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The STEM Guitar Project 2020-2021 Evaluation Report

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The STEM Guitar Project

2020-2021 Evaluation Report

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2020-2021 Evaluation Report

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The STEM Guitar Project

2020-2021 Evaluation Report

Executive Summary

Introduction

This is the Executive Summary of the 2020-2021 evaluation report for The STEM (Science, Technology, Engineering, and Math) Guitar Project funded by the National Science Foundation Advanced Technological Education (NSF ATE Award #1700531). This evaluation report is prepared for Sinclair Community College in Dayton, Ohio, the primary institution involved with the Project. The report covers the period from June 2020 through May 2021 and focuses on the formative and some summative aspects of the Project evaluated within the context of the 2020-2021 program implementation. Limitations, conclusions, and recommendations are included in this Executive Summary.

Results

The context for the 2020-2021 program evaluation includes the Project context of implementation within the corona virus pandemic situation (COVID situation) and includes the Project background and the program evaluation approaches, design, and methods. The Project background deals with the Project's overall description, goals, objectives, and program theory. The Project's goal is focused on increasing student interest, engagement, and learning of STEM principles, practices, and careers through guitar design and building. The program theory is based on the STEM Guitar Project's intent to mitigate the skills gap and need for technicians with advanced technical knowledge and hands-on experience made possible through its faculty professional development Guitar Building Institutes in 2020-2021. Two of the Project Team members are conducting a research project (independent of the program evaluation) about the STEM Guitar 10-year program implementation; results are expected to be shared at the end of the project.

The STEM Guitar Project trained a total of 116 Faculty and veteran participants. Ninety Faculty members were trained in STEM Guitar Building Remote Learning Institutes (SGBRLIs): (1) one conducted in Summer 2020 with 75 participants and (2) one in Spring 2021 with 15 participants. Twenty-six veterans were trained in three workshops, two of which were done remotely and one in-person: (1) six in the Fall 2020 remote learning, (2) 15 in early Spring 2021 remote learning, and (3) five veterans in in the mid-May 2021 in-person workshop. Eighty-one percent of the Faculty provided evaluation data while 65% of the veterans did the same.

The evaluation goals and questions remain based on the Project's continuing goals and focus guided by Guskey's (2002) five levels of evaluating professional development and the Project's program theory and philosophy. The five evaluation questions are based on: (1)

diversity of participants, (2) program effects on Project participants, (3) support for STEM Guitar program implementation (4) effects on students, and (5) the Project spread and overall sustainability. Data collection methods included a retrospective evaluation for the Faculty and pre-post evaluation surveys for the veterans. Perspectives from the Trainers/Facilitators were gathered. Archival data like the minutes of meetings, social media analytics, and other Project documentations were included in the data pool. Mixed methods and developmental evaluation approaches were used as part of evaluation approaches. Evaluation capacity building was used to help the Project Team develop its evaluative thinking to optimize use of evaluation results for continuous program improvement. Appropriate qualitative (e.g., applied thematic analysis) and quantitative (e.g., non-parametric and descriptive statistics) analysis tools are used accordingly.

Formative and summative results are presented in this report. Formative results include the Project Team working structure and process, Project implementation, and Project output. Summative results include data showing increased involvement of STEM Guitar participants, program effects on participants, and support for faculty in their STEM Guitar program implementation. The report highlights how the Project helped the Faculty program implementation and included emerging outcomes that included effects on students, wider Project spread, and overall sustainability.

The STEM Guitar Project working structure and process remains seamless through several years of Project existence. The Project overall working and decision-making process involves the dedication and full commitment of the Project EXECOM and Team members to the STEM Guitar Project that are spread across the United States. The quality of support and Project team processes promulgated continuous Project quality improvement. The Project maintains a cumulative agenda and minutes that makes it easy to track Project decisions, milestones, and events.

Program implementation for 2020-2021 started with participant recruitment marketed within underrepresented groups. The Project implementation in 2020-2021 had been responsive to the COVID -19 situation across the country that made it difficult to conduct face-to-face Institutes. The continuation of the STEM Guitar program was made possible through remote learning called the STEM Guitar Remote Learning Institutes (SGBRLIs). Improvement of the COVID situation in the country paved the way to an in-person veterans workshop held in mid May 2021. This was a most welcome turnaround for both the Trainers and participants.

Agendas for the Summer 2020 and Spring 2021 program participants were reviewed and adjusted according to the perceived needs of the accepted participants. Agendas for the Faculty were meant to support the Faculty program implementation in their classrooms to help participants in increasing their students' learning and acquisition of guitar-building STEM-related learning. Some of these efforts focused on the review of the Institute agendas to enable use of the newly developed MLAs and videos embedded in Canvas, an electronic curricular software, intended for classroom use. For the veterans' Fall 2020 and Spring 2021 SGBRLI workshops, the agenda review focused on trainers' handling and overt

demonstration of employable hard and soft skills, and when feasible, included basic entrepreneurial knowledge such as time management, concepts of feasibility, efficiency and team work, among others. The Team efforts in developing, adapting, and revising content materials are evident in the different teaching-learning materials posted on “Files” within Canvas. It is not unusual to see every now and then Project Team members sharing self-created materials or ideas about new materials on emails and Facebook. Project learning materials developed in the previous years were further enhanced and more materials were added in 2020-2021.

It is always important to learn from the Institute experiences. Participants reported about the helpfulness of the SBGRLI sessions. A majority of Faculty and veterans who attended the remote learning sessions found the synchronous sessions very helpful; Most of them consulted with their Trainer outside of the synchronous sessions and they found this highly helpful. About half of the Faculty interacted with and asked the help of and/or helped their fellow trainees. More than 70% of the veterans interacted and worked with and/or help their fellow trainees regardless of whether they had remote learning or in-person learning. As the Project PI said, “it is just like the veterans...they are brothers/sisters and had shared common experiences; guitar building is another shared experience they most welcome and enjoy.”

Comparisons and Integrated responses of SGBRLI Faculty, veterans, and Trainers about program improvement and areas of growth were presented to better understand the context from which they were coming. Thematic analysis was conducted using a priori categories in terms of implementation improvement, improvement of content, SGBRLI materials used, and application of learning from training. There was overwhelming response about the quality of Trainers/Facilitators and the support they provided before, during, and after the training. There were suggested improvements in the content and materials used, and comments about application of learning for classroom use, naturally by the Faculty. While support is generally provided by the Team during synchronous sessions and email communications, participants noted that there has been no real supportive community that emerged during and even after the implementation of the SGBRLI. The COVID situation did not allow for the Project summit scheduled in November 2020 to be held. The participants are being invited to join the online Guitar Summit that will be held in June 2021. Seemingly, the veterans that underwent training in the Fall of 2020 were “advanced trainees”, having gone to a previous electric guitar build, a requirement for attending a CNC SGBRLI. All Fall 2020 veteran participants were very happy, and satisfied with their online training. Overall, everyone indicated very positive results about the Institute implementation.

The Project output included the guitar products produced by participants, the 2020 photo story book, and the STEM guitar kits, as well the materials, videos, and other learning materials/references for future use of all participants in their academic endeavors, as with the case of the Faculty, and in dealing with “real” life, as in the case of the veterans. Pictures of the Institute and workshop outputs show the support they got from the Project as they showcased products from CNC machining or built guitars with different artistic expressions. The products show the learning and creativity of the participants. E-portfolios are part of the project output,

especially for the Faculty. This was not a requirement for the veterans although some of them submitted this. The e-portfolios were submitted for the Trainers review (not included in this evaluation) to assess participants eligibility for added incentives, as well as to earn the certificate of participation.

The 2020 STEM Guitar Photo Story Book is the seventh photo story book produced by the project with one member of the Project Team at the helm and other members' materials for the book content. All the story books may be viewed at the Project's website (<http://guitarbuilding.org/about/grant-evaluation/>). The 2020 photo story book focused on the adjustment of the Project's professional development training to remote online training. Participants' products, achievements, and feedback during the training were included, including some of the project highlights garnered from various social media.

STEM Guitar kits are available through the Sinclair College Guitar Manufacturing Team's effort, a self-sustaining endeavor operating independently without the NSF grant support. Finished products are advertised on the STEM Guitar website "Storefront" (<http://www.guitarbuilding.org/store/>). The production team ensures that guitar kits are made available in time for the Institutes and Faculty requests for classroom use. The COVID effects manifested in the lower guitar kit sales receipts/volume in 2020-2021. During the COVID period many schools did not allow in-person classes. This affected any lab-related activities, including guitar building.

The STEM Guitar Project has more than 100 teaching/learning material resources and still counting. The repository of the STEM Guitar teaching and learning materials is the Project website <http://guitarbuilding.org>. As of this date, the Project is continuously developing its website to ensure that all recent materials used and created by the Project Team and Faculty participants are made accessible to everyone. The Project Team has been responding to the participants' feedback regarding improvements of MLAs, videos, and other learning materials and references.

The summative results include evidence of increased diversity and involvement of the STEM Guitar 2020-2021 participants. There was a 2% increased participation of female Faculty trainees in the Project. The Project reached out to poor (mid-to high-poverty) schools and schools with greater proportion of under-represented population in 90 academic institutions. A majority of these institutions have student populations of more than 1,000 across 21 states within the four major Census and Regional Divisions of the United States. The Project has established that each Faculty has an average direct reach to about 20 students. Thus, in 2020-2021, close to 2,000 additional students from poor and underrepresented academic institutions would have a variety of experience with STEM Guitar either through direct information from their Faculty, the social media, direct build in their classrooms, and/or the faculty implementation of MLAs or use of Canvas.

The participants' reported learning outcomes are in terms of their learned hard and soft skills. The Project has established mapping of the hard and soft skills learned within the

STEM Guitar building as being related to helpful employability skills. In the sense of the Project Institutes and using the concept of Guskey's 5th evaluation level, the "students" are the Faculty and veteran participants. The Project continues to follow-up on the Faculty participants' actual use of knowledge in the classrooms and is trying to clarify knowledge about classroom student outcomes. The "students" (Faculty) of the Institutes/workshops were asked to identify their three most important learnings from the Institute/workshops. While there was an array of learning of different skills related to guitar building, the participants identified the following as their top three most important **new** learnings: (1) the curriculum (use of Canvas and CNC design for the groups that did CNC), (2) electricity, circuits, and proper soldering, and (3) guitar finishing. The three most important **enhanced** learnings are: (1) electricity, circuits, and proper soldering, (2) guitar finishing, and (3) overall guitar assembly. There was no specific prodding to identify new or enhanced soft skills, yet some participants mentioned the importance of soft skills such as communication and collaboration, patience and perseverance, creativity and innovation and time management. The veterans were asked about their levels of proficiency among the soft skills identified in the 21st century learning. There were no significant differences in the pre-post- responses of the veterans. They reported proficiency and expertise among the soft skills identified, the top three of which are: (1) Productivity and accountability, (2) communication and collaboration, and (3) leadership and responsibility. Reported proficiency and expertise in these three soft skills is not surprising for the veterans have been honed with these during their military service. One of the participants from the early Spring 2021 veteran's workshop must have shown outstanding hard and soft skills learned; he was hired at the Sinclair Guitar Manufacturing Shop immediately after the workshop

The Project tried to establish structures and processes to facilitate administrative support for Faculty; there was formal administrative support as early as the application for program participation. This clears the path for the Faculty to move ahead through their classroom implementation. The Faculty are encouraged to participate in the Project's Applied Learning Community; however, the yearly Summit scheduled in November 2020 did not materialize because of the COVID situation. Participants are now invited to join in the virtual Summit slated for June 2021. Meanwhile, participants had the website for curriculum download and exchange, as well as blogging. About half of the total Project website access in 2020-2021 was on curriculum, a testament to the seed of engagement and involvement in the Project sown by the Project Team

The Faculty reported that the Project is helping them prepare for their classroom implementation through the use of MLAs and the physical guitar build that helped them make STEM Connections. The physical guitar built served as inspiration and motivation to use this hands-on and problem-based strategy in integrating STEM in their classrooms. The fact that the Faculty are also planning to order guitar kits indicate that they are planning on the physical build of guitars. The Faculty response to their level of preparedness to implement the STEM Guitar program in the coming school year was relatively conservative compared to their responses about the materials and process they learned and their plan to purchase guitar kits. It is hard to say if this is because of uncertainties of the COVID situation or any other contextual situations in

their academic environment. The results of the 10-year research study may give light on this issue.

The Project website (www.guitarbuilding.org) has been a big help for everyone interested in the STEM Guitar project. The website, available remotely, is open to everyone and anyone across the world. Interest in the website content is indicated by the proportion of page views. About half of the total website access was related to the Project curriculum and process, which could be indicators of Faculty access with their program implementation. The level of website access could also indicate the level of interest on particular materials or news about the Project. It is interesting to see an “anomalous” spike on March 23, 2021 in the website daily views. That date was about the time the Project received the Gerhard Salinger Award from the International Technology and Engineering Educators Association (ITEEA); the news went viral. This shows the importance of sharing worthy news through this medium, enhancing further the value of the Project to the community.

Data analytics for the Project’s website, the STEM Guitar Project Facebook (SGP_FB) account and guitar kit sales show basically the same trend in terms of activities within the time of the year. Fewer access reports of the website, the SGP_FB account and sales of guitar kits clearly showed the “COVID effect” on the Project. However, the Project website views and access to the SGP_FB account show similar trends of active involvement (through “Impressions”, “Reach” and “Engagement”) and seemingly more activities in the month of February 2021. The “Viral Reach” and “Engagement” data means unique people accessing the page do not simply download the content but contribute/add more and enrich the Project content. By doing so, Project content is developed further with extended reach as the Project content access increased at an exponential pace. The Project PI posited that the February 2021 consistent spikes in all these social media, as well as the guitar kit sales, are indicative of the usual program implementation and physical guitar build toward the end of the school year. Also, there were 90 faculty trained in Summer 2020. A majority of these Faculty reported they will order guitar kits in the upcoming school year, indicating they would implement the program.

Follow-up with the case study schools was not feasible because of the COVID situation but the Faculty continued to monitor student performance and whereabouts. Five of the case study students are attending Sno-Isle Tech (a technical academic institution with a 2-year certificate program) or plans to attend Sno-Isle. The Senior student who is graduating from high school and Sno-Isle Tech is pursuing electrical engineering at college. The other student is a junior who has one more year, both in high school and Sno-Isle Tech. Although follow-up with students had not been feasible in 2020-2021, activities with students in various schools continue as their states and institutions allow. Despite mask and social distancing requirements, high school students continued guitar building involvement during the COVID period, learning STEM-related hard and soft skills.

The wider spread and extent of the STEM Guitar Project is evidenced by the Project span of implementation, as well as coverage and magnitude of interest in the Project. It is noteworthy that the span of the Project reached almost all the US states (except North and

South Dakota), including Alaska and Hawaii, as well as Australia and Canada. Faculty Champions across the United States continue to implement the program in their schools, despite the COVID situation. The COVID situation did not deter the STEM Guitar Project from conducting the STEM Guitar Institutes. Project implementation in 2020-2021 added participants spread across 21 states within the four major US region.

Project team members received several awards and recognitions because of their involvement in the STEM Guitar Project. Most of them work hard and stay behind the scenes. It is worth mentioning though, at least three significant recognitions for Project Team members because of their involvement with the Project: (1) the Gerhard Salinger Award for enhancing STEM education through technology/engineering design-based instruction awarded by the International Technology and Engineering Association (ITEEA), where six Project Team members were named award recipients, (2) the Congressional Recognition for Teacher Excellence Award to one active Project Team who is a high school Faculty in Pennsylvania, and (3) the recognition of the STEM Guitar Project by Gibson Guitar Nashville. The two Project PIs worked together to help Gibson Guitar Nashville revamp its onboarding orientation for their new hires, creating skills assessment for the interview process, design, and implementation of the company's new hire training program called "The Gibson Main Stage Training Program." It was quite an honor for the STEM Guitar Project that the Gibson training modules created were similar to the way the STEM Guitar modules are created, and that one of the Project PIs was contracted for three months to help oversee the start of this training program.

The STEM Guitar Project dissemination is a joint and continuous effort among the Project Team throughout the grant period. The Project Team though has been following the practice of formally documenting any Project media exposure in the Project spreadsheet started in this current grant. Project Team members wrote articles for journals like the *American Lutherie* and presented in events and conferences of professional organizations. Topics varied and are usually about the STEM Guitar project, building guitars, integrating STEM learning in guitar, and guitar building lesson materials and portfolio. During the project year 2020-2021, at least six Project Team members were involved with these topics. For this project year 2020-2021, two media exposures had been formally reported in February 2021: (1) a remote/online report about the activities of the 4th grade class regarding sounds and vibrations in guitars at the West Lafayette Intermediate Schools publication, and (2) the remote publication about Engineering, Technology, and Guitars in celebration of the Fender Engineering Week in Fender, Corona, CA. Every STEM guitar building workshop with the veterans has been followed by a music concert (with the American Patriot Music Organization) featuring the veterans as they showcase the guitars built from the workshop. The May 2021 workshop held at Somerset Vineyard & Winery in Temecula; CA is no exception. Local media networks such as the CBS Radio at the EZ 103.1 FM radio station aired information about the event on KFROG 92.9

The overall Project sustainability is a continuous Project concern as overall sustainability efforts have been part of the Project activities since the beginning of the grant.

The Project continues to experience a wider span of academic partnerships as more and more participants around the US states and from other countries such as Australia, Canada, and Colombia are becoming involved. The Project-developed Administrator Video is a way by which the Project promotes the academic institutional partnership. All Faculty participants in the Project are required to get formal administrative support prior to their training in any STEM Guitar Institutes. Once Administrators understand the integration of STEM guitar curricula with their school curricula, “buy-in” follows readily. Strong STEM Guitar connections have been established with different institutions across the United States that hosted STEM Guitar Institutes in the past; for example: San Diego City College, San Diego, CA; Travis Early College HS in Austin TX and Anuntuck Community College in Enfield, CT. The stability of the Project’s connections is shown through the repeat GBI hosting in 2020 of institutions like: Sinclair Community College in Dayton, OH; Pennridge High School in Perkasio, PA; Grants Pass High School in Grants Pass, OR; and Kankakee Community College, Kankakee, IL. Every year since the start of the first grant, Faculty Champions emerge. The Faculty Champions serve as the best ambassadors to academic institutions as they model the STEM Guitar curricular Project-based learning implementation in their institutions.

Partnerships with professional associations through the team members’ professional conference presentations, and for some members, memberships in these associations, are continued and pursued. Additionally, the Project maintains its connections with different NSF Advanced Technological Education (ATE) Centers such as the National Center for Manufacturing Education (NCME) and Materials Education (MatEdU); these centers are committed to providing up-to-date information on manufacturing processes and information on various materials needed to make a guitar (e.g., metal, wood, polymers, etc.) and the properties of each of those materials.

The STEM Guitar Project is able to explore and develop continuing business and industry partnerships with business/industry connections. Relationships with business and industry contribute to the Project buy-in, acceptance, relevance, crowd-sourced funding, and greater visibility for Project promotions and funding to support the potential skills certification. Among the Project’s corporate partners are: Fender Musical Instruments, Taylor Guitars, Gibson Guitar, Martin Guitar and Heritage Guitars, Credly,, All Parts, Black Diamond Strings, D’Addario, Forest Scientific Corporation, FML (Frank Miller Lumber), Indasa, ShopBot, and Stewart MacDonald. The corporate partners continue to support the STEM Guitar Project by providing personnel expertise and in-kind support to participants. For instance, Fender Musical Instruments donated \$7,000 worth of woodworking materials in 2020-2021.

The STEM Guitar Project reaches out to the larger community. The Project Team maintains a strong presence during the National Association of Music Merchants (NAMM) conference where interested music celebrities attract more attention, publicity, and media exposure to the Project. Many Faculty continue to reach out to their local media, state department of education, and government officials to add to the wider exposure and community awareness about the STEM Guitar Project. Often times, these efforts add to the increasing positive image of their class in their institutions, district, and the larger community.

The Project maintains connections with community non-profits and interested groups and organizations in Temecula, CA; Boulder City, NV; Lake Stevens, WA; and Dayton, OH.

Current STEM guitar building activity involvement which is not dependent on the current NSF grant funding is likely to continue. Examples are the international STEM Guitar outreach (through one of the Project Team members) at the University of Medellin in Colombia, the STEM Guitar manufacturing/production at Sinclair Community College, and the emerging school supply chain like those institutions with facilities and capabilities and where there are Faculty Champions dedicated to implementing the guitar-building problem-based learning program. The Project Team continues to explore other sourcing possibilities like local manufacturing, which may be interested in making guitar kits, as well as importing materials that may help optimize costs. The Project Team continues to generate ideas for new programs and/or STEM Guitar-related program expansion that may generate other private funding support. Currently, while the Project Team is also reviewing the potential for other funding support, there are some inquiries from institutions interested in sponsoring the STEM Guitar Institute for their own group. This will be sustainable especially if the institutions are providing the funding for the endeavor. At the time of this writing, logistics regarding this potential endeavor (such as, costs, materials, and personnel) are being reviewed by the Project Team.

Limitations

Limitations noted in the previous years' reports continue to be experienced within this reporting period. This Project has an affinity with informal STEM education (National Research Council, 2010, 2015) in the sense that faculty involvement in the professional development is voluntary and curricular implementation varies from participant to participant. Although classroom implementation and curricular integration are highly encouraged, some curricular implementation was conducted out-of-school or as limited program offerings like school extension classes. Thus, systemic collection of direct student academic data and other outcome constructs (as behaviors and attitudes toward STEM) across the implementing groups remains a big challenge. Student outcomes may be included in the results of the research study on the 10-year experience of the Project being conducted by the Project Team independent of this evaluation. This research is still on-going and results are not part of this report.

With the limitation regarding the classroom student data and challenges of the COVID situation, Faculty data are used as the archetypal "student" in the tradition of Guskey's five levels of evaluation for professional development. Evaluating Faculty's use of knowledge and Faculty's learning outcomes represent Guskey's 4th and 5th levels of evaluating professional development. Evaluation data were received only from 81% of the faculty and 65% of the veteran participants. The small data sets limited the quantitative analyses to descriptives and non-parametric tests, as applicable. Not everyone from both the faculty and veteran respondents provided answers to all evaluation questions.

Conclusions

The STEM Guitar project has the primary goal of increasing student interest, engagement, and learning of STEM principles, practices, and careers through guitar design and building to help solve the critical STEM technician shortage, narrowing the skills gap. Along with this primary goal are Project concerns about: 1) the increased involvement of diverse secondary and post-secondary faculty; (2) effects on faculty regarding their practice effecting student outcomes; 3) student learning about STEM concepts, behaviors and attitudes toward STEM; 4) Project facilitating a replicable and sustained Community of Practice Applied Learning Community; and 5) wider reach of the STEM Guitar Project and its overall Project sustainability. The Project has established mechanisms, processes and best practices through the years that were further honed and implemented in 2020-2021. The major goal was geared toward the academe although the application, aspirations, and learning from the STEM guitar program are transferable to the veterans; the veterans' training focus being on employability skills, narrowing the skills gap. In fact, one of the veteran trainees from the early Spring 2021 veterans' workshop was hired immediately by the Sinclair Guitar Manufacturing Shop. While the Project also trained veterans, these concluding narratives are more related to the Faculty context.

The 2020-2021 STEM Guitar Project program implementation increased the involvement of diverse secondary and post-secondary faculty trained in the inter-disciplinary approach to teaching guitar building making STEM connections to a certain degree. The Project served 2% more faculty trainees with diverse background. The Project continued to reach out to relatively large-populated poor (mid-to high-poverty) schools and schools with greater proportion of under-represented population in 90 academic institutions within 21 states in the four major regions in the US. This implies that close to 2,000 additional students from poor and underrepresented academic institutions would have a variety of experience about STEM Guitar either through direct information from their Faculty, the social media, direct build in their classrooms, and/or the faculty implementation of MLAs or use of Canvas. The Faculty use of STEM Guitar program materials in making STEM connections would have important effects on their classroom practice effecting student outcomes. The trained Faculty as "students" of SGBRLI experienced for themselves learning how to make STEM connections using the physical guitar building and the different STEM Guitar MLAs. As "students" of SGBRLI, they personally experienced learning the guitar building -related hard and soft skills they can model for their classroom students; these skills have been mapped with employability skills.

Through the Project grant years, and especially the Project year 2020-2021, the STEM Guitar Project endured and was able to adjust accordingly with the challenges of the COVID situation in conducting its program implementation. This was possible because the Project established practices, mechanisms, connections, and support for STEM Guitar program implementation. The participants' response about how the Project helped Faculty prepare for their program implementation were very favorable. The Project also modeled inspiring behaviors as evidenced by the Project awards and recognition that could help motivate Faculty, especially when faced with trying situations. The combination of all of these will promote and support strong Faculty classroom implementation. It can be said that there is

program impact in the sense of the program's reach and established practices; even companies in the Guitar Industry like Gibson Guitar are willing to adopt the STEM Guitar training practices. There are still some areas of growth in terms of the program reach to more diverse populations. More importantly, there are areas of growth and concerns about issues related to gathering outcomes data, both from the Faculty and Students. The nature of SGBRLI has more issues in terms of participant data collection, unlike previous years' Institute implementation where participants could be personally reminded by the Trainers about their evaluation and other Project requirements. Also, gathering student data is always the most challenging even with incentives given to the Faculty. There is just so much going in the classroom and the academic life (not to mention the personal life) of the Faculty. The Project is hopeful about its research on the Project's 10-year life and beyond.

Recommendations

The following course of actions related to the Project's best practices and areas of growth are recommended to the Project Team:

- 1) To ensure the STEM Guitar best practices are shared with anyone interested for further program impact, work on formal documentations in video and/or writing about:
 - a. Best practices in working with a team that are based all around the United States ensuring optimum Project results
 - b. STEM Guitar training similar to the what was created for Gibson Guitar;
 - c. Best practices for onboarding school administrators to the STEM program implementation in their schools
 - d. How to Make the STEM Guitar Applied Learning Community More Active and Meaningful for the Faculty
 - e. Best practices in creating course materials (videos, MLAs, Canvas curriculum, etc.)
 - f. Best practices in developing and maintaining business/industry partners who can help with in-kind, expertise, and financial help
 - g. Best practices in reaching out to the larger community and involving the larger community in the STEM Guitar program
 - h. Best practices in soliciting media support and other media exposure

- 2) To mitigate the areas of growth mentioned in the conclusion:
 - a. Improve the marketing/solicitation of applicants from diverse groups by being more proactive in searching for these groups and doing regular follow-ups with the group.
 - b. Involve and incentivize a team of Faculty to help devise feasible ways of getting faculty and student data outcomes
 - c. Ensure that the MLAs developed have goals/expectations related to specific hard and soft skills endemic to the particular lesson and have corresponding assessments for every skill included.

The STEM Guitar Project

2020-2021 Evaluation Report

Introduction and Project Context

This is the 2020-2021 evaluation report for The STEM (Science, Technology, Engineering, and Math) Guitar Project funded by the National Science Foundation Advanced Technological Education (NSF ATE Award #1700531). This evaluation report is prepared for Sinclair Community College in Dayton, Ohio, the primary institution involved with the Project. It covers the period from May 2020 through April 2021. Like the previous year's evaluation report, this report focuses on the formative and some summative aspects of the Project. The STEM Guitar building with the veterans started with the supplemental grant in Year 3 and continued in this project fiscal year. The challenges of the corona virus pandemic (COVID situation) in the country led the Project Team to a productive and creative way of reaching out to both the faculty and the veterans. The Project Team reached out to a total of 116 Faculty and veterans. Two Faculty remote/online learning Institutes (one in Summer 2020 with three program tracks; one in Spring 2021) were implemented. Two veteran online/remote learning workshops (one in late Fall 2020; and one in early Spring 2021) and one in-person veterans' workshop (in mid-May 2021) were conducted. The online Institutes were referred to as the STEM Guitar Building Remote Learning Institutes (SGBRLIs). Project Team members validated the different areas covered in this report through their data sharing and their Project implementation perspectives. The report includes the executive summary, project background, formative and summative results, conclusions, and recommendations.

The Project Background

The Project background deals with the Project's overall description of its fourth year (with extension) of implementation that showcased its goals, objectives and program theory, as well as the Project working structure and process.

Overall Description, Goals, Objectives, and Program Theory

Sinclair Community College continues to espouse its commitment to collaborative work with various partners from community colleges, universities, K-12 institutions, two NSF ATE national centers, as well as industry partners and other guitar manufacturers to conduct professional development Institutes for secondary and post-secondary faculty. The STEM Guitar Project, during its extension year, enjoys the advantage of building on its successful NSF ATE STEM-Guitar building-related Projects for the past nine years (NSF ATE DUE #1304405 & NSF ATE DUE #0903336). The main goal continues to focus on continued increase of student interest, engagement, and learning of STEM principles, practices, and careers through guitar design and building. The Project believes that doing so will help solve the critical STEM technician shortage, narrowing the skills gap (Queen, 2018).

The extension year of the STEM Guitar Project (fiscal year 2020-2021) trained a total of 116 Faculty and veteran participants. There were 90 Faculty participants (75 from the 2020 Summer SGBRLI; 15 from the 2021 Spring SGBRLI). Of these 90 Faculty participants, data were generated from 81% of Faculty (62 from Summer 2020 and 11 from Spring 2021). The 75 faculty from Summer 2020 were all trained online/remotely in three tracks: solid body electric guitar building, acoustic guitar building, and CNC (Computer Numerical Control) machining in manufacturing guitar parts. The 15 Faculty trained in SGBRLI Spring 2021 focused on electric guitar online/remote build. Usually, Faculty guitar building implementation involved a range of eight to 20 students per faculty for each period that they implemented the program. Usually, the culmination of the STEM Guitar Project in classrooms leads to students who are excited about making guitars and deeply engaged in science, mathematics, and engineering practices critically needed by employers. Additionally, through the students' involvement in the guitar build, the Project supports and helps develop student academic gains and career interests in STEM; thus, promoting development of well-trained technicians, as well as recruiting and retaining students throughout the STEM pipeline, narrowing skills gap.

Inspired by the pilot Project efforts of working with some veterans during the second and third years, the STEM Guitar Project extended its program in 2020-2021 to 26 veterans conducting three veterans workshops (two online guitar building workshops where one involved advance training that included CNC for six veterans in the Fall 2020 and the other involved online electric guitar building for 15 veteran participants in early Spring 2021; and one in-person electric guitar training in mid-May 2021 for five veterans). Basic demographic data (gender and ethnicity) were known about all 26 veterans; however, only 17 (65%) of the participants (five from the Fall 2020 online training, nine from the early Spring 2021 online training, and three from the mid-May 2021 in-person training) provided evaluation data. This veterans' online/remote trainings were made possible through a supplemental grant support from NSF. As the Guitar Building Institutes (GBI's) and workshops focus on guitar design and building skills creating a clear linkage to broader STEM concepts, the Project continues to mitigate the skills gap and need for technicians with advanced technical knowledge and hands-on experiences.

The STEM Guitar Project support, especially for faculty, includes the Applied Learning Community (the STEM Guitar Project's brand of Community of Practice). This is made possible through the yearly Program Summit that allows faculty to maintain and cultivate newly-learned instructional practices. The COVID situation deterred the Project from holding its usual Faculty Summit in November 2020. However, continued Project support is also made possible through the Project website's (guitarbuilding.org) publication of Modular Learning Activities (MLA's), videos, and other materials that can be used by faculty in their guitar building implementation, as well as the promotion of sharing through the Project's STEM Guitar Facebook account. The Project Team also remains available via email and telephone access to about 900 GBI and workshop alumni.

As in previous years, the STEM Guitar Project continues to promote strategies to uphold and extend its sustainability and continue its efforts to increase enrollment of populations

traditionally underrepresented in STEM, despite the COVID situation. Strategies include strengthening the collaborative manufacturing process and connections with national standards, job readiness/related skills, and guitar design and building activities; advocating strong involvement of school administrators in systemic and broad dissemination of Institute lessons and laboratory experiences in schools and colleges; and involving veterans regional and national associations to reach out to veterans around the country. Dissemination of lessons learned is made possible via the Project's online platform, which also supports sustainability and expansion of the Project at participants' institutions and beyond.

Program Evaluation

This section includes the program evaluation approaches, design, methods, evaluation questions, and limitations.

Evaluation Approaches, Design, and Methods

Overall, the program evaluation of the STEM Guitar Project employed a mixed research methods analysis. Additionally, the external evaluator utilized developmental evaluation (Patton, 2011) approaches especially in dealing with the formative component of the program evaluation. The external evaluator recognizes the importance of interpersonal and communication skills in conducting effective evaluations (Stevahn, etc., 2020). She makes sure that she responds immediately to Team Members' Project concerns and maintains good communications with the Team via email and telephone.

Applied thematic analysis technique (Clarke & Braun, 2017; Guest, Mac Queen, and Namey, 2012), was used again as part of the mixed methods analysis. As Guest, etc. (2012) referred to this technique, it refers to the “*common purpose of solving practical problems*” (p. 11) with the “*bounding of the analysis*” (p. 35.). Additionally, Clarke & Braun's (2017) view thematic analysis plan as a flexible and non-research design analysis plan that is well suited to this situation, as it is a non-research program evaluation.

Qualitative data were gathered along with the evaluation quantitative surveys of the 2020-2021 participants. Some qualitative data were also gathered from the perspectives of the Facilitators/Trainers as well as archival data about the Project, such as review of archival data from the STEM Guitar website, Facebook account, and the overall perspectives of the Project Team communications as reflected on the email exchanges and the cumulative Project Team agenda. An integrated qualitative thematic analysis using a priori codes and categories based on the skills concepts and innate processes involved with guitar building, as pre-identified by the Project Team, were primarily used in analyzing responses across participants, especially with regards to suggestions for improvement or areas of growth. The other qualitative data relative to participants' challenges and learning outcomes were thematically reviewed by groups of respondents since the four groups of participants (two faculty and two veterans) had different contexts and slightly different agenda during their online/remote learning.

Ninety percent inter-rater reliability is achieved by completing an inter-rater reliability coding with at least 10% of the qualitative data handled. Given such qualitative data, exploratory sequential, descriptive, and comparative analytic approaches were used with the thematically categorized data in integrating qualitative and quantitative data. Qualitative data display incorporated some mixed methods approaches in the tradition of Creswell & Plano-Clark (2011), where the integration of the quantitative and qualitative are presented in a matrix in Appendix 1. A mixed method approach and analysis involves an optimum mix of qualitative and appropriate quantitative data collection and analysis techniques. They reflect, not only results in terms of numbers, but perspectives that can be assembled from qualitative data to enhance quantitative results when triangulated. Appropriate non-parametric and descriptive statistics analysis were used accordingly (Derick, White & Toher, 2019) for Items that can be compared from the pre-post evaluations of the veterans e.g., responses about the soft levels of proficiency in soft skills.

The external evaluator is following up on the progress of the Project's research project as it uses a retrospective research survey design to determine the STEM Guitar project impact through the years. Because of the COVID situation and the changes in the way classes were handled in the case study school, no new case study data are included in this report. The case study faculty are continuing efforts to gather any more program evidence of student effects based on their student interaction via social media.

Like the previous years, the developmental evaluation (DE) approach informed the Project's process and formative evaluation in 2020-2021. As in the previous two years, Team members were encouraged and involved in evaluative thinking enabling intentional process use (Patton, 2015, 2011, 2008) of evaluation feedback and findings for Project continuous improvement, increasing Team members' sense of program accountability (Archibald, 2018; Carden & Earl, 2007; Schwandt, 2018).

The five evaluation questions used in the previous years remained as bases for the program evaluation of this Project. The evaluation has formative and summative components. The formative components have implications and direct effects on expected outcomes being measured per the evaluation question. DE is useful in the ongoing development and exploration of useful pathways in the Project's team processes and professional development implementation endeavors. DE activities and process-use (King, 2007; Preskill & Russ-Eft, 2016) are enhanced with the involvement of the Trainers/Facilitators/Instructors in self-reflections and reflective discussions during Project Team meetings. As has been planned for the Project, the summative components draw from Guskey's (2000, 2002) five levels of evidence for evaluating the Project's professional development, checking on participants' reactions, participants' learning, the organizational support provided, the use of knowledge, and the learning outcomes. The outcomes are geared toward (1) the increased involvement of diverse secondary and post-secondary faculty; (2) effects on faculty regarding their practice effecting student outcomes; (3) student learning about STEM concepts, behaviors and attitudes toward STEM; (4) Project facilitating a replicable and sustained Community of Practice; and (5) wider reach of the STEM Guitar Project and its overall Project sustainability.

The External Evaluator also continues to act as an evaluation coach (Grob, 2018),

aware that Deterding's and Solmeyer's (2018) ideas about involving practitioners in cumulative study add to relevance and applicability of results. She helps in examining how the Project refines and streamlines its data collection process by adapting previous years' learning to a more focused data collection effort.

Evaluation Goals, and Questions

This extension year 2020-2021 Project evaluation for The STEM Guitar Project maintained the two overall evaluation goals based on the Project overall goals: (1) to determine how well the Project helped faculty increase their students' interest, engagement, and learning of STEM principles, practices, and careers through guitar design and building; and (2) to assess the Project's success in creating a replicable model for establishing and maintaining the STEM Guitar Projects' Applied Learning Community, the Project's brand of community of practice. The same five evaluation questions addressing both the formative and summative components from the previous Project years were the bases for this Project evaluation: (1) To what degree has the Project increased the number of diverse secondary and post-secondary faculty trained in an interdisciplinary Project-based approach to teach innovative inquiry-based learning techniques that are inspired by the STEM skills gap? (2) How successful were faculty participants in increasing the number of secondary and post-secondary students that learn STEM concepts, as well as improving their attitudes and behaviors towards STEM, as a result of faculty training in this Project? (3) How successful has the Project been in demonstrating improvement of student learning outcomes that relate to STEM principles, career skills, and aspirations? (4) To what extent has Project facilitation of more interaction and collaboration among faculty participants resulted in a replicable and sustained Applied Learning Community? (5) How successful were the Project's efforts to increase the number of institutions that formally adopt and establish standards and strategies for STEM Guitar Project curricula resulting in wider reach and overall Project sustainability?

Limitations

. Limitations noted in the previous years' reports continue to be experienced within this reporting period. This Project has an affinity with informal STEM education (National Research Council, 2010, 2015) in the sense that faculty involvement in the professional development is voluntary and curricular implementation varies from participant to participant. Although classroom implementation and curricular integration are highly encouraged, some curricular implementation was conducted out-of-school or as limited program offerings like school extension classes. Thus, systemic collection of direct student academic data and other outcome constructs (as behaviors and attitudes toward STEM) across the implementing groups remains a big challenge. Student outcomes may be included in the results of the research study on the 10-year experience of the Project being conducted by the Project Team independent of this evaluation. This research is still on-going and results are not part of this report.

With the limitation regarding the classroom student data and challenges of the COVID situation, Faculty data are used as the archetypal "student" in the tradition of Guskey's five levels of evaluation for professional development. Evaluating Faculty's use of knowledge and

Faculty's learning outcomes represent Guskey's 4th and 5th levels of evaluating professional development. Evaluation data were received only from 81% of the faculty and 65% of the veteran participants. The small data sets limited the quantitative analyses to descriptives and non-parametric tests, as applicable. Not everyone from both the faculty and veteran respondents provided answers to all evaluation questions.

2020-2021 Formative and Summative Results

Formative Results

This report about program formative results deals with the Project Team working structure and process, as well as Project implementation and product output established during the 2020-2021 Project year.

Project Team Working Structure and Process

The Executive Committee (EXECOM), composed of the Lead Project Principal Investigator (PI) and four co-PIs, meets virtually once a month. The EXECOM continues to take pro-active roles in Project leadership and promotion of collaborative participation among Project Team members. This makes possible the seamless STEM Guitar Project working structure and process through several years of Project existence. The Project overall working and decision-making process involves the dedication and full commitment of the Project EXECOM and Team members to the STEM Guitar Project, as evident in the quality of support and Project Team processes developed in improving the Project.

Everyone in the Project Team, having been introduced to evaluative thinking, is in “continuous improvement mode”, as the Project Team continues to use various tools available to them throughout the Project period. With team members spread across the United States, use of telephone, email communications, and online platforms and tools such as Zoom conference calls have been critical in sharing information and making Project decisions. Other software and online platforms used, especially for gathering written perspectives of Project Team members, are Google Docs and Survey Monkey. Spreadsheets for Project activities are developed as the need arises, to facilitate better data sharing and collection. Many times, pivotal questions from the External Evaluator steer this development (for example, Project spreadsheets for sharing Project media exposure and Project's dissemination through publications and conference presentations continue to be useful for the Project Team, including responses to critical questions about Project best practices and fidelity of implementation).

The Project Team members continue to work collaboratively, communicating through remote connections and maintaining documentation of cumulative agenda and meeting conference minutes. This collaborative Project decision-making process allows for greater opportunities to respond to Project issues accordingly. Regular formal virtual meetings were

held as a group and sub-groups (The Project EXECOM and specialty sub-teams); informal virtual meetings were held as needed (for example, specialty sub-teams meet virtually as often as necessary. The External Evaluator has immediate access to the PI via email and telephone communications). The Project Team takes advantage of strategic times when a majority of Project Team members are available for some functions and/or conferences (for example, the National Association of Music Merchants - NAMM event in Florida and the STEM Guitar summits).

Overall, with a stable Project Leadership and Project Team structure, the Team is open to a wide variety of tools to help improve the Project implementation process and initiatives. This includes Project documentation, recruitment and selection of participants, materials and curricular development process (kit preparation; Modular Learning Activities MLAs; video preparation, revision, vetting and launch of manuals for GBI implementation and guide for faculty implementation), and process preparation and implementation of the SGBRLI (including development of the curriculum on Canvas, videos, and other learning materials that help facilitate remote learning).

Project Implementation

This Project implementation section starts with the recruitment of participants, as well as focus on developing the SGBRLI agenda, curricular preparation/adaptation, and process for implementation and evaluation.

Recruitment and Selection of Participants

The STEM Guitar Project is heavily based on its professional development starting with the faculty Institutes and the veterans' workshops. Faculty Institute participants are recruited through various modes but the three most prevalent sources are: word-of-mouth advertisement by previous participants, direct email to individual potential participants, and solicitations posted on the home page of the Project website (www.guitarbuilding.org). Solicitation of participants, to some extent is always geared toward underrepresented groups, although not all applicants from this group may have responded to the Project's marketing efforts.

Recruited Institute participants were invited to complete an online application (via Survey Monkey). The application survey was developed by the External Evaluator in consultation with the Project Team. The application survey included demographic information that determined the Project's target population - underrepresented populations. The survey also included questions to tease out applicants' intent about use and implementation of the program as well as facilitating program-related experiences and support for program implementation. With the COVID situation around the country, SGBRLI becomes the modus operandi for the Project and no host/site selection was needed.

Selection criteria for faculty are generally recommended by the specialty sub-teams for the program tracks, with focus on under-represented populations. The Project's primary

definition of underrepresented populations is based on the National Science Foundation (NSF) identified concern about underrepresentation of women, persons with disabilities, and race/ethnic groups (such as blacks, Hispanics, and American Native Americans) in science and engineering education and employment. The STEM Guitar Project extends its definition to include “persons with disabilities” beyond physical disability and includes “economic disability”, thus, prioritizing involvement of institutions serving a greater proportion of students with “free and reduced” lunch as important to the Project.

Completion of the Electric Guitar Building Institute or an extensive experience in building electric guitars is part of the requirements for Acoustic Guitar Building Institute applicants. Members of the Project Team volunteered and/or were assigned to be either lead or support trainers for the Institutes, with everyone on the team having at least one Institute. Usually, the more experienced and senior team member ends up leading Institutes. All online trainings were centralized using online tools such as Zoom and introduction of the participants to the use of online Canvas curriculum. Three Faculty SGBRLI were conducted in Summer 2020 and one other faculty SGBRLI held in Spring 2021.

Veteran participants were recruited and chosen through veteran-related offices and organizations. One online CNC-guitar build workshop was conducted for the veterans in Fall 2020, another veterans’ online training for building electric guitar was held in early Spring 2021, and one in-person training in mid-May 2021. This is the first time during this COVID-19 period that a face-to-face guitar building session is being held.

Institute Evaluation

Preparation for program implementation is the Project’s process that facilitates and models guitar-building program implementation for Institute participants. The Institutes were meant to help participants in increasing their students’ learning and acquisition of guitar-building STEM-related learning. The Project implementation in 2020-2021 had been responsive to the COVID -19 situation across the country making it difficult to conduct face-to-face Institutes; thus, the SGBRLI.

Agenda for the Summer 2020 and Spring 2021 faculty were reviewed and adjusted according to the perceived needs of the accepted participants. Some of these efforts focused on the review of the Institute agenda to enable use of the newly developed MLAs and videos embedded in Canvas, an electronic curricular software, intended for classroom use. These efforts were meant to help Faculty in their online classes in the future. Additionally, included in the preparations were issues related to Faculty fidelity of classroom implementation. There was emphasis on Faculty learning and reflection as depicted through their writing and corresponding pictures documented in the Faculty participants’ e-portfolio requirement.

For the veterans’ Fall 2020 and early Spring 2021 SGBRLI workshops, the agenda review focused on trainers’ handling and overt demonstration of employable hard and soft skills, and when feasible, to include basic entrepreneurial knowledge such as time management,

concepts of feasibility, efficiency and team work, among others. Similar efforts were exerted for the May 2021 in-person veterans' workshop; except, that this time, adjustments were made for the in-person demonstrations and interactions during the guitar build.

The External Evaluator, in consultation with the Project Team, adapted the Institute evaluations to ensure overall quality of training and fidelity of the SGBRLI implementation for the participants (both for Faculty and Veterans) and the trainers/facilitators (for both Faculty and Veterans). The instrument for Institute participants is meant to collect data about their reactions to the Institute, what they learned, as well as get their perspectives about any areas of growth. The Faculty evaluation instrument was designed as retrospective and the pre-post surveys for the veterans. The veterans were given pre-post evaluation instruments. The instrument for Institute Trainers is meant to get their perspectives about the overall Institute program and quality of Institute program implementations and was gathered retrospectively. These instruments are highly influenced by Guskey's (2002) evaluation of professional development. Corresponding evaluation results about the formative and summative aspects of the Project are presented in the ensuing portion of this report.

Materials and Curricular Development Process

The STEM Guitar Project encourages a collaborative process in developing teaching and learning materials. Initiative and leadership in developing specific guitar build concepts start with the Project Team member who has concept-specific expertise; materials are then shared with the rest of the team for feedback, further development, organization (for ease of access by each program track: acoustic guitar, electric guitar, Hybrid/CNC, and veterans' group), and final vetting.

The STEM Guitar Project has developed several MLAs through the years, especially about building electric guitars; it was then a matter of reviewing these and developing better online presence, especially the videos created. The Team efforts in developing, adapting, and revising content materials are evident in the different teaching-learning materials posted on "Files" within Canvas. Is it not unusual to see every now and then Project Team members sharing self-created materials or ideas about new materials on emails and Facebook. Project learning materials developed in the previous years are further enhanced and more materials were added in 2020-2021. These were evident in the feedback shared by the trainers of the online/remote training conducted with faculty and the veterans. The following were shared by the 2020-2021 trainers regarding the materials developed to prepare for the SGBRLI:"

- [I did] *Custom guitar wiring schematics 9-10 online guitar building videos*
- *I did a couple new videos and provided links to some of the other videos on my YouTube channel.*
- *I made four new, instructional videos for this Institute; and, supplied five more videos I had made prior. I also edited the algebra-based MLA on Fret Spacing Math to correct an error in that Modular Learning Activity.*
- *I made specialty work holding clamps and jigs for the kits for easier single person procedures, like setting the neck.*

Participants' Experiences and Areas of Growth

This section corresponds to Guskey's first level of evaluation where participants' reactions about their professional development are taken. This section includes the participants' reports about experiences with their particular Institutes/workshops, as well as their comments and suggestions about areas of growth.

SGBRLI Experiences

Only the remote/online learning (SGBRLI) participants were asked about their experiences with the conduct of the SGBRLI sessions and consultations with their Trainer and fellow trainees. Tables 1 through 4 show results of participants' responses regarding their experiences with their specific SGBRLIs. Note that the numbers responding to particular questions are not necessarily the same as the total evaluation respondents.

Table 1. shows that although not everybody attended the optional sessions, overall, those that did, found the optional sessions very helpful.

Table 1. Accessed Optional Session

% Helpfulness of pre- sessions based on "Yes" Accessed pre-sessions	2020	2021 Spring	2020 Fall	2021 Early
	Summer Faculty Trainees (n=58)	Faculty Trainees (=6)	Veterans Trainees (n=3)	Spring Veterans Trainees (n=6)
Very helpful (9-10 pts)	50%	83%	100%	50%
Useful (7-8 pts)	38%	17%	-	33%
Moderately helpful (5-6 pts)	10%	-	-	-
Not very helpful (< than 5 pts)	2%	-	-	17%

Table 2 shows that in general, participants found the synchronous sessions very helpful. The 2020 Summer Faculty trainees reported relatively less usefulness of the synchronous sessions. This is understandable as this was the first time that the SGBRLI was offered and adjustments were still being made as the sessions occurred at that time.

Table 2. Helpfulness of Synchronous Sessions

Helpfulness of the synchronous sessions	2020 Summer Faculty Trainees (n=58)	2021 Spring Faculty Trainees (n=11)	2020 Fall Veterans Trainees (n=5)	2021 Early Spring Veterans Trainees (n=9)
Very helpful (9-10 pts)	38%	64%	100%	78%
Useful (7-8 pts)	38%	18%	-	11%
Moderately helpful (5-6 pts)	19%	9%	-	11%
Not very helpful (< 5 pts)	5%	9%	-	-

Table 3. shows that most of the participants consulted with their Trainers outside of the synchronous sessions and that, overall, they found these consultations very helpful.

Table 3. Helpfulness of Outside Consultation with Trainers

% Helpfulness of pre-sessions based on “Yes” Outside Consultation with Trainers	2020 Summer Faculty Trainees (n=41)	2021 Spring Faculty Trainees (=6)	2020 Fall Veterans Trainees (n=4)	2021 Early Spring Veterans Trainees (n=9)
Very helpful (9-10 pts)	80%	100%	100%	89%
Useful (7-8 pts)	10%	-	-	11%
Moderately helpful (5-6 pts)	5%	-	-	-
Not very helpful (< than 5 pts)	5%	-	-	-

Table 4 indicates that the participants interacted with their fellow trainees and that in general, the interactions were helpful. It is noteworthy though that the veterans tended to interact more with their fellow trainees compared with the Faculty. It is understandable as there were relatively fewer veteran participants in their sessions; that made the interactions more feasible than the wider spread in terms of numbers of Faculty.

Table 4. Helpfulness of Outside Interaction with Fellow Trainees

% Helpfulness of pre- sessions based on “Yes” Outside Interaction with Fellow Trainees	2020 Summer Faculty Trainees (n=33)	2021 Spring Faculty Trainees (=6)	2020 Fall Veterans Trainees (n=5)	2021 Early Spring Veterans Trainees (n=7)
Very helpful (9-10 pts)	42%	50%	100%	72%
Useful (7-8 pts)	55%	50%	-	14%
Moderately helpful (5-6 pts)	3%	-	-	14%
Not very helpful (< than 5 pts)	-	-	-	-

Areas of Growth

It is always important to learn from the Institute experiences. As such, thematic analysis was conducted from the various SGBRLI participants responses (Faculty, Veterans, and the Trainers/Facilitators); results from these were integrated and presented in Appendix 1. A priori categories generated were: implementation improvement, improvement of content, SGBRLI materials used, and application of learning from training. There was overwhelming response about the quality of Trainers/Facilitators and the support they provided before, during, and after the training. There were suggested improvements in the content and materials used, and comments about application of learning for classroom use, naturally by the Faculty. All of these are summarized in Appendix 1 with typical quotes from the different participants.

Note that not very many suggestions for improvements came from participants in late 2020 and early 2021. This was due to the responsive Project Team members that acted immediately from the feedback received from the Faculty trained in Summer 2020. Major and continuous improvements on the curricular videos and Canvas are being undertaken even up to this writing. Seemingly, the veterans that underwent training in the Fall of 2020 were “advanced trainees”, having gone to previous electric guitar build, a requirement for attending a CNC SGBRLI. All Fall 2020 veteran participants were very happy, and satisfied with their online training. Overall, everyone indicated very positive results about the Institute implementation (refer to Appendix 1).

The nature of set modules and SGBRLI activities did not lend to opportunities for building real community among Faculty participants. This has been noted by a number of Faculty saying that the SGBRLI did not allow for more team interaction and support for each other (see Appendix 1). While support is generally provided by the Team during synchronous sessions and email communications, participants noted that there has been no real supportive community that emerged during and even after the implementation of the SGBRLI.

The COVID situation did not allow for the Project summit intended to be held in

November 2020. The participants are being invited to join the online STEM Guitar Summit that will be held in June 2021. Hopefully, the 2020-2021 Faculty participants could join the STEM Guitar Roll of Champions, potentially building the community that participants hoped to experience.

Feedback from the May 2021 Veteran Trainees

Only two of the three May 2021 veteran participants that provided written post evaluation information provided comments/suggestions about the workshop. Both of them expressed gratitude about their opportunity to have attended the workshop; one of them provided suggestion about improving the video materials. The veteran trainer provided a post-workshop evaluation video of these three participants. All participants were grateful about their experiences during the guitar build saying they “learned new things”, the build expression was a “decompression” for them, as well as “super therapeutic”.

Project Output

The Project output includes various products (such as the actual products and guitar built by participants; the STEM Guitar Story Book, guitar kits, MLAS, videos, and other materials) and reference to the number of trained participants. Part of the participants’ learning, support received, and use of knowledge (Guskey’s, 2nd, 3rd, and 4th levels of evaluation) could also be garnered through the output that are directly related to the participants.

Guitar Products Produced by Participants

Faculty Output

Figure 1, shows examples of the finished guitars built by the Faculty. These finished guitars show the Trainers’ support behind the scenes for the participants to come up with these products. It shows the participants’ levels of creativity and how much they learned in the process. The set of guitars on the left were based from guitars designed and built by the Faculty using CNC. The set of guitars on the right were based on the economy kits made available during the 2021 Spring SGBRLI. Along with the guitar pictures and building are the e-portfolio requirements of the Institutes where the participants (“students”) use of knowledge and learning outcomes in terms of the finished product and the participants’ learned skills learned were assessed. The Project Team usually does the assessment (separate from this program evaluation) in order for the participants to be given credits and incentives from the Institutes. The physical guitar built and the STEM integration gave the Faculty great ideas for program implementation as reflected in the summative portion of this report.

Figure 1. Guitar Products from the Faculty Participants



Guitars Built by the 2020 Summer Faculty Trainees

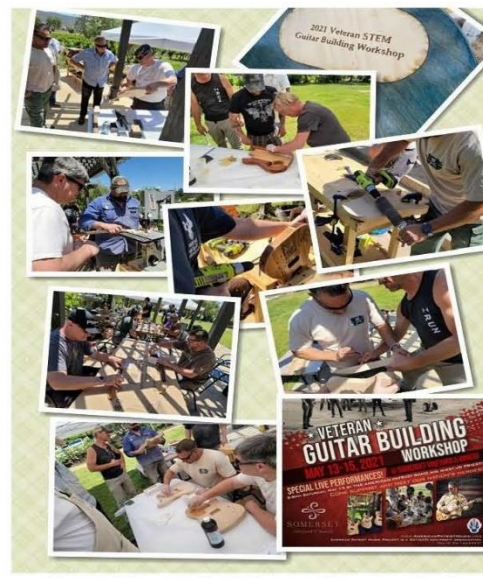


Guitars Built by the 2021 Spring Faculty Trainees

The Veterans' Output

Figure 2. shows pictures of veteran participants in action, the different process/tools they handled, and their workshop outputs. Different levels of creativity and engagement are evident from these pictures. The set of pictures on the left were from the 2020 Fall veterans' CNC workshop that got to complete their guitar products in early Spring 2021; the set of pictures on the right were from the May 2021 veterans' workshop.

Figure 2. The 2021 Veteran Participants in Action



The STEM Guitar Photo Story Book

The STEM Guitar Project has been producing the STEM Guitar Photo Book. The 2020 STEM Guitar Photo Story Book (Chang, 2020) is the seventh (this has been produced yearly since 2014) photo story book produced by the Project under the helm of Nancy Chang, with other members of the Project Team contributing materials for the book content. All the story books may be viewed at the Project's website (<http://guitarbuilding.org/about/grant-evaluation/>). The 2020 photo story book (Figure 3) focused on the adjustment of the Project's professional development training to remote online training. Participants' products, achievements, and feedback during the training were included, such as some of the project highlights garnered from various social media. Materials in the story book usually showcase the Project participants' (the Institute "students") use of knowledge, as well as the classroom student learning outcomes (Guskey's 4th and 5th levels of evaluation).

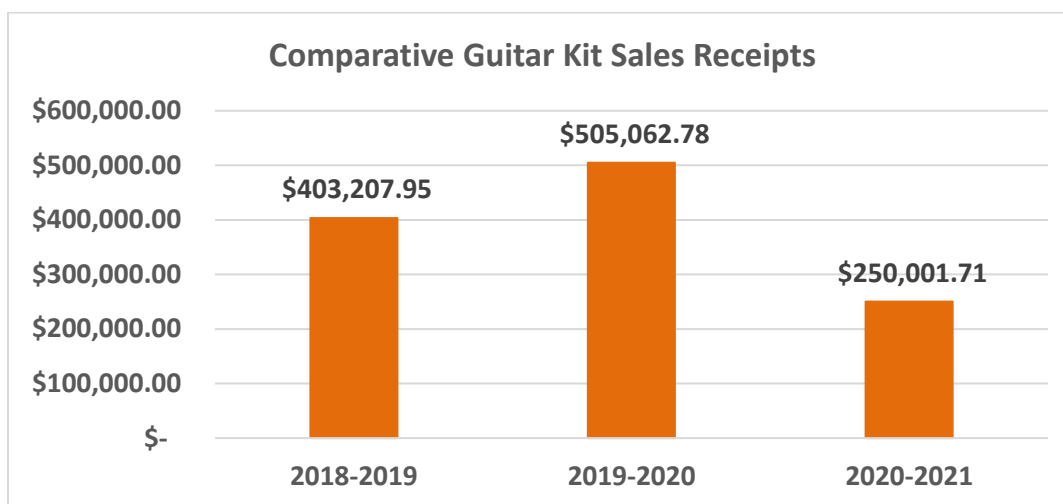
Figure 3. 2020 Photo Story Book Cover



The STEM Guitar Kits

As in past STEM Guitar grant years, the Sinclair Community College Manufacturing Team continues to work, even during this extension in the current grant, as an independent/self-sufficient group not funded by the STEM Guitar grant. STEM Guitar kits are available through the Sinclair College Guitar Manufacturing Team's effort. Finished products are advertised on the STEM Guitar website "Storefront" (<http://www.guitarbuilding.org/store/>). This manufacturing team is an integral part of the STEM Guitar program as the Lead PI continues to provide oversight of this team as part of his administrative and academic role at Sinclair Community College. The production team ensures that guitar kits are made available in time for the Institutes and Faculty requests for classroom use. Note the effects of the COVID situation on the guitar kit sales receipts/volume in 2020-2021 (see Figure 4). During the COVID period many schools did not allow in-person classes that affected any lab-related activities, including guitar building.

Figure 4. Three-year Comparative Guitar Kit Sales/Volume



MLAs and Videos and Other Learning Materials/References

The repository of the STEM Guitar teaching and learning materials is the Project website <http://guitarbuilding.org>. The site is organized with particular website breadcrumbs that lead to different materials needed in the programs. There are four key breadcrumbs for faculty teaching learning resources: “Teach”, “Downloads”, “Models” “Videos”, and “Community”. The “Community” breadcrumb is where the faculty is encouraged to share their own developed teaching materials and videos. As the Project Team members are prolific, they continue to develop online materials and videos to help their students and extend the use of resources with other faculty. The STEM Guitar Project has more than 100 teaching-learning material resources and still counting. As of this date, the Project is continuously developing its website to ensure that all recent materials used and created by the Project Team and Faculty participants are made accessible to everyone. The Project would like to ensure that materials are accessible to all even beyond the life of this current grant. And no doubt, the Project Team has been responding to the participants’ feedback regarding improvements of MLAs, videos, and other learning materials and references. It is not uncommon that one gets email communications from the Project Team anytime sharing developed materials and references, as well as showcasing their own projects in their institutions serving as models for the rest of the STEM Guitar Project community.

Trained Participants

The COVID situation in the country affected the Project Output in terms of the number of Faculty trained. As of May 2021, the Project trained a total of 300 Faculty participants for the current grant in 22 sites/trainings [18 in-person & four online]. This is 10 faculty less than the target 310 participants for the duration of the grant. The targeted 21 sites/trainings were met though. To date, 57 total veterans were trained in six workshops [four in-person & two online]. The veterans’ workshop conducted in mid-May 2021 was conducted in-person (finally). The

Project Team truly appreciates this opportunity as several participants, especially the veterans preferred the in-person training.

For the fiscal year 2020-2021, the STEM Guitar Project trained a total of 116 Faculty and veteran participants. There were 90 Faculty participants (75 from the 2020 Summer SGBRLI, 15 from the 2021 Spring SGBRLI). Of these 90 Faculty participants, data were generated from 81% of Faculty (62 from Summer 2020 and 11 from Spring 2021). There were 26 veteran participants (six from the Fall 2020 online veterans' workshops, 15 from the early Spring 2021 online workshop), and five from the mid-May 2021 in-person workshop) trained. Basic demographic data (gender and ethnicity) were known about them; however, evaluation data were provided only by 65% of the 26 of the participants (five from the Fall 2020 online training, nine from the Spring 2021 online training, and three from the mid-May 2021 training).

Summative Results: The Project Moving Toward Outcomes

The summative component of this evaluation report shows attributes of Guskey's 3rd, 4th, and 5th levels of evaluating professional development. These are highlighted with the focus on the learning outcomes related to the evaluation questions about (1) increased involvement of diverse participants (faculty, also including veterans participants]; (2) effects on program participants (especially on faculty regarding their practice effecting student outcomes); (3) support for faculty and the Project facilitating its brand of a replicable and sustained Community of Practice in terms of its Applied Learning Community; (4) student learning about STEM concepts, behaviors and attitudes toward STEM, and (5) wider reach of the STEM Guitar Project [including the veterans, and participants in the outreach Project] and its overall Project sustainability. These evaluation question areas are based on the major goals of the Project.

Increased Involvement of Diverse STEM Guitar Project Participants

The increased involvement of the STEM Guitar participants in 2020-2021 is evidenced by the 2% increase in participation of female Faculty trainees in the project. Additionally, evaluation data indicate that the Project continued to reach out to poor (mid-to high-poverty) schools and schools with greater proportion of under-represented population in 90 academic institutions. A majority of these institutions have student populations of more than 1,000 across 21 states within the four major Census and Regional Divisions of the United States. The Project has established that each Faculty has an average direct reach to about 20 students; Thus, in 2020-2021, close to 2,000 additional students from poor and underrepresented academic institutions would have a variety of experience with STEM Guitar either through direct information from their Faculty, the social media, direct build in their classrooms, and/or the faculty implementation of MLAs or use of Canvas.

Effects on the 2020-2021 Program Participants

This section deals with effects of the STEM Guitar program on 2020-2021 SGBRLI participants. The reported learning outcomes are in terms of the participants' hard and soft skills learning as presented in this sub-section. The skills acquired by the participants are helpful employability skills. Appendix 2 and 3 show mapping of the hard skills and soft skills learned within the STEM Guitar building to employability skills. In the sense of the Project Institutes, using the concept of Guskey's 5th evaluation level., the "students" are the Faculty and veteran participants. Thus, this report is on the hard and soft skills learned by the participants. Beyond this, however, the Project is still following up on the Faculty participants' actual use of knowledge in the classrooms and trying to get into knowledge about classroom student outcomes.

Skills Learned by Participants

This section includes the comparison of participants' reported three most important skills learned, and additional data outcomes gathered from the veterans.

Comparison of Participants' Reported Most Important Skills

Table 5 shows the skills reported by the Institute/workshop participants. Each participant was asked to write the **three most important skills** they learned from the Institutes/workshops asking them to mark if these are New (N) or Enhanced (E) learning for them. More than half of the 2020 Summer Faculty participants reported learning the curriculum and STEM connections as very important. The 2020 Fall veteran trainees worked on CNC training and noted this as their most important learning. The fact that the report here is 111% means that some of the veterans may have written the CNC learning for all the three most important skills they learned.

Table 5. Skills Learned by Participants

Skills	Faculty (2020 Summer, (n=56)		Faculty (2021 Spring, (n=11)		Veterans (2020 Fall, n=5)		Veterans (2021 Early Spring, n = 9)		Veterans (May 2021) (N=3)	
	N	E	N	E	N	E	N	E	N	E
Org/Set-up for operations	2%	2%	-	-	20%	-	-	-	67%	-
Use & selection of tools	23%	7%	-	9%	-	-	13%	13%	67%	-
Body shaping/wood working	4%	-	9%	9%	-	-	25%	-	100%	-
Measurement	34%		18%	-	-	-	-	-	100%	-
Electricity & soldering	14%	7%	36%	55%	-	-	75%	-	100%	-
Neck, headstock & stringing	21%	5%	27%	-	-	-	50%	-	-	-

Intonation	16%	9%	45%	-	-	-	25%	-	-	-
Overall guitar assembly	29%	2%	9%	-	25%	-	20%	-	100%	-
Finishing	16%	20%	18%	27%	-	-	88%	-	100%	-
Laser and engraving	-	-	-	-	-	-	-	-	100%	-
Zoom instruction & Canvas	9%	-	-	-	60%	-	13%	-	-	-
Curriculum (CNC & STEM)	59%	9%	-	-	111%	-	13%	-	-	-
Communication & Motivation	-	4%	-	-	-	-	-	-	-	-
Creativity & Problem solving	-	4%	-	-	-	-	-	-	-	-
Patience/perseverance	-	9%	-	-	-	-	-	-	-	-
Time Management	4%	-	-	9%	-	-	-	-	-	-

Trainers/Facilitators (six for Faculty and five for veterans) reported that, in general, the participants achieved the learning outcomes for the SGBRLI. Four of the six Trainers/Facilitators for the Faculty were conservative in their assessment of the participants' learning outcomes referring to the achievement of "most" of the participants. However, two of the six Trainers/Facilitators reported that the Faculty participants absolutely met the learning outcomes. Representative comment are as follows:

Learning outcomes appear to be met. We have 1 more rock star meeting. Beautiful instruments, and great questions and student growth in 5 weeks of online classes.

The Trainers/Facilitators for the veterans were conservative in their assessment of the veterans' achievement of the learning outcomes. As one of the Trainers/Facilitators said:

Achievement of learning outcomes was variable based on the participant's engagement. I think the participant's got out of the opportunity what they were willing to put into it.

Veterans' Workshop Goals and Accomplishment

Evaluation results from the veterans (both from the remote/online and in-person workshops) indicated that they achieved what they wanted from the workshops (learn new skills for personal improvement) and built their own guitars as shown in Table 6. It shows that, in general, the veteran trainees joined the veterans' workshops to learn new skills for personal improvement. The veterans' trainers noted that the participants' efforts put into the experience is commensurate to whatever they would get out of it. True enough, the majority of the veterans

learned new skills and almost all were able to build their own guitars (except for one that had physical challenges). One of the participants from the early Spring 2021 veteran’s remote/online workshop must have shown outstanding hard and soft skills learned; he was hired at the Sinclair Guitar Manufacturing Shop immediately after the workshop

Table 6. Veterans’ Workshop Goals, Accomplishment

Workshop Goals (taken from pre-evaluation):	Veterans Fall 2020 Trainees (N=6)	Veterans Early Spring 2021 Trainees (N=15)	Veterans May 2021 Trainees (N=3)
Learn new skills for personal improvement	67%	73%	100-%
Enhance skills for personal improvement	17%	20%	-
Learn new skills for purposes of employment	17%	7%	-
Accomplished (taken from post evaluation: responses)	(n=5) reporting	(n=9) reporting	(n=3 reporting)
Creating a body design/Build own guitar	100%	89%	100%

Veterans’ Reported Soft Skills

The embedded skills in the STEM Guitar program 21st Century-related skills is detailed in Appendix 3. The veterans were asked about their level of proficiency for seven non-technical soft skills areas as indicated in Table 7, both in the pre- and post-evaluation. Non-parametric comparison was conducted on the veterans’ groups of responses, as applicable. No significant changes on the post evaluation of the soft skills were found, as most veterans seem to be confident about their proficiencies on these skills levels. Most of them marked “Proficient” and “Expert” for themselves. The comparison across the veteran groups, however, shows interesting results about the participants for the particular workshop. The veteran trainers agree that the 2021 early Spring veteran trainees were outstanding trainees; in fact, one of the veteran trainees from this group was hired immediately after the workshop to work at the Sinclair Guitar Manufacturing Shop. However, because of smaller number of veterans reporting, percentage-wise, a greater percentage of the May 2021 veteran participants reported more “expert” proficiencies in almost all of the soft skills areas in question.

Table 7. 2019 Veterans' Report About Soft Skills

Percentage Reported as Proficient and Expert	Veterans 2020 Summer Trainees (n=5)		Veterans 2021 Early Spring Trainees (n=9)		Veterans May 2021 Trainees (N=3)	
	Proficient	Expert	Proficient	Expert	Proficient	Expert
Communication and collaboration	40%	20%	57%	32%		67%
Creativity and innovation	80%	0	44%	22%	33%	33%
Critical thinking and problem solving	60%	20%	57%	22%	33%	33%
Flexibility and adaptability	60%	20%	78%	11%		67%
Grit, initiative and self-direction	60%	0	67%	22%	33%	33%
Productivity and accountability	80%	20%	44%	44%	33%	33%
Leadership and responsibility	60%	20%	56%	33%		67%

Support for STEM Guitar Program Faculty Implementation

This section focuses on different supports for faculty classroom implementation of the STEM Guitar program. As has been the STEM Guitar Project practice, the Project Team continues to think about and prepare for different ways of supporting the STEM Guitar program implementation. This section includes the Project's established best practices and support materials for faculty teaching, the Faculty participants' responses regarding how the Project helped Faculty prepare for their program implementation, facilitation of administrative support for Faculty, and the adherence to sustain the Project's Applied Learning Community.

Established Practices and Support Materials for Faculty Teaching

The third level of Guskey's evaluation of professional development has something to do with support for Faculty program implementation. Continuous capacity building and honing of the team's innate evaluative thinking encourage Project Team members to reflect and act continuously on establishing best practices, ask more questions, and help establish the necessary supportive Project structures and practices for program implementation. Despite the uncertainties posed by the COVID situation, the Project Team continued working on guidelines and process for participants' in-depth Institute participation. Support materials for Faculty are geared toward making available learning/teaching materials they can take with them immediately after the Institutes (e.g., use of Canvas in their curriculum, teaching/learning portfolio documenting participants' own learning and program process). These learning/teaching materials are meant to support participants' learning, as well as help them in their classroom implementation. For the veterans' workshops, continuous improvement is also ensured, especially in helping simplify the process and enhance employability skills learning. A lot of

improvements about the support video materials are geared toward these processes. Revisions and improvements based on evaluation feedback have been part of the Project's continuous improvement initiatives, making sure that participants could optimize their learning as they participate in the Institutes/workshops and take with them relevant useful materials, regardless of whether they are going back to the classrooms, as in the case of the Faculty, or to "real" life and/or employment, as in the case of the veterans. Part of institutionalizing these materials is helping improve the Project website to ensure the hosting of materials that will be relevant, not only during the life of the grant but beyond the grant.

Support Mechanisms for Faculty Implementation

Support mechanisms for Faculty are basically seen in terms of the school administration support and the Project's Applied Learning Community.

School Administration Support

Data indicating organizational support and change are important in ensuring success in implementation of the program. The continued practice of getting the formal signed administrators' support during the STEM Guitar GBI application is the only mode of data collection the project has at this time that indicates evidence of administrative support for all faculty participants. This happens every year even during the Faculty application within the context of COVID situations in the academic institutions. The continued implementation by STEM Guitar Project Institute alumni is testament to the success of getting school administration on board as early as the Faculty application for the Institutes. Faculty Champions tend to be more proactive and continue with their guitar building endeavors. Further data supporting this is expected to be included in the Project's 10-year research project. Otherwise, data from administrators' perspectives about guitar implementation in their schools are relatively limited.

The Applied Learning Community

The STEM Guitar Project is facilitating its brand of a replicable and sustained Community of Practice with its Applied Learning Community as a major part of support for the faculty. The most organized and formal part of the STEM Guitar Applied Learning Community is the STEM Summit. The STEM Summit is an endeavor engaged in by the Project in past years but has been consciously brought into the current and future Project years as a systematic way of following up with faculty participants who serve as "champions" in implementing the STEM Guitar curriculum. Because of the COVID situation, the usual November Faculty Summit was cancelled. This projected Summit may not have been realized but evidence of Faculty involvement in the Project through their website access of the curriculum and involvement in the website forum is an extension of the Project's Applied Learning Community. In 2020-2021, the total percentage of website access for the STEM Guitar curriculum and Forum blog through the STEM Guitar website (www.guitarbuildig.org) is 48%. Accessing the website for viewing and download of curricular materials and participating in the blog means the Faculty are able to have

more ideas and curricular materials for classroom implementation. Additionally, the Faculty has the chance to share curricular materials with the rest of the academic community as they upload and their own-created curricular materials. This is testament to the seed of engagement and involvement in the Project sown by the Project Team.

A virtual Faculty Summit is being planned for June 2021 in the interest of maintaining interest among and support for Faculty implementing the STEM Guitar curriculum. The plan is to solicit videotaped presentation contributions from the past Faculty STEM Guitar participants, as well as the Project Team. This will be shared ahead of time with everyone interested. A session is scheduled to reflect upon/discuss the proposed particular content/ideas/classroom techniques, etc. so that everyone can benefit from the shared content/ideas/techniques.

How the Project Helped Faculty Program Implementation

Establishing Project guidelines and structures, and ensuring adherence to established practices, help showcase how well participants use what they learned from the guitar program; as well as show effects of the program (Guskey's 4th level of evaluating professional development).

Program Implementation Intent of Faculty Participants

Faculty responses to the retrospective evaluation of their SGBRLI experiences indicated that the Project is helping the faculty prepare for their classroom implementation through the use of MLAs and the physical guitar build that helped them make STEM Connections. The Faculty themselves claimed that the Institute helped prepare them to implement the program using the learning materials they got through the Institute. The physical guitar built served as inspiration and motivation to use this hands-on and problem-based strategy in integrating STEM in their classrooms. The fact that the Faculty are also planning to order guitar kits indicates that they are planning on the physical build of guitars. The Faculty response to their preparation to implement the STEM Guitar program in the coming school year was relatively conservative compared to their responses about the materials and process they learned and their plan to purchase guitar kits. (see Table 8). It is hard to say if this is because of uncertainties of the COVID situation or any other contextual situations in their academic environment. The results of the 10-year research study may give light on this issue.

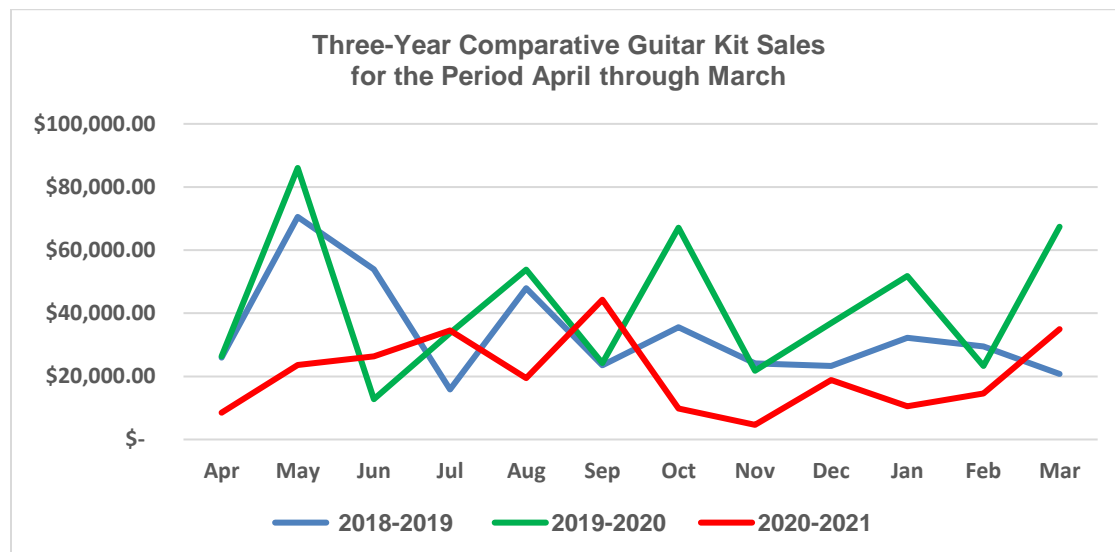
Table 8. 2020-2021 Faculty Report re: Effects of SGBRLI

	Faculty 2020 Summer Trainees (n=62)	Faculty 2021 Spring Trainees (n=11)
MLAs helped overall understanding of STEM connections	87%	100%
Physical guitar building helped with STEM connections	90%	100%
Prepared and fully prepared to implement the STEM Guitar program in the coming school year	55%	73%
Foresees using the learning materials in 2020-2021 school year	82%	91%
Planning to purchase guitar kits	73%	73%

Guitar Orders as Indicator of Program Implementation

The trends in guitar sales (see Figure 5) show that, overall, guitar kit sales in the school year 2020-2021 decreased, indicating decreased hands-on and in-person activities because of the COVID situation during the school year. This was very much unlike the previous year (2019-2020) that indicated the effects of the faculty Hybrid CNC-Electric guitar training in the summers of 2018 and 2019; more faculty embarked in the CNC-manufactured guitar parts during the period. However, there was a big spike of guitar kit sales order in September, which was the start of school year 2020-2021, following the faculty Summer 2020 SGBRLI. It is clear from Figure 5 that there is seasonality in the guitar kit orders. The Sinclair Guitar Manufacturing Team has been very responsive to all Faculty guitar kit orders, making sure the kits are available for the dates requested.

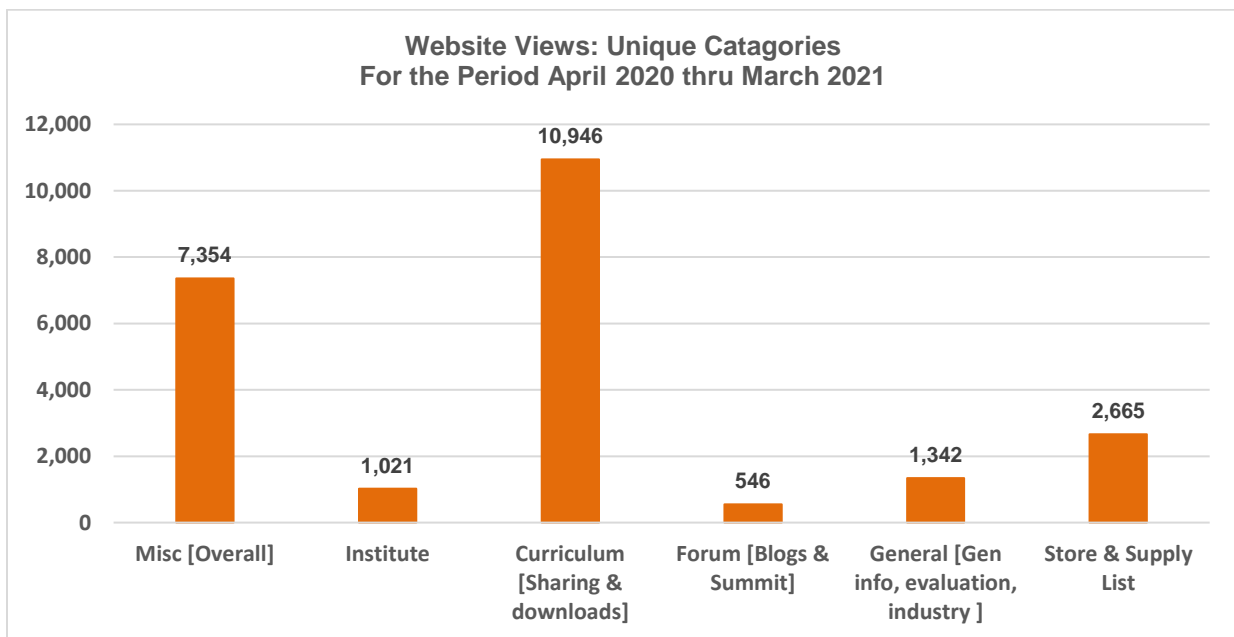
Figure 5. Comparative Guitar Kit Sales



The Project Website as a Help for Implementation

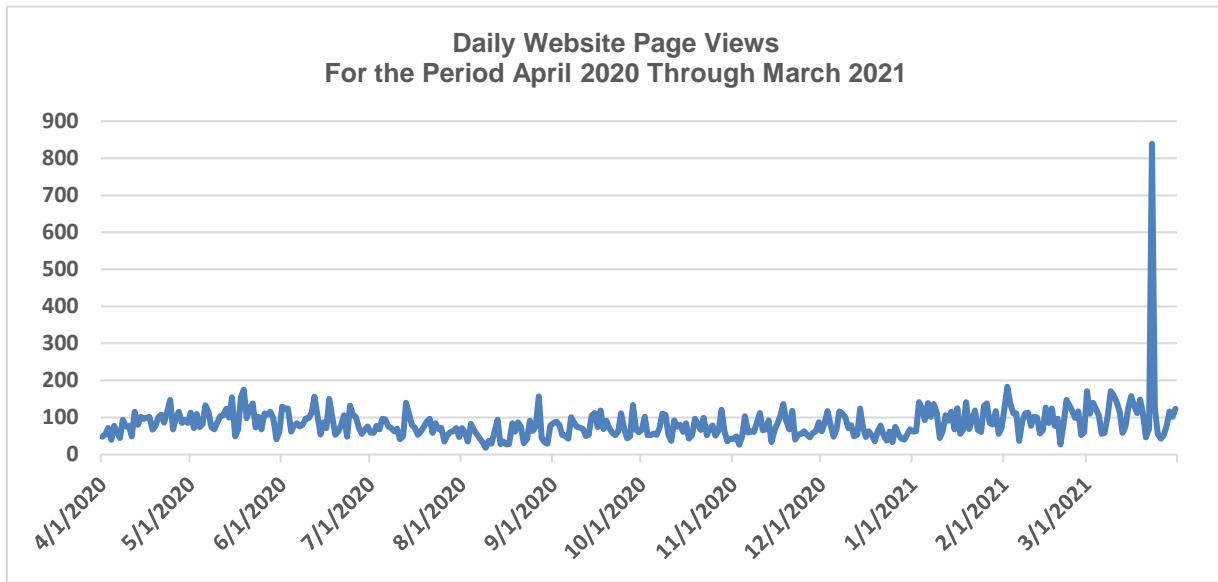
The Project website (www.guitarbuilding.org) has been a big help for everyone interested in the STEM Guitar project. The website, being available remotely, is open to everyone and anyone across the world. Specifically for the people in the academe, evidences of the usefulness and Project help through the website are clear. Interests in the website content are indicated by the proportion of page views (see Figure 6). About half of the total website access was related to the Project curriculum and process (sharing and download), which could be indicators of Faculty access with their program implementation

Figure 6. Website Unique Page Views



The level of website access could also indicate the level of interest on particular materials or news about the Project. It is interesting to see an “anomalous” spike on March 23, 2021 in the website daily views (see Figure 7). That date was about the time the Project received the Gerhard Salinger Award from the International Technology and Engineering Educators Association (ITEEA). This shows the importance of sharing worthy news through this medium, enhancing further the value of the Project to the community.

Figure 7. Daily Website Page Views



The 2020-2021 quarterly (see Figure 8) graph shows higher website views in late winter and spring indicating the end of school year when most of the hands-on school projects are completed. This trend is confirmed with the four-year monthly view comparison in Figure 9. Note the lower monthly website views during the school year 2020-2021, which is greatly affected by the COVID situation.

Figure 8. Website Quarterly Views

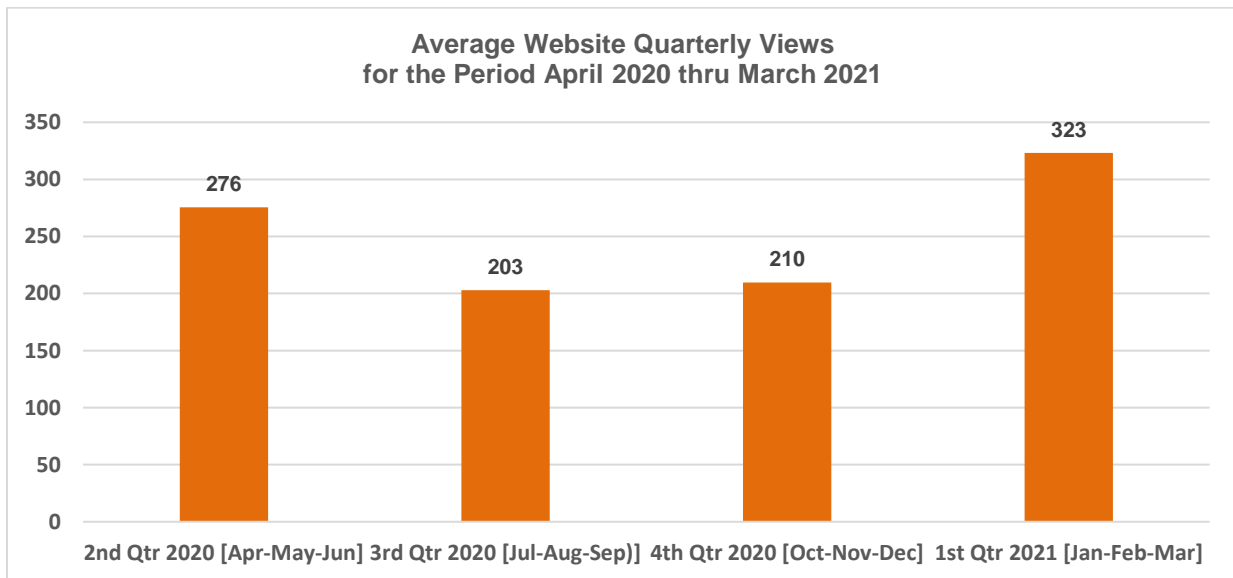
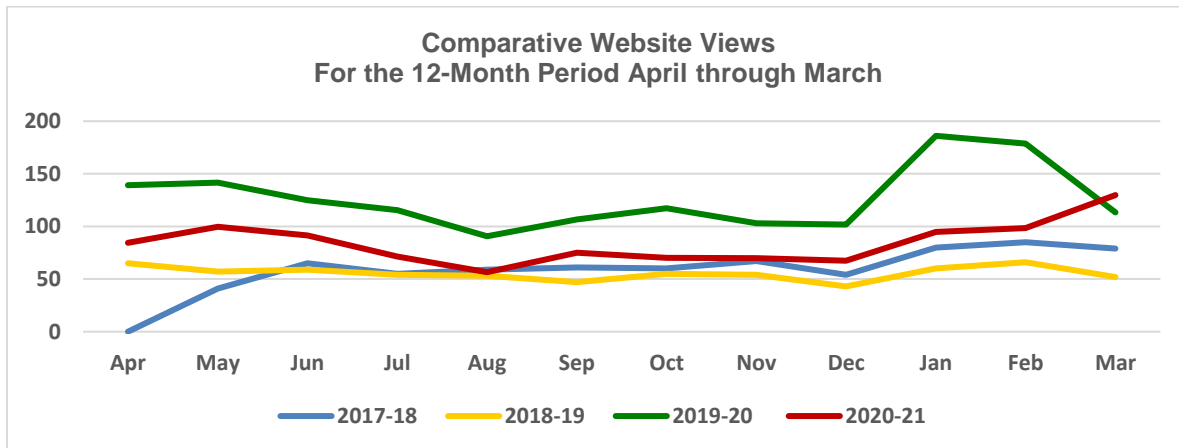


Figure 9. Website 12-Month Period Views



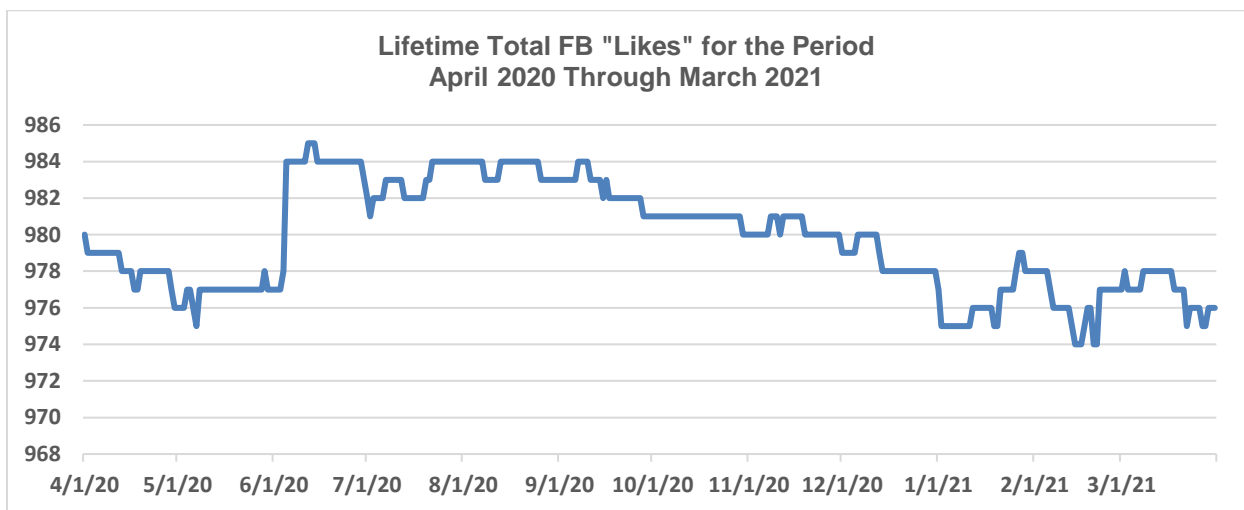
The “STEM Guitar Project” Facebook Account

There is a current “STEM Guitar Project” Facebook (SGP_FB) account that is actively liked and accessed by people in the community. The fact that this has remote access via the Internet means anybody around the world can “Like”, Provide “impressions”, “Reach”. Or “Engage” with the account. Appendix 4 has the definitions for the meaning of the type of access people make on the account. All account data included in this report are based on FB’s standard 28-day analytic report. These are the important types of Facebook Account views as these signify people’s interests and engagement on the SGP_FB account contents.

SGP_FB “Likes”

The SGP_FB account gets an average daily “Likes” of more than 960 people in 2020-2021 (see Figure 10).

Figure 10. SGP_FB “Likes”

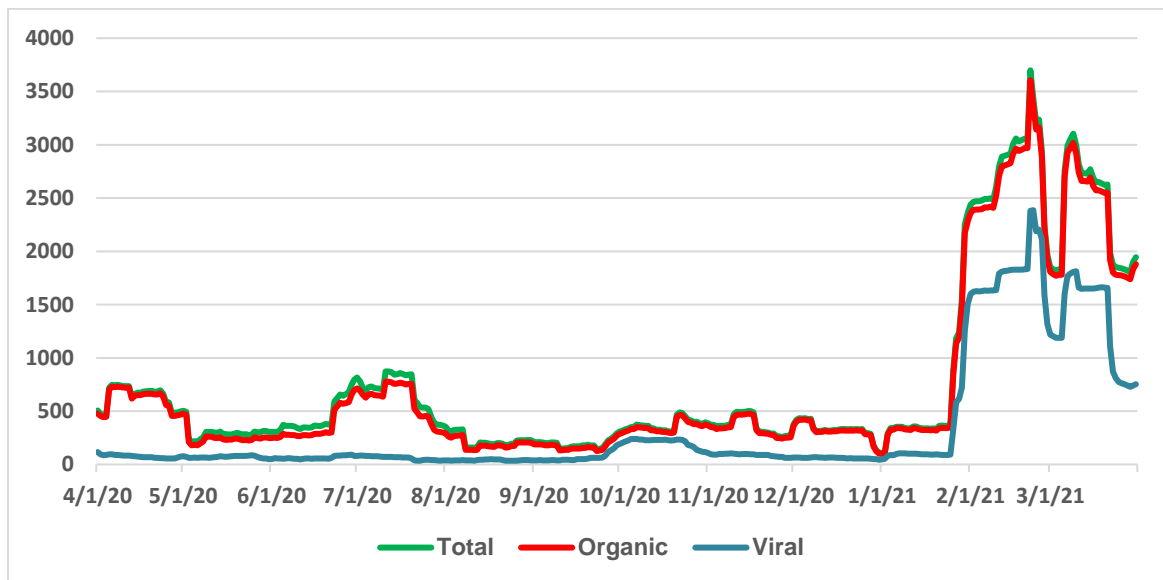


SGP_FB “Impressions”

More than a simple “Like” of entries on the account, SGP_FB “Impression” (see Figure 11) means the total **count of the number of times** any Project content (information or any posts, check-ins, ads or other social information) enters other people’s screen. When the “Impression” is “Organic”, it means that the count of “Impression” is voluntary and not paid. When the “Impression” is “Viral”, it means that the count of the Project content entering other people’s screen has attached social information, meaning that a friend of the person that initially accessed the Project information likes the Project’s page, checks into the Project’s page, shares a photo of the Project’s page and/or shares a photo of the Project’s page. Figure 11 shows the Total, organic, and viral “Impressions” on the SGP_FB account. “Impression” yields the total count and could mean repeat exposure; the viral “Impression” count would not have as much impact as a viral “Reach” data account (refer to Figure 12).

It looks like greater interest in the content of the SGP_FB account has been registered for the month of February. The Project PI surmised that, even during the COVID situation, the Project held its first SGBRLI in the summer of 2020 and that the spikes are Faculty implementation at the end of the school year 2020-2021. Note that this is corroborated by the increasing trend in the SGP_FB “Reach,” Engagement” and the guitar kit sales (refer to Figure 12, 13, and 14) starting February on to March 2021.

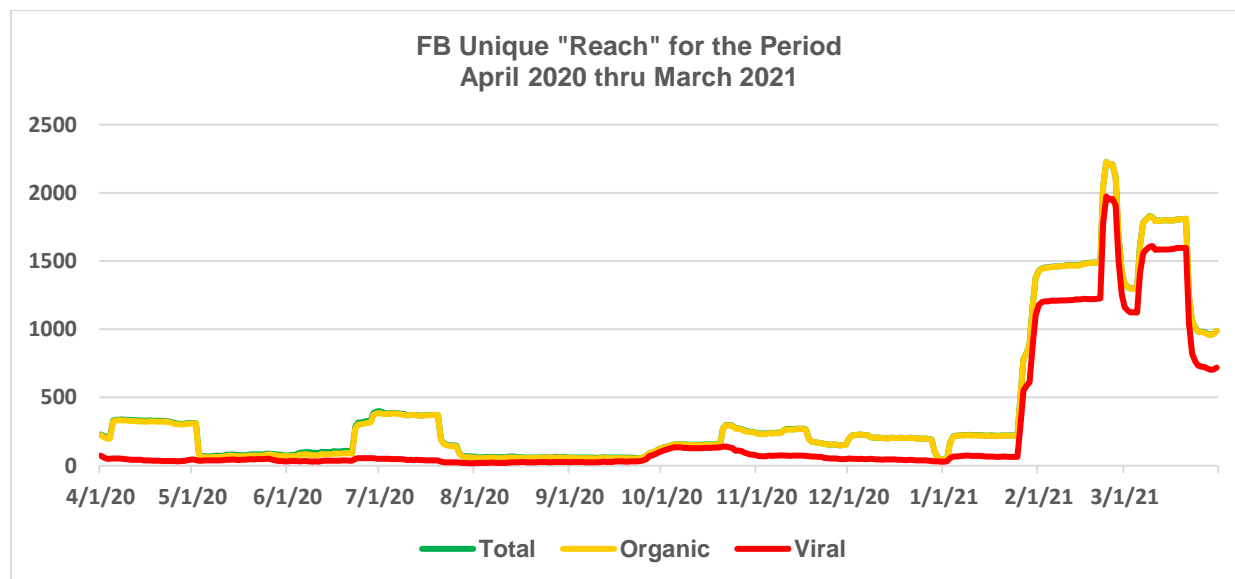
Figure 11. SGP_FB “Impression”



The SGP_FB “Reach” (see Figure 12) indicate **unique user’s** interest and involvement with the STEM Guitar Project. This means that SGP_FB “Reach” data records the **unique users** of any Project content (information or any posts, check-ins, ads or other social information) enters other people’s screen. When the “Reach” record is “Organic”, it means that the unique users got into the page voluntarily. When the “Reach” record is “Viral”, it means that

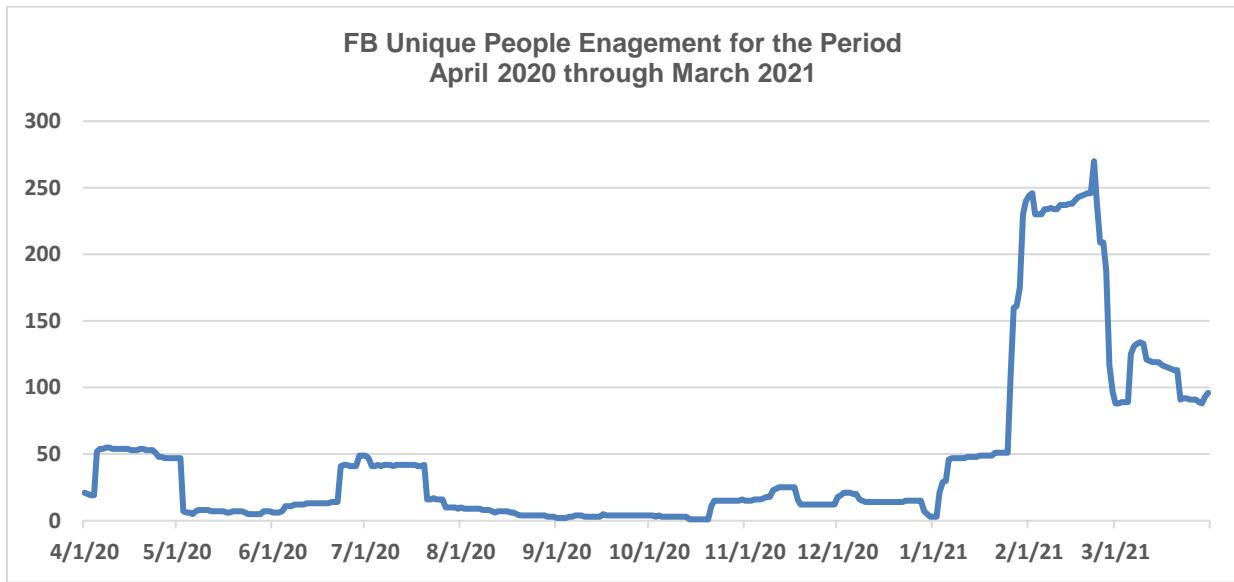
the unique users that accessed the Project content and have them on their screen, have attached social information. This means that a friend (or friends) of the unique individual that initially accessed the Project information likes the Project's page, checks into the Project's page, shares a photo of the Project's page and/or shares a photo of the Project's page. Although the total count of visits (through "Impressions") was a little bit higher than "Reach", the spike in the trend for unique users visiting the SGP_FB account and are truly interested in the Project's content is still the same. Note that as described above, this trend follows the trend for the SGP_FB "Impression" (refer to Figure 11), "Engagement" (see Figure 13), and guitar kit sales (See Figure 14). The fact that "Reach" accounts for unique users means that the exponential impact of exposure is greater than the viral "Impression" count. This is the reason why when one hears the phrase "the post/content went viral", it implies lots of exposure or distribution of such post or content. Figure 12 shows the Total, organic, and viral "Reach" on the SBP_FB account.

Figure 12. SGP_FB "Reach"



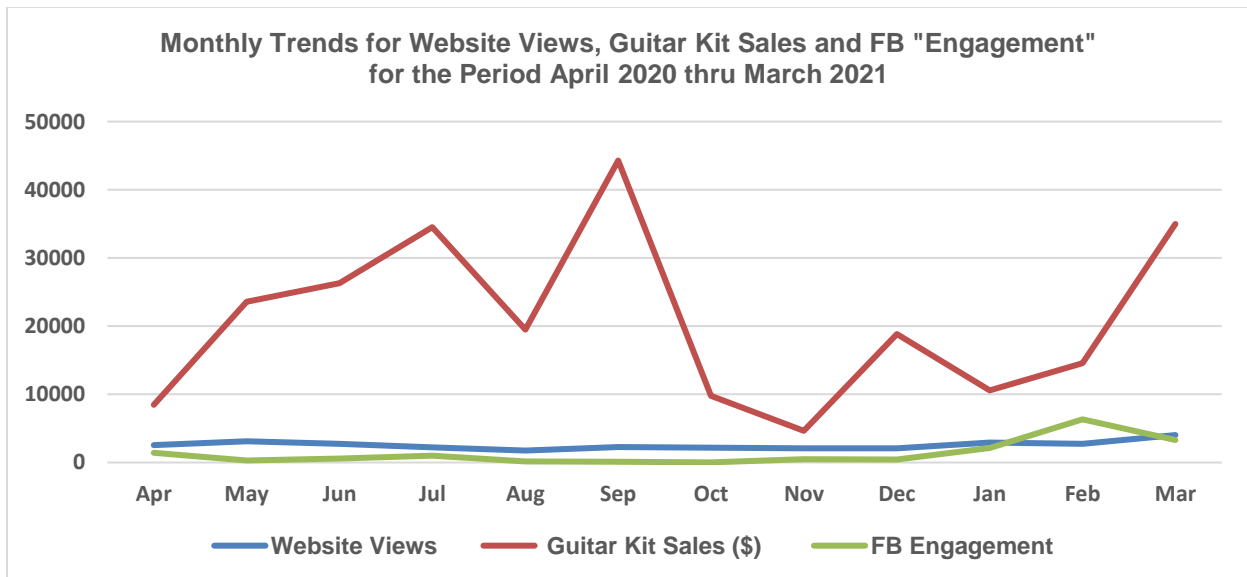
The report on the SGP_FB "Engagement" (see Figure 13) is more important because this involves proactive actions of unique users who engage with the Project content and create/include stories or some kind of narrative and other descriptions in their entries. Again, as noted in Figures 11 and 12, the trend and dates of spike for the SGP_FB "Engagement" is parallel with "Impression" and "Reach". This implies that the unique people that accessed the page do not simply download the content but contribute/add more and enrich the Project content by doing so.

Figure 13. SGP_FB “Engagement”



The similar trends of the SGP_FP data with the website access and guitar kit sales (see Figure 14) imply a very active February 2021 for people interested and involved with the STEM Guitar Project.

Figure 14. Trends for Website and SGP_FB Views and Guitar Kit Sales



Follow-up Participants' Data: The 10-year Faculty Retrospective Survey Research

The Project is currently conducting a follow-up research and gathering follow-up data from Project participants over the course of the Project's more than 10 years of existence. Any lessons learned from the Project's 10-year research could also lend to its sustainability. Two members of the Project Executive Team are leading the 10-year Faculty retrospective research. Data are basically taken from the survey of targeted sample of the STEM Guitar Project participants over the 10-year period. The survey instrument was validated before survey administration. Survey data are augmented by some selected interviews and archival analysis of data and documentation of related STEM guitar experiences. Basic research foci are about the project implementation and support they received and needed in the project implementation, the project impact, and questions related to guitar building and STEM education integration, experiences and challenges in project implementation, including lesson plan and portfolio analysis. Research results will be shared at the end of the grant project.

Student Effects: Toward Determining Classroom Student Outcomes

Follow-up with the case study schools was not feasible because of the COVID situation but the Faculty continued to monitor student performance and whereabouts. Per the case study school counselor data, two guitar building students (both white males) are attending Sno-Isle Tech (a technical academic institution with a 2-year certificate program) during school year 2020-2021. One is a senior, who will be graduating both from high school and from Sno-Isle Tech at the end of 2020-2021 school year. This student is pursuing electrical engineering at college. The other student is a junior who has one more year, both in high school and Sno-Isle Tech. Next year, four guitar building students (three are white males; one is mixed-race female) are attending Sno-Isle Tech. Of these four, the student in his junior year is continuing on as a senior next year; the other three will be starting their first year at Sno-Isle Tech next year as high school juniors.

Although follow-up with students had not been feasible in 2020-2021, activities with students in various schools continue as their states and institutions allow. Figure 15 shows students wearing masks, not because of the sawdust from the woodworking phase of the guitar build, but more so because of the mandate to wear masks. Despite that, these high school students continued guitar building involvement during the COVID period learning STEM-related hard and soft skills.

Figure 15. Student STEM Involvement Under COVID Context



STEM Guitar Project Wider Spread and Overall Project Sustainability.

The wider spread extent of the STEM Guitar Project is evidenced by the Project span of implementation, as well as coverage and magnitude of interests in the Project. The Project's sustainability efforts involve promoting the supply chain as well as encouraging program media exposure, attendance in STEM-related/guitar-building/music-related events, and conference presentation/ publications, as well as building academic, business/industry and community partnerships. Relationships with academic, professional associations, business/industry, and the larger community promote Project buy-in, acceptance, relevance, crowd-sourced funding, and more visibility for Project promotions and funding support. Currently, while the Project Team is also reviewing the potential for other funding support, there are some inquiries from institutions interested to sponsor the STEM Guitar Institute for their own group. This will be sustainable especially if the institutions are providing the funding for the endeavor. At the time of this writing, logistics regarding this potential endeavor (such as, costs, materials, and personnel) are being reviewed by the Project Team.

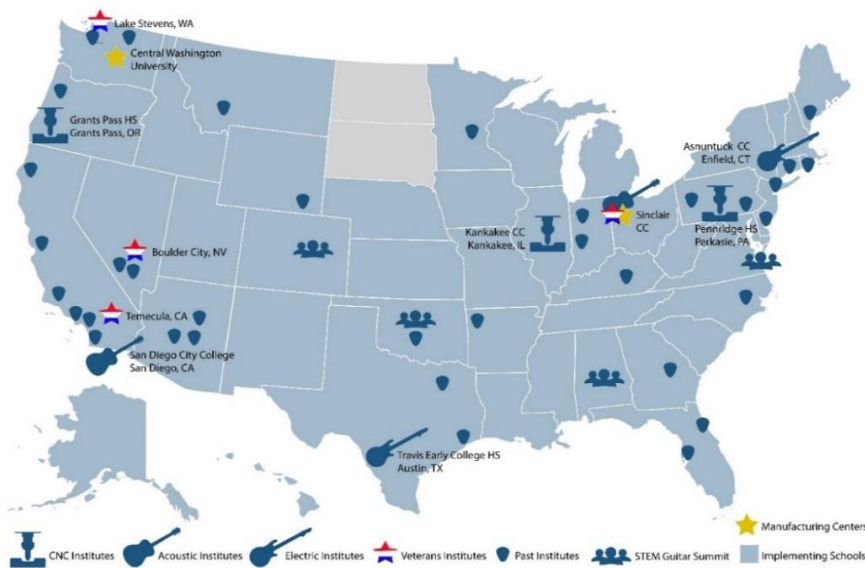
Project Implementation Spread Across the United States

The evidence of the STEM Project spread is shown in terms of the continued program implementation and training across the United States, the regional distribution of the 2020-2021 Faculty trainees, as well as the regional guitar kit sales in 2020-2021.

The Project Spread Over the Grant Years

Figure 16 shows the map of the United States that indicated ALL the schools and states involved with the STEM Guitar Project, as well as areas where STEM Guitar building/professional development training for Faculty and veterans had been implemented. It is noteworthy that the span of the Project reached almost all the US states (except North and South Dakota), including Alaska and Hawaii. Not included in this map are Faculty representing schools in Australia and Canada who had gone through STEM Guitar building Institutes in the past and had continued to implement in their schools as evidenced by their guitar kit orders.

Figure 16. The STEM Guitar Map of Implementation



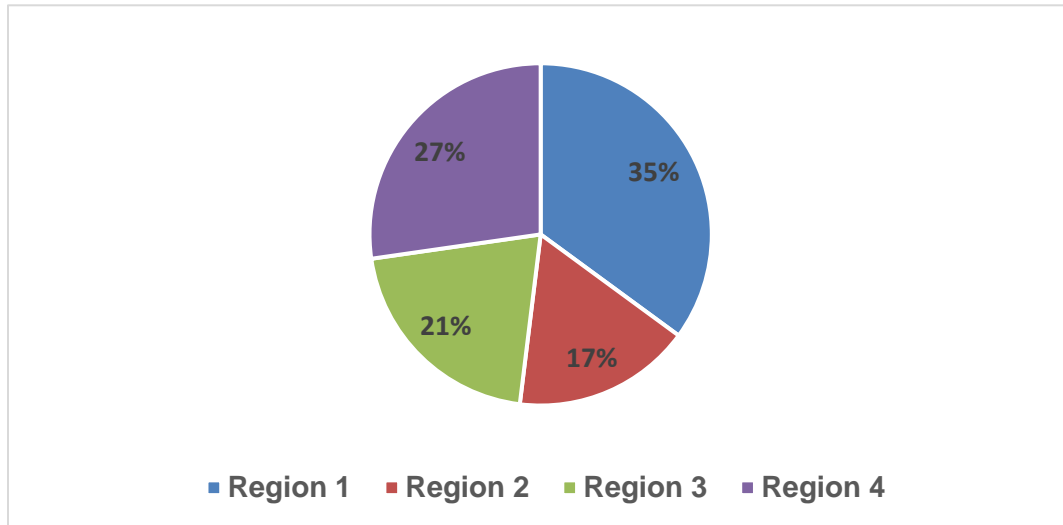
Source: STEM Guitar Project website (<http://guitarbuilding.org>)

The Span of Faculty Implementation in 2020-2021 through Training

The COVID situation did not deter the STEM Guitar Project from conducting the STEM Guitar Institutes. During the project year 2020-2021, all STEM Guitar Institutes were conducted remotely, except for the veterans' guitar build workshop conducted in mid-May 2021. The Project Team was excited to do an in-person training this time, opening possibilities for in-person Institutes in the coming months. Interest in learning STEM Guitar building hard and soft skills continues across different regions across the United States. However, two states (North and South Dakota) remain enigmatic for the Project. There were no Faculty interested from these states from the start of the first grant until the current grant.

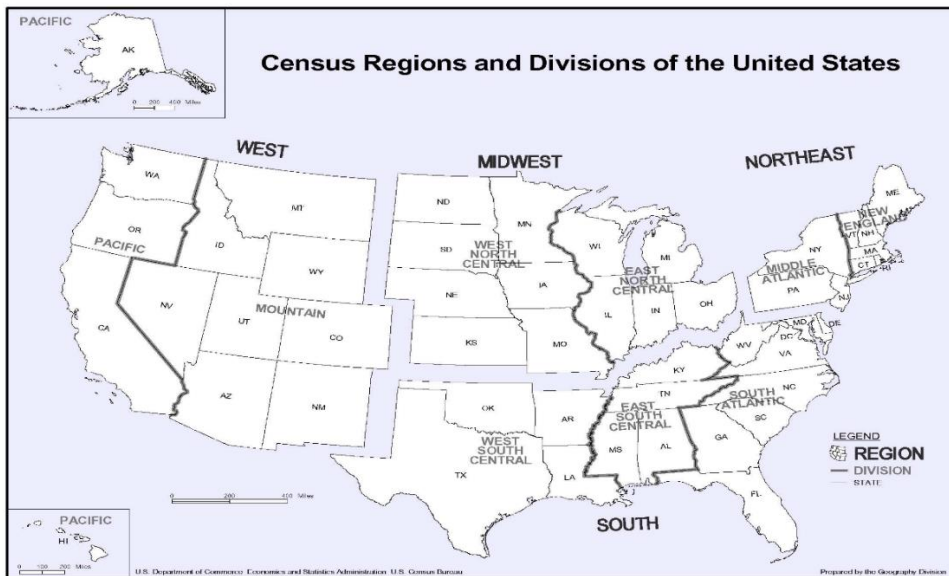
Figure 17 shows the 2020-2021 distribution of Faculty participants across the United States indicating the Project's diverse involvement in the different locations around the country. Of the 90 Faculty trainees in 2020-2021, 77 Faculty indicated their state and locales. There were Faculty trainees from 21 states across the four major Census Regions and Division of the United States (four from Region 1-Northeast, six from Region 2-Midwest, seven from Region 3-South, and five from Region 4-West).

Figure 17. Faculty 2020-2021 Trainees by Region (N=77)



For reference, the US Regional distribution is shown in Figure 18.

Figure 18. Census Regions/Divisions in the US

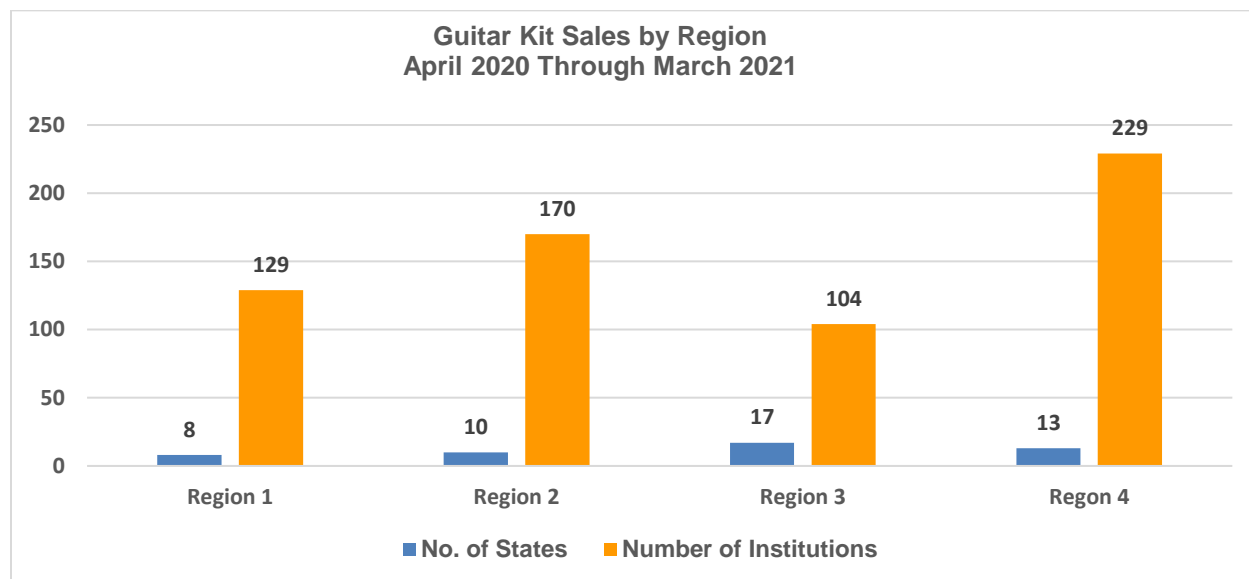


Source: https://en.wikipedia.org/wiki/List_of_regions_of_the_United_States

Guitar Kit Sales in 2020-2021

Although there were relatively fewer guitar kit sales in 2020-2021, sales were distributed to 48 states across the four major Census/Divisions of the United States (see Figure 19). Note that Faculty trainees in 2020-2021 came only from 21 states, indicating that the Faculty alumni, who are mostly Faculty Champions continue to implement the program in their schools, despite the COVID situation.

Figure 19. 2020-2021 Guitar Kit Sales by Region



The 2020-2021 Faculty trainees were asked if they intended to order guitar kits. About half of the Faculty trainees indicated intention to purchase guitar kits during the first half of the school year immediately after their Institutes (see Table 9).

Table 9. Guitar Kit Order Schedule

Time to order guitar kits	2020 Summer Faculty Trainees (n=45)	2021 Spring Faculty Trainees (n=8)
First quarter of the coming school year	22%	25%
Second quarter of the coming school year	22%	25%
Third quarter of the coming school year	13%	13%
Fourth quarter of the coming school year	9%	-
Another time	33%	37%

Project Awards and Recognition

Project team members received several awards and recognitions because of their involvement in the STEM Guitar Project. Most of them work hard and stay behind the scenes. It is worth mentioning, though, at least three significant recognitions for Project Team members because of their involvement with the Project.

- 1) The Gerhard Salinger Award for enhancing STEM education through technology/engineering design-based instruction awarded by the International Technology and Engineering Association (ITEEA) - The major work for the submission of the documents for the award was headed by a core team of six. All six of them were named as award recipients. Mr. Douglas Hunt of Southern Wells Jr-Sr High School, was at the helm (see Figure 20). The other five core team award recipients were: Dr. Debbie French of Wake Forest University, Mr. Alex Moll of Lake Stevens Middle School, Mr. Tom Singer of Sinclair Community College, Dr. Mark French of Purdue University, and Mr. Matt Peitzman of Penrridge High School. As Doug mentioned, this was a team effort as other Project Team members supported this core team behind the scenes with data and critique of the document. This is quite a milestone for the STEM Guitar Project over its more than 10 years of existence.

Figure 20. ITEEA Awardees



- 2) The Congressional Recognition for Teacher Excellence Award received by Matt Peitzman of Penrridge High School (See Figure 21 for his award) - This was made possible through the efforts of Mr. Brian Fitzpatrick of Pennsylvania's 1st Congressional District. Part of the recognition for Matt (as facilitated by Rep. Fitzpatrick) was the raising of the United States Flag in Congress for one day in his

honor. News about this award caused a big spike in the Project's website (www.guitarbuilding.org) indicating people's awareness about the significance of this award.

Figure 21. Teacher Excellence Award



- 3) The recognition received by the STEM Guitar Project from Gibson Guitar Nashville - Gibson Guitar saw the STEM Guitar website and contacted the Project. Gibson Guitar recognizes the value of the STEM Guitar training process and the expertise of the two STEM Guitar Project PIs: Mike Aikens, the first PI of the series of STEM Guitar projects, and Tom Singer, the current Project PI. This was evidenced by the fact that the two Project PIs worked together to help Gibson Guitar Nashville in revamping their onboarding orientation for their new hires, creating skills assessment for the interview process, design, and implementation of the company's new hire training program called "The Gibson Main Stage Training Program." Gibson Guitar. It was quite an honor for the STEM Guitar Project that the training modules Gibson Guitar created were similar to the way the STEM Guitar modules are created. For Gibson Guitar, the training modules created involved videoing the processes, voice over with the SME and re-write of its SOW (standard of work) for each process, including pictures captured from the video. Nashville contracted Mike, providing housing and a fair compensation, to oversee the first three months (January, February, March 2021) of the process. When Mike submitted his final report on his way out, Gibson gifted him with a beautiful '59 Custom ES-355 Reissue guitar as a token of appreciation. As Mike said, "*It was a fantastic experience for both Gibson and myself.*" The Project gets to support Gibson Guitar continuously as it is on weekly call for support, if needed. See Figure 22 for a memento of this experience. Rob Ulrich, Gibson Guitar Nashville Training Supervisor (he is the one pictured with Mike in Figure 22) said, *I had the great honor and privilege of working with one of the coolest, kindest, most supportive people I've ever met, Mr. [Mike Aikens](#) of the [STEM](#)*

[Guitar Project](#). I learned so much from him while helping to put the final touches on Gibson's first actual training program

Figure 22. Gibson Guitar Connections



Project Dissemination

Publications and Conferences

The STEM Guitar Project dissemination is a joint and continuous effort among a Project Team throughout the grant period. Topics varied and they are usually about the STEM Guitar project, building guitars, integrating STEM learning in guitar, and guitar building lesson materials and portfolio. For the project year 2020-2021, the most active in the subject of dissemination are the university Faculty in the Project Team (Dr. Mark French, Dr. Debbie French, and Dr. Sean Hauze), all of whom have shared materials either virtually (the usual mode under the COVID situation in the country) or in terms of articles or journals in professional publications. Mark has been a very active contributor of his scholarly publication in the *American Lutherie*; a quarterly journal that focuses on all aspects of the art, craft, and science of stringed instruments. Mark

has an article published every quarter during the grant period 2020-2021; one of his articles was co-authored by Doug Hunt. Debbie and Sean have been taking advantage of the virtual environment to continue with their scholarly pursuits. Debbie did three virtual presentations, one she did by herself and two with other colleagues within the STM Guitar Project, Sean Hauze and Matt Peitzman, and another colleague outside of the project. Alex Moll, another Project Team member, did one other virtual conference presentation.

Media Exposure

As much as possible, the Project Team takes advantage of every opportunity for media exposure and sharing of information about the STEM Project in cooperation with the academic institutions or industry partners. The STEM Guitar Faculty Champions are also oriented that way. Many of these Faculty Champions' efforts are not necessarily shared with the Project Team. Occasionally, the Project Team gets pleasant surprises as Faculty Champions post some of their activities and/or media exposure on the STEM Guitar Project Facebook account. The Project Team, though, has been following the practice of formally documenting any Project media exposure in the Project spreadsheet started in this current grant. For this project year 2020-2021, two media exposures had been formally reported in February 2021: (1) a remote/online report about the activities of the 4th grade class regarding sounds and vibrations in guitars at the West Lafayette Intermediate Schools publication, and (2) the remote publication about Engineering, Technology, and Guitars in celebration of the Fender Engineering Week in Fender, Corona, CA.

Another media exposure for the STEM Guitar Project worth mentioning is the media mileage and exposure the Project gets as it works with the Phoenix Patriot Foundation and the American Patriot Music Project, through its Executive Director, Tony Villegas. The STEM Guitar Project trains the veterans and helps them learn employability skills through guitar building. Tony has been leading the recruitment and selection of the veterans that went through the STEM Guitar building workshops for the past three years and still ongoing. Every STEM guitar building workshop with the veterans has been followed by a music concert (with the American Patriot Music Organization) featuring the veterans as they showcase the guitars built from the workshop. The May 2021 workshop held at Somerset Vineyard & Winery in Temecula; CA is no exception. (refer to Figure 2 from the Project Output Section about the May 2021 STEM Guitar workshop with the veterans). In this particular build, just like the other builds, Tony was able to get local media networks to talk about the Project. This time, it is with the CBS Radio at the EZ 103.1 FM radio station aired on KFROG 92.9.

Overall Project Sustainability

The overall Project sustainability is a continuous Project concern as these efforts have been part of Project activities since the beginning of the grant. These activities involve the development and maintenance of Project partnerships with the academic institutions, the business/industry, and the larger community, current STEM Guitar activities not dependent on NSF funding, including exploring other funding support. The lessons learned from the Project's 10-year research could also lend to its sustainability.

Continuing Project Partnerships with Academic Institutions

Reaching out continuously to academic administrators became part of the primal effort of the STEM Guitar program to promote the STEM Guitar program buy-in. Curricular integration of the STEM Guitar program is critical to realizing the Project goals. The Project continues to experience wider span of academic partnerships as more and more participants around the US states and other countries such as Australia, Canada, and Colombia are becoming involved in the Project.

The Project developed Administrator Video is a way by which the Project promotes the academic institutional partnership. All Faculty participants in the Project are required to get formal administrative support prior to their training in any STEM Guitar Institutes. Once Administrators understand the integration of STEM guitar curricula with their school curricula, “buy-in” follows readily. For instance, one of the Faculty Champions teaching at Kankakee Community College (KCC), who is now a member of the Project Team, taught the STEM Guitar course at KCC in the fall of 2015. The STEM Guitar GBI had a great impact on the current college President as he was one of the first group of KCC's STEM Guitar students. The Dean of KCC's Technology Division was one of the GBI participants when KCC hosted it in 2016. The KCC administrators consider using the STEM Guitar course as a model for other Project-based STEM courses in the College. The College started its first STEM 3-D Printers course following the STEM Guitar model.

Strong STEM Guitar connections have been established with different institutions across the United States that hosted STEM Guitar Institutes in the past, for example: San Diego City College, San Diego, CA; Travis Early College HS in Austin TX and Anuntuck Community College in Enfield, CT. The stability of the Project's connections is shown through the repeat GBI hosting in 2020 of institutions like: Sinclair Community College in Dayton, OH; Pennridge High School in Perkasio, PA; Grants Pass High School in Grants Pass, OR; and Kankakee Community College, Kankakee, IL.

Every year since the start of the first grant, Faculty Champions emerge. The Faculty Champions serve as the best ambassadors to academic institutions as they model the STEM Guitar curricular Project-based learning implementation in their institutions. Faculty Champions are invited to join the yearly Project Summit where they are able to show positive program effects in their classroom practice and their students. The Faculty Summit usually showcases classroom practices and students as they presented exemplars of their STEM Guitar-related program implementation. These revolved around classroom best practices, ideas for new Projects, as well as impacts on students (school performance, learning more about STEM concepts, gaining STEM-related hard and soft skills, and improving students' attitudes and interest toward STEM and STEM careers).

Partnerships with professional associations through the team members' professional conference presentations, and for some members, memberships in these associations, are continued and pursued. Additionally, the Project maintains its connections with different NSF Advanced Technological Education (ATE) Centers such as the National Center for

Manufacturing Education (NCME) and Materials Education (MatEdU); these centers are committed in providing up-to-date information on manufacturing processes and information on various materials needed to make a guitar (e.g., metal, wood, polymers, etc.) and the properties of each of those materials.

Continuing Business/Industry Partner Development and the Larger Community

Project minutes of meetings show that the STEM Guitar Project is able to explore and develop continuing business and industry partnerships with business/industry connections. Relationships with business and industry contribute to the Project buy-in, acceptance, relevance, crowd-sourced funding, and more visibility for Project promotions and funding support. The Project still intends to be aligned and working seamlessly with industry partners. The Team would like to enhance employability skills through the Project's Institutes/ training by creating an industry-recognized badging or skill identification system, and standard-based certification. The skill sets will be cross-walked with the Project's educational competencies, developing a process of skills recognition learned from the STEM Guitar programs that would equate to industry service technician levels. Additionally, there is interest in digital badging that can be used to electronically award badges to participants upon completing the certificate requirements. Among specific industry partners being tapped for the skills certification venture are: Fender Musical Instruments, Taylor Guitars, Martin Guitar and Heritage Guitars, and Credly, which has emerged as the leader in digital badging. Professional networking sites, such as LinkedIn and ZipRecruiter, will also be explored in relation to this venture.

Interview with the Project PI, updated Project minutes of meetings/records show the Project's existing corporate partners [(All Parts, Black Diamond Strings, D'Addario, Fender Musical Instruments, Forest Scientific Corporation, FML (Frank Miller Lumber), Indasa, ShopBot, Stewart MacDonald] continue to support the STEM Guitar Project by providing personnel expertise and in-kind support to participants. Fender, in particular, donated \$7,000 worth of woodworking materials used in making the guitar kits. In certain cases, like for some regional participants, financial support through crowd-sourced funding is extended. Boeing Company remains a major partner, especially for the Washington State participants. Boeing provided input regarding employability hard and soft skills that are important to consider in developing the guitar building curriculum. Continued Project efforts in exploring Project connections with employability technical and soft skills were spearheaded by this initial partnership with Boeing and the support of the NSF funded MatEdU Center in Edmonds Community College located in Washington State. Taylor Guitar Company in San Diego, California, continues to provide a key role in supporting the current grant's new acoustic guitar building track by way of technical support and potentially supplying the educational guitar kit materials for the Project's acoustic guitar build.

Continuous communication and sharing of information are key in developing new and maintaining existing Project partners in the larger community. Expert guitar builders and music celebrities, who have been oriented to the Project, remain the best Project supporters in the community. Data records from minutes of meetings indicated that the STEM Guitar Project

maintains a strong presence during the NAMM conference where connections with music industry-related companies and music celebrities are developed and enhanced. Apart from the authentic merit of the Project shared with the community, interested music celebrities attract more attention, publicity, and media exposure to the Project.

Many STEM Guitar Faculty continue to reach out to their local media and newspapers, state department of education, and government officials add to the wider exposure and community awareness about the STEM Guitar Project. Often times, these efforts add to the increasing positive image of their class in their institutions, district, and the larger community.

The Project extension activities to veterans in the previous years and current connections enable the STEM Guitar Project to establish and maintain connections with different community non-profits and interested groups and organizations in Temecula, CA; Boulder City, NV; Lake Stevens, WA; and Dayton, OH.

Initiatives Not Dependent on NSF Funding

Current STEM guitar building activity involvement which is not dependent on the current NSF grant funding is likely to continue. Examples of this are:

- (1) The international STEM Guitar outreach at the University of Medellin in Colombia - One member of the Project Team, in collaboration with and support from his University (Purdue University), continues this initiative. In this outreach, students build guitars and learn the engineering behind them.
- (2) The STEM Guitar Manufacturing/Production – Part indicator of the Project sustainability is the guitar kit sales. The current manufacturing of guitar kits at Sinclair College is self-sufficient; this endeavor remains to be the main supply chain for the Project and will likely continue to supply the guitar kit demands of current and future STEM guitar implementers. There has been an exponential increase in demand for guitar kits and supplies through the years. Most of guitar kit demand has been supplied by the guitar kit Manufacturing/Production Team at Sinclair Community College (SCC), a self-sustaining entity not included in the grant expense budget. There is stability with the current guitar kit manufacturing at SCC; it has developed its infrastructure, process and practice. The guitar kits, as ordered, are distributed to different educational institutions around the US by the SCC Manufacturing/Production Team. The Storefront on the Project website has links to url addresses for ordering guitar kits and supplies:

- Acoustic guitar kit and supplies

<http://guitarbuilding.org/store/#!/Acoustic-Guitar-Kits-and-Supplies/c/34779027>

- Body plank and partially milled guitar kits

<http://guitarbuilding.org/store/#!/Body-Blank-and-Partially-Milled-Guitar-kits/c/22671282>

- Guitar/Bass Kits

<http://guitarbuilding.org/store/#!/Guitar-Bass-Kits/c/61961017>

- Guitar Hardware Kits (plus neck and fretboard options)

<http://guitarbuilding.org/store/#!/Guitar-Hardware-kits-plus-Neck-and-Fret-board-Options/c/23151741>

- Guitar Tools and Supplies

<http://guitarbuilding.org/store/#!/Guitar-Tools-and-Supplies/c/22671272>

(3) Emerging supply chain - Although the Project's three program tracks (AGB, EGB, HGB) provide more complexity for guitar kits and supplies, the HGB faculty Institutes seem to provide additional resources, thus, expanding the supply chain especially for pre-cut body parts. Demand for pre-designed/pre-cut guitar parts has been decreasing after the HGB program track was introduced. The STEM Project Team continues to exert more efforts to grow its school supply chain. The Project Team continues to reach out to participating institutions who may have facilities that can handle the manufacturing and preparation of guitar kits. Potential groups are those institutions with facilities and capabilities and where there are Faculty Champions dedicated to implementing the guitar-building problem-based learning program. The Project Team continues to explore other sourcing possibilities like local manufacturing, which may be interested in making guitar kits, as well as importing materials that may help optimize costs.

Exploring Future Grant Opportunities and Other Funding Support

The Project Team continues to generate ideas for new programs and/or STEM Guitar-related program expansion. New ideas for related guitar-building/music Project-idea as an expansion of the current guitar-building based-learning are being explored for potential grant opportunities. The Project Team also continues to explore possible partnership with groups willing to help the team in organizing a possible foundation. This foundation is meant to help with the promotion and funding solicitation for the Project.

Conclusions

The STEM Guitar project has the primary goal of increasing student interest, engagement, and learning of STEM principles, practices, and careers through guitar design and building to help solve the critical STEM technician shortage, narrowing the skills gap. Along with this primary goal are Project concerns about: 1) the increased involvement of diverse secondary and post-secondary faculty; (2) effects on faculty regarding their practice effecting student outcomes; 3) student learning about STEM concepts, behaviors and attitudes toward STEM; 4) Project facilitating a replicable and sustained Community of Practice Applied Learning Community; and 5) wider reach of the STEM Guitar Project and its overall Project sustainability. The Project has established mechanisms, processes and best practices through the years that were further honed and implemented in 2020-2021. The major goal was geared toward the academe although the application, aspirations, and learning from the STEM guitar program are transferable to the veterans; the veterans' training focus being on employability skills, narrowing the skills gap. In fact, one of the veteran trainees from the early Spring 2021 veterans' workshop was hired immediately by the Sinclair Guitar Manufacturing Shop. While the Project also trained veterans, these concluding narratives are more related to the Faculty context.

The 2020-2021 STEM Guitar Project program implementation increased the involvement of diverse secondary and post-secondary faculty trained in the inter-disciplinary approach to teaching guitar building making STEM connections to a certain degree. The Project served 2% more faculty trainees with diverse background. The Project continued to reach out to relatively large-populated poor (mid-to high-poverty) schools and schools with greater proportion of under-represented population in 90 academic institutions within 21 states in the four major regions in the US. This implies that close to 2,000 additional students from poor and underrepresented academic institutions would have a variety of experience about STEM Guitar either through direct information from their Faculty, the social media, direct build in their classrooms, and/or the faculty implementation of MLAs or use of Canvas. The Faculty use of STEM Guitar program materials in making STEM connections would have important effects on their classroom practice effecting student outcomes. The trained Faculty as "students" of SGBRLI experienced for themselves learning how to make STEM connections using the physical guitar building and the different STEM Guitar MLAs. As "students" of SGBRLI, they personally experienced learning the guitar building - related hard and soft skills they can model for their classroom students; these skills have been mapped with employability skills.

Through the Project grant years, and especially the Project year 2020-2021, the STEM Guitar Project endured and was able to adjust accordingly with the challenges of the COVID situation in conducting its program implementation. This was possible because the Project established practices, mechanisms, connections, and support for STEM Guitar program implementation. The participants' response about how the Project helped Faculty prepare for their program implementation were very favorable. The Project also modeled inspiring behaviors as evidenced by the Project awards and recognition that could help motivate Faculty, especially when faced with trying situations. The combination of all of these will promote and support strong

Faculty classroom implementation. It can be said that there is program impact in the sense of the program's reach and established practices; even companies in the Guitar Industry like Gibson Guitar are willing to adopt the STEM Guitar training practices. There are still some areas of growth in terms of the program reach to more diverse populations. More importantly, there are areas of growth and concerns about issues related to gathering outcomes data, both from the Faculty and Students. The nature of SGBRLI has more issues in terms of participant data collection, unlike previous years' Institute implementation where participants could be personally reminded by the Trainers about their evaluation and other Project requirements. Also, gathering student data is always the most challenging even with incentives given to the Faculty. There is just so much going on in the classroom and the academic life (not to mention the personal life) of the Faculty. The Project is hopeful about its research on the Project's 10-year life and beyond.

Recommendations

The following course of actions related to the Project's best practices and areas of growth are recommended to the Project Team:

- 3) To ensure the STEM Guitar best practices are shared with anyone interested for further program impact, work on formal documentations in video and/or writing about:
 - a. Best practices in working with a team that are based all around the United States ensuring optimum Project results
 - b. STEM Guitar training similar to the what was created for Gibson Guitar;
 - c. Best practices for onboarding school administrators to the STEM program implementation in their schools
 - d. How to Make the STEM Guitar Applied Learning Community More Active and Meaningful for the Faculty
 - e. Best practices in creating course materials (videos, MLAs, Canvas curriculum, etc.)
 - f. Best practices in developing and maintaining business/industry partners who can help with in-kind, expertise, and financial help
 - g. Best practices in reaching out to the larger community and involving the larger community in the STEM Guitar program
 - h. Best practices in soliciting media support and other media exposure
- 4) To mitigate the areas of growth mentioned in the conclusion:
 - a. Improve the marketing/solicitation of applicants from diverse groups by being more proactive in searching for these groups and doing regular follow-ups with the group.
 - b. Involve and incentivize a team of Faculty to help devise feasible ways of getting faculty and student data outcomes
 - c. Ensure that the MLAs developed have goals/expectations related to specific hard and soft skills endemic to the particular lesson and have corresponding assessments for every skill included.

Appendixes

Appendix 1. 2020-2021 Participants' Institute Experiences

Category	Themes	Faculty Summer 2020 (n=53)	Faculty Spring 2021 (n=11)	Vets Fall 2020 (n= 5)	Vets Early Spring 2021 (n = 9)	Faculty & Vets Trainers (N=11)
Prep for implementation	Upfront information about schedules, process, & requirements	9%	0	0	0	9%
		<i>[We need] A better checklist of quizzes and assignments that need to be completed, with due dates.</i>				<i>I think we need to make sure, as presenters, that we prepare a more specific agenda and timeline along with specific tasks for each presenter.</i>
Implementation improvements	Praise & gratefulness	19%	18%	100%	67%	9%
		<i>The instructors were always willing to help with any problems and answer questions.</i>	<i>I appreciated how they [the Trainers] all specialized in different parts of the build. It was a fun experience and I learned a ton of information!</i>	<i>I am grateful beyond words for the time, energy and patience the instructors brought to class every session, and for their responsiveness to my questions outside of class.</i>	<i>THANK YOU for incredible knowledge, CLEAR application of STEM methodology, and ENTHUSIASM that made me excited to be in the class</i>	<i>Can't think of anything, the team does a Great job.</i>
	Positive – overall views about the Institutes	11%	0	100%	0	0
		<i>The zoom meetings were good because ideas and thoughts were shared by all instructors and students.</i>		<i>I got soooo much out of this course, and it was genuinely a lot of fun.</i>		

Category	Themes	Faculty Summer 2020 (n=53)	Faculty Spring 2021 (n=11)	Vets Fall 2020 (n= 5)	Vets Early Spring 2021 (n = 9)	Faculty & Vets Trainers (N=11)
Implementation improvements	Process – remote course handling and timing (e.g., more synchronous sessions; in-person session preferred, course sequences); diversity of trainers	11% <i>Only suggestion is to be explicit about the steps to follow: what to do first, second, third, etc.</i>	27% <i>Also, add more diversity in instructional team. As a woman it is already daunting/a strain on my mindset to take a guitar building course.</i>	0	22% <i>Don't assume everyone understands the names of items to use. Have a more work-along sessions/everyone doing the task.</i>	9% <i>A primary advantage of the face-to-face workshops is getting everyone in one place and away from distractions. I sometimes couldn't help feeling that the teachers were treating the STEM Guitar activity as just one more thing on their task list. It seems like problem inherent in remote learning.</i>
	Process – organization and handling of materials (Canvas navigation, video sequencing)	23% <i>All the videos should be in the same order as the steps outlined for the class. Several videos had guitars further along and I thought I did something wrong or missed something.</i> <i>A tour (Interactive) of the learning platform to uncover and work out bugs and potential issues</i>	0	0	0	0



Category	Themes	Faculty Summer 2020 (n=53)	Faculty Spring 2021 (n=11)	Vets Fall 2020 (n= 5)	Vets Early-Spring 2021 (n = 9)	Faculty & Vets Trainers (N=11)
Improvement of content	Inclusion of more instructions about frets and finishing; add photo documentation requirement	2%	9%	0	0	9%
		<i>Some instruction on how to achieve some different types of finishes would have been helpful.</i>	<i>I'm still not sure I'm understanding the fret spacing formulas and how to arrive at them. Maybe the use of some type of similar, easier concept that is a step below what was presented or a nice parallel to it.</i>			<i>I think we should have the veterans submit a few photos of their process along the way and of their completed guitar at the end</i>
Materials used	Videos (quality improvements, sequencing and in synch with Trainer's presentation) – Canvas (improvement, prior run-through, more materials, access and navigation)	19%	0	0	11%	27%
		<i>It would be helpful to have up-to-date instructions using the current form of the software in video. I know this is hard to do because of frequent updates.</i> <i>There seemed to be some struggles with Canvas, therefore pre-training on Canvas for Instructors would be beneficial,</i> <i>Although everything was placed sequentially in the course [through Canvas], there did not seem to be an obvious way to see where I stop from one day to the next.</i>			<i>Clean up the videos some. Shorten the length so it is easier for us to find the information we need.</i>	<i>Of course, anything can be made better. That said, I think this Canvas version of the STEM Guitar Teacher Institute is pretty well organized and contains loads of great information. [need be reviewed by experts] Further, the instructional videos can surely be refined and possibly be redone with a more professional touch;</i>



Category	Themes	Faculty Summer 2020 (n=53)	Faculty Spring 2021 (n=11)	Vets Fall 2020 (n= 5)	Vets Early Spring 2021 (n = 9)	Faculty & Vets Trainers (N=11)
Application of training		4%	9%	0	0	0
	Positive and negative aspects from the Institutes lending to classroom application	<p><i>I feel that if awarded the opportunity to do run this program in my classroom, I would be able to make great use of the material as it is with minor adaptations for students.</i></p> <p><i>It may be better to establish build milestones and tie synchronous session discussions to them; having done it, discussions could focus more on how you would achieve this milestone in a class setting.</i></p>	<p><i>The instructional videos on canvas seem very helpful and will be very useful to me when I work through the modules this summer.</i></p>			



Appendix 2. Skills Gained with Guitar Building

STEM Guitar Project Track	STEAM Classification	Categories [Guitar Building Phase and Basic Core Competencies]	Specific Technical Skills
ALL	Art	All/basic competencies	Music ability
ALL	Engineering	All/basic competencies	Identifying a problem
ALL	Engineering	All/basic competencies	Problem solving
ALL	Engineering	All/basic competencies	Use proper measure tools with accuracy in positioning fret board and affecting guitar setup
ALL	Math	All/basic competencies	Brainstorming to fix a mistake or problem
ALL	Science	All/basic competencies	Asking questions
ALL	Science	All/basic competencies	Problem solving, working through a problem to a solution
ALL	Science	All/basic competencies	Providing and receiving peer review and feedback
ALL	Science	All/basic competencies	Science as an iterative process, not linear
ALL	Science	All/basic competencies	Teamwork of sharing tools and experiences
ALL	Engineering	Curriculum	How to write an MLA
ALL	Art	Design/cnc machining/manufacturing	Design head stock shape
ALL	Art	Design/cnc machining/manufacturing	Head stock design - sketching and transfer to wood
ALL	Engineering	Design/cnc machining/manufacturing	Develop and use model skill
ALL	Science	Design/cnc machining/manufacturing	Developing / using models
ALL	Technology	Design/cnc machining/manufacturing	Ability to use tools and machines correctly and safely
ALL	Technology	Design/cnc machining/manufacturing	Process planning
ALL	Technology	Design/cnc machining/manufacturing	Set up / operation of vector / raster lasering, operation of the laser
ALL	Technology	Design/cnc machining/manufacturing	Troubleshooting, problem solving, critical thinking
ALL	Technology	Design/cnc machining/manufacturing	Use of laser and CAD woodworking machine
ALL	Technology	Design/cnc	Using design software skills

		machining/manufacturing	
ALL	Technology	Design/cnc machining/manufacturing	Using H2O and heat to remove wood dents (CNC)
HGB	Art	Design/cnc machining/manufacturing	Art designs and logos
HGB	Art	Design/cnc machining/manufacturing	Gluing up body blanks for CNC
HGB	Math	Design/cnc machining/manufacturing	Ability to calculate chip load in order to efficiently program the CNC router's feed rate
HGB	Technology	Design/cnc machining/manufacturing	Advanced CAD techniques for 3-D cuts
HGB	Technology	Design/cnc machining/manufacturing	Applying tolerances when machining parts
HGB	Technology	Design/cnc machining/manufacturing	Create tool paths from 3D CAD model to machine body
HGB	Technology	Design/cnc machining/manufacturing	Development of tool path and routing
HGB	Technology	Design/cnc machining/manufacturing	Generating and validating tool path (CNC)
HGB	Technology	Design/cnc machining/manufacturing	Operating a CNC
HGB	Technology	Design/cnc machining/manufacturing	Troubleshooting - why tooling fails
HGB	Technology	Design/cnc machining/manufacturing	Turning a CAD drawing into a CNC program
ALL	Math	Fret design/manufacturing & computing	Algebra fret calculation
ALL	Math	Fret design/manufacturing & computing	Calculate fret positions given a scale length for a 12 semi-tone stringed instrument
ALL	Math	Fret design/manufacturing & computing	Calculating gear ratios
ALL	Math	Fret design/manufacturing & computing	Measurement
ALL	Math	Fret design/manufacturing & computing	Precision and accuracy in measurement

ALL	Math	Fret design/manufacturing & computing	Radiusing
ALL	Science	Fret design/manufacturing & computing	Precision and accuracy in measurements
ALL	Art	Guitar context & construction	How to book match, use wood efficiently (optimization)
ALL	Math	Guitar context & construction	Calculating the material cost for guitar CNC body blanks
ALL	Math	Guitar context & construction	Using metric or imperial measure conversion in proper drill bit selection
ALL	Science	Guitar context & construction	Cleanup of materials
ALL	Science	Guitar context & construction	Tap testing of hard, soft woods
ALL	Science	Guitar context & construction	Tonal qualities of woods and selections
ALL	Technology	Guitar context & construction	Selection and use of hand tools
ALL	Technology	Guitar context & construction	Skill in technical sketching and geometrical shape description
ALL	Technology	Guitar context & construction	Use of band saw and ROSS? to execute a head stock design
ALL	Technology	Guitar context & construction	Use of power tools and specialty tools & jigs to shape and finish guitar
ALL	Technology	Guitar context & construction	Use of spreadsheet software
ALL	Technology	Guitar context & construction	Using calipers to measure screws and drills
ALL	Technology	Guitar context & construction	Using the fastener MLA to decide what size drill for what size screw hole
ALL	Technology	Guitar context & construction	Wood bonding
EGB, HGB	Art	Guitar context & construction	Body contouring
EGB, HGB	Technology	Guitar context & construction	Guitar, shape, modifications
HGB	Technology	Guitar context & construction	Gluing, process, body blanks [via video]

ALL	Art	Guitar finish/conditioning & finishing	Choosing color scheme, coating processes for beautification
ALL	Art	Guitar finish/conditioning & finishing	Finishing; prep, apply levels & buff & polish finish
ALL	Art	Guitar finish/conditioning & finishing	Guitar finish; finish materials, gloss, matte, & road worn
ALL	Art	Guitar finish/conditioning & finishing	Water slide and logo - artwork to apply on guitar
ALL	Technology	Guitar finish/conditioning & finishing	Apply spray paint without causing runs
ALL	Technology	Guitar finish/conditioning & finishing	Buffing and finishing for gloss, coating for protection and beautification
ALL	Math	Guitar set-up/quality control	Application of golden mean in designing shape of head stock and body
ALL	Math	Guitar set-up/quality control	Symmetry / balance
ALL	Technology	Guitar set-up/quality control	Fret level, crown, polish
AGB	Technology	Intonation/Physics of sound	Neck pocket routing, contour, fitting, and bridge attachment
AGB	Technology	Intonation/Physics of sound	Sound box construction, bracing, rim preparation, gluing and flushing edges,
ALL	Technology	Intonation/Physics of sound	Intonation – measuring oscilloscope and / or use app
ALL	Technology	Intonation/Physics of sound	Measurement, accuracy, inspections, and tolerances
ALL	Technology	Intonation/Physics of sound	Tuner dress rehearsal (fit check, engineering, manufacturing)
EGB, HGB	Technology	Intonation/Physics of sound	Pickup height set up after install to set proper sound
EGB, HGB	Technology	Intonation/Physics of sound	Pickup, ohms, measurement, quality control, engineering, & meter use
ALL	Engineering	Soldering/electricity & electronics	Physical and electrical precision measurement
EGB, HGB	Engineering	Soldering/electricity & electronics	Humbucker, single coil,
EGB, HGB	Engineering	Soldering/electricity & electronics	Selection of pickups and alternate wire options
EGB, HGB	Engineering	Soldering/electricity & electronics	Translating a schematic diagram into a pictorial wiring diagram, soldering

EGB, HGB	Technology	Soldering/electricity & electronics	Testing electrical components before installing, soldering, electricity, shielding, grounding
EGB, HGB	Technology	Soldering/electricity & electronics	Translating the schematic or wiring diagram into a functional physical circuit - wiring, mounting, soldering
EGB, HGB	Technology	Soldering/electricity & electronics	Use of multi-meter

Appendix 3. Embedded Soft Skills (Attitudes) Learned Within STEM Guitar

Communication and Collaboration (C & C)

- Work in teams
- Help others with a problem
- Working collaboratively in a group

Creativity and Innovation (C & I)

- Emotional connection to wood patterns and colors
- CNC - positive feelings of seeing something made from design
- Craftsmanship
- Openness to learning/intellectual curiosity/appreciation for the sense of discovery

Critical Thinking & Problem Solving (Ct & Ps)

- EGB / AGB - guitar setup, engineering; neck, bridge, neck relief, bridge choice, installations, & critical thinking skills
- Brainstorming a fix to a mistake or problem (teamwork, confidence, perseverance)
– **also, in G, I, & Sd**
- Develop scientific, logical world view
- Brainstorming to fix a mistake
- Methodical
- Openness to learning/intellectual curiosity/appreciation for the sense of discovery
- **also, in S & Cc**
- Problem solving

Flexibility and Adaptability (F & A)

- First algebra success or relevance for many students (fret equation)
- Pretty cool how we were able to figure out fret spacing with math. Didn't know you could do that.
- Digital-age/information literacy
- Multi-tasking

Productivity & Accountability (P & A)

- Quality mindset
- Finishing a Project to completion
- Attendance frequently increases
- EGB- 100% of students who start build, finish build
- Responsibility/sense of Accountability

Grit, Initiative, and Self direction (G, I, & Sd)

- Grit
- Persistence
- Perseverance
- Confidence; self-confidence
- Initiative/self-directive/asking for help when needed
- Attentiveness
- Assuming attention to detail
- EGB- 100% of students who start build, finish build

Leadership & Responsibility (L & R)

- Pride
- Respect for tools, careful use, storage, organization
- Ethical reasoning

ocial Cross-cultural Skills (S & Cc)

- Openness to learning/intellectual curiosity/appreciation for the sense of discovery
- Inter-cultural skills

Appendix 4. Facebook Definition of Data Variables

“Likes”

- Lifetime: The total number of people who have liked your Page. (Unique Users)

“Reach”

- Total Reach 28 Days: The number of people who had any content from your Page or about your Page enter their screen. This includes posts, check-ins, ads, social information from people who interact with your Page and more. (Unique Users).
- Total Organic Reach 28 Days: The number of people who had any content from your Page or about your Page enter their screen through unpaid distribution. This includes posts, check-ins, social information from people who interact with your Page and more. (Unique Users).
- Total Viral Reach 28 Days: The number of people who had any content from your Page or about your Page enter their screen through with social information attached. As a form of organic distribution, social information displays when a person's friend interacted with your Page or post. This includes when someone's friend likes or follows your Page, engages with a post, shares a photo of your Page and checks into your Page. (Unique Users).
- Total Reach of Page Posts - 28 Days: The number of people who had any of your Page's posts enter their screen. Posts include statuses, photos, links, videos and more. (Unique Users).
- Total Organic Reach of Page Posts - 28 Days: The number of people who had any of your Page's posts enter their screen through unpaid distribution. (Unique Users).
- Total Viral Reach of Page Posts - 28 Days: The number of people who had any of your Page's posts enter their screen with social information attached. As a form of organic distribution, social information displays when a person's friend interacted with your Page or post. This includes when someone's friend likes or follows your Page, engages with a post, shares a photo of your Page and checks into your Page. (Unique Users)

“Engagement”

- Total Engagement 28 Days: 28 Days: The number of people who engaged with your Page. Engagement includes any click or story created. (Unique Users).

“Impression”

- Total impressions - 28 Days: The number of times any content from your Page or about your Page entered a person's screen. This includes posts, check-ins, ads, social information from people who interact with your Page and more. (Total Count).
- Total organic impression - 28 Days: The number of times any content from your Page or about your Page entered a person's screen through unpaid distribution. This includes posts, check-ins, social information from people who interact with your Page and more. (Total Count).
- Total Viral Impressions- 28 Days: The number of times any content from your Page or about your Page entered a person's screen with social information attached. Social information displays when a person's friend interacted with your Page or post. This includes when someone's friend likes or follows your Page, engages with a post, shares a photo of your Page and checks into your Page. (Total Count).
- Total Impressions of the Page Post - 28 Days: The number of times your Page's posts entered a person's screen. Posts include statuses, photos, links, videos and more. (Total Count).
- Total organic impressions of your Page post - 28 Days: The number of times your Page's posts entered a person's screen through unpaid distribution. (Total Count).
- Total Viral Impressions of your page posts - 28 Days: The number of times your Page's posts entered a person's screen with social information attached. Social information displays when a person's friend interacted with your Page or post. This includes when someone's friend likes or follows your Page, engages with a post, shares a photo of your Page and checks into your Page. (Total Count).

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