HARMONIZING INNOVATION - EXPLORING THE RELATIONSHIP BETWEEN MUSIC AND TECHNOLOGY IN THE MODERN AGE

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Brief description of components:

4 mp3 files containing the completed songs that make up the EP.

Identify hardware and software used to produce the thesis and necessary to access the product submitted:

Logic Pro X - version 10.8.1.

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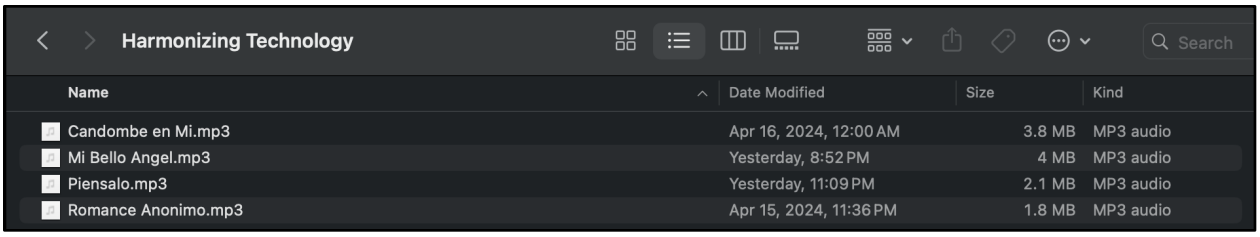
List of all files submitted:



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Abstract

The relationship between music and technology might not seem apparent at first glance. In fact, as a student at Guilford College, I was challenged with a decision about where to focus my studies. I ended up choosing to double major in Computer Technology & Information Systems (CTIS) and Music. When I reveal this fun fact about myself to the average person, they would usually look at me in disbelief and say something along the lines of "Those are two extremely contrasting majors, are you sure you know what you are doing?", and in the beginning, these comments would leave me wondering if they were right and if I was trying to force myself to walk two paths that would never meet. But I have walked these two diverse paths for four years now, and I finally have a clear understanding about how interconnected they truly are. To prove just how much these two topics truly are connected I will create a two-step process. During the first semester of my senior year, I will create a musical EP with the help of my guitar teacher, Dr. Kami Rowan, consisting of five songs; two of which will be classical music, two will be corridos, and the last one a creation of my own. This will serve as a product to demonstrate all that I have learned musically and creatively during my time at Guilford as a Music major. During the process of making my EP, I will also take notes on what technological aspects were used while I was creating the final product. Any part of the process where technology was an essential part will be noted. The second step in proving my theory that music and technology are closely related and correlated will take place during the final semester of my senior year. Here, I will begin to implement research-based breakdowns in how acoustic sound is converted into electrical soundwaves that can be recorded/read by the computer, how we are able to manipulate those saved soundwaves through digital audio workstations to produce the best

sound quality available, what exactly those manipulations consist of and how they work (i.e. How does EQ work? How does compression work? What purpose do they serve?), and overall, how the use of technology has become an essential part of the musical process in the 21st century.

The intersection of music and technology is a fascinating exploration and journey that spans the entirety of human history, as we navigate the complex landscape of the 21st century, where technology has become an indispensable part of our daily lives, the fusion of music and technology is more evident than ever. My decision to pursue a double major in CTIS and Music at Guilford College exemplifies the symbiotic relationship between these seemingly disparate fields. Through this thesis work, which involves creating a musical EP and delving into the technological aspects of music, I aim to illuminate the deep connections that exist between music and technology. This exploration not only showcases the evolution of musical expression but also underscores the integral role technology plays in shaping the contemporary musical landscape. By seamlessly integrating these two diverse paths, I hope to demonstrate how the synthesis of music and technology is not only possible but also essential for a comprehensive understanding of both realms.

Chapter 1: Introduction

Origins of Music

Music has been an integral part of human civilization thought to date back at least 50,000 years, but what exactly is music? What distinguishes it from other forms of noise such as speech and bird calls? The official dictionary definition of music is "an art of sound in time that expresses ideas and emotions in significant forms through the elements of rhythm, melody, harmony, and color."*)* Music is created for many reasons, with four of the primary reasons being for dance, ritual, entertainment (personal & communal), and social cohesion. *(Montagu)* Music's universal presence is evident through various cultures and civilizations throughout history, with the echoes of melodies resonating through the ages, transcending the boundaries of language, geography, and time.

In the timeline of history, music emerged as a constant companion to the human experience. From the rhythmic beats of ancient tribal drum rituals used by the Native American tribes, who believed that the sounds of their drums compared to a human's heartbeat and resembled the heartbeat of Mother Earth, to the harmonious and entertaining concertos of classical compositions, where the music was meant to have an effect deeper than words, touching the emotions and soul. From the Swing era of the 1930's, a new style of Jazz that took accentuating beats 2 and 4, replacing the steady eighth notes with "swinging" eighth notes that also had added accents and syncopation, anchored together by a steady walking bass line, giving the song an undeniable groove/beat that caused people to dance and swing around, to the social nightlife created by the unison of beats developed by producers and musicians in the 21st

century, heard throughout sound systems at clubs and social gatherings. All of the unique melodies from each era have been engraved into the collective history of mankind, with each piece of music full of expression that allow us to peer into the very soul of human existence, since music is a cross-Chapter between the rhythm of life and the harmony of our songs.

But when did humanity decide that music was a thing? We don't know the exact date for sure, but thanks to archaeological discoveries, we have found evidence of a prehistoric bone flute, the oldest musical instrument discovered - emphasis on discovered, because we only have facts on what we have found, not on what we have yet to find - that dates back to more than 50,000 years ago. (*Hear the World's Oldest Instrument, the 50,000-Year-Old Neanderthal Flute - Classic FM*) Thanks to fossilized evidence, it has been determined that this instrument was made during the Paleolithic era, more commonly known as the Stone Age. It is a flute, and it was discovered in 1995, inside the Divje Babe cave near the Idrijca River in Slovenia. It was

Figure 1. Neanderthal Flute

made from the left femur bone of a young cave bear and it was pierced by two well-preserved and two damaged holes. The position of the holes was originally believed to be accidental or made by animal bites, but through thorough musical experimentation, it was found that the four

holes were able to create four different pitches that resembled four of the exact notes found in the modern day traditional diatonic scale. (*Neanderthal Flute - NMS*) This finding became solid evidence that Neanderthals were indeed capable of a certain level of innovative artistic expression, and they weren't just primitive hominids.

It is believed by many researchers and authors that music originated even further before 50,000 years ago, but we have no evidence to justify these beliefs. Many scholars believe that music originated through the practice of vocalization, suggesting that music emerged as an extension of human expression, rooted in the primal instincts and social dynamics of early human societies. Vocalization was the primary use of communication used by the early societies, long before any modern language existed. There was an immense range of sounds that would be used to signify different things. These sounds included cries, calls, chants, and melodic phrasing, which served multiple communicative functions within the different social groups. Vocalization wasn't only used to get points across, but it was also used to express a diverse range of emotions, including joy, sadness, sorrow, and excitement, creating social cohesion and emotional bonds within communities. Through these expressive vocalizations, certain rhythmic patterns and tonal variations began to appear, reflecting certain musical elements naturally. Over time, certain vocalization patterns began to be integrated within ceremonial and ritualistic practices, such as birth ceremonies, important hunts, and successful harvests. As societies & civilizations continued to grow more structured and sophisticated, so did the use of vocalization. This increased use of vocalization eventually led to many different languages being developed. In return, being able to communicate and share knowledge allowed for a huge wave of innovation to begin its course. This eventually opened the doors for the invention of musical instruments, the development of notation systems, and the refinement of musical techniques across the world which allowed for a

diverse range of musical expression. Music evolved into one cohesive language that could be understood by anyone who knew how to analyze and dissect the language.

Music and Me

Music has always been present in my life, whether in the form of corridos or classical music; however, I didn't always acknowledge this presence. It wasn't until my late teenage years when I began to appreciate music more to the point where it began to transform into an inseparable part of my existence. I have always been fond of music and enjoyed breaking the silence with calm hip hop vibes or listening to some Kanye West on full blast in my car stereo, but it was not until I picked up my first guitar that I really realized how much music would really affect my life.

I remember thinking when I picked up the guitar and began to learn a song called 'Depression & Obsession' by XXXTentacion, that it was an extremely complex song because of all the different sounds that I heard throughout the song. I did not mind that it was going to be complicated, I just wanted to reproduce the beautiful sounds I heard from my favorite song at the time. I wanted to replicate the notes that danced through the air and feel that inexplicable stirring within me that I would feel when listening to that song. You can imagine how much my mind was blown when I went on YouTube and found a tutorial, only to discover that the song only consisted of a simple repetition of the same three easy chords. I was taken aback by the fact that such a beautiful piece of music could be so simple yet sound so good. This moment ignited the spark to embark on the journey of mastering music, to evoke emotions that words alone could never hope to express.

Having to learn to play an instrument is a part of the process that is not talked about enough. The struggle of learning an instrument is an essential part of becoming a musician, but it is also the hardest and most time consuming. I believe this is the main reason why being a musician is seen as such a unique skill and why so many people begin the journey but quit a month or two in. To have to sit down for hours on end and repeat the same movements over and over until it sounds perfect is a challenging task. But since I was able to push through this blocker, I can now sit on the other side with a newfound respect for every musician, because I understand how much of an effort it truly is to learn an instrument. To sound good on an instrument, one needs to have commitment, acceptance of failure, and patience, just to name a few.

Figure 2. Hand Calluses

For my personal experience, I chose the guitar as my instrument of choice, and began to learn music. I remember how excruciatingly painful it would be to practice with my noncalcified fingers, with the pain of sliding my fingers along the fretboard reminding me to stop trying and to give up. The sound of playing the wrong notes buzzing over and over and at the speed of a tortoise did not help with motivation either, but I pushed through, because I felt connected with the music. I remember my frustration and disappointment when I would try to play songs for

someone after hours of practice only for me to get some notes wrong or completely blank on what came next.

I did not begin to see the fruition of my efforts until five years later (the present day), where I finally began to feel comfortable and confident with my playing to the point where I could play comfortably in front of my peers. Five years after I started playing guitar, I am still beginning to feel confident in my playing abilities. I have the utmost respect for people who play better than I do, because I know that means they have grinded harder than me, it truly takes a certain level of perseverance to become proficient on an instrument. Just like the gym, it is a kind of success that cannot be cheated, only obtained through hard work and dedication.

Now that I am of decent caliber, I can play good music in front of other people. I truly enjoy seeing other people vibe to my music and sing along to the songs. Seeing how music brings people together firsthand has been such a liberating experience for me. I was always shy and embarrassed to play my songs in front of others because I would be nervous that I would mess up or that they wouldn't like it, but now that I have reached a certain level of musicianship, those feelings are basically nonexistent. When I play with my friends, we get other people to sing along to our music, and it always astonishes me because someone that I least expect pulls out the lyrics and sings to the top of their lungs. It makes me feel good that we (musicians) can create an atmosphere of comfort and expression where we can get the most introverted person to karaoke with us. This ability to express myself with music that I feel in the soul reflects in my playing, and I get lost in the moment, forgetting about everything except for the song that is being played. This experience allows me to be in the present, out of my head, enjoying life.

As I continue to hone my craft and explore the endless possibilities of musical expression, I am reminded of the profound impact that music has had on my life. It has been a

journey of self-discovery, growth, and connection, one that has enriched my existence in ways I could never have imagined. Learning music has been like learning a new language, where I can connect and express myself through my choice of music, more specifically through social cohesion. Through music, I have found not only a means of creative expression but a source of peace, joy, and belonging.

The Relationship Between Technology and Music

The bone flute is evidence that the first humans had a certain capacity of thought about music and had enough creativity to create music, or at least some basic instruments. And just like any other strong species, humanity evolved, and continues to evolve. Musical evolution really began to take place after centuries of vocalization practice, more evidently with the invention of musical notation, or the visual representation of musical sounds/expressions, with set rules and timing. Before notation was developed, most music was vocal, in the form of chants or singing, and was passed down vocally from generation to generation. The earliest known written records of any form of notation stem from the discovery of those from early Egyptian civilization, dating back to 3200 BCE, which is the accepted date at which history “begins". The first sign of musical notation came around during the 9th century, when the use of neumes became common practice amidst Western Europeans. (*Tignor*)

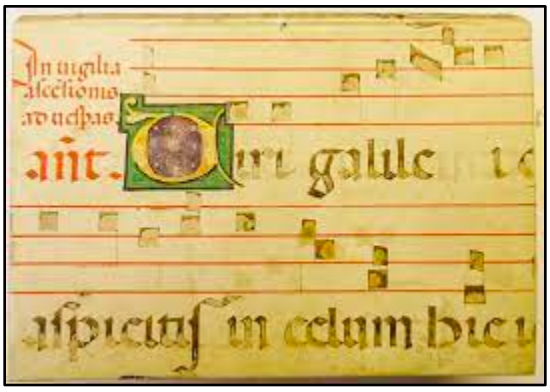

Figure 3. Early Neume Notation

Neumes were originally developed by early Greek and Roman grammarians to guide declamation, or the rise and fall of the pitches, but that is where it ended. This early notation system could not communicate time or rhythm, so it only truly helped if the singers knew their songs and lyrics aurally. Many European intellectuals such as Guido D'Arezzo, saw the potential and were able to add significant developments that allowed neumes to be sight-read through notation. Some essential developments included the creation of a system of four-lined staves, which organized the pitches into groups (early version of the modern day five-lined stave system), time signatures, solfege (do, re, mi, fa, so, la, ti, do), and note length. (*Strayer*)

Instrumental music did not become popular until the 1600's. (*"How Did Music Notation Actually Begin?"*) During this period, instrumental music surpassed vocal music as the most popular genre, leading to even more improvements to musical notation in response to the works of Baroque and Renaissance composers. Instruments, such as the lute and vihuela, played a vital role in the improvements of notation, since composers felt that there still was not enough information in the current systems to express all the characteristics and expressions of their music. Bar lines, dynamic markings and performance directions were added to the system, and this process kept being repeated and improved until the integration of the five-stave notation system that we all know and love today was implemented as the norm.

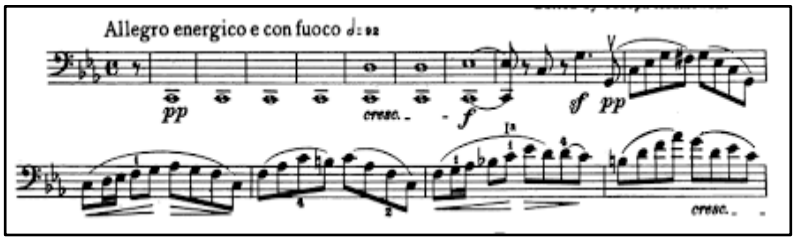

Figure 4. Modern Day Musical Notation

Writing songs on paper and notating them was the most common form of sharing musical experiences, but it was a rather complicated process. One had to know how to play an instrument or sing and needed the ability to read musical notation. The alternative was to find someone capable of doing any of those things, or going to a public space where musicians would gather. The beginning of musical notation marked a significant turning point in the intersection of technology and music. While it might not seem as technologically advanced as today's digital music production tools, the development of musical notation was revolutionary in its time and laid the groundwork for subsequent technological advancements in music. It ultimately formed a structure and theory for music and led to the ability for it to be measured, analyzed, and communicated in a way other than oral tradition.

As humanity continued to evolve, so did technology, and the next big jump in musical significant technological advancement took place around the 20th century, when technology finally began to take a more serious role with daily life. The ability to record music and play it at any time without the need of any musicians being physically present allowed people to take portable music home and listen to it whenever they wanted. The technological creation that allowed for this to happen was known as the phonograph. Thomas Edison was credited with the first phonograph invention, which later evolved into vinyl records. (*"History of the Cylinder Phonograph | History of Edison Sound Recordings | Articles and Essays | Inventing Entertainment"*) This device was only one of Edison's many patents, but what made this one so

special was the fact that it allowed sound waves to be reciprocated. A machine made up of a sheet of tinfoil wrapped around a drum of cylinder shape while a handle was turned that would then rotate and move in a lateral position. When the handle moved, it would touch a metal stylus that was attached to one side of a diaphragm. Located on the opposite side of the diaphragm, there was a small mouthpiece where the sound would travel through. When the sound waves traveled through the mouthpiece, it vibrated the diaphragm, and in turn, caused the stylus to move accordingly to the pressure caused by the vibrations on top of the tinfoil. This all created a groove on the tinfoil surface. To play back the sound that was produced, the stylus was put back in the beginning groove and the cylinder would have to be winded again. Whenever it landed on a groove, the diaphragm would vibrate, forcing air into the mouthpiece, which in return would send out the sound.

However, this was a very early model, and the sound reproduced was not high quality at all. In fact, the sound reproduced was actually very poor audio quality. As records indicate "...the results were barely audible, and the first recorded words 'Mary had a little lamb' were hardly auspicious…" (*A Brief History of Recording to ca. 1950*)) But the phonograph was still a pivotal turning point. Although the sound reproduced was scratchy and nearly inaudible by modern standards, it made it clear that the recording of sound and music was possible. Later models improved the quality, and soon, phonograph recordings turned into vinyl records. Vinyl records became the dominant format for recording and distributing music due to their convenience, durability, and superior sound quality. The transition from the phonograph to vinyl records represents a shift from early experimental technology to a mature, standardized format that would dominate the music industry for much of the 20th century. Vinyl records remained

popular until the rise of digital formats like CDs and later, digital downloads and streaming services.

Figure 5. Early Phonograph

Vinyl recording allowed a new wave of technology to revolutionize the way music was heard. Then followed the cassette tape, an invention that was created by the Belgian Philips company in 1962. These tapes used magnetic recording, a revolutionary innovation that worked by using a tiny electromagnet with an iron core wrapped in a wire and a small gap in between. When audio was recorded, the coil of wire would create a magnetic field around the core. This created a fringe pattern using magnetic flux. It caused the oxide on the tape to magnetize. How this worked was that "...during playback, the motion of the tape pulls a varying magnetic field across the gap. This created a varying magnetic field in the core and therefore a signal in the coil. This signal was amplified to drive the speakers." ("*How Tape Recorders Work*") The most famous example of the cassette tape player is the Sony Walkman. After the cassette, the era of CDs followed. This signified a huge transition from the analog realm to the digital realm.

Analog signal in music refers to continuous waveforms that represent sound waves in their natural form, without digital conversion. These signals are characterized by their smooth, continuous changes in voltage or air pressure, mirroring the nuances of musical instruments and

voices. Unlike digital signals, which are discrete and quantized, analog signals capture the full richness and rawness of musical expression. When reproduced through analog equipment like vinyl records, they often create a warm, organic quality sound. Digital signals in music are like assembling a picture using tiny colored blocks, where each block represents a small piece of the sound. These signals are made up of discrete chunks of data using bits, each representing a specific point in time. The sound is chopped into tiny pieces and represented as binary numbers. Unlike analog signals, which are smooth and continuous, digital signals are precise and can be easily replicated or manipulated using computers. They are commonly used in modern music production, streaming services, and digital audio players due to their accuracy and versatility. So, analog is smooth and continuous, while digital is made up of lots of tiny steps or pieces. Each has its own vibe, where analog often feels warmer and more natural, while digital can be super precise and easy to copy. (*"Analog vs. Digital Audio Recording"*)

In 1974, Philips Company decided to develop an optical audio disk with error correction code, also known as a Compact Disc. These disks were made accessible to the public around 1982. It was able to store not only music, but it could also store data and videos. It was a portable size as well, no larger than 12 cm in diameter. The shiny side had all the information stored in it, and it was read through a laser beam. The Walkman also evolved and was made CD accessible, therefore making CDs popular and travel size.

Figure 6. Sony Walkman

What came after CD was the MP3, developed by the German Fraunhofer-Gesellshaft in 1987. The Mp3 was made accessible to the public around the early 2000's. It was the first audio compression technology that compressed any music file in exchange for a small loss of sound quality. CD's had higher sound quality, but there was a limit to the amount of music that could be encoded into them. This, however, was not a problem with the MP3. With this new technology, music files were made so small that the download limit was basically endless. Since the auditory information had to be compressed to become digitized, quality of sound was lost while music became easier to manipulate, save and store. This meant that any amount of music could now be contained in a single MP3 player. At this point, people chose accessibility and quantity over quality of sound. The Apple iPod became the most popular choice, which was a portable and stylish MP3 player that could be fit into a pocket, and headphones could be plugged in. This marked the beginning of streaming music.

Figure 8. Early MP3's

Technology and Me

As I reflect on my journey from a Business major to a CTIS major, I realize how each step has shaped my understanding of myself and my aspirations. Initially entering college, I was simply grateful for the opportunity, yet uncertain about my future path. During my time as a Business major, I concluded that I could obtain a career (i.e.. contractor, business owner, entrepreneur) by getting certification classes without the need for college, and I didn't want to feel like I wasted my one opportunity to chase a career that only college could provide. The realization that a broad business degree might not fulfill my desire for specialized knowledge and career prospects prompted me to explore STEM fields. I started out with physics, but I also quickly realized that math, vectors, and me did not get along. I dropped out of that degree in less than a semester and began to truly reflect on what I wanted to pursue.

I took many things into consideration, and my final thought process was "I'm in college, and I don't know what I want to do, but I do know that I want to learn something new and worthwhile while simultaneously generating a good income to do the things that I want to do in the future." This conclusion led me to explore the world of computers and coding. My strong

sense of curiosity made me pursue this path, because I was always mesmerized by the technology involved in the creation of such things, and I wanted to understand how a bunch of 0's and 1's generated masterpieces like Red Dead Redemption or how anyone could connect through a phone call or the internet countries away. Technology was such a huge mystery to me, and I felt like getting into Computing Technology and Information Systems (CTIS) would bring a better understanding of how human ingenuity was able to create things such as the internet.

I knew it was going to be a difficult task, but I also knew I was able to survive physics, and if I could survive that, then I could survive anything. I committed to my final major switch during the second semester of my sophomore year, and right then I became a CTIS major as well as a Music major. Fast forward to the present, and I am in my last semester of college, with all prerequisites completed for both majors and on track to graduating May 2024. It has been a difficult journey, there is no denying that, but it has been a rewarding experience. There have been many sleepless study sessions and stressful exams, but when I submit a piece of code and the system returns a working program with no errors is a feeling that is hard to describe. The way I see it, I have learned a completely new language, just like I did with music. It is the equivalent of when I practice a hard riff over and over until I finally play it accurately. Both rewarding experiences can only be achieved through hard work and discipline. Now, thanks to my grit, I can communicate with others who know the languages of computers and music.

Currently, I have managed to get a job in the technology industry, more specifically as a software engineer. I have committed to a career in technology, and this will now be a part of my person just as much as music. While music has become my passion and creative outlet, software engineering has provided its own outlet for creativity — one that involves problem-solving, innovation, and constant learning. Software engineering promises a new realm of exploration and

expression. Through my experience and knowledge, I can take the best of both worlds and apply skills that will benefit and help me grow simultaneously in both fields.

Conjunction; The 21st century

Fast forward to the present time, and technology in music is in full effect. After the MP3, technology and music finally began its streaming era. The streaming era began recently, following the beginning of the internet. The internet enabled a "information superhighway". In 1990 Tim Berners-Lee invented the World Wide Web, where data could be accessed online through websites and hyperlinks. Then the internet enabled a way to connect everyone from anywhere in the world through a wireless system. With the introduction of the internet, music began being put on the web. This enabled free, digital, and unlimited access to any type of music libraries that were on the internet. Streaming platforms like LimeWire were created, where you could basically download and stream any music illegally. Eventually, these platforms were banned due to artists not getting paid and copyright issues. Legal streaming platforms like Spotify, YouTube, and Apple Music became the norm. The internet also enabled the use of Digital Audio Workstations (DAW) and other various music editing software.

The discovery of the prehistoric bone flute dating back over 50,000 years stands as a testament to the innate human impulse to create and communicate through music. The evolution of musical notation marked a pivotal turning point in music history, allowing for the preservation and dissemination of musical compositions across generations. The arrival of technology, from the phonograph to the MP3 player, revolutionized the way music is accessed and experienced, allowing access to vast libraries of musical compositions and enabling new levels of artistic collaboration and experimentation. Today we have Spotify and Apple Music as the top streaming

platforms. Editing software like Logic Pro, FL Studio, and Garage band that can be accessed via the computer and enable the user to record, edit and produce music. There is now an unlimited amount of music available on the internet, ranging from Classical Concertos by Mozart to the newest albums released by J.Cole. It is imperative to recognize and celebrate the enduring power of music as a universal language that transcends boundaries and connects humanity across time and space. In its melodies and rhythms, the echoes of the shared human experience are found, resonating with emotion, creativity, and the timeless search for expression and connection. Technology has made our appreciation and celebration more possible by enabling access to music in so many ways in the 21st century.

Chapter 2 : Unification

The EP

I decided to create an EP as an exploration and application of the fusion of technology and music. An Extended Play (EP) is a musical recording that contains more tracks than a single (one or two tracks) but is shorter in duration than a full-length album. The main driver of this decision was that I wanted to demonstrate how intertwined my two majors really are, and I thought of no better way to demonstrate that than to practice and perform my music, record it, and then use technology to enhance and perfect the final product. This process would be a perfect demonstration of how the two topics are more related than one would originally think. From an artistic perspective, this process would demonstrate everything I have learned musically while in school, practicing consistently and effectively. From a technological standpoint, it would demonstrate all the technical skills that I have gained and show my understanding of technology and why it's so important to the creative process.

My song choices were based on two main factors. Songs that identify me and songs that demonstrate the use of different technologies. The EP consists of 4 songs, with two of the songs being corridos, and two of the songs being classical pieces. I chose the two corridos pieces because this is the music that I most enjoy playing, and it has been the main influence that made me pursue the life of music initially. Corridos remind me of the diverse culture that I originate from and help me remember my Mexican roots.

‘Mi Bello Angel’ is a piece that was originally written by Ulices Chaidez back in 2021, but the version that I play is the cover version by Natanael Cano, released in 2023. This song is basically a love song that is extremely upbeat and energetic, and contains beautiful arrangements

alongside a wide variety of musical elements that engulf the piece. I am not necessarily in an emotional state of love, but the musical aspect of the song made me appreciate the song to the point where I was practicing it every day.

'Piensalo' is the second corrido of the EP, and this one was written by Junior H, also in 2023. This piece talks about heartbreak, and sounds sadder than the other corrido, but it still has an upbeat, almost happy energy to it that just makes it sound so good. The song has some complex solos, but my favorite part is the part where I was able to transpose certain saxophone solos with guitar instead of the sax. I was able to manipulate the solo via my editing software to make it sound unique and different from the other guitar solos.

The rest of the music in the EP would fall under the classical category. I chose two classical pieces because those are two of the pieces that have been an integral part of my musical career here at Guilford. I have been studying classical guitar as part of my curriculum for the last 4 years of my life, and I have discovered so many new things thanks to that specific music, even if I had never been exposed to it growing up. I have grown a newfound appreciation for classical music, and these pieces also served to explore the different recording strategies that were required for classical guitar as opposed to the electroacoustic guitar, which I will touch on later on in my analysis.

'Candombe en Mi' is a piece written by Máximo Diego Pujol back in 2006, and it was one of the first complex classical pieces that I ever got my hands on, thanks to my guitar professor, Dr. Kami Rowan. Candombes are a style of dance music that originated in Uruguay, although Máximo Pujol is Argentinian. The piece has a slow, almost pensive B section that is sandwiched in between two fast paced, percussive A sections. The song has complex left-hand movements that travel all around the neck of the guitar with an impressive return of sound.

‘Romance Anonimo’ is a love ballad that holds a special place in my heart because it was one of the first songs that I ever learned. Granted, when I first learned it, I couldn’t make it sound as good as I can now, but it is a song that has been with me through my entire process. The official composer of the song is unknown, but the first recordings of it started appearing around the late 19th century. The song has a slow but elegant romantic vibe to it. The title of the song literally translates to anonymous romance, and it is a very accurate description of the atmosphere created by the piece.

My decision to create an EP served the purpose of showcasing the interconnectedness of my two majors - music and technology. Through the process of composing, practicing, and recording, I aimed to illustrate how these fields are deeply intertwined. This allowed me to both demonstrate my musical skills learned through consistent practice and technological skills learned to enhance the final product. The selection of songs, comprising two corridos and two classical pieces, was to reflect on my cultural roots and musical influences, and to explore the diverse range of technologies in music production. Ultimately, this EP not only represents a personal and artistic endeavor but also stands as a testament to the symbiotic relationship between music and technology, paving the way for further exploration and innovation in both fields.

Technology used during the Creation of EP

A. Activity Diagram

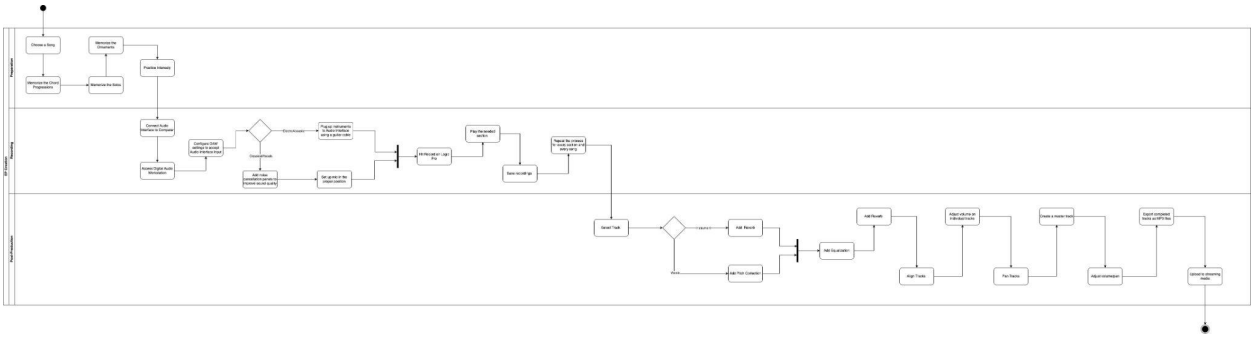

Figure 9. Recording Process Activity Diagram

The process of creating an EP involved a huge number of steps ranging from selecting a song to cover, to editing which side of the headphones the sound should come out of. It was a long process that involved the combination of artistic ability and technological knowledge. The main objective of this analysis is to fully explain the procedure required to efficiently create this EP. This analysis will cover every aspect of the process, with full and clear explanations as to how and why something was used. Each step, like recording and mixing, needed careful attention to make sure everything sounded just right.

I incorporated and used tools that I learned through the CTIS pathway through the Systems Analysis and Design course. I created an activity diagram to represent a structured step-by-step process of the entire recording process, from start to finish. An activity diagram is a type of UML (Unified Modeling Language) diagram used to visualize the flow of activities or actions within a system or process. It depicts the sequential steps and decision points involved in completing a particular task or achieving a specific goal. I decided to use an activity diagram to show a physical representation of the requirements of creating a piece of music, recording it, and editing it. It allowed me to have a structured diagram that I could look at and see what step of the

process I was in at any given moment. It also allowed me to have a representation of the process for an audience that didn't truly grasp all the steps required to complete a proper recording.

To begin the process, I had to decide what songs I wanted to learn. I go into further detail about the songs I chose and why I chose them in *Chapter 2: The EP.* After the song selection was confirmed, I had to go into YouTube and watch tutorials on how to learn the song. (i.e. what key the songs were in, the solo arrangements, and the lyrics) This was the first use of technology in my process. After I had the songs memorized, it was time to practice, and practice I did. I created a schedule where I practiced each song on a every other day basis from November 2023, with 30 minutes reserved for each song.

When I felt like the song quality that I was producing was up to par, I decided that it was finally time to record. To begin the recording process, I connected my computer to an audio interface, which is the centerpiece of all of the studio gear. Everything communicates through the interface to the source, whether it be a computer or a guitar. I used my old reliable Scarlett 2i2. The interface basically serves as a hub that can receive analog signals, (like those that come from guitars, microphones, MIDI keyboards) and convert them into a digital format that the computer can then recognize. Once on the computer, the signal can be further manipulated using a DAW (Digital Audio Workstation). *("What Is an Audio Interface?")* Those digital signals are then turned back to analog so they can be monitored from a pair of headphones or speakers.

After the audio interface was connected, I was able to record what was required for the EP. I have access to Logic Pro, which is a digital audio workstation. A DAW is a software application that runs on the computer and enables the user to record, edit and produce music. The DAW allowed me to record my instrumental tracks, my vocal tracks, and then edit them to produce a higher quality sound. For the electroacoustic guitar recording process, I had to

configure the DAW to accept an instrument track, which was connected via the guitar using a guitar cable that connected to the audio interface, which then transformed those analog signals into digital signals that the DAW could accept and edit.

Figure 10. DAW, Interface, and PC Connection

As for the classical guitar and the vocals recording process, I had to take a different approach. Since the classical guitar had no guitar cable connection, I had to connect a microphone using an XLR cable that was also connected to the audio interface. An XLR cable is designed to transmit balanced audio signals, which means they have two conductors that carry the audio signal and a third conductor that serves as a ground. This balanced configuration helps reduce noise and interference. *("What Is XLR?")* I chose to use a condenser microphone because they work extremely well at capturing sounds accurately. They pick up all the details well and make sure that extra noise is reduced in the recording. I had to tactically place noise cancellation panels to improve sound quality in my makeshift studio. (It was my dorm closet). I then placed the microphone right in front of the guitar's sound hole and recorded those tracks. I used the same procedure for the vocals, with the only difference being that I place the microphone at mouth level height for best sound quality. These processes were all repeated for every single song and every part that was needed.

For the electroacoustic corridos guitar tracks, I had a chords track, a solo track, and an ornament track. The chords track laid down the chord progression of the song and created a blanket to fill in the musical gaps, making the music sound richer and more interesting. The solo tracks had all the solos that occur in the pieces, where there are no vocals, just the guitar going absurd. The ornament tracks served as decorations that made the music more colorful and expressive, giving it personality and character.

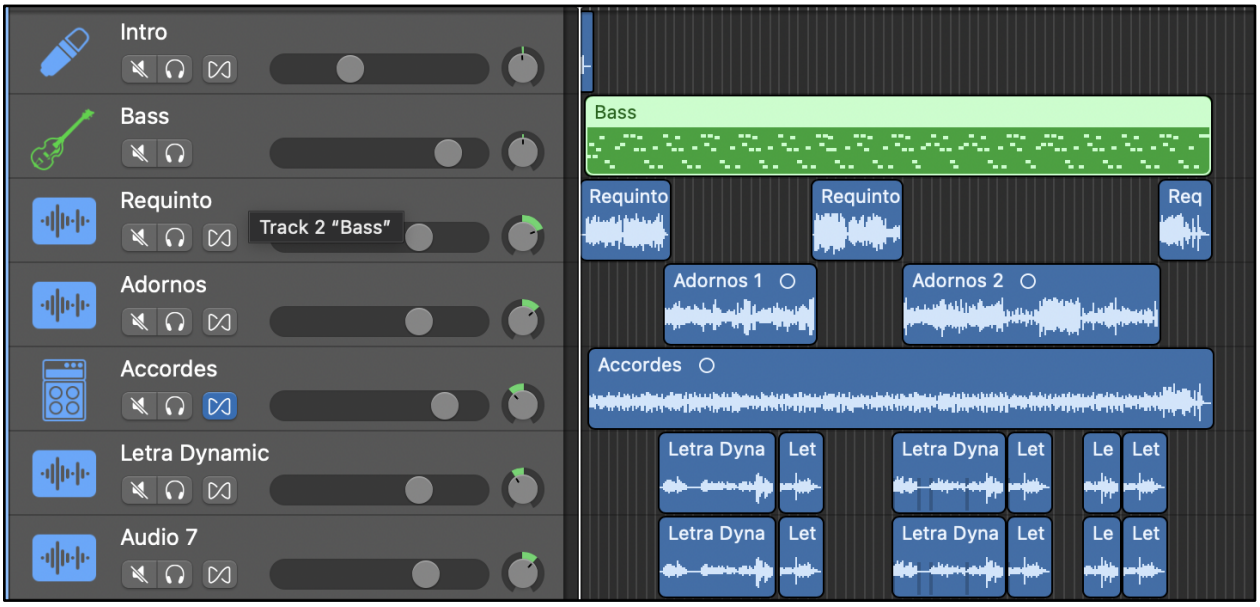

Figure 11. Corridos Track Layout

For the vocals, I had two duplicate tracks overlaid on top of each other to give the vocals more power and depth. As for the bass tracks, I created two. The first was recorded in the same process as all the other electroacoustic instruments, and the second bass track I generated using the piano roll plug-in that was preinstalled in Logic Pro. A plug-in refers to a software component that adds specific functionality or processing to the audio being worked on within the Pro Tools environment These plug-ins can be used for a variety of purposes, including audio effects and processing tools. I will touch on the piano roll plug-in later in the analysis.

For the classical tracks, I kept it simple and classic. I only had one track per song since the classical pieces literally only consisted of one long guitar solo. That does not mean that I recorded, and I was done. I still had to edit and re-record the pieces multiple times so that no mistakes were heard, since the room for error was minimal because there were no other instruments to blend and hide the mistakes.

After I finally had all my tracks recorded, and all songs completed start to finish, I got to work with the DAW. There is so much potential that the DAW offers, but the tools that I focused on were the editors, piano roll tool, built-in plug-ins, and faders. For the editor tools, I used the scissor tool and the volume level tool. The scissor tool allowed me to go into fine tuning with the timing of the tracks. It also gave me the ability to cut certain Chapters with errors and record them as many times as needed until the errors were no longer present. For the timing of the tracks, I was able to precisely Chapter off the region that was off beat, grab it, and shift it just enough to where it fell right on beat. I used this for multiple Chapters in the corridos, since I had multiple tracks that overlapped each other. Maybe I am not good enough with recording yet, but I did find that many of my tracks did need adjustments, although they tended to be very miniscule adjustments.

As for the rerecording, the scissor tool allowed me to, once again, Chapter off specific regions. I went and selected small Chapters where I was not satisfied with the final recording. I then went back and recorded a brand-new track where I played that specific Chapter correctly, and then I cut that Chapter on the new track, put it on the original track, and then merged the regions. This process allowed me to get multiple attempts at a perfect track, and it got a lot of stress off my shoulders, since I didn't need to play the whole piece from start to finish at 100% accuracy.

Another extremely useful tool of the editing process was the piano roll tool. It is called the piano roll tool because the piano roll itself is a long strip of paper with holes punched into it at specific locations corresponding to musical notes and their durations. The Logic Pro tool replicates this format in a digital way. This tool allowed me to have access to a virtual MIDI instrument that I was able to manipulate to my exact needs. What a MIDI instrument does is act as a virtual instrument that can customize things such as note pitch, duration, and what instrument to replicate. This allows for the creation, manipulation, and playback of music electronically generated. MIDI stands for Musical Instrument Digital Interface and there is an infinite range of instruments that it can replicate. A user can even create their own sounds and use them to create music. (*How To Use the Piano Roll In Logic Pro*) In my case, I used the piano roll tool to replicate a bass, in order to have a steady bassline keeping the foundation of the song together as well as keeping the rhythm steady and concise. I was able to choose the best sounding bass and then I manipulated it for both corridos songs to have simple but effective basslines in my tracks. I was able to choose what exact note to play, how long it would ring for, and where in the song it would play.

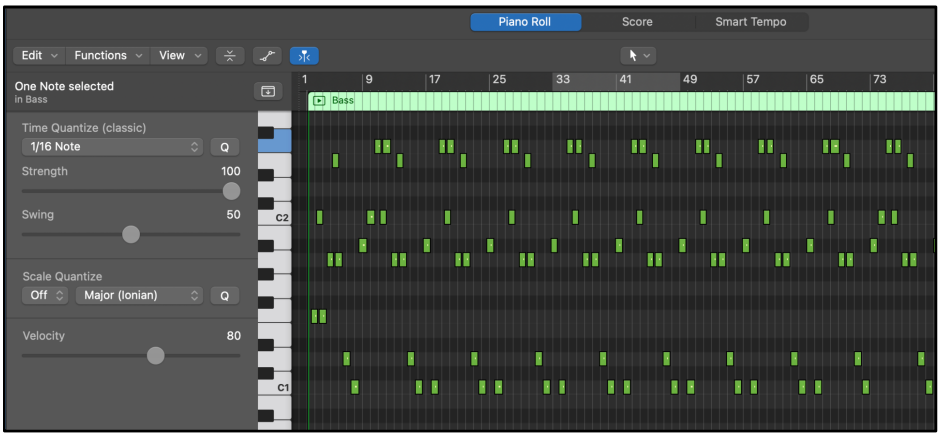

Figure 12. Piano Roll Midi Plugin

After I had everything ready, I was able to proceed with using the built-in plug-ins in Logic Pro for every individual track. Audio effect plug-ins manipulate how an audio signal sounds. Effects can be controlled via various parameters including rate, feedback, or drive. The audio effect plug-ins that I used included equalization (EQs), compressor, reverbs, pitch correction, and delays.

The first plug-in that I focused on customizing was the channel EQ plug-in. Equalization, more commonly known as EQ, is one of the most popular audio processing tools in music production. It allows the user to select a certain frequency range and adjust the gain (volume) levels of said frequency. The range can be wide and general, or it can be specific and narrow. After the range is selected, the user can then completely remove/cut a problem frequency or amplify a frequency that needs more emphasis. The volume at each frequency is measured in decibels, a unit of measurement used to measure logarithmic scales, which means that small distances on the scale represent small changes, while larger distances represent larger change measured. A good visualization of the decibel system is to compare a ticking watch and a jet engine. The jet engine is usually around 135 decibels, while a ticking watch would probably be around 20 decibels. This customization allows for all desired frequencies in the track to balance out and have a stronger emphasis on the important ones. *("EQ Explained - The Basics")* The channel EQ plug-in offered in Logic Pro had a built-in Analyzer graphic tool that made it extremely user friendly and easy to navigate.

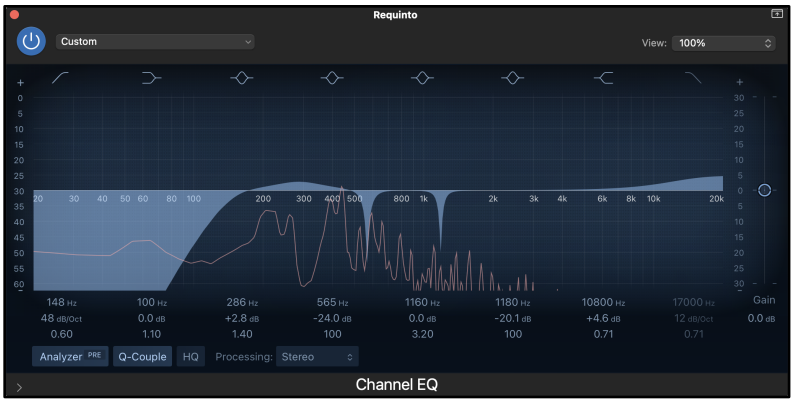

Figure 13. EQ Plugin

The analyzer tool showed which frequencies in the track had the most gain in real time, allowing a huge helping hand in identifying problem spots. As seen in **Figure 13**, the orange soundwaves represent the gain of each frequency.

Another useful tool that I used on almost every track was the compressor. The purpose of the compressor is to control the dynamic range of a specific sound. The dynamic range is the difference between the quietest and loudest parts that an audio signal has access to. When compression is engaged, the loudest signal levels are reduced, while simultaneously boosting the level of the quieter parts. This allows for the overall sound to be more consistent and controlled.

There are four factors that enable the compressor to work effectively. These factors consist of the threshold, the ratio, the attack, and the release. The threshold setting decides what the cap limit is for signal that will bypass the compressor and which signals will be affected/cut by the compressor. The threshold is also measured in +/- decibels. The ratio controls how much the compressor reduces the level of the audio signal once it crosses the threshold. For example, a ratio of 2:1 means that for every 2 decibels (dB) the input signal exceeds the threshold, the compressor will allow only 1 dB to pass through. Higher ratios result in more concentrated compression. The attack determines how fast the compressor will kick in after the signals reach the selected threshold. Having a fast attack time means that the unwanted signals get cut off

almost immediately, but it also means that it will be a very noticeable change to the overall sound output. A slower attack time allows for a smoother transition, which lets the unwanted sounds have a fade-out effect. The final part that makes up compression is the release. The release setting controls how long it will take for the compressor to “let go” of a signal or release it back to its uncompressed state. After the affected sound goes below the marked threshold, the compressor will disengage at a slower or faster time frame to return to normal. *(“The Secret to Compressor Attack And Release Time.”)*

The next plug-in that I decided to implement was the reverb plug-in. I added reverb to the guitar solo tracks and the vocal tracks. The plug-in reverb works just like how reverb works in real life. When a sound is produced, it projects sound waves that spread out in all directions, traveling through space until they reflect off a surface. Upon contacting the surface, some of the waves' kinetic energy is absorbed, converting into thermal energy within the surface. However, surfaces do not absorb all the sound waves' energy. The remaining energy is reflected from the point of contact, generating new reflected sound waves. These waves then disperse in all directions until reaching another surface. This process repeats until there are no longer any sound waves left to be dispersed. Natural reverb is affected by the size of the room and physical properties. Take, for example, screaming in a tight room as opposed to screaming in an empty gymnasium. The reverb in the gymnasium will sound bright and echoey, as opposed to the close and intimate reverb from the tight room.

For the digital reverb plug-in, I worked with the one that had three different settings that I could customize. These settings were the decay, the dry/wet parameter, and the attack. The decay setting determines how long the reflecting sounds keep going after the source sound stops. A longer decay time results in a more prolonged reverb, simulating larger or more reflective spaces,

while a shorter decay time creates a tighter and more controlled sound. Decay is typically measured in seconds or milliseconds. The dry/wet parameter decides how much of the processed signal will take effect on the track. If the dry parameter is turned up to 100%, only the unaffected original signal will be heard, while turning the wet parameter to 100% would only return the processed signal. By balancing the dry/wet mix, I have the flexibility to blend the original sound with the processed one, allowing me to find a good equilibrium between clarity and the strength of the effect. The attack setting serves the same purpose as it does with the compressor, determining how quickly the reverb will kick in after the signals reach the selected range.

When recording the vocals, I chose to use my own voice, knowing that I do not have the best singing voice. With the help of the pitch correction plug-in, I was able to manipulate the vocal recordings to make sure that every note sung was in the correct key with the correct note. The way that pitch correction worked in my favor was that I set the specific key that the track follows. For my singing tracks, those keys were the keys of D major and A major. After I applied the key filter, I was able to adjust how fast I wanted the pitch correction to take effect using the response feature. If I did it fast, I would have the famous t-pain autotune sound, but if I did it too slowly, the effects would barely take effect, so I had to find a balance. The tolerance feature allowed me to decide if I wanted the pitch to be 100% corrected or to have leniency. With a tight tolerance, the pitch correction algorithm would be more precise and less forgiving, and with a looser tolerance, the algorithm would be more forgiving and accept a wider range of pitches as acceptable.

After I explored all the different plugins available, and believed the tracks all individually sounded good, I got to the final step of the process. The final step consisted of adjusting the volume levels and panning for stereo purposes. To adjust volume levels really just

meant to go and listen to each piece as a whole track and going in and raising certain volume levels for specific tracks to make them stand out more in the piece. For example, when I had guitar solos, I needed those to be clearly heard, so those volumes were increased. As for panning, that was a left/right configuration of what side of the stereo the selected track would play out of. To put it into simpler terms, I had to decide whether I wanted a track to sound louder from the left side or the right side.

The very last thing I had to do was create the master track. The master track represents the final stage in the signal chain of a digital audio workstation (DAW), where all the audio tracks are combined and processed before being sent to the speakers or recorded to a final audio file. This essentially allowed me to combine all the individual tracks into one single track that I could export as cleanly and effectively as possible. It serves a crucial role in shaping the overall sound and ensuring the quality and coherence of the final audio output.

Final Thoughts

After months of editing and rerecording, I was able to produce a finished product. Although I've come to realize that the more time I spend as a musician, the better I get, and the less satisfied I am with my work. I had to re-record different tracks multiple times throughout the entire experience because I would come back and listen to it, thinking to myself, "I can do better". Even now, I listen to certain sections of the tracks and think to myself, "maybe I could do better.", but I recognize that this is part of the process. Technology has the capacity to make musical expression "perfect", or at least perceived as perfected. I recognize that I am not perfect when it comes to being a musician or recording engineer, but what I have come to realize is that the knowledge gained from this experience is where the value truly lies for me. Music is a

language, and so is technology. I learned how to play guitar by studying musical notation, the aspects of music theory, and the kinesthetic skill set required to play the instrument and be an effective musician. In the same way, I learned technology by studying the language of computers, software, and technical equipment. The vital realization is that these two languages have major overlaps and can effectively communicate with one another, and this overlap was clearly demonstrated through the making of my EP. I found the space in which both music and technology meet and work in harmony as one.

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I extend my heartfelt gratitude to Kami Rowan for her invaluable guidance and unwavering support in my journey to learn and comprehend music. Her patient instruction and profound insight have illuminated the intricate world of melodies and harmonies, empowering me to explore the depths of musical expression with newfound confidence and joy.

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