French, D., Rhew, B., Hauze, S. & Dorsey, S. (2023). Using ePortfolios as an authentic assessment tool for integrated stem professional development. *Contemporary Issues in Technology and Teacher Education, 23*(1), 84-102.

Using ePortfolios as an Authentic Assessment Tool for Integrated STEM Professional Development

Debbie Frinch
Wake Forest University

Brad Rhew
Winston-Salem/Forsyth County Schools

Sean Hauze
San Diego State University

Sophia Dorsey
Winston-Salem/Forsyth County Schools

Electronic portfolios (ePortfolios) are used in collegiate science, technology, engineering, and math (STEM) courses and in preservice teacher education, yet there is a dearth of research on the use of ePortfolios for in-service teacher professional development (PD). This article presents the results of using ePortfolios as both a model for teachers to incorporate in their classes and an evaluation tool for an integrated STEM PD. Participants for this study were K-16 faculty members who participated in the National Science Foundation-funded STEM Guitar Faculty PD Institutes. Data were obtained from three sources: faculty participants' ePortfolios, alumni retrospective survey responses, and focus group data. Emergent themes included the importance of being willing to try new things, new skills learned, students' ability to build guitars, and identifying curricular connections to the guitar. Quantitative survey responses are reported using descriptive statistics. Two thirds (67.65%) of faculty members referred to their portfolios as they implemented the program. Over half showed their ePortfolios to their students (56%) or other teachers or administration (59%). Over a quarter (27%) of teachers used ePortfolios in their classroom. These results have implications for PD providers. ePortfolios an informative and useful evaluation tool for PD providers. They are useful for faculty members beyond the PD.

With the gradual adoption of the *Next Generation Science Standards* (NGSS; NGSS Lead States, 2013**),** precollegiate science teachers must plan to integrate science and engineering practices alongside core science and engineering content and crosscutting concepts by creating three-dimensional lessons (Houseal, 2015; National Research Council [NRC], 2012). The NGSS are the first set of standards that require engineering to be taught alongside science. However, few science teachers have any collegiate coursework in engineering (Cunningham & Carlsen, 2014). Additionally, few teachers have had any training on how to integrate two or more different disciplines effectively (Czerniak & Johnson, 2014). As such, professional development is needed in designing effective, integrated science, technology, engineering, and mathematics (STEM) lessons based on the NGSS.

Project-based learning (PBL) is one student-centered pedagogical approach that can be used to incorporate the three dimensions of the NGSS (Williams & Houseal, 2015). PBL lends itself well to teaching integrated STEM subjects. PBL has been shown to increase students' STEM content knowledge (Hauze et al., 2017), ability to transfer knowledge to novel situations within STEM subjects (Malicky et al., 2010), and practice using problem-solving and critical thinking skills (Alismail & McGuire, 2015; Drew, 2013)

Yet, "successful implementation of PBL in the classroom lies on the teacher's ability to effectively scaffold students' learning, motivate, support and guide them along the way" (Kokotsaki et al., 2016, p. 272). As it may be challenging to adopt new teaching methods without having first experienced those methods (Loucks-Horsley et al., 2010), offering professional development where faculty members can engage as students to learn integrated STEM subjects by working through an engaging project is one strategy to equip teachers to meet these curricular demands set forth by the NGSS.

As teacher professional development opportunities shift in response to the change in standards, options for evaluating professional development should also shift. Professional development (PD) providers may wish to select a deliverable or evaluation tool that is a more authentic representation of participants' experiences in the PD. Evaluating professional development programs is one challenge in the science teacher education community (Luft & Hewson, 2014).

This paper describes the use of ePortfolios as an evaluation tool for participants in the integrated STEM Guitar faculty professional development institutes (STEM Guitar Institutes). The STEM Guitar Institute provided an opportunity for faculty members to become immersed in integrated STEM education through the design and construction of an electric or acoustic guitar as the project. In addition to building the guitar, faculty members worked through Modular Learning Activities (MLAs), which are aligned with the NGSS and other national standards. Throughout the institutes, faculty members had opportunities to reflect on their experiences, connect the material to their grade or content area, and elaborate on ways they could effectively integrate STEM subjects into their courses in an electronic portfolio (ePortfolio).

The purpose of this research was to explore the use of ePortfolios as an evaluation tool for an integrated STEM teacher professional development opportunity. In particular, we examined whether the ePortfolios were useful for grant evaluators as well as for the participating teachers.

Literature Review

Traditional portfolios have been used to assess teachers' knowledge and skills learned or refined through the professional development opportunity (Guskey, 2000). Portfolios allow the creator to select artifacts that document "achievement, progress, growth, and reflection" (Ziegler & Montplaisir, 2012, p. 16). Portfolios have since moved into the digital age and are now hosted through a variety of online platforms (Beetham, 2006).

While ePortfolios are similar to traditional portfolios in many ways, they have some distinct advantages. For example, ePortfolios can be shared with a broader audience than can a traditional physical portfolio (Johnsen, 2012). ePortfolios can also house different types of media, such as videos. Given this ability to combine media that are commonly used in online education, it comes as no surprise that the COVID-19 pandemic accelerated the use of ePortfolios as an authentic assessment tool, as evidenced by several recently published studies (e.g., Das, 2021; Farrell et al., 2021; Guàrdia et al., 2021).

Portfolios of either format typically have at least one of the following three primary functions. They may be used as alternative assessments (Buhagiar, 2007; Maher & Gerbic, 2009), as platforms for peer review, and as a "showcase portfolio where the purpose is to document competence and achievements" (Maher & Gerbic, 2009, p. 45).

In this research, we adopted the latter definition and examined the use of ePortfolios as a platform for teachers to document the STEM Guitar build process and highlight their knowledge and skills acquired through this integrated STEM PD opportunity. Once again, the COVID-19 pandemic served as an accelerator for adoption of ePortfolios as the need for authentic assessment increased due to the lack of ability for traditionally proctored exams (Hsu, 2020; Misdi, 2020). Additionally, ePortfolios allowed teachers to give their students real-time feedback, which would not have been feasible with traditional paper-pencil portfolios. With this feedback, students could address their learning in a timely manner.

The ePortfolio is becoming increasingly more common to document students' authentic experiences in undergraduate and graduate STEM courses and programs (Ziegler & Montplaisir, 2012). They are also more commonly used in preservice teacher education programs (e.g., Chye et al., 2013). As such, ePortfolios may also be useful in STEM teacher PD. While some professional development programs incorporate the use of ePortfolios (e.g., Scherz, Bailer, & Eylon, 2008), there remains a dearth of research on their use in STEM teacher PD settings.

The ePortfolio may also provide an opportunity for teachers to reflect upon what they are learning throughout the PD. Many educators continuously look for ways to improve their teaching instruction and have a greater impact on student learning. PD opportunities not only allow teachers to grow professionally, but it provides the space for them to reflect on their practice. When teachers engage in reflective practice, it has a direct impact on their instructional practice as well as on student learning and achievement (Drago-Severson, 2009).

PD provides the space for teachers to engage with their colleagues, learn from each other, and reflect on their own practices. When teachers are given the opportunity to reflect on their teaching and engage in collective inquiry with their peers, they are able to find ways to improve their craft and have a greater impact on student achievement (DuFour et al., 2006). Additionally, teachers who engage in reflection as part of their own PD are able to strengthen their reflective skills to subsequently apply similar methods in their teaching practice; thereby, teachers are able to strengthen reflective skills in their students as well (Körkkö et al., 2016). While ePortfolios are used to capture evidence of knowledge and skills learned, they also allow learners to reflect upon their work, especially when used in the field of preservice teacher education (Maher & Gerbic, 2009; Picardo & Sabourin, 2018).

Theoretical Framework

This research adopted a constructivist theoretical perspective to describe teachers' experiences, knowledge acquisition, and skills development during the STEM Guitar Institutes, as evidenced by teachers' documentation and self-reflection in their ePortfolios (Koro-Ljungberg et al. 2009). The ePortfolio is a pedagogical tool aligned with constructivist principles (Blocher et al, 2003; Granberg, 2010), as they provide a platform for teachers "to be actively engaged in their own learning" (Maher & Grabic, 2009, p. 45). However, when selecting technology tools (whether analog or digital) to implement in their courses, teachers must decide how to "integrate the technology, pedagogy, and content" (Koehler & Mishra, 2009, p. 66), or technology, pedagogy, and content knowledge (TPACK).

Additionally, this study investigated the role of self-reflection as a key element of andragogy and other aspects of adult learning theory, including self-directed learning and experiential learning (Cercone, 2008; Knowles, 1978). The basic principles of constructivism writ large, as well as the specific elements of andragogy, provide the theoretical foundation for this work.

This research adds to the body of work by "studying how [science] teachers learn in the midst of PDPs [professional development programs]" and "studying how teachers put their learning into practice" (Luft & Hewson, 2014, p. 903).

Research Questions

The following research questions guided this study:

RQ1: What build processes did teachers choose to document in their ePortfolios during the STEM Guitar Institute and how thoroughly were these processes described?

RQ2: What themes emerged from analyzing participant reflection as documented in their ePortfolios?

RQ3: How did teachers report using their ePortfolios after the PD experience?

RQ4: What are the pros and cons of using ePortfolios as an authentic assessment tool for an integrated STEM PD institute from the perspective of PD providers?

Methods

Participants

Over the past 11 years, the National Science Foundation-funded STEM Guitar Grant has developed innovative, relevant integrated STEM PD Institutes for K-16 faculty. During this time — spanning three grant awards — the grant team trained over 770 faculty members across 48 states within the United States and territories through STEM Guitar Institute PD offerings. Each STEM Guitar Institute provided faculty participants with 50 hours of PD that provided theoretical background of project-based learning, as well as practical application of building the guitar and integrating STEM content learning activities throughout.

Each faculty participant who successfully completed the PD left with a finished custom-built guitar, along with a set of resources, including step-by-step guides and related lesson plans aligned to national standards. These lesson plans included topics such as using algebraic formulas to calculate fret spacing of the guitar and using computer-aided drafting (CAD) software to design components of the guitar.

A typical weeklong in-person electric guitar workshop schedule is described in Table 1. The acoustic and hybrid computer numerical control and electric guitar workshops followed a similar format. This schedule was modified for electronic asynchronous delivery with a few synchronous sessions during the COVID pandemic.

While our target audience was high school and community college faculty, faculty members from all grade levels were welcome. Table 2 includes the number of teachers in the Retrospective Survey who taught each grade (some teachers taught more than one grade level).

Table 1
Typical In-person Electric STEM Guitar Workshop Schedule

Session	Monday	Tuesday	Wednesday	Thursday	Friday
Morning	• Welcome & Workshop Overview • Go over participants' Guitar Anatomy & Cost Analysis Homework • Shop Safety	• Math Lesson on Fret Spacing • Swirl dipping guitar bodies (optional)	• Fasteners MLA • Teachers work to develop their own MLA (Grants 1 & 2)	•Discuss Implementation Plans • Integrated STEM Education Connections	• Complete Intonation & Setup • Peer review of guitars using rubric
Afternoon	• Introduce ePortfolio & Implementation Plan assignments • Design & Cut Headstock • Glue fretboard to neck • Body Sculpting	•Apply finish to body • Fret Installation	• Install hardware • Solder • File and dress frets	• Attach the neck • Rough in the bridge for intonation • Solder electrical components	• Institute Wrap- Up • Rock Star Friday! Group Photo

Note. The in-person workshop lasted at least 40 hours. Participating teachers also engaged in pre- and postworkshop activities, which added up to 10 hours.

Additionally, STEM faculty were our target audience, but all disciplines were welcome. In fact, the STEM Guitar program can be successfully implemented by STEM and non-STEM faculty alike, as evidenced by student learning gains on pre- and postassessments (Hauze et al., 2017). Table 3 includes the subject breakdown of teachers who participated in the Retrospective Survey. Again, some teachers may have taught in more than one discipline. While the number of examples of subjects in the "Other" category varied widely, many teachers taught music, fine arts, design, or wood shop.

Table 2
Grades Taught by STEM Guitar Participants

Grade	Frequency Taught
1st Grade	3
2nd Grade	2
3rd Grade	3

Grade	Frequency Taught
4th Grade	2
5th Grade	3
6th Grade	11
7th Grade	21
8th Grade	21
9th Grade	71
10th Grade	79
11th Grade	88
12th Grade	89
Undergraduate - Community College	18
Undergraduate - University	8
Graduate	4
Postgraduate	0
School Administrator	1
Other	3
Note. As many teachers taught more than one grade level, the frequency of the grade taught was provided.	

Table 3
Frequency of Subjects Taught by Participants of the STEM Guitar Institute

Subject	Frequency of Responses
Technology	49
Engineering	46
Science	33
Math	17
Other	62
Note. As numerous teachers taught classes in more than one discipline, the frequency of responses is given.	

Highlighting the integration of STEM components occured throughout the workshop. Participants were asked to document 10 build processes by taking photographs or videos of the process, writing a short description of how to complete that process, listing any tools or supplies needed, and identifying how they could connect that process to their content area and integrate other STEM subjects.

Once participants had completed the bulk of the guitar build and classroom activities, they had an opportunity to debrief and discuss examples of STEM integration they saw in the workshop as well as to identify how they could incorporate interdisciplinary instruction in their classrooms. Table 4 shows participants' responses from a 2016 workshop regarding ways the guitar could be used to teach integrated STEM subjects.

Table 4
Connections Participants Identified Between STEM Subjects and the Guitar

Science	Technology	Engineering	Mathematics
The iterative scientific process The physics of sound waves Electrical circuits Botany, wood types & acoustic properties Chemistry of finishes Electricity/ magnetism Hydrophobic/ hydrophilic properties Hearing (decibel scale)	Excel calculations Tools, processes, order, techniques Shop safety Soldering Machining Intonation Filtering, amplification Drawing/Computer Aided Design (CAD) Computer numerical control devices	Engineering design process Problem-solving Fasteners Drawing/ Computer Aided Design (CAD) Reading blueprints/ schematics Constraints Form/function Ergonomics	Units, measurement Fret spacing Fasteners Cost analysis Geometry (frets, fret dot location) Logarithmic scales (decibel scale)

In addition to receiving these prebuilt learning activities, faculty participants of the first two grants were asked to submit an integrated STEM lesson incorporating some aspect of the guitar that is related to their grade or subject. Despite offering generous participant support packages, we did not get the desired response rate. While some participants invested time and effort into creating a high-quality product, others submitted a lesson that appeared merely to satisfy a requirement.

Despite having a common template, many lesson plans had missing sections. Other participants submitted lesson plans without accompanying materials (e.g., student handouts, presentations, etc.), so they were not useful for other teachers. For the third grant, we asked teachers to document 10 build processes of their choosing in an ePortfolio, reflect upon their experiences, identify knowledge and skills learned, and describe their top three take-aways from the workshop. The criteria and corresponding purposes — both for the participating faculty members, as well as the grant evaluators — are outlined below in Table 5.

Table 5
ePortfolio Criteria and Corresponding Purposes

ePortfolio Criteria	Purpose for Participating Faculty	Purpose for Grant Evaluators
Create an ePortfolio on Google Sites	To gain experience creating an ePortfolio from a students' perspective.	Model how ePortfolios, which are typically used in collegiate STEM courses, can be used with a variety of grades/subjects.
Ten photos and description of build processes, including tools and supplies needed.	An opportunity to stop and record ten build processes so they have these photos and descriptions as reference for when they take the STEM Guitar Project back to their classes.	What were the most common build processes teachers included in their ePortfolios? For the online workshops, this also provided documentation/evidence that participants were completing these tasks at home.
What knowledge and skills did you hone and/or acquire through the STEM Guitar Institute?	An opportunity for faculty to highlight knowledge and skills within and outside of their discipline to make integrated STEM connections within their curriculum.	What knowledge and skills did faculty identify? What connections did they make to their classes?
Reflection section: What improvements would you make?	An opportunity to reflect upon their experiences and to identify areas where they could improve on the build process or build workflow at their school.	Were there any common areas for improvement that we as PD facilitators needed to know about?
Take-aways: What were the biggest take-aways from the Institute?	An opportunity for faculty to reflect on their experiences with an integrated STEM Institute and how they could apply what they learned to their classes.	What did faculty learn from the Institute and how are they going to incorporate the guitar build into their programs?

To better assess the STEM Guitar Institute's impact on teachers and their students after they implemented the program in their classes, we asked past participants to complete a retrospective survey. Participants who completed the survey received a $50 gift certificate to the STEM Guitar Storefront. We received 176 responses to the survey (response rate of 15%). However, because the ePortfolios were only adopted during the current grant, a limited number of participants (n = 34) responding to the survey had completed the ePortfolio. The data for this study included these survey responses, data from past participants' ePortfolios (n = 45), and focus group comments related to the ePortfolios from spring 2022 (n = 43).

Data Analysis

Participants' ePortfolio responses were copied and pasted into a spreadsheet, then loaded into a computer-assisted qualitative data analysis (CAQDAS) software package for analysis. This analysis of the qualitative data from the ePortfolios was iteratively coded resulting in emergent themes (as in Saldaña, 2016). The frequency of these themes was recorded and then reported in numerical form and as a percent. Second, STEM Guitar Institute alumni were asked in the Retrospective Survey (deployed March 2020) about how they used their ePortfolios after the PD was over. Descriptive statistics were used to analyze the quantitative data collected via the Retrospective Survey. Finally, key quotes from participants in the March 2022 focus groups were included as supporting data.

Results

Completion rates for ePortfolios varied from 50% to 82% across various PD institutes, with an average completion rate of 62%. The ePortfolio was an optional task; faculty members who completed an ePortfolio along with an implementation plan were eligible to receive an additional participant support package, which included luthier-specific tools and supplies.

Forty-five participants submitted ePortfolios. As participants may have mentioned a build process more than once during the 10 required entries, the frequency may be greater than 45. As might be expected, participants chose to document more photogenic processes in their ePortfolios. Such examples include finishing/painting (48 instances), headstock design and cutting the headstock (32 instances), hardware installation (35 instances), sanding/body sculpting (30 instances), install and dress frets (17 instances), and additional customizations (17 instances).

Other popular photos included those where the guitar was finally taking shape, such as when the neck got attached to the body (14 instances) and general build/assembly (13 instances). Participants also tended to document processes that are typically challenging such as soldering and installing electrical components (30 instances), intonating the guitar (34 instances), and stringing the guitar (12 instances). Teachers also included photos of the Modular Learning Activities they worked on throughout the PD (12 instances). Many participants (80%) noted connections they could make with their courses (36 instances).

Building a guitar in a week is ambitious. As classroom activities take up a considerable amount of the workshop, that further adds to the time constraints. As such, the grant team wanted to use the ePortfolios to encourage participants to take a few minutes to document the build processes and reflect upon how they might improve these processes in the future. The 10 photo captions from the ePortfolios often included detailed descriptions of build processes (205 instances), the tools needed to complete the build process (100 instances), and supplies (113 instances).

Nearly half of the ePortfolios (n = 21, 46%) were detailed enough that participants could revisit them later and be reminded of how to complete the build process. Some teachers uploaded videos of the process (optional), and others provided step-by-step photos of the process. Only a few entries provided just a general description of the build process (n = 9, 20%) where participants talked about the steps they completed but did not provide enough information for someone to be reminded of the entire process.

One component of the STEM Guitar Workshops was to encourage teachers to emphasize hard and soft skills in their instruction. Thus, we provided teachers with an opportunity to document the skills needed to complete a build process in their ePortfolios. Teachers noted hard skills, such as soldering the electronics, using hand and power tools, cutting out the headstock, and installing and dressing the frets (97 instances), and soft skills, such as patience, creativity, attention to detail, and perseverance (66 instances). For example, a participant commented,

One skill that was integral to completing this task was learning how to use a soldering iron. I had never soldered before, so this was a new experience for me. Another skill that was integral to completing this task was having a basic understanding of how electronics work. I enjoyed learning about the different types of wires and why they need to be grounded. It would be interesting to expand on this topic more, especially for students who may become electricians.

Another participant highlighted the need for soft skills when intonating the guitar, “This is a feeler gauge that I used for intonating my guitar. The skills necessary for this task were really patience, accuracy, and precision.” Teachers were also encouraged to reflect upon the build process as well as note any ways they would improve how they completed a task.

Throughout the 10 photo entries, there were 105 instances of general reflection and 172 instances where teachers indicated suggestions for improvement. Finally, only 3% of the ePortfolio entries provided only a caption for their photo. This result indicates that most teachers were invested in documenting and reflecting on the guitar build process.

The ePortfolios also offered a glimpse at how teachers transferred prior knowledge to their guitar building experiences (n = 14, 31%) as well as how teachers planned to transfer their new knowledge to their courses (n = 36, 80%) and for personal applications such as hobbies and household tasks (n = 16, 36%). In a traditional workshop setting, PD leaders may have such conversations with participants throughout the guitar build, but it is nice to have them recorded in ePortfolios.

Analysis of Reflection Piece

Teachers were also asked to reflect further upon their experiences at the STEM Guitar Institute and describe three takeaways from the Institute. The following themes emerged. Participants noticed the importance of trying and learning new things (n = 16, 35.6%). Participants also remarked at how it was possible for their students to complete the STEM Guitar build successfully (n = 16, 35.6%).

Participants highlighted STEM connections they could make to their discipline (*n* = 12; 26.7%) and noted that the guitar project would be an engaging vehicle to teach integrated STEM concepts to their students (*n* = 11, 24.44%). Additionally, teachers appreciated the opportunity to be a student and reflected upon student-centered teaching practices (*n* = 9; 20%).

For participants in the 2020 workshops that were hosted virtually due to the COVID-19 pandemic, teachers also appreciated the opportunity to have high-quality project-based learning and integrated STEM instruction modeled in a virtual setting (*n* = 9; 20%).

Finally, teachers reported an increased confidence with build processes and the guitar project (*n* = 7, 15.6%), they discovered a passion for building guitars (*n* = 7, 15.6%), and they noted how practice was essential to progressing from a novice to expert for guitar build processes (*n* = 7, 15.6%). These themes are summarized and an exemplar quote is provided for each theme in Table 6.

Throughout the ePortfolios, key themes of perseverance (23 instances) and overcoming obstacles (16 instances) were noted. Participants spoke of increasing their confidence as well as having a sense of pride in their work.

Using ePortfolios After the Institute

To determine whether the ePortfolios were used by the teachers after the STEM Guitar institutes, we asked alumni about their use in the Retrospective Survey. Participants reported using their ePortfolios in a variety of ways. Thirty-four participants responding to the survey had created an ePortfolio. Over two thirds (*n* = 23; 67.65%) reported referring to their ePortfolio to remind themselves of how to complete a build process during the school year. Over half (*n* = 20; 58.82%) reported showing their ePortfolio to other teachers and/or administrators. Similarly, over half (*n* = 19, 55.88%) reported showing their ePortfolios to their students. Additionally, over one fourth of the teachers (*n* = 9; 26.74%) reported using ePortfolios as an assessment tool or culminating event in their classes. Finally, six teachers (17.65%) reported using ePortfolios in other ways.

Focus Groups

STEM Guitar Institute alumni had an opportunity to reflect further on their guitar-building experience at one of three optional focus groups held in March 2022. Participants received two signature guitar kits as compensation for participating in a 90-minute focus group. Forty-three alumni participated in the focus groups. One participant noted,

> I still have my portofolio up because I liked it so much. I also built mine in WordPress and YouTube videos. If I was to teach older students or adults, I would have them do the same.

Table 6
Emergent Themes from Reflections in STEM Guitar Participants' ePortfolios

Emergent Theme	Frequency (*n* = 45)	Exemplar Quote
Importance of learning and trying new things	16 (35.6%)	"…new skills can be learned with the combination of desire to learn and not being afraid to try no matter the competency level."
Building a guitar is possible for students	16 (35.6%)	"Students can do this. The materials provided make clear that students of all ages, cultural backgrounds, and abilities can engage with this content in meaningful ways. I can help them do this."
STEM Connections to their discipline	12 (26.7%)	"The cross-curricular and networking possibilities are HUGE. I love how you can tie it to whatever you are teaching. I will MOST DEFINITELY be showing off my guitar to my Chemistry students and they will swirl dip popsicle sticks in class. I will also be implementing the MLA's into my STEM class and it is such a great way to hook some students that might not be interested in physics or electronics."
The guitar is an engaging vehicle to teach integrated STEM	11 (22.44%)	"The STEM Guitar project can be used in any subject area with success in covering that course's standards. It can even be utilized in Arts related classes (e.g., I guess it could be considered STEAM Guitar). The variety of MLA's that are inclusive for use with these kits is phenomenal."
Teachers appreciated opportunity to be a student and see student-centered instruction modeled	9 (20%)	"In looking back at what I take away from this class doesn't seem like much for an adult, but I think it is going to take me far and make me a better teacher. I can take these skills and transfer them to what I do in the classroom."
Saw quality, problem and project-based, online instruction modeled (those participating in online workshops)	9 (20%)	"Clearly having you model this online was perfect for me. The future is still not clear as to what degree we will be meeting with the students this year due to Covid concerns. Having your team teach this content to me online has paved the way for me to do the same this year." "Problem-based learning-I love the idea of problem-based learning and use it in my classroom on a regular basis but only for small problems. I have always been afraid that no problem could encompass all that my physics or engineering students need to know. This guitar and the MLAs associated with it show me that I could cover all of the topics from the second semester of my physics class with one project and add some engineering topics and skills as well. That is truly a powerful thought."
Increased confidence in build processes	7 (15.6%)	"This entire project oozes self-betterment and confidence. It's an amazing thing to feel, but to also to share with students. They liked to see that a social studies teacher was also tackling this project, and it provides a great sense of connection."
New passion for building guitars	7 (15.6%)	"I'm also finding I'm really excited to try to build other guitars I've wanted to own."
Practice is essential to progress from novice to expert	7 (15.6%)	"Perfection comes with practice."

Another participant noted, “I like the e-portfolio, I still use it to remember the steps and process. Finally, another participant reflected,

> ...but the use of Google sites for the portfolio has totally changed how I teach. I have to do a series of music classes like music of the decades, and I make my students put together a virtual mix tape, and they have to embed a video and lyrics and dedication and right, and all because of how you guys did the portfolio....[It’s] one of the easiest things for me to teach, and it’s easy for kids to do, and it’s easy to grade.

These participant quotes exemplify how important it is for teachers to have a space to learn new technologies and pedagogical techniques, reflect upon their experiences, and make those interdisciplinary connections.

When asked about whether participants would prefer to write a lesson plan or do an ePortfolio, the responses were clear. A couple of focus group participants noted that formal lesson plans were not expected at their school, and they did not want to be writing lesson plans during their summer vacation. Another participant noted that at early PDs during the first grant the lesson plan activity felt disconnected with the rest of the PD and, “really took me out of the moment, and so I'm now just hearing about this portfolio thing which sounds amazing!”

Conclusion

Pros and Cons of Using ePortfolios

Using ePortfolios can be an effective tool to capture teachers’ thoughts, document progress, and provide teachers with an opportunity to reflect upon their experiences. During the COVID-19 pandemic, the grant team rapidly (< 60 days) switched the face-to-face workshops to online delivery. Participants were sent the guitar kits as well as some luthier-specific tools needed to complete the kit. Because of this virtual environment, the grant team could not see participants’ progress through the guitar build.

The ePortfolios served as a window into our participants’ experiences throughout the workshop and provided validation that participants were completing tasks and building their guitars. In one instance, a participant put his workshop experience into context by describing the protests that were taking place in his city during the institute. While the institute leaders engaged in many conversations with participating faculty members through virtual methods (e.g., email, discussion forums, Zoom meetings, etc.), this was an additional opportunity to connect with participants as well as to learn how participants viewed their institute experience, identify curricular connections, and learn what were the participants’ key take-aways from the institute.

When selecting an ePortfolio platform, a variety of factors, such as ease and accessibility of a platform, must be taken into consideration. As we did not want the ePortfolio to be teachers’ primary focus or a distraction from the workshop, their access and familiarity with the platform must be considered. Google Sites was chosen, as it is freely available and has many support videos for how to create an ePortfolio within Google Sites.

While a few teachers at each workshop had questions about how to create an ePortfolio, most teachers navigated this process seamlessly. The biggest hurdle our team faced was gaining access to the teachers' ePortfolios through the Google platform, as many forgot to change the appropriate share settings in Google. A few teachers were uncomfortable with using Google Sites and submitted their ePortfolio using Google Docs or Google Slides. In a few instances, teachers used another platform more familiar to them. For our purposes, the practice of creating an ePortfolio was the primary goal rather than having teachers gain experience with a particular ePortfolio platform.

Analyzing ePortfolio content is another consideration. Having set criteria for participants to follow is helpful for both participants and PD providers. If there are specific objectives in mind, it may also be helpful to develop a rubric to assess the portfolios. PD providers may want to share the rubric with the participants, depending on the goals. In this instance, we provided teachers with ePortfolio requirements, but did not have strict requirements or rubrics. Analyzing such a wealth of information may be time-consuming, but it does allow PD providers to gain rich insight into their participants' experiences.

Discussion

The results of this study have implications for STEM education PD providers who are interested in using alternative assessments such as ePortfolios. They are an effective tool to evaluate teachers' knowledge and skills as well as to provide an opportunity for teachers to reflect upon their experiences during the PD.

Additionally, ePortfolios provide a platform for teachers to capture and annotate their work for future reference, in addition to allowing teachers to share their work with a broader audience. Here, the ePortfolios were also used as a model for teachers to consider incorporating in their classes, which many did. Thus, they are useful for teachers beyond the PD opportunity. As such, using ePortfolios as a PD deliverable provided value to both the PD providers and the participating teachers, particularly in the field of integrated STEM education.

The ePortfolio also enabled teachers to share their experiences with PD leaders, other teachers, and their administration and students. It not only served as a self-reflection process through which teacher participants were able to develop knowledge through an active, constructivist learning process, but it also provided a how-to guide for teachers to refer to when implementing the STEM Guitar build in their own classrooms.

Through the development, ePortfolios provided teachers with an opportunity to reflect upon the build processes, skills teachers learned or honed, and identify other opportunities to use the skills in other courses. By having teachers complete this process, it also modeled how they might use ePortfolios as a summative assessment in their classrooms.

The following participant quote summarizes these findings,

> I have several thoughts about how I will implement this project in my class. My students will be required to complete an e-portfolio of their project. I really like how it is causing me to slow down and contemplate the project as a whole.

The results of this research and corresponding literature provide compelling rationale to leverage ePortfolios for teacher PD. The self-reflective process of developing the ePortfolio content, as well as the resulting artifact of the ePortfolio itself, adds considerable value to the professional development process and aids in the construction and reinforcement of teachers' knowledge base.

References

Alismail, H. A., & McGuire, P. (2015). 21st century standards and curriculum: Current research and practice. *Journal of Education and Practice, 6*(6), 150-154.

Beetham, H. (2005). *E-portfolios in post-16 learning in the UK: Developments, issues and opportunities*. http://www.jisc.ac.uk/media/documents/themes/elearning/eportfolioped.pdf

Blocher, J. M., Echols, J., de Monies, L. S., Willis, E., & Tucker, G. (2003). Shifting from instruction to construction: A personal meaningful experience. *Action in Teacher Education*, *24*(4), 74-78.

Buhagiar, M. A. (2007). Classroom assessment within that alternative assessment paradigm: Revisiting the territory. *The Curriculum Journal 18,* 39-56.

Cercone, K. (2008). Characteristics of adult learners with implications for online learning design. *Association for the Advancement of Computing in Education (AACE) Review*, *16*(2), 137-159.

Chye, S. Y., Liau, A. K., & Liu, W. C. (2013). Student teachers' motivation and perceptions of e-portfolio in the context of problem-based learning. *The Asia-Pacific Education Researcher*, *22*(4), 367-375.

Cunningham, C. M., & Carlsen, W. S. (2014). Precollege engineering education. In N. G. Lederman & S. K. Abel (Eds.), *Handbook of research on science education* (Vol. 2; pp. 747-758). Routledge.

Czerniak, C. M., & Johnson, C. C. (2014). Interdisciplinary science teaching. In N. G. Lederman & S. K. Abel (Eds.), *Handbook of research on science education* (Vol. 2; pp. 395-411). Routledge.

Das, S. (2021). Preparing e-portfolio as an element of online training by clinical chemistry residents in the COVID-19 era. *Biochemistry and Molecular Biology Education*, *49*(3), 316.

Drago-Severson, E. (2009). *Leading adult learning: Supporting adult development in our schools*. Corwin Press.

Drew, S. V. (2013). Open up the ceiling on the common core state standards: Preparing students for 21st-century literacy—now. *Journal of Adolescent and Adult Literacy, 56*(4), 321-330.

DuFour, R., DuFour, R. B., Eaker, R. E., Many, T. W., & Mattos, M. W. (2016). *Learning by doing: A handbook for professional learning communities at work* (3rd ed.). Solution Tree.

Farrell, O., Buckley, K., Donaldson, L., & Farrelly, T. (2021). Goodbye exams, hello eportfolio. *Irish Journal of Technology Enhanced Learning*, *6*(1), 1-6.

Granberg, C. (2010). E-portfolios in teacher education 2002–2009: The social construction of discourse, design and dissemination. *European Journal of Teacher Education*, *33*(3), 309-322.

Guàrdia, L., Maina, M., Clougher, D., & Mancini, F. (2021). Opportunities and challenges for teaching and learning innovation in a global pandemic: The case of the EPICA ePortfolio solution. *Proceedings of the International Conferences on Mobile Learning and Educational Technologies, virtual conference* (pp. 245–249). International Association for the Development of the Information Society.

Guskey, T. R. (2000). *Evaluating professional development*. Corwin.

Hauze, S., French, D., Castañeda-Emenaker, I., French, M., & Singer, T. (2017, March). Quantifying K-12 and college student learning outcomes of STEM guitar building. In *2017 IEEE Integrated STEM Education Conference (ISEC)* (pp. 121-126). Institute of Electrical and Electronics Engineers. https://doi.org/10.1109/ISECon.2017.7910226

Houseal, A. (2015). A visual representation of three-dimensional learning: A tool for evaluating curriculum. *Science Scope, 39*(1), 58-62.

Hsu, C. (2020). E-portfolio as a final assessment for a graduate online course in pandemic. *American Journal of Humanities and Social Sciences Research, 4*(12), 99-104.

Johnsen, H. L. (2012). Making learning visible with ePortfolios: Coupling the right pedagogy with the right technology. *International Journal of ePortfolio, 2*, 139–148.

Knowles, M. S. (1978). Andragogy: Adult learning theory in perspective. *Community College Review*, 5(3), 9-20.

Kokotsaki, D., Menzies, V., & Wiggins, A. (2016). Project-based learning: A review of the literature. *Improving Schools, 19*(3), 267-277.

Koehler, M., & Mishra, P. (2009). What is technological pedagogical content knowledge (TPACK)? *Contemporary Issues in Technology and Teacher Education, 9*(1), 60-70. https://citejournal.org/volume-9/issue-1-09/general/what-is-technological-pedagogicalcontent-knowledge

Koro-Ljungberg, M., Yendol-Hoppey, D., Smith, J. J., & Hayes, S. B. (2009). (E)pistemological awareness, instantiation of methods, and uninformed methodological ambiguity in qualitative research projects. *Educational Researcher, 38*(9), 687-699.

Körkkö, M., Kyrö-Ämmälä, O., & Turunen, T. (2016). Professional development through reflection in teacher education. *Teaching and Teacher Education, 55,* 198-206.

Loucks-Horsley, S., Stiles, K. E., Mundry, S., Love, N., & Hewson, P. W. (2010). *Designing professional development for teachers of science and mathematics*. Corwin.

Luft, J. A., & Hewson, P. W. (2014). Research on teacher professional development programs in science. In N. G. Lederman & S. K. Abell (Eds.), *Handbook of research on science education* (Vol. 2; pp. 889-909). Routledge.

Maher, M., & Gerbic, P. (2009). E-portfolios as a pedagogical device in primary teacher education: The AUT University experience. *Australian Journal of Teacher Education*, *34*(5), 4.

Malicky, D. M., Kohl, J. G., & Huang, M. Z. (2010). Integrating a machine shop class into the mechanical engineering curriculum: Experiential and inductive learning. I*nternational Journal of Mechanical Engineering Education, 38*(2), 135-146.

Misdi, M. (2020). E-portfolio as an authentic learning assessment in a response to COVID-19 outbreak in Indonesian higher education: Toward critical student-writers. *Research and Innovation in Language Learning*, *3*(2), 158-162.

National Research Council. (2012). *A framework for K-12 science education: Practices, crosscutting concepts, and core ideas*. National Academies Press.

NGSS Lead States. (2013). *Next generation science standards: For states, by states*. The National Academies Press.

Picardo, K., & Sabourin, K. (2018). Measuring student learning gains in independent research experiences in the sciences through reflective practice and eportfolios. *Bioscene: Journal of College Biology Teaching*, *44*(2), 29-36.

Saldaña, J. 2016. *The coding manual for qualitative researchers*. Sage.

Scherz, Z., Bialer, L., & Eylon, B. S. (2008). Learning about teachers' accomplishment in 'Learning Skills for Science' practice: The use of portfolios in an evidence-based continuous professional development programme. *International Journal of Science Education*, *30*(5), 643-667.

Williams, M., & Houseal, A. (2018). Composting: A problem, place, or project? Using the PBL trifecta (PBL^3) in the classroom. *Science Scope, 41*(6), 36-44.

Ziegler, B., & Montplaisir, L. (2012). Measuring student understanding in a portfolio-based course. *Journal of College Science Teaching*, *42*(1), 16-25.