Journal of the Association for Technology in Music Instruction

Volume 5 | Number 1 Article 3

2025

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Recommended Citation
Kaiser, Jeff (2025) "Developing a Curiosity-Centered Pedagogy for Music Technology," *Journal of the Association for Technology in Music Instruction*: Vol. 5 : No. 1 , Article 3.

Available at: https://trace.tennessee.edu/jatmi/vol5/iss1/3

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Journal of the Association for Technology in Music Instruction

Vol. 5, No. 1 (2025)

Developing a Curiosity-Centered Pedagogy for Music Technology

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ABSTRACT

Two of the foundations of learning are attention and active engagement, the latter being "an algorithm also called curiosity" (Dehaene 2021, p. 145). Curiosity is fundamental to being human, encourages exploration, and when curiosity is engaged, optimizes learning. We know that a person who is not engaged does not learn as much "because learning requires an active generation of hypotheses…" (Dehaene 2021, p. xxvii) as well as testing and refining these hypotheses through exploration. Curiosity motivates and deepens this process.

In music technology, we have the attention of our students, as the relevance and meaningfulness of our area of study are readily apparent in popular culture and are hopefully made even more clear in the classroom. Knowing this attention is present, I will explore how we can use music technology to best engage the algorithm called curiosity and increase the level of active engagement. Contrarily, I will interrogate and give examples of how we—as professors in programs focusing on music technology—can crush curiosity in students and how to avoid this.

Introduction: A Pedagogy Lacking Curiosity

In my first year as a tenure-track professor, I taught our introductory-level digital audio production course. As many of you have taught similar courses, you understand the amount of material that is traditionally covered. In particular, I remember giving a lecture on compressors, presenting in great detail about ratios, thresholds, attack/release, look-ahead, knees, make-up gain, as well as RMS and peak differences. Of course, I went into different designs, including optical, VCA, FET, and more. I also covered aesthetic considerations as well as sidechaining, parallel, and serial compression. The students, of course, had to include compressors on a project over the weekend, and I then gave a test on compressors the following week.

There were several things happening here I will admit: I needed to feel like I had covered everything that I believed students should know, I felt I needed to cover material that would tell my colleagues and administrators I was doing my job, and part of me even felt compelled to show off that I knew all these things. The students wanted to feel like they had a good professor who knew their stuff, that they were learning materials that would be taught at a good school, and that the material covered was pertinent to their education and careers. These aspects of metacognition, at that time, defined for me what comprised a "great lecture." And surely meeting these goals would put me in the hall of fame for great lectures on compressors. I even posted on social media that I had, indeed, given a great lecture on compressors.

Jump to the next semester when these same students were in the advanced production course, and their professor asked me if I had taught compression, as the students were not using compressors properly and did not seem to understand them. As one does, I broke out my slides and their tests and showed them both to the professor. We shrugged and chalked it up to the students not remembering. Later that semester, I had a similar discussion over the question, "Did you teach automation?" which I had, indeed, taught in very great detail and still had my slides and tests to prove it. This time, however, the discussion included a student who told the professor that I had never taught automation. I pulled out that particular student's exam on automation to show the professor I had not only taught automation, but the student had done quite well on the test…which they did not even remember taking!

What was missing from my "great lecture" was an absolutely critical component of teaching: what was being learned and retained. What did it even mean to learn, and how does learning take place? I had fallen into a teaching model that relied primarily on my knowledge and authority.

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Confluences

There is an interesting confluence of the neuroscience of learning and radical pedagogy regarding the idea of how we learn and how we teach.

In the late 1960's, educator and critical theorist Paulo Freire wrote in his book, *Pedagogy of the Oppressed*, about the failures of a learning model based on what he referred to as "banking," where educators functioned as bankers, with students being passive recipients of "deposits" of knowledge (Freire 2000, p. 72) which the educator would then test on how the recipient student "records, memorizes, and repeats" the information (Freire 2000, p. 71). Freire unpacked this process in the classroom, writing:

> the teacher teaches and the students are taught;
> the teacher knows everything and the students know nothing;
> the teacher thinks and the students are thought about;
> the teacher talks and the students listen—meekly;
> the teacher disciplines and the students are disciplined;
> …the teacher confuses the authority of knowledge with his or her own professional authority. (Freire, 2000, p. 73)

Freire contrasts the banking model with the model of "problem-posing," where students and teachers are active co-constructors of knowledge in a critically engaged space, writing "Banking education resists dialogue; problem-posing education regards dialogue as indispensable to the act of cognition…Banking education treats students as objects of assistance; problem-posing education makes them critical thinkers…" (Freire, 2000, p. 83).

In 2020, some fifty years later, cognitive neuroscientist Stanislas Dehaene wrote about how we learn in his book, aptly titled, *How We Learn: Why Brains Learn Better Than Any Machine…for Now* (2020). While the language Dehaene uses is from the perspective of neuroscience and not so overtly politically driven as Freire, he has similar ideas as to how best to learn, which he (and others) refer to as an "active engagement" component (Dehaene, 2020, p. 177). This active engagement is related to Freire's thoughts that the students must be actively involved with the construction of knowledge, not passive recipients of information.

Dehaene also addresses the question "What is learning?" as it needs to precede all discussion of what should go on in the classroom. How can we know how best to learn without a conscious, explicit, and refined definition of what is learning? Many of us went to schools where the definition of learning was not only vague, but the success of learning was defined by the ability to answer correctly ("records, memorizes, and repeats") (Freire, 2000, p. 71) on quizzes and exams. Dehaene starts his first chapter with a general definition of learning, the first of many definitions: "To learn is to form an internal model of the external world" (Dehaene, 2020, p. 5). What we learn, in this sense, becomes part of us. What we learn is related to what we are doing in the external world, and as it relates to what we are doing, it is reinforced by activity and has an increased possibility of retention.[1]

Focusing on this definition, how do these internal models happen? What encourages them, and what discourages them? What helps correct them, and what helps retention of the internal model?

Dehaene has Four Pillars of how we learn: attention, active engagement, error feedback, and finally, consolidation (Dehaene, 2020, p. 145-146). These pillars, in aspects and different names and varieties, are shared by others in neuroscience.

The first pillar, attention (i.e., what we need to attend to), is the algorithm that is also related to relevance. According to scholar David Eagleman in his book *Livewired: The Inside Story of the Ever-Changing Brain*, things considered relevant jump to the forefront of what is important to learn (Eagleman, 2020, p. 149). Things that grab our attention are the things that seem relevant and want attention. As Dehaene writes about attention, it "refers to all the mechanisms by which the brain selects information, amplifies it, channels it, and deepens its processing" (Dehaene, 2020, p. 147). All these things happen in the midst of us being "bombarded" with information that is vying for our attention, not just special interests deemed relevant, but all of our regular senses that are involved with human activity from moment to moment. There are several "attention systems" that include, among others, ideas of when (alerting), what (orienting), and how (executive attention) (Dehaene, 2020, p. 150). In our field,

[1] Dehaene follows with other definitions of learning, which I will not be expanding on, but I think are quite thought-provoking, "learning is adjusting the parameters of a mental model," "learning is exploiting a combinatorial explosion," "learning is minimizing errors," "learning is optimizing a reward function," "learning is restricting search space," and "learning is projecting a priori hypotheses" (Dehaene, 2020, pp. 5-26).

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the idea of what to attend to, which "amplifies any object of interest" (Dehaene, 2020, p. 150), is of special note, and how this attention is optimized in our classrooms (regarding the technologies taught) becomes worthy of our attention as professors. The question then becomes, is our external statement of authority ("you need to know this") enough, or is it the students' internal sense of relevance that drives attention?

Strangely, teaching from authority can make everybody feel like they are learning, and we as professors get a moment to show off the depth of our knowledge. This was the dynamic playing out in my lecture discussed in the introduction, a dynamic that has been the subject of research in recent years. One such study has a title that says it all: "Measuring actual learning versus feeling of learning in response to being actively engaged in the classroom" (Deslauriers et al., 2019). Students may at first feel like they learn more in a traditional classroom (lecture) than in an actively engaged classroom. The study shows that "a superstar lecturer could create such a positive feeling of learning that students would choose those lectures over active learning" (Deslauriers et al., 2019, p. 19256). However, the study also found that students learn and retain more (actual learning) in an active environment, even though the extra effort the students expend to learn in an active environment they may "initially take…to signify poorer learning" (Deslauriers et al., 2019, p. 19251).

STEM teachers will frequently still default to the lecture model, which may be influenced by this sense of "feeling" and "that students resist active teaching strategies," "complain about forced interaction," "resent the increase in responsibility for their own learning," and complain that students working with students is wrong: "the blind can't lead the blind." There is hope for changing these attitudes, as this same study offers a strategy to improve the reception of active learning methods, showing that if the professor takes the time to explain the pedagogical goals and methods of active learning, the students' opinions can change (Deslauriers et al., 2019, p. 19251).

A Pedagogy of Curiosity

After I read these studies, I decided to switch my methods of teaching the topic of compressors from a lecture format to an active, problem-solving learning model and leave the content more ambiguous in the hope of setting up curiosity, discovery, and discussion. Changing

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my teaching method was a challenge, as I had to leave behind the goals mentioned earlier about coverage, colleagues, students' desires, and me showing off.

In the chosen class, towards the end, I casually mentioned that students should try compressors to help control sonic material that had too wide a variation between the loud bits and soft bits, so that the compressor could make it more usable in a mix. After adding a compressor plugin to an example track, I showed the students only three things: crank the ratio up high, set the gain to auto-makeup, and then mess with the threshold while playing back the material. I then gave them a mixing assignment over the weekend and asked them to play around with compression and explore different models of compressors. The introduction to compressors was a few minutes as opposed to the entire class time, and left the material ambiguous.

Students returned to the next class excited about compressors, many with joyous discoveries, ways to be subtle or radical with compression, preferred compressor models, and more. We had a rich, experience-based discussion of the possibilities of audio compressors. The great details of the topics that I had presented in the earlier example in pure lecture format ended up being discussed and shared organically by the students and me. It was a great discussion, and learning had taken place.

As we learn in such moments, learning is related to play, and lectures are not play. Lectures are a form of content transfer where we state explicitly what is going on in our tech. Studies, however, show that lectures of "unconfounded" information that "disambiguates" the content (Schulz & Bonawitz, 2007) can limit the "exploration and discovery" by students and therefore lectures can limit what is learned and retained (Bonawitz et al., 2011, p. 3). Dehaene and others note that a form of learning that focuses on curiosity, i.e., discovery and exploration, may lead to higher retention of the subject matter (Bonawitz et al., 2011; Dehaene, 2020, p. 181).

Avoid the Crush

How do instructors crush the curiosity that can aid in learning and retention, and how can we avoid doing it? We, as educators, need to focus on the role that negative emotions play in the learning process and consider these issues beyond the content that is being covered in the class. As Dehaene writes,

> Negative emotions crush our brain's learning potential, whereas providing the brain with a fear-free environment may reopen the gates of neuronal plasticity. There will be no progress in education without simultaneously considering the emotional and cognitive facets of our brain—in today's cognitive neuroscience, both are considered key ingredients of the learning cocktail. (Dehaene, 2020, p. xxiii)

Some of these fear-inducing, negative-emotion generating elements of the classroom that "crush" the curiosity of students have been mentioned in passing, but a few more exist.

Rigor

False ideas of rigor growing out of ideas of authority, coverage models, and pedagogy not rooted in what we now know about humans and learning can reinforce negative emotions about learning and even invoke reactive counter-ideologies about education in general. Pedagogically, instructors can use rigor as an empty argument for the perpetuation of past ways of teaching: "I was taught it this way, I know this topic, and I'm rigorous," so doing it "this way" is what defines rigor. These arguments create a logistical and structural rigor that support a checklist for the memorization and repetition of the elements the professor assigned in the syllabus and rubrics. This form of rigor does not encourage exploration and discovery, but the checking off of boxes. While some critics believe active learning leads to a loss of rigor, others argue that active learning increases rigor; this conflict of opinions is something referred to as the "rigor wars" (Supiano, 2022). If we see rigor not as an external structure we impose upon students but as an internal creative and intellectual process that is informed by self-reflection, self-testing, collective construction, and collective "error feedback" that we encourage through the educational environment we set up (Gannon, 2023; Jack & Sathy, 2021; Supiano, 2022), then rigor builds on the centering of curiosity and what we know about how humans learn. Through this centering of curiosity, we create an environment that deepens the learning process, leading to the creation and retention of strong internal models.

Coverage Model

Overwhelming students by presenting too much unidirectional material (from lecturer to students) because we think they need to know it, decreases the quality of learning and limits the deepening of the internal model. An interesting toy study that dealt with the idea of the quality of play, defined quality play as "sustained play…with longer durations and…more variety in the manners of toy play" (Dauch et al., 2018). If the child has too many toys, it decreases the quality of play (Dauch et al., 2018). (Think about this idea of too many toys in relation to how many DAW plugins you might have.) I would suggest that courses be designed in reverse (i.e., "backward design"). In reverse design, you first identify desired goals/results you would like to see, determine what is acceptable evidence of those results, and then build activities into the class time that will reinforce the results (Wiggins & McTighe, 2005, p. 254). This design process is the opposite of the "coverage model," where we first create a list of topics/content we would like to cover. With the coverage model, density becomes problematic because, much like our DAW plugins, we always have too much content. At least in my experience and observation of others, the density of material to be covered traditionally drives the course structure, limiting time for curiosity, creativity, exploration, and discovery. The coverage model also falls into the learning problem of "disambiguated" content: if the content is delivered unidirectionally and disambiguated, the student no longer needs to explore, another way to halt curiosity.

Talking Too Much and Entangled Metacognition

When we teach, we are giving attention to the knowledge of the students (Dehaene, 2020, p. 171). We are in a constant mode of metacognition, thinking about our thinking and thinking about our students' thinking. And the student is thinking about their thinking and thinking about the professor's thinking. I refer to the above idea as entangled metacognition, which has the potential to create powerful positive connections between us and our students—with the equal potential to create negative connections. In attending to our students' knowledge, we harken back to our own fears and concerns about what they need to know. We have our own fear that we are not covering what is necessary for the students' future success in both coursework and jobs, and we worry about what our colleagues and administrators think about what we are doing.

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What is often missing is an examination of the efficiency of learning. What cognitive science teaches us is that the unidirectional presentation of content (i.e., talking too much) is not efficient, and can limit retention in addition to limiting the aforementioned curiosity. This inefficiency can also trigger the student's own fears,

> Metacognition remains the main culprit [for students who struggle]: after a while, they no longer have any reason to be curious, because they have learned…that they do not succeed in learning…Such dismay is not uncommon: many girls convince themselves that mathematics is not for them, and children from underprivileged neighborhoods sometimes come to believe that school is hostile for them and teaches nothing useful for their future. (Dehaene, 2020, p. 194)

Lectures do not help mitigate these fears but reinforce them. We need to uplift and restore students' self-confidence by providing problem-solving models (i.e., projects), such as Freire mentioned, that are tailored to the students' level and challenging enough to engage their curiosity but not so challenging as to ensure defeat: models where the students feel the reward of success in problem-solving brought about by their curiosity and discovery. We can then work to restore positive metacognition.

The stereotypical lecture model can discourage thinking (and also participation) by enforcing sitting in non-participative silence, which punishes curiosity (which is active). We then demand that the students participate at random moments to answer questions in the midst of our simultaneously asking them to sit in silence.

> The neurophysiological interpretation of this situation is simple: within the dopamine circuit, the reward signals induced by curiosity and its satisfaction compete with external rewards and punishments. It is therefore possible to discourage curiosity by punishing each exploration attempt. Picture a child who repeatedly tries to participate and is systematically reprimanded, mocked, or punished…This child quickly learns to inhibit their curiosity drive and stop participating in class… (Dehaene, 2020, p. 195)

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Questions and discussions need to be nurtured and encouraged, which rewards the students' curiosity. This time spent on participation might necessarily diminish the amount of material we can cover via lecture.

Laura Schulz is a professor and researcher in the Center for Brains, Minds and Machines at the Massachusetts Institute of Technology, specializing in human cognition in early childhood. Schulz studies the fundamentals of human learning through, among other things, interactions with toys. Studies of early childhood learning are applicable to other age groups because they provide insights into the fundamental principles of the way humans learn. Toy studies may seem superfluous to college professors, but they emphasize cognitive processes as well as human/human and human/technology interactions that have a powerful effect on learning. How children learn can inform how learning takes place at any age, of course, with the understanding that we will need to adjust the content and methodologies to make the classroom environment age-appropriate.

Schulz created a really fun study where she presented a multifaceted, uniquely constructed toy and taught the children about one facet of that toy, that it could squeak (Schulz & Bonawitz, 2007). She then made an excuse and left the room. The children grabbed the toys and made squeaks. But they did not explore other functions. They just squeaked away. For a different group of children, she bumped into the toy and it squeaked, she then asked, "I wonder what else it can do?" and then made an excuse and left the room. With curiosity triggered, in her absence the children explored and discovered the many facets of the toy and shared their discoveries with each other.

This study shows that students, when they were shown what to do, stuck with what they were taught. They did this for many reasons, including the idea that the teacher presented the material, the teacher is the authority, and so this is what you do with the toy. Students, when let loose, fueled by their individual and collective curiosity, discovered so much more.

Grades and Error Feedback

Although error feedback is a part of teaching, testing can run the risk of crushing curiosity, as tests reinforce knowing the material within the confines of what is being covered. If the student learns the data necessary for the test and puts the data in the required location of the exam, a good grade is given. Testing that encourages curiosity reinforces values of creativity, especially error feedback that happens in close proximity to the activities. Grades and comments given weeks (even days) later are not as helpful.

Also, talk less. For me, I would suggest limiting the lecture time to a maximum of 50 percent of class time in total and have student presentations and activities take up 50 percent of the time, keeping “error feedback”—as both self- and collectively-driven—close to the activity. For example, in my class, which is held two days a week, Thursday is lecture/discussion, and the introduction of assignments. On Tuesday students present their work in the class for a critically engaged discussion. This type of error feedback, “critical engagement,” encourages creativity. Critical engagement refers to the process of having students help each other to find what is critically important in their project and how to best bring that out. “Critical engagement” is my preferred term, as terms such as critique and criticize are frequently perceived as “finding fault,” which can be a curiosity crusher. This type of error feedback is not only a great skill for a tech environment but is one that can lead to better critical thinking and help later in life, as noted in a study by Google that placed critical thinking above STEM skills.

> [A]mong the eight most important qualities of Google’s top employees, STEM expertise comes in dead last. The seven top characteristics of success at Google are all soft skills: being a good coach; communicating and listening well; possessing insights into others (including others different values and points of view); having empathy toward and being supportive of one’s colleagues; being a good critical thinker and problem solver; and being able to make connections across complex ideas. (Strauss et al., 2017)

For grading, I use a variation of Labor-Based Grading as developed by professor and author Asao B. Inoue in his book *Labor-Based Grading Contracts: Building Equity and Inclusion in the Compassionate Writing Classroom* (Inoue, 2023). This method focuses on the amount of labor done in the classroom and on the assignments, where being critically engaged becomes a valued part of the work.

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Conclusion

Letting go of control (authority) has had positive repercussions in my courses, leading to classes that surpass my expectations.

So much curricular design is focused on details about what will be covered in the course. As music technologists, we love the tools of our technology, from software to hardware, and equally, we love talking about these tools. This is frequently what course design for music technology is: talking about our tools while turning knobs and sliders with a few projects along the way. But I argue that we need fundamental thinking about "what is learning" and "how we learn" before we even start designing our music technology courses. We need to allow these pedagogical ideas to influence the course design beyond a list of content covered, and we need to regularly challenge ourselves by the constantly expanding field of research in learning and neuroscience, and how our course design reflects this research. We need to always remember: pedagogy needs to be before content.

Two of the foundations of learning that I explored are attention and active engagement, the latter being an algorithm that can also be called "curiosity" (DeHaene 2020, p. 145). In music technology, we have the attention of our students. Generally, students want to be in these classes as this is not an obscure and rare field: the relevance and meaningfulness of our area of study are readily apparent throughout popular culture and are hopefully made even more clear in the classroom. Knowing this attention already exists, I explored possible ways we can best engage the algorithm called curiosity in teaching technology and increase the level of active engagement of our students in the classroom.

"Curiosity is a fundamental drive" (Dehaene, 2020, p. 187) of being human, and when curiosity is engaged in the classroom, learning is optimized. We know that a passive person "learns almost nothing because learning requires an active generation of hypotheses," (Dehaene, 2020, xxvii) as well as testing and refining hypotheses through exploration and error feedback. Curiosity has the power to motivate this process of testing and refining (Dehaene, 2020, p. 187). Curiosity keeps students and professors exploring, helps us to maintain relevance, makes us responsive to growing and changing diverse musical educational interests, positively introduces

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students to possible futures, keeps the focus on creativity and fun, and curiosity never dismisses the value of joy in what we do.

Conversely, as professors in programs that focus on music technology, we have the power to crush students' curiosity with our teaching methods. One way to avoid crushing students' curiosity is to understand that we, as professors, are not conduits of knowledge but facilitators of the collective construction of knowledge. For this reason, we must first and foremost maintain curiosity in ourselves and our students to optimize that collective construction.

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