# AI in Music Education: A Constructivist Approach

## A Literature Revi

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## Introduction

Artificial Intelligence (AI) is a highly controversial topic in academic circles. While some professors refuse to acknowledge its existence and discourage students from using it for any coursework, others tailor courses to encourage usage of AI. The author of this paper, a musicology professor, has chosen a middle road regarding AI, with some use but not full use, to create a holistic experience for students that acknowledges their current experience in a technological world. The author's limited experience with AI in music education led to a curiosity to know more about this new technology, and to learn to integrate it as part of a constructivist learning approach in my courses. Thus follows the research question: *How can AI be used in a constructivist approach to music education for university music students?*

## Constructivism and the use of AI

Constructivist Learning Theory (CLT) posits that learning experiences are constructed by a learner though activity and based on new experiences as well as their own existing knowledge. Piaget's research about how children learn theorized that people learn by connecting their experiences with ideas presented to them (Kimmons and Caskurlu, 2020). Rather than being passively absorbed, knowledge is constructed through active learning, social experiences, occurs in the mind, and is driven by motivation (Kimmons & Caskurlu, 2020).

To wit, there are different kinds of CLT. Cognitive CLT is a form in which students make sense of new knowledge by incorporating it into their existing knowledge and experiences to that point. Radical CLT leaves the learning construction almost entirely in the hands of the student and asks the instructor to create opportunities for the student to learn in self-directed manner, which may differ based upon background and experience. Social CLT implies that interaction is key in education and that people glean knowledge from individual relationships, their culture and

environment, as well as their role within larger communities (Kimmons & Caskurlu, 2020). Thus, AI can be used in this important branch of constructivism, as it is part of a learner's interaction. The following literature review seeks to show this, and will begin with a review of the significant research regarding constructivist learning in music education.

## Literature Review

### Constructivism in Music Education

Constructivism, particularly the social variety, has long been viewed as a positive force in music education. While diversity of opinion exists as to its value, the research has shown that a CLT approach to music education creates an interactive learning atmosphere in which students are key stakeholders in their own learning experience. This is detailed and discussed by Morford (2007), as well as the question of what the educator's role should be in constructivist post-secondary music education. Morford emphasizes that the student's interaction with the subject matter should be the focus of learning, not the content itself. The instructor therefore has a collaborative role with the student; their work is "promoting an environment in which pupils can acquire knowledge through investigation of relevant questions" (Avriham, 2000, p. 476). Morford also addresses potential conflict surrounding CLT, as CLT must be driven from internal motivation by the student. However, to maintain relevance and motivation, Morford implies that the subjects must be chosen by the students, who may not have the same learning goals as university administrators and outside governing bodies (Morford, 2007). In most American universities, music students are required to take predetermined courses such as music theory, history, counterpoint, ensembles and private lessons – and this may be in direct conflict with a constructivist approach based on internal motivation and relevance for the students. One hopes that curricular design has been well considered as to what students need to be successful in a

musical career. Morford suggests that rather than following an outside entity's curricular requirements (such as National Association of Schools of Music), that instead, subjects "…might exist as a self-constructed, active expression of the subject matter with which the student chooses to engage" (Morford, p. 80). Morford does not offer practical suggestions as to how this might be accomplished, while acknowledging that change such as this is slow and arduous, and suggesting that American universities must consider a fundamental shift to this model. Morford notes that constructivism is best approached in the individual classroom rather than the curricular level, and then addresses how CLT applies to studio lessons. In an outline by scholar Zarro (2003), a CLT approach to the private studio lesson included student "buy-in" by engaging students to choose their own repertoire, how many hours they will practice (keeping a journal of such to indicate progress), taking part in group lessons which focus on a certain composer, time period, technique or work, and encouraging students to find their own interpretations of work and compose their own, if helpful. This is in direct opposition to the traditional model of studio teaching, in which the instructor makes all decisions about the factors listed above, and interpretations are often based upon previously existing models. In conclusion, Morford encourages the use of CLT in small-scale environments such as the studio and classroom, but has no answers as to how constructivism might be used in large- scale curricular ways, indicating that it may not be possible.

Scott (2011) lays a further foundation for understanding CLT within a music education framework. In this article, Scott addresses CLT at both the higher education level, where future music teachers are trained, and at the K-12 level, where those same students become instructors to their own students. Scott begins by providing background upon the founders of cognitive constructivism, including Piaget (Piaget, 1966) and Dewey (Dewey, 1966), and differentiating them from Vygosky's theory of social constructivism (Vygosky & Luria, 1930) which suggests

that “learning is a process of social integration in communities of practice” (Scott, p. 192). Moreover, Scott believes in a synthesis of these two types of CLT, and references research supporting this from Cobb (2005) and Windschitl (2002). Like Morford, Scott firmly supports the reform of education curriculum through a constructivist lens, and yet also sees the challenges of instructors moving from a traditional to a CLT curricular model. CLT requires a different kind of advanced preparation, in the form of posing analytical questions to students based around an activity. Suggestions as to how this might be accomplished include watching a video of a choral concert in which students sang, and posing questions to the students about the quality of the concert, what could have gone better, audience engagement, etc. This is in contrast to the traditional approach of students participating only in rehearsal practice, which by nature involves repetition but may not involve critical thought and engagement with past learning experiences, a key foundation of CLT.

Scott acknowledges that music education, especially at the K-12 levels, does involve some form of repetition for learning. Students often listen to a phrase, or watch a teacher play the phrase, and then repeat it to learn it. While Scott believes repetition can be useful, Scott does not believe it is the best educational tool, and that CLT learning might include the instructor asking students critical thinking questions such as, “Why do you think we should end the piece with a glissando in the soprano” (Scott, 2011, p. 194)? Scott encourages support for higher education instructors, especially those who are teaching K-12 future educators, in the form of release time to rework courses, voluntary training in CLT, and in-service opportunities. Scott also suggests the renaming of certain required courses to better reflect a CLT approach, such as changing the title “Methods for Teaching Elementary General Methods” to “Teaching and Learning in Elementary General Music” (Scott, 2011, p. 195). Scott proposes the design of a new course for future music teachers

called “School Music—Emerging Theory and Practice” (Scott, 2011, p. 195). This course addresses models of learning to better prepare students for the classroom and ways to apply the ideas in practice.

Shively acknowledges that his approach is specifically from a performance standpoint for instrumental music, then engages in discussion of the complexities of understanding constructivism, as it has been misunderstood by many educators. He gives examples of literature review research by Webster (2011), spanning 20 years, and Wiggins’ (2015) guidelines regarding learners and learning (for a list, see Wiggins, 2015). Shively notes that the specifics of a constructivist approach can be somewhat ambiguous, and that it remains the teacher’s decision to know what to keep or change in their current approach. In his study, Shively takes a moderate approach, neither discounting the traditional, teacher-centered approach, nor fully endorsing CLT, as it may need to be combined with other learning theories in order to produce results in differing circumstances, such as elementary music education.

Shively is clear that emerging trends in music education are often assumed to be constructivist in nature, but may not be. He gives the example that course offerings such as jazz, rock or mariachi band, while likely inclusive, may not be student-centered (Shively, 2015). Like Scott, he discusses the traditional ensemble model of teacher-centered conductor, and offers a CLT approach which involves student conducting, interpretation and discussion as well as traditional rehearsal. Shively emphasizes building upon what a student already knows and connecting it to new knowledge, rather than the new content being the sole focus. While this idea remains compelling, conflict may arise when the student simply has very little knowledge to build upon. For example, an elementary school student will begin with far less knowledge of music than a college music major. Thus, the question for the instructor becomes one of truly learning who their

students are, and what kind of scaffolding they must build upon. In a diverse and inclusive classroom, an instructor might include different kinds of music such as jazz, mariachi, pop, R and B, bluegrass, electronica, or K-pop, in order to connect students to a lesson about classical music (Shively, 2015). It is a subtle truth that the most incongruent styles of music nearly always have something in common, if the right scaffolding is in place for the learner.

Along with the benefits of CLT in music education, drawbacks are identified by Garnett, (2013). In it, Garnett specifically addresses a constructivist approach to curricula in the form of policy, and that while curricula may be based upon CLT principles, it does not necessarily garner constructivist results in the classroom. Garnett begins with an analysis of England's past approaches to music in conservatoires, which mostly trained the technique of performers, and universities, which considered music in a socio-political context as an academic discipline. He further details the implementation and reform of England's National Curriculum (for children aged 5-14) in 2010, an attempt to integrate these two disparate approaches to music and explains its features through a CLT lens. Examples included changing the definition musical learning from what students can do to what they can understand, the integration of activities such as composing, performing and listening, and the inclusion of diverse styles of music (Garnett, 2013).

Garnett's criticisms of the CLT-based National Curriculum include a lack of true constructivist principle, for as it claims to build student's understanding based upon experiences with music, the curriculum necessarily draws upon the knowledge of those who teach and write the course content. A second problematic area is the assessment of a CLT curriculum. As Garnett quotes, "… where assessment becomes focused on the outcomes of a particular task, the effect can easily be to concentrate on the student's demonstration of the particular task – their behavior – rather than on the understanding that gives rise to the behavior" (Garnett, 2013, p. 169) The last

area of concern in the National Curriculum that Garnett identifies is the increased focus on specialization of both the instructors and students (aged 14 onwards). The CLT goals combining composing, performing and listening are run roughshod when students then go on to specialize in one of these areas and are forced to eschew the others. Thus, Garnett speculates that the constructivist curriculum may collapse into a narrow behaviorist model guided by abstract concepts. While Garnett does not offer solutions to the problems he identifies, the study is nonetheless valuable for its detailed examination of CLT in policy versus practice.

## AI in Music Education

Constructivist principles such as those above integrate the social aspect of learning as an important tool. What if, however, the social learning and interaction was not limited to human beings? This is how we come to a meeting point between CLT and AI. The use of AI in music education, while growing since 1960s (Miller, 2003), continues to develop. New AI programs are available to help students learn how to compose, perform, and teach. These include Solfegg.io, which teaches a solfege system to students, Chordify, which quickly teaches chord patterns and EarMaster, which trains aural recall and recognition (Patterson, 2023). These are marketed to assist with, but not replace, the job of music educators. Some remain skeptical of this, while others tout the value of AI in making certain tedious musical tasks obsolete, such as finding chords and melodies that work well together, and brainstorming musical lyrics (Johnson, 2022). In fact, this is the tip of the iceberg, as the following studies seek to show.

The work of Zhang and Wan (2020) details the origins of AI in music education specific to China, and its beginnings in the 1960s with electronic keyboard sampling. This study is specific to the use of AI in courseware, as well as the live classroom. Examples of how AI is used in Chinese music education include performing tasks such as processing and analyzing music

(previously done by a synthesizer or musician), allowing students to play back a phrase their teacher has just played, and analyzing student performances in an ensemble setting. The AI courseware thus helps to support student learning in understanding diverse aspects of music. Zhang and Wan address the use of intelligent instruments (meaning electronic and AI enabled) to assist with specific tasks in music education.

In music teaching, the courses of composition, instrumental, analytical work and so on all adopt intelligent teaching methods, so that students can play, listen and modify at any time while creating, which improves the efficiency of students' creation (Zhang and Wan, 2020, p. 43)

This supports a CLT framework of interaction, building upon current knowledge and creative practices. Zhang et al., note that the use of AI in music education is limited to teaching certain subjects, such as music theory, pitch, and tone. Music history, depending on the courseware, might be included in this. However, when it comes to emotional expression and musical interpretation, human interaction is needed. Therefore, AI, while proficient at making certain educational tasks easier and more interactive in the online or in person classroom, cannot yet perform tasks that require emotional input and creative decisions.

In like manner, Yu, et al., (2023) detail a thorough study of the use of AI in music education, covering four specific points of practice. The first is the application of AI in intelligent instruments, such as an electronic piano. Compared with the traditional method of teaching the piano, this use of AI offers compelling opportunities for students, such as online performance, collaboration, self- evaluation, feedback loops from the teacher, and a much less expensive option in terms of cost compared to a traditional piano (Yu, et al., 2023). This firmly supports constructivist learning theory. The second point of discussion involves the application of intelligent music software. With this type of AI support, students can edit, adjust, process and play

back music that they have either composed or come into contact with. This allows students and teachers to collaborate with one another and for students to explore facets of music that interest them which may be outside of the teacher's knowledge base. This is a key framework of CLT. To this second point, Yu et al. address accessibility for non-traditional students, a situation in which AI can provide tremendous support, such as transcriptions for hearing disabled students, and auditory and motor cues attached to music (Yu, et al., 2023). This enables an inclusive teaching model and empowers such students to learn in new and transformational ways, another key foundation of CLT. The third point in the article involves the use of online learning and assistance, and what is called AI sparring. AI in this case is used essentially for instructional design of online music courses and to monitor and grade the results of assessments. All courses are connected to the internet, and can be taken on a desktop or mobile phone, with the ability for students to self-motivate and explore new areas of music as they learn; again supporting CLT. AI platforms in China include the Little Leaf piano application, which marks an incorrect note or rhythm during practice time with high levels of accuracy, and Artium in India, in which users can "track and improve their learning based on AI's immediate feedback and can perform regularly online in the Artium community" (Yu, et al., 2023, p. 42). The last area of discussion was the application of AI to autonomous teaching; Yu's article, however, was quite vague as to how this was specifically accomplished. It implied that teachers and students could engage in a more active learning environment either together or separately, but no specific teaching examples were given, which would have strengthened the article in general. Overall, this was a strongly written article with direct application of AI to the music education field. Here follows specific case studies of how AI is used within music educational systems, and the education of music students about AI itself.

Yuan, S. (2020) provides fascinating research in proposing a technology and music course which teaches students about the use of AI in their profession (see Figure A in Appendix for lecture topics). The course has three primary goals; the first is to help students understand the connections between music and technology and stimulate their interest in learning more – CLT based learning in action. The second is to assist students in problem solving and in asking "AI type questions" to obtain the answers (Yuan, 2020). Once again, this is a constructivist approach in that students begin exploring the material by asking their own questions. The final goal is to train music students in the use of AI, and best practices for its use.

Yuan identifies several areas in which AI can be helpful to music students, especially as it applies to music theory, a course which has practical applications to any music student. Multiple uses of AI are detailed in this study. The first use is in music retrieval, in which a small amount of information, such as a musical phrase or text is given to the AI, which then searches for additional information about the given section. The next is audio identification, in which the AI classifies and identifies a musical work, either from Chinese or Western art tradition, based upon its pitch classification and instrumentation. This is complemented by score identification, in which the AI has boolean operators which classify a score, based upon image graphics and selectors. The next area of focus is called algorithmic composition, in which the AI creates new music based upon the style of a certain composer and may focus on orchestration and accompaniment as well. The next area is analysis and recommendation of music, in which the AI formally analyzes the works based on image files of musical scores and provides the student with the musical style, compositional form and composer trends. The final area in Yuan's study is machine and virtual performance, in which Yuan discusses an AI called Musical Robot, which simulates playing an instrument through a digital platform – these are many and varied including piano, marimba, violin, etc (Yuan, 2020).

A second part of this study is the combination of live and simulated elements in an online performance platform – here Yuan gives the example of an air guitar virtual program designed by the Computer Science department of the University of Helsinki, which produces sound (Yuan, 2020). This was a very practical and interesting study, which had many implications for CLT as it encourages students to explore the many facets of AI related to music.

Other studies from both the North American and the Western world engage the use of AI less in the classroom but in the preparation of the course materials, and professional composition and performance. Regarding AI-produced sound, Zulić, (2019) presented research upon Yamaha's experiment with a keyboard that produced sound based upon the movement of dancer Kaiji Moriyama (Zulić, 2019). addressed AIVA, the first AI powered virtual composer who is registered with an author's rights society, and other possibilities along previous lines of using AI in the music field. Terrien & Güsewell (2021)'s study addressed the question of how teachers began using AI-assisted distance learning in music during the COVID 19 pandemic, difficulties and impact upon pedagogy of studio teachers, and what this experience was like for music educators. Cooper's (2024) study approached whether it was possible to distinguish music lesson plans generated by AI with those built by a human, using human music educators as assessors. The ultimate result of this study was that with a 55% accuracy rate, the assessors could not tell the difference between lessons generated by AI or humans though the human-built lessons contained a greater level of accuracy (Cooper, 2024). One wonders, however, if both faculty and students will have the motivation to acquire necessary skills of a professional musician or pedagogue when so much of it can be done for them by AI. Are musicians "AI"-ing themselves out of their jobs?

The answer may lie in statistical studies. Hong Yun, Z., et al, provide a relevant view on this, presenting an extensive literature review regarding the use of AI in both gameplay and music

education. In the literature review, several uses of AI, such as those detailed above, were addressed, particularly its use to composers who create music for gameplay. An extensive graph analysis is then shown to define all parameters of Fuzzy AHP, and the results of the study regarding the use of AI and gameplay in music learning. The study had its drawbacks – one being that the topic was somewhat unclear, as the authors seemed to use the terms "music education" and "use of music in educational games" interchangeably. The study results indicate that music was a key factor in helping students to interact on a deeper level with educational games, and that AI could be of great assistance to composers who are creating such music. In no way did the authors advocate for replacing composers with AI, but to use it as tool to help composers make short work of certain tasks, and to help students learn more effectively. This supports CLT as it encourages interaction and social learning based upon gameplay and the music that results from this.

A second case study of AI use is Yuan, Y's. study (2024), addressing the use of AI in the vocal curriculum of music, though in a looser sense than the abstract implies. In this study, Yuan gives a detailed history of the use of AI in music education, provides a thorough analysis of the algorithms used in typical AI programs for teaching music subjects, and proposes that applied music (private lessons) are ubiquitous. According to Yuan, in the future, these lessons will be driven by AI. While not giving specific examples of how voice lessons will be taught by AI (Yuan, Y., 2023) Yuan delves into the possibilities of intelligent instruments. This includes playing back accompaniment or melodies for teaching, analyzing and understanding the text to be sung, showing students where they have made accuracy errors in their singing, and having a broader understanding of music in general. Yuan addresses the work of other scholars in this area, including the work of Vasil (2019) who included popular and commercial songs into a high school music program to add variety and interest for the students. Yuan recommended the work of

Schiller et al. in 2019 who "…used a visual analogue scale to self-assess their own voice. VLI (Vocal Load Index) and self-evaluation data were correlated using Spearman correlations" (Yuan, Y., 2023, p. 12). This allows for students to engage in further CLT, with self-assessment as well as discovery of new information. The results of this AI driven approach to vocal music were impressive in that nearly all students were highly engaged in the vocal course (please Figure B in Appendix for results.) Vocal technique and how this might be taught by AI, however, is not addressed at all in the study, nor how vocal modeling would work. Nor was there an AI-driven mechanism to judge the quality of the student's singing, merely whether or not they sang the notes accurately. This author believes that human emotion, interpretation and interaction is necessary for holistic student growth, and suggests that more work must be done in these areas before applied lessons can be fully driven by AI.

Within this context, the last study of Lv (2022) addresses a flipped classroom with use of stylus-driven AI, and results gained from a control group and an experimental group of piano students. Lv begins with an excellent literature review of different forms of AI driven music learning; the studies thus far indicate that AI works best in a classroom and indicates greater student engagement but not necessarily better learning outcomes. A point of note: one study showed that applied lessons in Turkish music were inconclusive as to what students were learning, as they may have been learning the music solely by ear than by reading it, a critical musical skill (Lv, 2023). Lv undertook this study to determine if learning outcomes would be higher in the stylu- driven AI experimental group than the control group, and results indicate that this was the case (see Figure C in Appendix for results). An example of how the stylus-driven AI worked follows here:

After completing the lesson, the students were shown a feedback window about their work, as well as a report window. Each validation criterion included specific details associated with it. For example, if he user drew a note at the wrong position or the wrong duration, wrote the wrong clef or key signature, or entered the wrong number of beats in a particular measure, the detailed feedback of the criteria checks pointed this out (Lv, 2022, p. 15307).

The results of the study indicated that the experimental group performed significantly higher on a final assessment (also given at the start of the study) at a mean rate of three points higher in the experimental group than the control group. It should be noted that in the same assessment, give at the start of the study, the experimental group achieved higher scores by two points than the control group. This begs the question of whether the students in the experimental group were simply more academically inclined to begin with, though the improvement of the point value is significant. Thus, it appears that learning outcomes were better achieved in this case by the use of AI stylus driven technology. This is both exciting, encouraging, and provides food for thought in terms of the educational future of piano courses in China and the world.

## Conclusion

My original research question, *How can AI be used in a constructivist approach to music education, whether in higher education or K-12?* has multifaceted answers. Not only does AI show from this literature review to be a strong aid of social constructivism, it provides a supportive context for students to gain new skills as well as construct upon what they already know. Scholars in this field stress the importance of reform in the traditional teacher-focused model, some to a flipped classroom with AI support, others to courses regarding the use of AI. In this way, AI provides music students the opportunity to engage in music research, composition, virtual

performances on intelligent instruments, tutoring in accuracy of practice sessions, and musical analysis. AI creates a space for self-directed learning outside of class, so that teachers can spend more time interacting and working with their students. It is clear from the studies that AI greatly increases student engagement; what is not yet clear is if it also increases student learning, or how much. Further studies are needed to prove this, as well as if or how AI might apply in situations necessitating emotion, interpretation and physical modeling of vocal practice.

In terms of applying this information to instructional practices, this author wishes to craft a course or module regarding these AI enabled skills for a college level audience of music majors. The availability of resources in this country may be different than in China, but new AI skills are available every day to support students in their studies and profession; and are only growing. Courses such as this will greatly assist music students, as evidenced by S. Yuan's study. The future of AI-supported CLT is bright, full of possibilities, and ready for the next generation to engage with all that awaits.

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# Appendix

## Figure A

(extracted from Yuan, S., 2020)

**Table 1.** Contents of the Popular Science Course of Music and AI

| Lecture Series | Lecture content | Lecture Series | Lecture content |
|---|---|---|---|
| Lecture 1 | AI overview | Lecture 9 | Watermarking and Music Copyright |
| Lecture 2 | Music retrieval | Lecture 10 | Interactive music |
| Lecture 3 | Score identification and score tracking | Lecture 11 | Sound installation art |
| Lecture 4 | Audio identification | Lecture 12 | 3D printing of musical instruments and smart speakers |
| Lecture 5 | MIDI and MusicXML analysis | Lecture 13 | Machine and virtual performance |
| Lecture 6 | Algorithmic composition and automatic accompaniment | Lecture 14 | Computer Music Research Institute and Famous Researchers |
| Lecture 7 | Intelligent Music Analysis and Music Recommendation | Lecture 15 | Computer music conferences, computer music journals, computer music websites, smart music software |
| Lecture 8 | Music emotion identification and music therapy | | |

## Figure B

(extracted from Yuan, Y., 2024)

**Table 2. Vocal Music Teaching Module Test and Analysis**

| Module | Frequency | Number of successes | Number of failures | Success rate |
|---|---|---|---|---|
| Systems management | 28 | 28 | 0 | 100% |
| Quality evaluation | 28 | 26 | 2 | 96% |
| Resource management | 28 | 28 | 0 | 100% |
| Enquire | 28 | 24 | 4 | 94% |

## Figure C

(extracted from Lv, 2022)

**Table 1** Results of preliminary testing

| Research group | Number of participants | Mean score | Sum of scores | z-value | p value |
|---|---|---|---|---|---|
| Experimental group | 59 | 14.28 | 842.52 | −1.47 | .11 |
| Control group | 59 | 12.05 | 710.95 | | |

**Table 2** Post-test results

| Research group | Number of participants | Mean score | Sum of scores | z-value | p value |
|---|---|---|---|---|---|
| Experimental group | 59 | 19.73 | 1164.07 | −2.43 | .01 |
| Control group | 59 | 16.03 | 945.77 | | |