Engineering Educators Bringing the World Together
2025 ASEE Annual Conference & Exposition
Palais des congrès de Montréal, Montréal, QC • June 22–25, 2025
Paper ID #47337

Bridging the Gap: Autoethnographic Insights into Project-Based Learning in Electrical Engineering

Wylam Patrick DeSimone, University of Georgia

Wylam Desimone is an Electrical Engineering student at the Georgia Institute of Technology, having transferred from the University of Georgia. He focuses on hardware development, product ideation, and rapid prototyping, creating innovative solutions for technical challenges. At the University of Georgia's Cultivate Lab, Wylam worked on a robotic guitar project as well as other studies focused on engineering education. He plans to continue research at the Georgia Institute of Technology, merging interests in academia and industry.

Parker Gavin Ferrer, University of Georgia

Parker Ferrer is a student at the University of Georgia pursuing a double major in Mechanical Engineering and Electrical Engineering with a focus on robotics and human-centered design. At the University of Georgia's Cultivate Lab, Parker played a key role in the mechanical prototyping and collaborative development of a self-playing guitar, combining his technical skillset with a passion for engineering education and meaningful, interdisciplinary innovation. He plans to make a lasting impact by applying his engineering skillset to develop solutions in automation and medical device design.

Dr. Sarah Jane Bork, University of Georgia

Dr. Sarah Jane (SJ) Bork is an Assistant Professor in Electrical and Computer Engineering with an emphasis on engineering education research. Dr. Bork's research has focused on examining the mental health experiences of engineering graduate students. She has studied different areas (e.g., social factors, engineering culture, etc.) using a variety of research methods (e.g., regression analysis, photovoice, factor analysis, interview data, etc.). Dr. Bork earned her doctorate degree from the University of Michigan's Engineering Education Research Program. Prior to this, she earned both a Bachelor's and Master's degree in Electrical Engineering from The Ohio State University.

Bridging the Gap: Autoethnographic Insights into Project-Based Learning in Electrical Engineering

Abstract

Project experience is crucial to electrical and computer engineering (ECE) education. Despite this, many students are limited to extracurricular involvement or secondary opportunities to gain project experience. This lack of a project-based curriculum creates a clear divide between those with and without access outside the classroom. This study focuses on the self-reflective experience of an electrical engineering undergraduate designing, building, and programming a robotics project. Through autoethnography and reflective journaling, the data from this study aims to demonstrate and document the impact that project-based learning has on the professional development of electrical engineering undergraduates.

The project that was developed is a self-playing, robotic guitar that uses Arduino microcontrollers and servo motors to perform music autonomously. Development of this project was organized into three main checkpoints: creating a picking system, developing a fretting system (which presses the strings to change the notes), and programming the guitar to pluck autonomously.

This study's primary methods were autoethnography and reflective journaling. Autoethnography allowed for personal reflection on the learning process, challenges, and conceptual changes throughout the project. Reflective journaling complemented these reflections by providing a structured way to analyze specific conceptual skills and provide evidence for shaped frameworks. This dual approach aimed to capture both the technical proficiency gained and the broader educational impact of hands-on project experiences on student learning. This was achieved by using photos of the project's progress, taken by the undergraduate, and further reflection on the emotional experiences associated with that moment and the technical challenges faced at that time. Meanwhile, additional weekly reflections ask the undergraduate to reflect on technical challenges, connections to coursework, and any difficulties encountered as they prepare for the upcoming week. The joint broad, staggered reflections and consistent, repetitive journals help to provide a sense of reflection regarding the undergraduate's mental state and progress on the project. At the end of the study, the undergraduate consolidated the conceptual data in a discussion and conclusion.

The results of this study include several key outcomes based on the weekly reflections and autoethnographic photo selection. Most prominently, the undergraduate demonstrated a wide range of newly developed technical skills in connection with theoretical concepts learned in coursework, contributing to a deeper conceptual understanding of the content. Furthermore, the study captured conceptual frameworks alongside project applications. Finally, the findings highlighted an opportunity for curriculum reform and further research by integrating project-based learning in the ECE curriculum. Through an isolated and emotional experience, this study was able to document the effect of project-based learning (PBL) on conceptual connections and early professional development.

Introduction

Project-based learning (PBL) has long been recognized as an integral tool in engineering education, enabling students to bridge theoretical knowledge with practical applications through hands-on experiences [1-2]. Research demonstrates that, compared to traditional curricula, students in PBL-focused programs exhibit significantly increased levels of self-efficacy, intrinsic value, cognitive strategy use, and self-regulation [1]. Furthermore, PBL fosters a greater abundance of self-regulated learners and increases students' confidence in their ability to engage in self-regulated work [2]. Despite these proven benefits, many electrical and computer engineering (ECE) programs lack sufficient opportunities to engage in PBL, leaving a critical skill development gap during the foundational years of education.

Throughout my year and a half as an undergraduate at the University of Georgia, I witnessed firsthand the disparity between students in extracurricular projects and those who lack such opportunities. This limitation inspired me to conduct research and document my experience with PBL through a combination of self-reflective journaling and autoethnography, specifically focusing on the development of a self-playing guitar. This project allowed me to pursue a personal goal while concurrently collecting data on both the technical and emotional challenges faced along the way.

To formulate the dataset for this examination, I included journal entries after work sessions on projects, weekly reflections from my summer research experience, a final project reflection, and pictures representing milestones with captions to explain emotional experiences. These elements provided insight into both my conceptual understanding and emotional mindset, structured throughout the period from May to December 2024.

Project Overview and Background

The emotionality of music is often conveyed through techniques like tempo, articulation, and pitch. For example, slow tempos and smooth legato articulation can evoke sadness, while fast tempos and staccato techniques often inspire excitement or joy [3]. These general trends help shape our understanding of how emotion is conveyed through music. In guitar, techniques such as bending, vibrato, natural harmonics, and pinch harmonics are commonly used to evoke powerful emotional responses [4].

This nuance of music was extremely interesting and as I continued to develop as an engineer, I found myself constantly wishing for a way to combine my knowledge of electrical engineering and robotics with my passion for music. It was then that I discovered Robotic Musicianship, a way to develop myself as an engineer while subsequently learning from a hands-on project.

Robotic musicians fall into two categories: "Musical Mechatronics," which focuses on constructing robots to generate sound, and "Machine Musicianship," which involves musical perception [5]. The intersection of both fields—the development of robots capable of both human-like musical expression and the ability to create and perform music—presented a significant engineering challenge.

Methodology The main methods of this paper were reflective journaling and autoethnography [8-9]. Both of these qualitative methods provided a means to explore personal experiences and emotions throughout the duration of the project. This culminated in a dataset that included weekly reflections from summer research, reflections from the fall semester, and photographs accompanying notes capturing the emotional aspects of my experience.

Summer 2024 Reflections
During the summer research semester, my reflections centered on learning the basics of conducting research and aligning my work with my broader career goals. Prompts used during this time included:

- Why do you want to do research?
- What are your goals and interests?
- How do you hope this experience fits into your larger career goals?

As the semester progressed, reflections became more cyclical and iterative, focusing on weekly goal setting and self-evaluation of set goals and their related progress:

- Thinking about the goals you set last week,
    - What tasks did you accomplish?
    - What went well / supported you completing those goals?
    - What do you wish you could have done differently?
- Thinking ahead to next week,
    - What are your goals for the next week?
    - How do you plan to get support / help this week for your goals/tasks? Be as specific as possible.

These prompts allowed me to track my progress as a researcher and provided insight into the development of my confidence and ability to conduct research as an undergraduate.

Fall 2024 Reflections
Reflections during the Fall 2024 semester were more project specific, focusing on the development of the self-playing guitar and the conceptual connections I was forming. Prompts included:

- What specific tasks did you set for yourself this session?
- How much progress did you make on these tasks?
- Did you apply any concepts from your previous coursework?
    - If yes, which concepts? Did applying this concept deepen your understanding?
- How have you handled questions that you couldn't answer?
- Are you enjoying the work? What's enjoyable? What is not?
- Can I explain what I am doing to other undergraduates?
- Is there a balance between working and fun? Is this project contributing to my learning?

These targeted prompts helped me gather specific data on my conceptual development and emotional engagement with the project. They also highlighted an increase in collaboration with my peers, as the project grew more complex.

Autoethnographic Reflection

In addition to journaling, the autoethnographic portion of my research highlighted specific milestones with photos and videos that helped identify broader themes of my personal and professional growth. The methods used to analyze this data were emotional and descriptive coding. Emotional coding allowed me to capture the recalled emotional experience, while descriptive coding summarized the given photo into a short phrase [6]. With this combinational analysis, I obtained a wide range of emotional and technical experiences related to my PBL experience.

Results and Discussion

The following sections will discuss the findings from the two data collection mechanisms (reflections and autoethnographic reflection).

Reflections (Summer and Fall, 2024)

Across the weekly reflection prompts, five key themes consistently appeared: Confidence Through Project Ownership, Conceptual Framework Development, Emotional Insights, Development of Hands-On Skills, and Collaboration. These themes serve as a basis of data, providing insights into the progress, emotional, and collaborative aspects of the project while highlighting the specific skills learned throughout the process. The following sections will detail these findings.

Confidence Through Project Ownership Throughout the reflections, there was an evident shift in my confidence. I started with uncertainty and fear, but as the weeks went by, I began to reflect more confidently on both my progress and abilities. Near the beginning, I went on to state that "*It felt like everyone was telling me it was what I needed to do to be successful, and I hated that idea.".* This feeling came from the overarching notion that the project I wanted to pursue did not "count" as research and stuck with me until I talked with my research mentor. Later I mentioned "*I didn't think I would be able to get the guitar project sorted out, and I was surprised by how many applications it could be used for."* This shift in project focus gave me a vision, and continuing the development, there was a large boost in my confidence. Though I was just starting the project, this approval gave me the confidence to learn and led to a more personally meaningful experience. There are distinct memories and notes where I wrote down "*I can't believe I get to do this project.*" It was transformative for me as an undergraduate researcher and gave me the confidence that I continue to carry.

Reflecting much later in the project, I noted: *"I feel proud of the challenges I've faced and overcome while working on this project.".* I started to feel more like an engineer and went on to note that:

> When assembling my first prototype this week, I felt like a real engineer, I was managing my wires, programming my microcontroller, and seeing the fruits of my labor starting to come together.

Completing this prototype, despite its issues, mishaps, or mistakes, showed me a valuable lesson about what goes into project creation. The tone in my reflections is evident, I went from being unsure if my project fit others' criteria of research to feeling like an engineer solving problems and building things.

Conceptual Framework Development Within my reflections, you can see points in which I connect concepts I learned in class to a practical aspect of the project. At one point, my motors were stuttering when attempting to turn, and I could not understand what I was doing incorrectly. When I swapped to a dedicated power supply and checked the current using a multimeter, I found that each motor was peaked at 1.5-2 Amps. This discovery instantly clicked with my coursework, and I even said to my research mentor: *"Since they're in parallel the current is being split across each of the six motors?"*

I knew this concept theoretically and had even applied it in course-based labs; within the project, however, I began to understand how power supply calculations would be handled in the real world. Documenting my experience and in response to "which concepts? Did applying this concept deepen your understanding?" I stated:

> The concept used for servo testing would be categorized by either power management or load analysis. I had to make sure that the power supply I was using could supply enough current for each of the servos. I know that each servo peaks around 1.5A - 2A, and since they are all in parallel, I must supply around 9A-12A in total since there are 6 servos. This deepened my understanding, as in lab we always completed tasks in which we already had a power supply capable of our needed current draw. Being forced to select my own external power supply helped me more deeply understand the process of battery/power supply selection due to the specific ratings of a system.

Designing the circuit for this project was simple in theory, and though I had learned all the skills theoretically in the classroom, I had never applied them to real situations. By the end of the study and project, I had reflected on a deeper understanding of Ohm's law, Kirchhoff's Voltage Law, and other theories. Most importantly to me, though, is that I had researched and created a parts list, made a circuit diagram, and went out of comfort zone to tackle the mechanical challenges of the project.

Emotional Insights The selected reflection prompts allowed for an emotion dataset, leading to an analysis of my emotional experiences as I worked through the project. As classes got more demanding and the semester as a whole became taxing, I began to state: *"There is more of an emphasis on work as I feel as though I am behind my own expectations, this is leading to a lot less enjoyment as I am always stressed about my progress."* This glimpse into my emotional state emphasized the challenge of balancing academic pressures with personal projects. Attempting to do research, projects, and other club commitments with academic pressures allowed me to understand something important about my own personal limits. I remember reflecting at the end of the semester, "*I wish I could've focused more on one project rather than spreading myself thin*". Being pulled in all these different directions I found myself losing the depth of involvement that each of my projects deserved. My ability to manage teams, contribute technically, and learn all diminished as I took on more and more responsibility. Through this, I began to understand both my personal limits and the need to prioritize smaller amounts of projects to achieve the greatest quality in each.

Development of Hands-On Skills One of the largest motivators for completing this project for me was to learn hands-on skills that experiences other than PBL cannot provide. As progress continued, my reflections showed the development of not only the previously discussed conceptual framework, but also hands-on skills overlooked in my other educational experiences.

As I worked through the project, I wanted to learn skills that applied to my career. In response to the prompt *"In simple terms (e.g., explain it to a parent), using 2-3 sentences, what are you thinking about doing?*" I stated:

> Creating a robotics-powered guitar that plays solely using electronics and code. This guitar would be able to mimic the playing of a human as well as achieve note combinations not possible with human limits.

The project had a variety of skills I wished to gain: being hands-on with electronics, programming microcontrollers, and combining music and engineering to solve problems. PBL gave me the opportunity to develop the skills I wanted to learn on my own terms in a project that I found personally interesting.

Moving through the project, in the quote previously mentioned, "*When assembling my first prototype this week, I felt like a real engineer, I was managing my wires, programming my microcontroller, and seeing the fruits of my labor starting to come together*." it was obvious that the skills I set out to learn were achieved through my continued work on the project. Before this, throughout my coursework I had created circuits in lab environments. However, I never had the chance to design, fabricate, and test my own designs from the ground up. The skills learned in this project became some of the most valuable and industry-applicable in my entire undergraduate experience at the University of Georgia.

Collaboration Beyond my personal experiences, I had the chance to collaborate both directly with the UGA Robotics club and with peers in my classes. While testing, proving, and applying theories learned in my coursework, I talked about my experience with many of my classmates and peers, where I went on to say: "*I found that I could express my conceptual connections as when I was explaining I could see that my classmates understood my choices for the servo system."* Being able to validate my ideas and work through my issues with classmates showed me not only what I still have to learn, but what I can show others after working on the guitar.

I began talking more and more with my peers as I struggled with the mechanical aspects of the projects, going on to say, *"I am always collaborating and bouncing ideas off of others and a lot of the time I see them learning right there with me."* This reflection highlighted the need for collaboration within engineering and showed me the interdisciplinary nature of the field as a whole. I knew that I, as an electrical engineer, needed assistance completing the mechanical aspects of the project. This is when I began working more heavily with a fellow student in the UGA Robotics club. As we worked together, rapidly iterating through designs, we both reflected on our conversations, stating, "*It's so interesting solving the problems associated with this project and finding which aspects each of us can tackle best*." We played off each other's strengths, and ultimately, collaboration is what pushed the project to its completion.

Autoethnographic Reflection

This section chronologically analyzes images from my work on the project, focusing on my emotional experiences throughout the project and associated technical challenges.

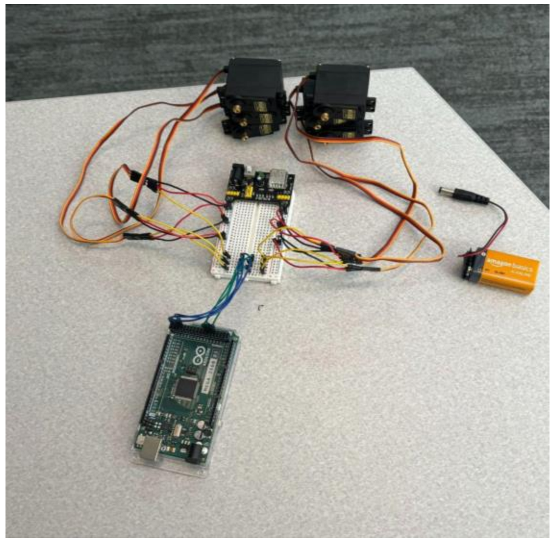

Figure 1. First attempt at wiring six motors (Picking System).

In the photo, I detailed my first-ever attempt at wiring all six of my motors. I was so proud as I had wired them correctly and, in that moment, I knew I had created a full electronic system without external assistance. Unfortunately, as previously discussed, this ultimately did not function correctly; however, this is where I discovered the stuttering motor problem which would ultimately lead to the most important conceptual connection of the whole project.

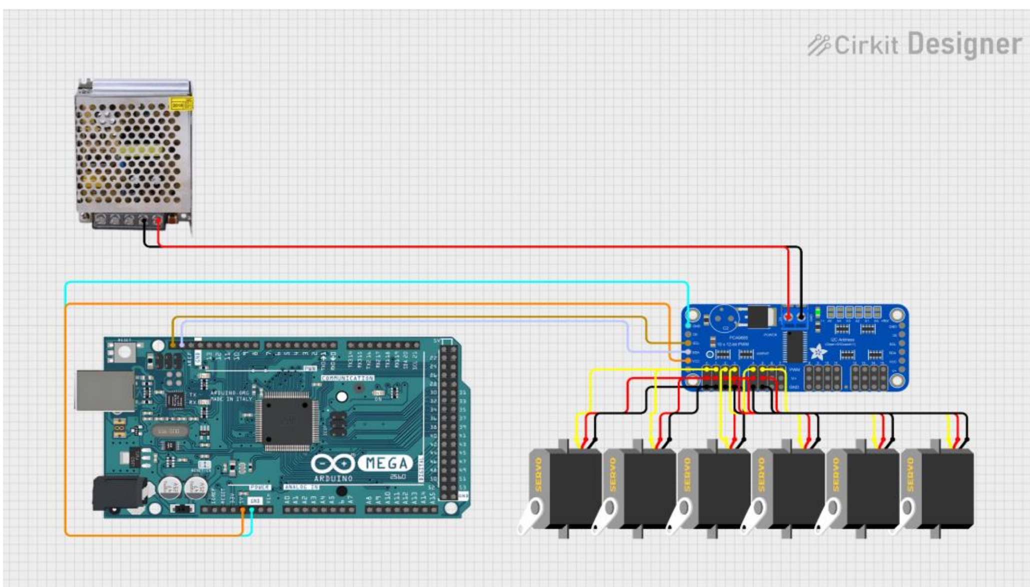

Figure 2. Updated wiring diagram using external power supply and dedicated servo driver controller (PCA8985).

Figure 2 details my updated wiring diagram with an external power supply and a dedicated servo drive controller. While I researched, I determined the best way to connect and power six servo motors would be through an external driver board. I had never used these boards before (PCA8985) however, they eliminated the need for a breadboard and provided simple connections for the servo to interact with the Arduino microcontroller. I noted in my meeting with my mentor that I felt as though I understood what I was doing on a deeper level. I knew how everything connected and added this drive controller with almost no physical trouble.

Figure 3: Still image captured from a video where all six motors turned concurrently

The image above is taken from a video in which I demonstrated all six of my servo motors working where I stated: *"I have been trying to get it to do this for weeks."* My happiness was evident in this video as all the research I had done and the parts I had purchased were working together. As a result, I felt a newfound confidence that I was going to get the project finished. It was a difficult experience handling this project all on my own and it was moments like the one in the photo above where I felt as though I had become an engineer.

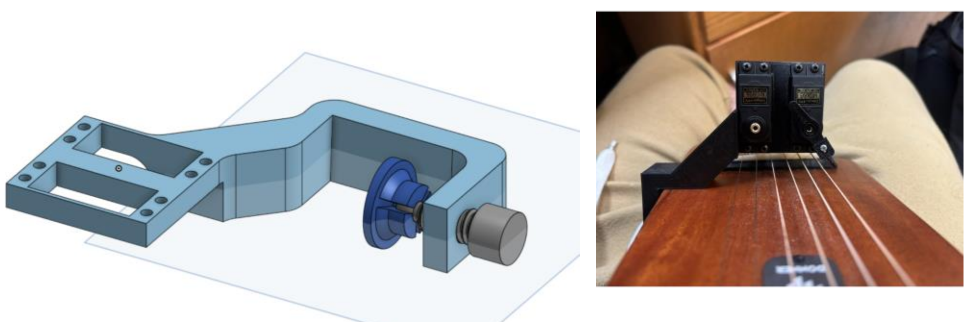

Figure 4. CAD (left) and physical (right) model of first prototype.

The two images are of both the CAD and physical model for my first prototype. After many failed prints I was able to get a prototype mounted and wired and with initial testing completed, I knew I needed a redesign. This, however, did not affect my emotional experience. I was so happy that I had completed a prototype and despite the frustration of the prototype not working, I was ready to iterate and complete another version. Additionally seeing my CAD become a physical prototype sparked more motivation to continue working on future versions.

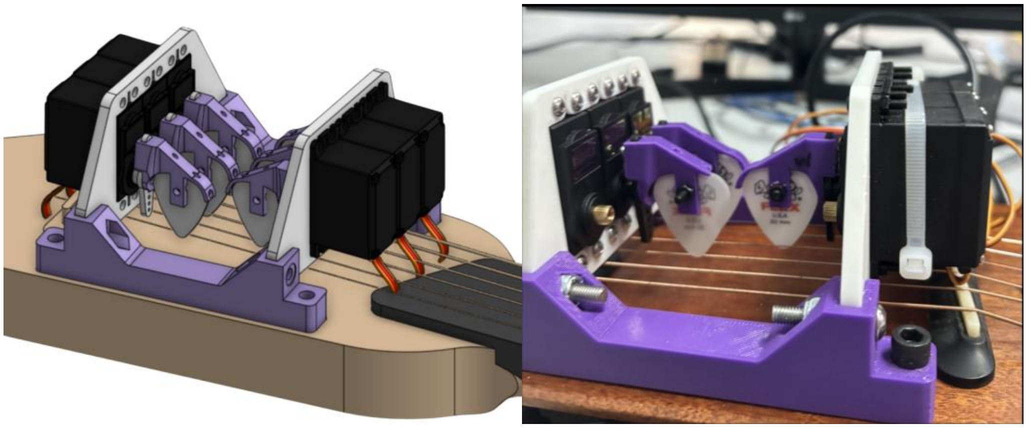

Figure 5. CAD (Left) and Picture (Right) of the final iteration during Christmas break

Figure 5 above illustrate the result of seeking help from my peers in the UGA Robotics club. Undergraduate student Parker (second author) played a crucial role in the ideation and prototyping, tackling one of the hardest mechanical aspects of the project–modeling the guitar.

Initially, I was hesitant to ask for help as I felt that seeking assistance would only highlight my shortcomings. However, with Parker added to the project, we both grew together. Reflecting on our final prototype, I am incredibly proud of the product we created. Without Parker, I would have never been able to model the guitar, make an interchangeable mounting system, or rapidly iterate through 3-4 designs in less than one month.

When taking these photos, I realized how much less stressed I was to make progress. Working with Parker, we faced challenges together, significantly increasing our productivity. I had not realized how isolating the project had become, so working with Parker allowed me to learn even more than before and increased my personal enjoyment of the project.

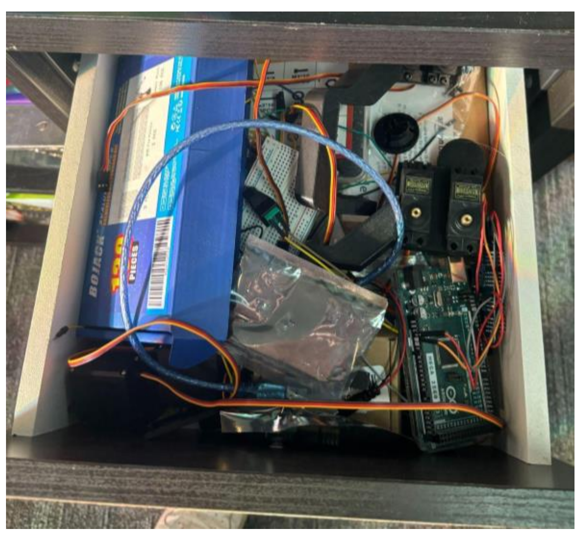

Figure 6. All my parts being put away for one last time in my lab.

The picture in Figure 6 was when all my parts were being put away for one last time in my research lab (the Cultivate Lab). Since I was moving to a Co-op position for the Spring 2025 semester, my time on the project was cut short. In this moment, rather than appreciating the work I put in, I remember feeling disappointed at my inability to complete the project. I thought back to all the things I could've done differently, but then, I realized how much I had learned. In part of my summer, and another semester, I learned how to program an Arduino, wire servo motors, perform power calculations to choose a power supply, and ultimately create a physical prototype based on my CAD model. Within this project, I can confidently say that I learned more applicable real-world skills than in any other course in my undergraduate degree.

Summary Discussion and Conclusion

The self-playing guitar project provided critical insights into the value of PBL in ECE education. Through my reflective journaling and technical milestones, the disparity between real-world applications and theoretical processes learned in coursework was evident. Designing, building, and programming a robotics-powered guitar demanded not only deeper technical knowledge but also iterative problem-solving, interdisciplinary collaboration, and self-directed learning—skills that are often underdeveloped in traditional classroom settings [11].

The results of my study highlighted the potential of integrating PBL more thoroughly into ECE curricula. Students who participated in hands-on projects develop a more robust conceptual framework when faced with a real-world engineering challenge [1]. For example, when I applied principles of power distribution to motor controllers and troubleshot current drops in a practical context. Virginia Tech adopted this approach in its Second-Year ECE design course, where students tackle the creation of a tractor robot [10]. In a course where milestone setting and conceptual development was emphasized, undergraduate ECE students were able to solidify theoretical concepts. I know from first-hand experience how these experiential learning processes can enhance both technical competencies and students' confidence as an engineer.

By further documenting the emotional and cognitive challenges of this project, I identified areas where traditional coursework could better support students in developing perseverance, adaptability, and self-efficacy. These qualities are essential for success in complex, real-world engineering projects, yet they remain forgotten despite their deep effect on under-represented engineering students [12].

While my study focused on a single project, its implications for curriculum reform are significant. Integrating structured PBL opportunities into core coursework could ensure that all students—not just those involved in extracurricular activities—benefit from the skill-building necessary for post-graduation engineering work [13].

Future research inspired by this study could explore the long-term impacts of PBL on student outcomes, such as employability, entrepreneurial success, and contributions to the engineering field. By expanding on this research, educators can continue to refine PBL frameworks, ultimately inspiring curriculum reform that prepares students more effectively for the challenges and opportunities of modern engineering careers. My project underscored the urgent need for such reforms, and I hope it catalyzes ongoing discussion and action within the ECE education community.

References

[1] B. Johnson, The impacts of Project Based Learning on self-directed learning and professional skill attainment: A comparison of project based learning to Traditional Engineering Education | IEEE conference publication | IEEE xplore, https://ieeexplore.ieee.org/abstract/document/7344028 (accessed Jan. 16, 2025).

[2] R. Ulseth, “Development of PBL students as self-directed learners,” *2016 ASEE Annual Conference & Exposition Proceedings*, 2016. doi:10.18260/p.26823

[3] A. Micallef Grimaud and T. Eerola, “Emotional expression through musical cues: A comparison of production and perception approaches,” *PLOS ONE*, vol. 17, no. 12, Dec. 2022. doi:10.1371/journal.pone.0279605

[4] *The Techniques of Guitar Playing CD. Seth F. Josel ; Ming Tsao*. Kassel: Bärenreiter, 2014.

[5] G. Weinberg, M. Bretan, G. Hoffman, and S. Driscoll, *Robotic Musicianship: Embodied Artificial Creativity and Mechatronic Musical Expression*. Cham, Switzerland: Springer, 2020.

[6] R. Cooper and B. Lilyea, “I’m interested in autoethnography, but how do I do it?,” *The Qualitative Report*, 2022. doi:10.46743/2160-3715/2022.5288

[7] J. Turns, B. Sattler, K. Yasuhara, J. Borgford-Parnell, and C. Atman, “Integrating reflection into Engineering Education,” *2014 ASEE Annual Conference & Exposition Proceedings*, 2014. doi:10.18260/1-2—20668

[8] L. Sepp *et al.*, “On an upward trend: Reflection in Engineering Education,” *2015 ASEE Annual Conference and Exposition Proceedings*, 2015. doi:10.18260/p.24533

[9] C. N. Poulos, “Conceptual foundations of autoethnography.,” *Essentials of autoethnography.*, pp. 3–17, 2021. doi:10.1037/0000222-001

[10] Schuman, Andrea, “Project-Based Learning for a second-year ECE Design course,” thesis, Virginia Tech, 2022

[11] J. Coutermarsh, K. Connor, and D. Millard, “Re engaging engineering students in hands on Education,” *2006 Annual Conference & Exposition Proceedings*, 2006. doi:10.18260/1-2—1115

[12] S. Mousavinezhad *et al.*, “IEEE Real World Engineering Projects (RWEP),” *2012 ASEE Annual Conference & Exposition Proceedings*, 2012. doi:10.18260/1-2—21470

[13] I. Jouny, “Outsourcing ? resilient ece curriculum,” *2007 Annual Conference & Exposition Proceedings*, 2007. doi:10.18260/1-2--1512