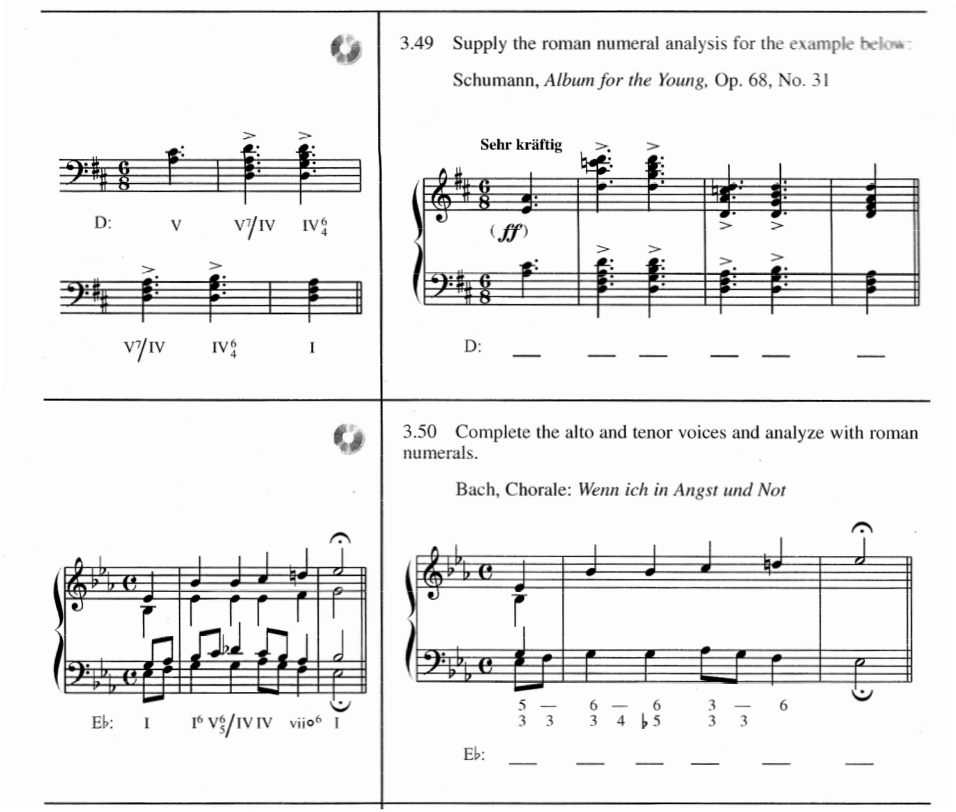
7 Skinner (1958, 974).

	Expository Frame 3.15 Melodic activity generated by nonharmonic tones is increased by chromatic alteration. Altered tones tend to continue in the direction they are inflected. The two most common alterations are the raised fourth and the lowered seventh scale degrees. The raised fourth degree usually continues up to the fifth, thus providing a tonal gesture toward the dominant. The lowered seventh degree resolves to the sixth, which often is set as the third of the subdominant chord. In addition to motivation, altered tones provide color. They do not necessarily weaken the influence of the tonal center, but a chromatic melodic style often is associated with an abundance of altered chords.
(No response required.)	
	3.16 In addition to their nonharmonic function, tones that are foreign to the prevailing tonality often are absorbed into the harmony to produce ALTERED CHORDS. Such chords perform a role similar to that of altered nonharmonic tones: they produce more colorful harmony, and, in some cases, help stress the structural function of the diatonic chords to which they resolve. A chord that contains a tone foreign to the prevailing
altered	tonality is called a(n) _____ chord.

Example 2
Expository frame 3.15 and learning frame 3.16 from *Harmonic Materials*, volume II, p. 67.

of V^7 of V in frames 3.19-3.24. The initial presentation of foundational concepts is mostly text-based, but later the questions begin to look more like more conventional music theory exercises consisting of roman numeral analysis and figured bass work (Example 3).

Unlike the learning frames, these exercises do not have answers embedded in the question. Each chapter ends with a summary of key points and a series of "mastery frames," where a student tests the knowledge accumulated over the course of the program. There are also supplementary assignments at the end of each chapter, which look very much like conventional workbook exercises, consisting of short analysis excerpts from the musical literature or brief harmonic realization exercises.



Example 3
Frames 3.49 and 3.50 from *Harmonic Materials*, volume II, p. 77.

Goals and content

In general, the learning goals of the frames and supplemental assignments are quite modest, merely introducing the student to a new concept and its basic application. The restricted learning goals of the text, combined with its design to facilitate self-teaching and self-pacing, might make *Harmonic Materials* an attractive resource for instructors who wish to use it with a flipped method of instruction. In fact, Paul Harder's original preface suggested that the text be used in precisely this way, recommending that "the core of knowledge contained in this book may be expanded by emphasis on creative writing, analysis, or the study of music literature. Because students evaluate their own exercises, the instructor is free to prepare more vital

and creative supplementary learning experiences."[8] Steinke, in his introduction to the 2010 edition, suggests that the text is merely to serve as an introduction, allowing the teacher to pursue more complex problems in class: "[A] rich learning experience can be created for instructors and students alike as they explore together the many exceptions to the so-called rules or principles. This allows them to ultimately link all that they study to actual musical literature or to create many varieties of assignments to solidify the understanding of the basic framework presented in these pages."[9]

In contrast to modern texts that are thick with musical examples, activities, and content, Steinke and Harder's *Harmonic Materials* is intentionally incomplete and requires the collaboration of an expert teacher to round out the learning experience. The text provides very few suggestions for supplemental assignments and activities that would help students move beyond basic identification and realization and toward the synthesis of concepts, creative application, and interpretation. There are some instructions for small compositions, which ask the student to work with harmonic vocabulary in a more flexible manner than would be possible with only figured bass realization. For example, at the end of the chapter on secondary dominants (Chapter 3.0), the student might "compose a small composition (at least four phrases long) that exploits both altered nonharmonic tones and secondary dominants."[10] The student is instructed to plan out a simple harmonic background using only diatonic chords, then embellish some chords with secondary function chords, then write a melody that conforms to the harmonic background and complete the composition by working up an appropriate accompaniment figuration. Similar composition assignments occur at the ends of almost all the chapters in the second volume.

The book also contains a few suggestions for supplementary activities at the end of each chapter that could allow the student to integrate knowledge at a deeper level in class discussion or as a writing assignment. For example, a supplementary activity on voice leading encourages students to "examine short excerpts from different musical styles for the way voices 'lead.' How are they alike, how are they different? Why are they different? Is the voice leading a significant factor in the definition of a particular style?"[11] Guided by a knowledgeable instructor, this activity could generate a lively and insightful discussion in class. However, instructions for supplementary activities are

8 Harder (1974, vii).

9 Steinke and Harder (2010, vol. 1, vii).

10 Ibid., vol. 2, 92.

11 Ibid., vol. 1, 116.

uneven and do not always necessarily point toward a more holistic understanding for the students. The previously mentioned chapter on applied chords instructs students to "continue activities of analyzing musical excerpts…by incorporating altered non-harmonic tones and secondary dominants and by developing short essays around these excerpts or new terms introduced in this chapter" and to "focus on ear training exercises dealing with increased chromaticism and in general musical listening."[12] Additional practice identifying chromatic chords in various musical contexts would be undoubtedly necessary after the students complete the programed portion, but the instructor would have to devise additional activities that enabled students to grasp deeper nuances of syntax and usage and to use this knowledge in more advanced interpretive or creative projects.

It seems that the content and pace of *Harmonic Materials* would transform delightfully into an online text with embedded musical examples and comprehension questions, similar to recent music theory ebooks such as Jane Clendinning and Elizabeth West Marvin's *Musicians' Guide* series or L. Poundie Burstein and Joseph Straus' *Concise Introduction to Tonal Harmony*, both published by Norton. Unfortunately, *Harmonic Materials* is very much a throwback to a pre-digital age. Until 2015, Pearson supported a supplemental online presence associated with the text, www.mymusitheorykit.com; this site has since been retired and not replaced. When the tenth edition of *Harmonic Materials* was published in 2010, it was still common for textbooks to come with audio discs, and many of the musical examples are flagged with an icon indicating the student can listen to a recording. An audio CD for volume I is available through the Pearson website for an additional $65 purchase, which seems to be a terrible investment given that many computers no longer have CD drives. The CD for volume II did not seem to be available at all. Today, the lack of a companion website with streaming audio means that musical recordings would be inaccessible for many students. The text stands alone, stripped of the multimedia experience students have now come to expect from their learning materials.

Teaching "common practice" in an age of tonal diversity

As the title suggests, *Harmonic Materials* is strictly a harmony course; there is very little information on any other musical parameter. This has some drawbacks within the text itself: students are expected to write melodies without any information on how a melody is constructed. Rhythm, texture, and timbre are also largely neglected,

12 Ibid., vol. 2, 88.

although there is a very helpful appendix that covers the basics of piano styles. There are no chapters covering form, which either must be addressed in a separate textbook or by the instructor's own materials.

Like many mid-century theory textbooks, *Harmonic Materials* focuses on western tonal practice of the eighteenth century. Though nominally covering western art music of the common practice period, ca. 1700-1900, the text is anchored upon the music of J. S. Bach. The index of musical examples contains references to over seventy Bach chorales and fourteen keyboard works. Beethoven is perhaps the next most-frequently excerpted composer with 37 compositions, while Chopin and Mozart follow close behind. Many later nineteenth century composers are represented by a few examples each: Elgar, Fauré, Franck, Grieg, Debussy, Nielsen, Ravel, Puccini, Wolf, Tchaikovsky, Richard Strauss, Johann Strauss, Stravinsky, and Sibelius. There are no full-length pieces, and most examples are only a few measures long. The musical examples must be somewhat limited due to the book's format and aims, and it is important to remember that the book was supposed to support a deeper exploration of repertoire in class.

There is a growing sense among music theorists that it is no longer sufficient to focus on the harmonic practice of a small number of composers within the western tradition in undergraduate theory courses.[13] Several texts, such as *Aural Skills in Context* by Evan Jones, Matthew Shaftel and Juan Chattah (2014); *Music Theory Remixed* by Kevin Holm Hudson (2017); and *The Musician's Guide to Theory and Analysis* by Jane Clendinning and Elizabeth West Marvin (2016) graft discussions of non-western and popular musics onto the traditional core of eighteenth-century harmony with the goal of developing a more varied theoretical skill set and a heightened sensitivity to differences in musical style. This is a welcome change, and it is likely that next decade will see even more diversified approaches.

Paul Harder worked at a time when many academic composers believed that serialism and atonality would displace tonality as the dominant musical language. *Harmonic Materials* begins with an apology for the study of western harmony written by Harder.[14] He argues that, despite the "assault" on tonal music by the Impressionists and Second Viennese composers, tonal music is still flourishing in commercial and popular music as well as churches and schools. "The time is not yet in sight when this study will be without meaning and thus disappear from the standard music

13 See, for example, Covach, (2015); Kulma and Naxher (2014); and Richards (2015).

14 Steinke and Harder (2010, xi). The quote originally appears in the third edition (Harder 1977, xi).

curriculum."[15] Harder's argument for the continued vitality of tonal music has stood the test of time and, as a result, seems somewhat less urgent today. Teachers of harmony have at their disposal another half-century's accumulation of tonal popular music as well as the results of a renewed interest in centricity among academic composers.

This landscape brings its own challenges, however. Undergraduate theory pedagogy has, on the whole, not yet come to terms with how best to equip students to understand and perform the growing plurality of tonal styles beyond the common practice. Though Harder recognized the importance of studying music outside the western tradition, he believed that a thorough grounding in classical harmony would transfer to an understanding of a wide variety of tonal music. "Even with the passage of centuries, basic concepts still 'rule' to a great extent and provide an important underpinning to many musics throughout the world with modifications, blendings, and adjustments to suit a particular milieu."[16] If the goal of the study of tonal harmony was to help students discover the persistence of basic principles throughout a wide diversity of tonal styles, the curriculum would need to do more than focus exclusively on eighteenth and nineteenth-century music, as Steinke and Harder's text does. For far too long we've taught by synecdoche, allowing common practice tonality to stand in for the whole. Just as the exclusive study of harmony doesn't help students understand melody or form, learning only about Austro-German male composers doesn't help students appreciate the music of women and composers from different nations and ethnicities. Learning only about music of the past doesn't help students understand the music of the present, unless the styles can be compared side by side, with theoretical consideration of similarities and differences.

As a legacy textbook, Steinke and Harder's *Harmonic Materials* provides insight into how challenging it is to truly diversify the curriculum given music theory's traditional focus on harmony and the tautological relationship established between harmony and western classical music. Harder's justifications for his focus on common practice music continues in the first chapter of the text, leading to some statements that are embarrassing at best and erroneous at worst. He states, "harmony…is missing from music that is outside the Western art music tradition."[17] This is true if only one adopts a very narrow definition of harmony—ignoring, for example, the drone-based triads produced by the Thai khaen, the homophony produced by string instruments

15 Ibid. 2010, xii.

16 Ibid., xiii.

17 Ibid., 1.

in Japenese gagaku ensembles, the complex verticalites generated by heterophony in gamelan, the canons and triadic parallelism foundational to several African traditions—or it is true if one adopts a very inclusive definition of Western art music, embracing every style it has touched: bluegrass, tango, jazz, Bulgarian choral music, Afropop, Nordic death metal, K-pop, and so on. The idea behind Harder's statement can be traced back to the racist world-music classification system of F. J. Fétis,[18] whose restrictive formulation sought to prove the aesthetic superiority of European music, allowing room for neither the contrast of different styles nor the tracing of continuities.

Harder's insistence of the centrality of harmony also tends to mischaracterize the nature of Western art music: "[D]uring the eighteenth and nineteenth centuries composers were so preoccupied with the expanding harmonic system that other musical elements—particularly rhythm—were neglected."[19] This statement appears in the third edition of 1974, and one wonders how this has been allowed to stand through the subsequent releases of the text. Did Harder feel he needed to dismiss rhythm in order to justify his exclusion of it in the textbook?

Another potentially misleading statement occurs in a chapter introducing the fundamentals of chorale-style part writing. Harder states that "much of the music composed since the middle of the eighteenth century is based on a four-part texture. The utility of this texture has been proved by more than two centuries of use." A comprehension question duly follows: "The texture that has prevailed as the basis of much of the music of the last 200 years is the ___-part texture."[20] A student working through this frame who had never produced a harmonic reduction of a full score could easily misunderstand Harder's point and believe him to be insisting upon two hundred years of nothing but Bach-style chorales, a point easily refuted by attending ensemble rehearsal or studio class. Telling rather than showing only further alienates music theory from the repertoire it purports to serve.

Skinner's error

Perhaps a larger pitfall of using *Harmonic Materials* is that a student could easily get the wrong impression of the task of theorizing. The vast majority of the text

18 Radano, and Bohlman (2000, 17-18).

19 Steinke and Harder (2010, vol. 1, 1).

20 Ibid., 55.

comprises low-level fill-in-the blank exercises, while more advanced activities are limited and lack variety. Distressingly, the text designates compositional and listening activities as "supplemental" rather than central. In other words, there is a significant gap left between textbook and the NASM standards for analytical and creative skills.[21] An experienced teacher with firm learning goals in mind might welcome the opportunity to fill that gap with his or her own materials, but a novice instructor might allow the text to become the course, leaving the more far-reaching goals of music theory instruction unmet.

This gap is largely a result of the text's grounding in Skinner's teaching philosophy, which originally emphasized efficiency of knowledge transfer. Skinner believed that his teaching machines would allow a single teacher to more effectively teach content to more students with less effort and in less time, and that a student could learn twice the amount of content in half the time.[22] Skinner's educational ideology arose to national attention amidst Cold War anxieties regarding the effectiveness of American education. In the mid-1950s, programed instruction was largely limited to military training, but acquired advocates for its more widespread use in public schools following the National Defense Education Act of 1958.[23] But by the early 1960s, criticisms of programed instruction were already beginning to accumulate, and over the next two decades the method disappeared from American curricula. An article published in 1991 introduced programed instruction by remarking that "most people think of it as a fad that died."[24] Skinner later blamed the rejection of programed instruction on educators' misguided attempts to promote problem-solving, research skills, and inquiry instead of mastery of facts.[25] However, the reason for programed instruction's failure may be simpler. Skinner's teaching machines did not actually result in the educational gains he claimed. Multiple studies showed that the apparent advantages of programed instruction, such as learning through question-and-answer activities, self-pacing, and immediate feedback did not significantly boost content acquisition.[26] The studies indicated that students using programed instruction were no better off

21 See Part VIII, Section B., "Common Body of Knowledge and Skills," NASM Handbook 2016-2017.

22 Skinner (1958, 971).

23 Tröller (2013).

24 Vargas and Vargas (1991).

25 Skinner (1986).

26 Feldhusen (1963), and Kulik, Schwalb, and Kulik (1982).

than those taught by traditional materials in terms of their content knowledge. And, while a chicken or a dog seemed continuously engaged by the minute shaping of their behavior by constant positive reinforcement, human learners became quickly bored with long series of questions that were constructed so that the correct answer was always apparent.[27]

Harmonic Materials is highly rated by readers on Amazon, despite its outdated content and its tediously painstaking presentation. The only consistent complaint seems to concern the price, which is a whopping $162 per volume on the publisher's website. User reviews indicate that many of the people who buy it are trying to refresh or relearn basic principles of harmony in order to pass graduate entry exams, so the exorbitant cost might be worthwhile if it allows a student to pass out of a full graduate course of remedial theory. As anyone who has graded graduate entry exams knows very well, shockingly little of what students learn in music theory is retained, even from good students who have been educated at good schools. While self-study resources such as Steinke and Harder can provide a timely intervention immediately prior to a test date, it seems that students might be better served by music theory courses that were explicitly organized to promote deep learning and information retention instead of coverage of content.

In 1958, Skinner could claim that "there is no evidence that what is easily learned is more readily forgotten,"[28] but a growing body of research now supplies that evidence.[29] Counterintuitively, it appears that students learn best under conditions that are the opposite of that which Skinner tried to create through programed instruction. A 2003 study found that students more successfully learned the underpinning concepts in problem-solving scenarios after they had struggled with an impasse. Surprisingly, the study also found that learning was rare in the absence of an impasse, despite the tutor's direct instruction.[30] The educational researcher Manu Kapur also found that the process of struggling through a difficult problem leads to deeper learning, even if the immediate results are incorrect. These studies suggest that the cognitive effort involved with struggle and the exploration of different pathways—what Kapur calls "productive failure"—leads eventually to a heightened ability to transfer skills and retain information. Conversely, a streamlined learning process that produces positive

27 Reed and Hayman, (1962), and Rigney and Fry, (1961).

28 Skinner (1958).

29 This evidence is summarized in Brown, Roediger III, and McDaniel (2014, 67-101).

30 VanLehn, Siler, Murray, Yamauchi, and Baggett (2003).

results quickly can become what Kapur calls "unproductive success," after which learning may fade or fail to transfer to other contexts.[31]

Music theory pedagogy in 2018 faces a different set of challenges than it did in 1968. How can we balance heritage content with current trends in the field? How can we teach a theory that is inclusive of all music? How do we engage learners who bring to their education a diversity of backgrounds, goals, and interests? What is the role of technology in learning? How do we foster deep learning instead of the "unproductive success" associated with plug-and-chug workbook exercises? What do we really want students do to show their music theoretical knowledge? Perhaps the time has come to step away from the old textbooks, which due to overly cautious editors and imaginary market forces seem obligated to offer different flavors of the same content and methods we have been teaching for the past three hundred years. Our students deserve more than to become tic tac toe-playing chickens, expertly performing tasks that are meaningless to them.

31 Kapur, (2008). Kapur presented two groups of students with tasks that were slightly beyond their ability level. The first group received well-structured problems that were written so that the problem was immediately apparent and solving it involved applying rules and principles in predictable ways. The second group received ill-structured problems, which were more like case studies, where students had to sift through multiple documents in order to determine what the problem was, what information was relevant, and what tools could be used to solve the problem. The initial results of the study were unsurprising: students in the well-structured group were successful at identifying the problem to be solved and in strategizing a solution in a relatively short amount of time. In contrast, the students in the ill-structured group found it difficult to identify the problem, instead engaging in chaotic discussions that involved multiple analyses of the problem and critiques of their analyses. While the students in the ill-structured group failed to arrive at the correct answer, post-tests revealed that they outperformed their peers in solving both well-structured and ill-structured problems. See also Kapur (2016).

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