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A Musical Perspective on STEM: Evaluating the EcoSonic Playground Project from a Co-equal STEAM Integration Standpoint

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Abstract

Research on teaching and learning in integrated education has focused on connections between arts and non-arts domains to provide a comprehensive experience for K-12 learners. Recently, STEAM (Science, Technology, Engineering, Arts, Mathematics) education has explored arts integration for more effective STEM learning. However, effective integration is often elusive; the arts are sometimes diluted as a consequence of well-intentioned integration within STEM subjects, with STEM learning risking similar superficial treatment within arts curricula. This qualitative pilot study focuses on The EcoSonic Playground Project (ESPP) – an integrated STEAM project for students of all ages – and evaluates its effectiveness from a co-equal integration standpoint, where participants use skills across STEM and arts areas equally in service of a common, musical goal. Findings suggested that this project supported, the application of existing cognitive and social-emotional skills and STEAM practices within an arts framework while fostering in participants the synthesis of new connections among skill areas. While recognizing findings are context specific, conclusions and recommendations may be of particular interest to educators and researchers exploring STEAM or other arts integration initiatives in the classroom.

Introduction

Integrated or cross-curricular learning has been a key principle of curriculum design, underpinning diverse educational philosophies for many years, dating back to Plato, Comenius and Rousseau (Barnes, 2011; Kerry, 2015; Pritchard, 2009; Rowley & Cooper, 2009). Integration occurs whenever students and their teachers apply skills in more than one subject or discipline to a complex experience, problem, question or theme (Fogarty, 1991). Integrated learning transcends traditional subject divides and is viewed as being more effective in terms of breadth and depth of learning, transfer of skills and knowledge retention (Land, 2013; Lipson, Valencia, Wixson & Peters 1993).

STEAM education is a recent manifestation of cross-curricular learning, integrating STEM subjects with the arts domains (e.g., DeSimone, 2014; Ghanbari, 2015; Land, 2013; Sousa & Palecki, 2013, Greher & Heines, 2014, etc.). STEAM proponents contend that thinking through an arts perspective could enhance scientific problem solving, organization of ideas, cross-disciplinary innovation, and creativity in the hard sciences (Catterall, 2013). However, effective integration is often elusive; the arts are sometimes diluted as a consequence of well-intentioned integration within STEM subjects, with STEM learning risking a similar superficial treatment within arts curricula (Davies, 2008; Mishook & Kornhaber, 2006 cited in Brown, Doherty & McLaughlin, 2007; Eisner, 2002; Wiggins, 2001). Educators must consider these potential problems when structuring integrated curricula to maintain effective learning in both STEM and arts domains.

This mixed-method case study examines The EcoSonic Playground Project (ESPP): a creative and cross-disciplinary project that asks students of all ages to design and build musical instruments from recycled materials. This study evaluates the ESPP's effectiveness in encouraging participants to draw on their prior experience, as well as apply and further develop STEAM, cognitive, and social-emotional skills. While we discuss the results in the context of the ESPP, a music-centered project, they should be of general interest to educators exploring STEAM or other arts integration initiatives in the classroom.

Project Overview

The EcoSonic Playground Project was developed at University of Massachusetts Lowell (UML) in 2016, with the aim of advancing connections between the arts and STEM subjects. The ESPP asks students of all ages to build PVC structures as scaffolding frameworks with the aid of architectural plans. Next, student-designed instruments made of recycled materials are attached to these structures in various ways. Each structure then becomes a multi-player "sound sculpture" requiring two or more people to create music. While there have been other initiatives that engage students to design and build musical instruments using recycled materials, a unique feature of this project is an accompanying STEAM curriculum that guides the making process while allowing students to practice skills across cognitive, social-emotional, and STEAM domains.

Since the Common Core Standards in the United States apply only to K-12 education and pertain only to English language arts and mathematics (NGACBP, 2010), we relied on standards suggested in The National Research Council's *A Framework for K-12 Science Education* (NRC, 2012) to provide an objective benchmark when developing our own STEAM curriculum. We also aligned our curriculum with UML's seven Essential Learning Outcomes (ELO's) that underlie the undergraduate core curriculum in all areas of study (University of Massachusetts Lowell, 2018). Future iterations of the ESPP will provide differentiated and developmentally appropriate "curriculum editions" aligned with the grade bands used by the NRC: grades K-2, 3-5, 6-8, and 9-12 (NRC, 2012, pp. 33-34). Lesson plans in these editions will reinforce STEAM practices typically learned at those grade levels.

To show the adaptability of the ESPP curriculum and to test its effectiveness across grade levels including potential effectiveness at a post-secondary level, we planned a series of pilot programs to cover a wide age range. The initial pilot iteration of the ESPP occurred at the university level where undergraduate students and faculty comprised the first working and playing groups. These groups completed the four main aspects of the program to ensure its viability: We collected and experimented with reusable materials, worked out structural and instrument designs, built two large-scale structures, and then presented those structures to students in the university music department to play. Two overarching questions arose out of this beginning phase: what would happen when we worked through EcoSonic Playground Project with our students, and how might the EcoSonic Playground promote effective integration of STEAM practices, cognitive and social-emotional skills at the university level? We examine this pilot study from a *co-equal* arts and STEM integration perspective (discussed further in the next section) at the undergraduate level.

Conceptual Frameworks: Integrated, Immersive, and Experiential Learning

Integrated learning approaches have become synonymous with learner-centered education (Barnes, 2011; Kerry, 2015; Rowley & Cooper, 2009). Ongoing neuro-scientific research further supports the effectiveness of connectivity in cross-disciplinary learning and teaching (Barnes, 2011; Pritchard, 2009; Sousa & Pilecki, 2013; Caine & Caine, 1991). This in turn has informed our conception of The EcoSonic Playground Project, which is adaptable to diverse learning contexts and allows the opportunity to create an informal, intensive and immersive learning environment (Eshach, 2007; Folkestad, 2006; Jaffurs, 2006).

Types and taxonomies of arts integration

While some researchers have classified types and taxonomies of integration from a multidisciplinary and interdisciplinary perspective (Barnes, 2011; Fogarty, 1991), Bresler (1995) posits four common types of arts integration: subservient, affective, social and co-equal integration. In *subservient* arts integration, the arts are mostly employed to provide curriculum content, pedagogy or structure. The arts are, in effect, subsumed by the other curriculum area(s). While arts communities are critical of this type of arts integration, this form is frequently enacted in schools (Barnes, 2015; Davies, 2008; Efland 2002 & Goldberg, 2017). While appreciating that particular themes and topics will tend to be more relevant to a particular subject area, research indicates that the arts rarely tend to feature as the major subject area (Burnaford et al, 2007; Davies 2015 & Efland, 2002). In other words, the arts tend to bookend rather than drive integrated learning.

In *affective* arts integration, the potential of the arts to impact on the affective domain of learning in terms of evoking feelings, self-expression and creativity is acknowledged and put to use in the curriculum. In *social* arts integration, the potentiality of the arts in terms of fostering communication and relationships within and between communities is encouraged. In *co-equal* integration, both the art and non-art domains contribute equally to learning. This non-hierarchical type of cross-curricular arrangement ensures the arts are not serving solely as a teaching methodology. Instead, all related planning, delivery, resourcing, assessment and evaluation address learning outcomes in the arts as much as in the other subjects entailed.

Other studies have outlined integration types from a quality arts provision perspective. This perspective refocuses integration taxonomy with the arts as the primary curricular concern. For example, Eisner (2002) presents the following four approaches to arts and STEM integration: 1. the arts are used to help students with a particular topic in another subject area; 2. arts specific integration is used to explore the similarities and differences between the various arts modes; 3. learning is oriented around a theme; or 4. learning is oriented around problem solving. Eisner's view of integration is that arts practices stimulate the imagination of the learner, a necessary ingredient for innovation in STEM areas (Eisner, 2003).

Benefits of integration to effective learning

There is a growing body of literature focused on music specifically as the "A" in STEAM (DeSimone, 2014; Salgian, Nakra, Ault, & Wang, 2013). The elevation of music to a stand-alone subject in the U.S. national standards' definition of a "well-rounded education" (Education, 2015, p. 807) highlights the necessity of a rigorous education in both music and STEM subjects.

Research shows that learning from an arts-centric STEAM perspective encourages students to draw on curiosity, observe accurately, perceive objects in another form, construct meanings, express observations, work with others, think spatially, and perceive kinesthetically (Sousa & Pilecki, 2013). Students may also question the notion of the lone artist, reflect upon the tension between product and process, and interrogate disciplinary-based understandings of creative thinking (Guyotte, Sochacka, Costantino, Kellam & Walther, 2015).

At the undergraduate level, balanced STEAM education teaches flexible, student-centered learning strategies not commonly associated with the hard sciences (Connor et al., 2015). Some studies have also explored strategies for teaching creativity in engineering courses to stimulate more innovative design thinking among undergraduates (Stouffer et al., 2004; Peters, 1998).

Merits of arts integration and inclusive practice

Connections between arts and non-arts domains have been explored with the aim of attaining a more comprehensive and appealing learning experience for all learners (DeMoss, 2005; DeMoss & Morris, 2012). An integrated approach reaches diverse learners of all ages and developmental levels (Burnaford, Brown, Doherty & McLaughlin, 2007; Fiske, 1999; Goldberg, 2017). Integrating the arts with experience-based approaches is an alternative to more conventional mainstream education methodologies, which have often failed to meet the developmental needs of diverse learners (Goldberg, 2017; Kerry, 2015; Loughlin & Anderson, 2015).

Arts-based approaches within special educational settings have been perceived by in service professionals as being more effective in developing their students' cognitive, social-emotional, physical-motor and linguistic abilities. Integrating the arts challenges students with disabilities and is believed to engage them in higher-order thinking, to support relationships within the classroom and to empower them to reach their potentiality while coping with their disability (Berry & Loughlin, 2015; Durham, 2010; Goldberg, 2017; Mason & Steedly 2004; NCCA, 2002; Winner, Goldstein & Vincent Lancrin, 2013). Anderson, Loughlin and Berry (2013) note how arts integration supports higher-order questioning and responding from students both with and without language difficulties.

Challenges of arts integration

Notwithstanding the benefits of integrated learning, there are recurrent concerns and frustrations regarding how the arts fare as a consequence of integration. The inherent integrative nature of art makes it vulnerable to exploitation in a curricular context, as stated earlier (Mishook & Kornhaber, 2006 cited in Brown, Doherty & McLaughlin, 2007). The arts may be subsumed or diluted into simply a secondary stream for learning non-arts skills, and therefore made to seem non-essential (Davis, 2008; Eisner, 2002). Dilution of the arts through integrated learning results in little subject-specific development regarding skills, concepts or subject-specific vocabulary. Subservient integration remains all too prevalent in schools, which means that teachers need to be mindful of arts integration from a quality arts education perspective (Wiggins, 2001).

Consequently, it is beneficial for those involved in curricular planning to ensure that they are conscious of the type of integration being employed and ensure from an arts advocacy perspective that the arts have a turn at leading rather than book-ending integrated learning. Research into STEAM integration shows varying levels of effectiveness in supporting education and skills for students throughout the learning process (e.g., Atkinson & Mayo, 2010; Bresler, 2011; S.-A. Brown, 2015; DeSimone, 2014; Ghanbari, 2015; Maguire et al., 2013; Peppler, 2013; Tookey, 1975, etc.). For example, studies have evaluated teachers' experience using music to teach extra-musical skills in general classroom settings (E. D. Brown, Benedett, & Armistead, 2010; King, 2015; de Vries, 2015). Other studies focus on music teachers bringing non-musical subjects into the music curriculum (e.g., cultural or social studies viewed through a musical lens) (Munroe, 2015). Both of these teaching approaches view the arts as separate or adding onto the core curriculum. However, the ESPP curriculum is situated in a *co-equal integration* framework.

Curricular connections between music, visual arts and science

The design and building activities of the ESPP draws primarily from three STEAM subject areas. These include physics and acoustics (experimenting with materials for sound quality; designing pitched and stringed instruments; designing multi-part instruments based on simple machines), architecture and design (following structural plans for instrument scaffolding; drawing design concepts prior to building instruments; creating plans from these designs; designing the completed structures once the scaffolding and instruments have been built), and mechanical and materials engineering (creating whole instruments out of several pieces of material; creating instruments that work as intended; experimenting with various materials to create new uses for them).

The curriculum is structured around methods researched in previous studies on integrated STEM curricula (Becker & Park, 2011; Bryan, Moore, Johnson, & Roehrig, 2015; Childress & Sanders, 2007; Sanders, 2009); music and visual art are added such that STEAM practices are applied to the objective of building and playing musical instruments. To help ensure that the project approaches the ideal of co-equal integration, we gathered a cross-disciplinary project team consisting of university faculty, staff, and undergraduate students, who worked with us through project development and implementation. This group of 14 people consisted of faculty from the music education, composition, materials and mechanical engineering, and sociology departments; staff from the university's Office of Sustainability; and students from the music education, engineering, and visual art programs.

Integrated STEAM Curriculum

Our team designed the ESPP curriculum around the core science and mathematics skills that students would typically learn at the undergraduate level. From 2009 to 2012, the National Governors Association Center for Best Practices (NGA Center) and the Council of Chief State School Officers (CCSSO) developed and refined the Common Core State Standards in the U.S. These standards outline essential learning goals in the areas of English language, arts (ELA) and mathematics; science and technical subjects are integrated into the ELA standards and focus on broad benchmarks in scientific literacy, such as technical text comprehension and quantitative thinking.

Since we did not have a model for more specific science standards in the U.S., or any common curriculum standards in postsecondary education, we referenced the National Research Council's *A Framework For K-12 Science Education* (NRC, 2012), which advocates a new approach to teaching STEM subjects in order to better prepare graduates in the U.S. for a technology-centered global workforce. The NRC identified eight essential STEM practices necessary for scientific inquiry and engineering design. These practices, while situated within a K-12 framework, are generalized enough to provide curricular guidance at the postsecondary level as well. (See Figure 1)

The ESPP curriculum is designed to reinforce developmentally appropriate learning benchmarks in STEM areas as indicated in the *Framework.* The designing/building learning activities of the curriculum follow a project timeline from experimenting with and choosing resonant recycled materials, through drawing plans for possible instruments, exploring the feasibility of different instrument models through trial and error, and finally building the working instruments. The activities are structured to use each of the NRC's eight STEM practices at various points in the timeline, as well as to allow students to use and develop seven cognitive "tools" needed for creative thinking across multiple subject domains (Mishra, Koehler & Henriksen, 2011). These cognitive tools are part of a body of research into transformative and cross-disciplinary learning, which emphasizes critical thinking, creative problem solving, and adaptability to better serve students in a rapidly changing technological world (Kozma, 2009; Mezirow, et al., 2000; Plucker & Zabelina, 2009; Root-Bernstein & Root-Bernstein, 1999). We also wanted to explore to what degree the curriculum encouraged the use or manifestation of ten social-emotional "skills" reported as resulting from engagement with music in the classroom (Hallam, 2010). It should be noted that some of these are actual skills that may be developed (such as creativity and discipline), while others are positive social-emotional effects arising from a nurturing setting (such as a sense of accomplishment or belonging). (See Figure 1)

STEAM Practices (NRC, 2012, p. 3)	*Cognitive Skills* (Mishra, Koehler & Henriksen, 2011, p. 24)	*Social-Emotional Skills* (Hallam, 2010, p. 279)
• **Asking** questions (for science) and defining problems (for engineering) • Developing and using models (**Developing Models**) • **Planning** and carrying out investigations • **Analyzing** and interpreting data • **Using mathematics** and computational thinking • Constructing explanations (for science) and designing solutions (for engineering) (**Explaining**) • Engaging in argument from evidence (**Arguing**) • Obtaining, evaluating, and communicating information (**Researching**)	• **Perceiving** (observing and imagining) • **Patterning** (analyzing existing relationships and creating new relationships) • **Abstracting** (focusing on relevant features, finding analogies between disparate things) • **Embodied thinking** (using kinesthetic thinking and empathizing) • **Modeling** (using dimensional thinking–representation, analogy, constructing from plans) • **Deep Play** (play that is creative, intentional, open-ended, transformative) • **Synthesizing** (combining multiple ways of knowing/thinking, utilizing all cognitive tools, divergent thinking)	• **Accomplishment** • **Belonging** • **Confidence** • **Cooperation** • **Creativity** • **Discipline** • **Engagement** • **Intrinsic Motivation** • **Perseverance** • **Teamwork**

Figure 1. Essential practices (NRC, 2012), cognitive skills (Mishra, et al., 2011), and social-emotional Skills (Hallam, 2010).

To investigate any possible effects of the ESPP on participants' use or development of these practices and skills, we posed the following questions:

1. What would happen when we worked through EcoSonic Playground Project with our students?

2. How might the EcoSonic Playground promote effective integration of STEAM, cognitive, and social-emotional skills at the university level?

Methodology

Participants

A diverse planning group of faculty and staff from multiple specializations in STEM and the arts collaborated to help with program design including faculty and staff from the music, engineering, and sociology departments, and the university Office of Sustainability. Once the initial curriculum was in place, we implemented the ESPP pilot with two groups of participants: A small, interdisciplinary cohort of undergraduates (N=5) that designed and built the instruments and a larger group of students (N=105) who were recruited from the music department to play them. We also collaborated with a faculty member at Marino Institute of Education, Trinity College Dublin, the University of Dublin who ran a parallel pilot program where undergraduates worked with younger students to create an ESPP from a visual arts perspective.[1]

Our working group consisted of undergraduate students from the music education, engineering, and visual art programs. To recruit participants for the working group, the project leader asked her colleagues to recommend students, directly recruited students attending the music education program, and applied through an engineering fellowship program for a student intern. The project leader communicated directly with potential participants through email and then by face-to-face meetings to determine interest level and willingness to commit to the ESPP. Once a working group was established, we agreed to a plan of regularly scheduled design and build meetings.

After the students had produced two working instruments, they presented them to the wider Music Department community to play. We documented three instances of playing with three different groups: first year undergraduates in an Introduction to Music Education Class (N=25); Mixed-year students at a department-wide Recital Hour (N=68); and upper elementary-aged students (N=12) as part of a structured class held at the university. We include aggregated data from the playing groups here to provide a musical corollary to the primary focus on building with the working group, and to studying the effectiveness of the curriculum.

Research procedures

Research focused on determining how participants effectively used combinations of STEAM

[1] Collaborating faculty coauthored this paper.

practices and cognitive and social-emotional skills throughout the four stages of the ESPP program: experimenting, designing, building, and playing the instruments. We have added data on the playing groups to this study because we wanted to see which of the integrated skills the participants used in music making and because making music is the ultimate goal of the ESPP program.

Several types of data were collected: group interviews with participants, researchers' written observations of students working on the project and/or playing the instruments, photographs of the working group developing the instruments, video recordings of the building process and of students' musical play, surveys of participants' experiences with the curriculum (Appendix A), and of the playing group's individual experiences with the ESPP instruments (Appendix B). We obtained IRB approval for all aspects of data collection and all program activities.

Data analysis

Given the complexity of the EcoSonic Playground Project, we determined that a mixed-method approach would be most effective (Bogdan & Biklen, 2007; Denzin & Lincoln, 2005; Fitzpatrick, 2014; Marshall & Rossman, 2006; Schmidt, 2014). For qualitative analysis we used NVivo software, which produced a four-leveled, descriptive coding scheme:

- Level 1: Behavioral codes were taken directly from the interview transcripts of students' self-reporting, their written answers to open-ended survey questions, and researcher observations of their work and playing. The codes consisted of single words that reappeared no less than five times throughout the data. In all, there were 147 behavioral codes assigned to the working group data and 72 behavioral codes assigned to the playing group data. We applied these codes to the videos and photographs for consistency when analyzing for visual corroboration of the participants' words.

- Level 2: We organized the behavioral codes into the eight STEAM Practices (NRC, 2012), seven Cognitive Skills (Mishra, Koehler & Henriksen, 2011), and ten Social-Emotional Skills (Hallam, 2010) associated with the curriculum (see Figure 1).

- Level 3: We used the existing headings for Practices and Skills as STEAM, Cognitive, and Social-Emotional Domains to maintain the organization.

- Level 4: We then identified themes, which emerged from the Level 2 analysis: These capture participant behaviors and skills development across Domains.

Each researcher and a student research assistant used this coding scheme to analyze the data and then analyses were cross-checked to ensure validity.

Quantitative measures were taken through two separate surveys given to the working and playing groups. Participants in the working group answered a ranking question on an emailed survey about the types of skills they used while working throughout the ESPP program (see appendix A). Participants in the playing group were given survey forms to fill out after their sessions with the instruments (see Appendix B). All playing groups were given the same survey regardless of age for consistency of data.

Participants answered multiple choice questions on demographics (e.g., age, major (the younger students did not answer this question), instrument played, etc.) and about their general musical experience (e.g., whether or not they composed music, how much experience they had with improvisation, etc.). They also answered Likert scale questions about their experience playing the ESPP instruments (e.g., how comfortable they were participating, confidence level while participating, etc.) (see Appendix B) and an open ended question, "Is there anything else you would like to tell us about your experience here today?". Data from each group were uploaded into SPSS and were analyzed for descriptive statistics: frequencies, cross tabulations, and Pearson correlation values.

Results

The results are presented separately for the working group and the playing group. Each section contains tables and graphic analyses of the qualitative data coding, examples of the verbatim interviews from each group, and presentation of the quantitative analyses. The working group created two large-scale ESPP instruments that the playing groups used during this study (see Figures 2 & 3).

Figure 2. The “Cube”: 6-foot cube; materials: 4-inch PVC pipe, plastic water barrels, metal cake plate toppers, tin cans, dryer tubes, table tennis paddle, metal auto-harp pieces.

Figure 3. The “Drum Set”: 10 feet long x 3 feet wide x 6 feet high; materials (from right to left): bicycle wheels, chain, large plastic water jugs, metal cake pan, computer tower covers, radiator cover, cake holder top, large metal washers, bird bath, telephone cord, and plastic paint bucket.

Working group

Overview

In descending order, the working group emphasized social-emotional skills, cognitive skills, and STEAM practices (see Figure 4 and Table 1). The students' reporting focused on aspects of the ESPP that supported their sense of working towards a larger objective: namely, helping to implement a project with the potential to reach beyond their small group. They mentioned STEAM practices as an expected part of their working and learning process.

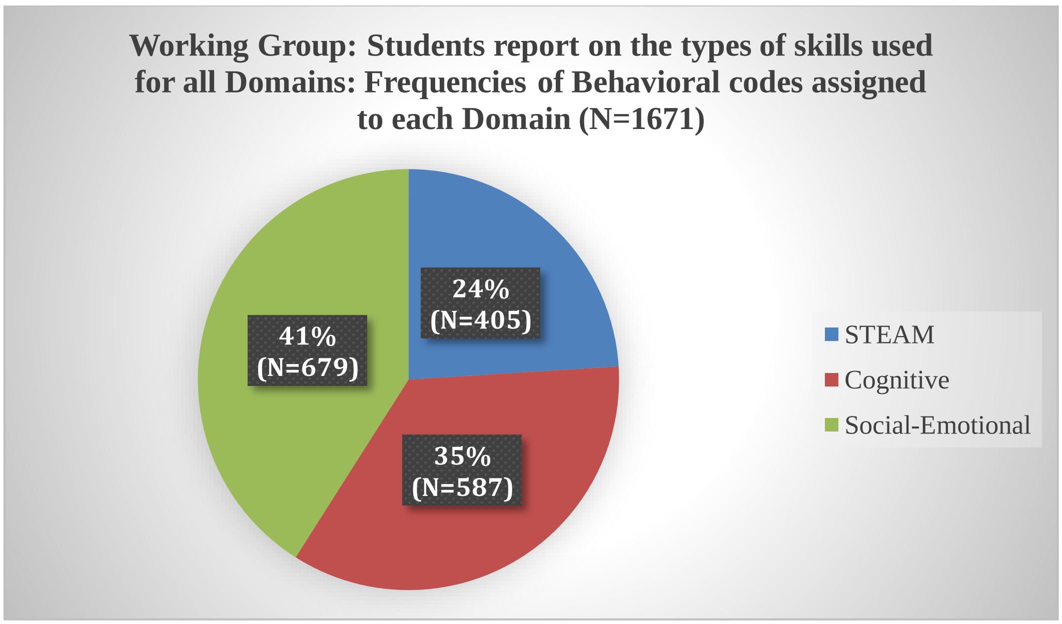

Figure 4. Overview of Working Group frequencies of coded instances within responses. Data comprised interview transcripts, videos of student work, and researcher observational notes.

Table 1:

Working Group: Frequencies of Coded Instances Within Responses for Each Domain.

Participant Group	Domain	N	%	Skills and Practices	N	%
Working	Social-Emotional	679	41	Engagement	235	34
				Creativity	156	22
				Perseverance	84	12
				Cooperation	64	8
				Confidence	54	7
				Teamwork	47	7
				Accomplishment	35	5
				Intrinsic Motivation	20	3
				Belonging	15	2
				Discipline	4	.5
	Cognitive	587	35	Synthesizing	187	32
				Embodied Thinking	121	20
				Patterning	103	18
				Deep Play	87	15
				Perceiving	83	14
				Abstracting	6	1
	STEAM	405	24	Analyzing	188	47
				Planning	57	14
				Explaining	53	13
				Developing	52	13
				Using Math	17	4
				Arguing	13	3
				Asking	14	3
				Researching	11	3
Total number of codes for all Domains = 1671						

Social-emotional and cognitive skills domains

In the cognitive and social-emotional domains, students in the working group generally reported applying skills for both personal growth and potential community benefit.[2] The ESPP provided an opportunity for the students to use knowledge and skills toward creating a project with the potential to contribute open access musical play with co-equal STEAM integration to children in our community.

The students reported with the most detail about developing their social-emotional and cognitive skills through the ESPP (see Figures 5 and 6). Note the emphasis on overcoming frustration, working as a team, shifting perspective, gaining confidence, and taking risks, which we understood as elements of Mishra, et. al.'s (2011) cognitive skills "deep play" and "synthesizing" (see Tables 2 and 3). We presented the students with a multi-faceted challenge where we asked them to rely heavily on previous knowledge and skills without providing step-by-step instruction. We made clear that we expected them to meet the challenges we set without dictating *how* they were to meet those challenges. While we provided scaffolding and support, we also acted as part of the group where we worked alongside our students. We were on an even field as we were also experiencing the ESPP process for the first time. While there was clearly a group leader, we made the process more democratic to give the students space to work through problems on their own.

As the ESPP building went on, the students became comfortable enough with the program that the balance of power shifted. The students took over the work process almost completely, such that they began to plan work sessions without us. While they continued to acknowledge the project leader, she was seen as more of a partner in the work. Once the students gained confidence in their ability to work through challenges, they took more risks, asked more questions, and did more self-motivated work outside of the hours we spent together.

Social-emotional skills domain in detail

[2] Our team's design for the ESPP is particularly relevant to our immediate environment; The City of Lowell was once an industrial center that went through economic decline and is now being redeveloped into a technological innovation hub.

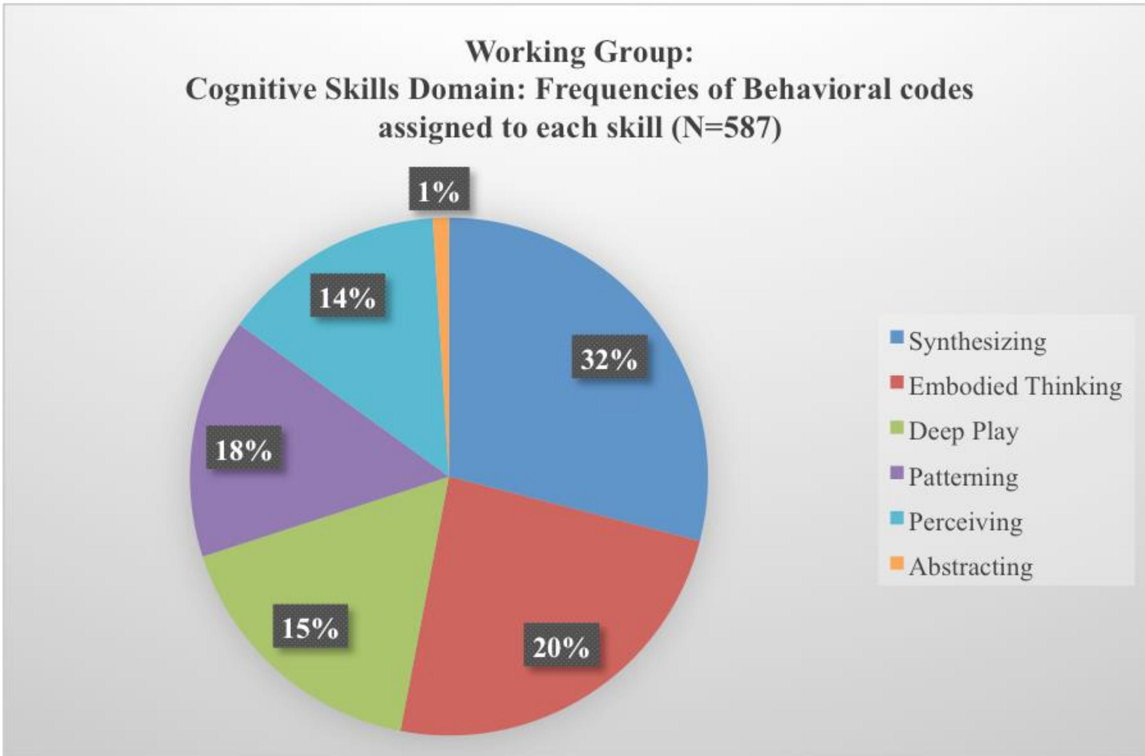

Figure 5. Total instances of Social-Emotional Behavioral codes assigned to each Social-Emotional skill. *Discipline* is missing.

Interview Data: Social-Emotional Skills

Table 2

Transcriptions of Interview Data Regarding Social-Emotional Skills, Organized Thematically.

Theme	Comments
Connecting to peers	*Aria* (Visual Art): I loved the combination of a wonderfully diverse and pleasant team with a project which was fostering so many of the values I hold close to my heart. I was extremely engaged in this project. *Gavin* (Materials Engineering): Despite not knowing much about music, I see it as a valid means of expressive communication; sometimes intent can be captured in a feeling rather than in words.

	Morgan (Music Education): I enjoyed my time learning from my peers. All of them came with drastically different backgrounds that added so much to the creative and building process. *Tom* (Mechanical Engineering): I believe that the project introduces a medium for social interaction through musical means.
Connecting to Community	*Aria* (Visual Art): I thought the intentions of process and result were wonderful, and responsible in both environmental and educational ways. I always was looking forward to meetings where I knew that I could apply my creativity to something meaningful. The EcoSonic Playground allowed me to apply what I know to something that will benefit others. Over time, I became more and more proud to get to work on this project. *Gavin* (Materials Engineering): I have always believed in using music as a means of communication and socialization so the concept of the project itself greatly appealed to me.
Resiliency	*Morgan* (Music Education): Every day on the project was a new problem to be solved, a new obstacle to at least attempt to overcome with a team. *Theo* (Music Education): The building did not always go as expected. Our project leader did not tell us the solution or what we should do because she was approaching this project as a learner with us. As frustrating as this was at first (we spent many hours brainstorming), it was positive in hindsight. I was able to have my own ideas and thoughts at the forefront of the process. If we were simply given the answer of how to combine these materials, there would have been little to no critical thinking. My ability to recreate this method in a later project would not have been as strong if I was not one of the parties thinking, designing and ultimately failing. It didn’t feel like work. *Tom* (Mechanical Engineering): I felt a little bit out of place at first since I’m a little rigid and mechanical in my approach to things. I felt insecure about being able to contribute creative ideas. I really

	liked the vision of the project though. Eventually I felt more comfortable working with the team. Everyone was kind and nice which made me relax a little bit more. I was more open to using tools in the environment that we were in. I felt freer to contribute instrument ideas.

Cognitive skills domain in detail

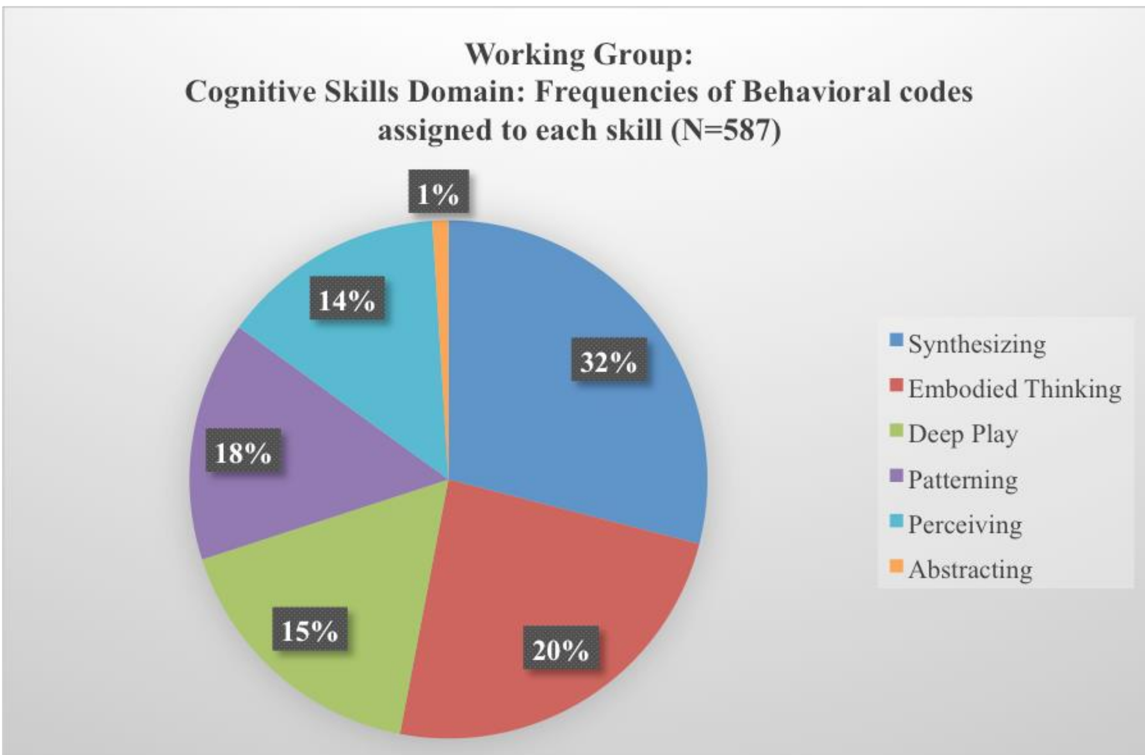

Figure 6. Total instances of Cognitive Behavioral codes assigned to each Cognitive skill: *Modeling* is missing.

Interview Data: Reports on Cognitive Skills

Table 3

Transcriptions of Interview Data Regarding Cognitive Skills: Organized Thematically.

Theme	Comments
Relying on prior skills and knowledge to synthesize and Learn new skills	*Aria* (Visual Art): I tended to apply many skills which I already had to this project. My familiarity with tools and materials were supplemented with the knowledge of my professors and teammates as to how to utilize those skills of mine. Through this, I was able to learn new ways to make things and reiterate the importance of trial and error. *Gavin* (Materials Engineering): This experience was effective in making me think more like a materials design engineer. There were a lot of factors and properties to consider and think about while deciding on materials. I also got to apply basic theory concerning string harmonics to help me with this process. *Morgan* (Music Education): The process of choosing our materials was a mixture of online research, asking professionals, and trial and error. *Theo* (Music Education): I looked at the raw materials and remember challenging myself to look beyond my concrete label of junk. Instead, I saw these objects as small building blocks. While they were incomplete alone, they became whole working parts when put together. With this thinking, I found myself able to contribute to the project.
Thinking about Design	*Aria* (Visual Art): I think that the project has broad goals and implementations in how it can teach sustainability, art, music and engineering. *Theo* (Music Education): It did not solve the problem of sustainability in itself. What it showed me was the amazing potential of reusing materials.

	Tom (Mechanical Engineering): The EcoSonic playground was never meant to eliminate large amounts of trash on its own, but rather, give students an opportunity to participate in a design process that has real world implications within their respective communities. At the same time, it teaches them about sustainability so that they can be more mindful of the decisions they make in the future.

STEAM practices domain

Researchers observed that the students applied their STEAM practices consistently and without self-consciousness or doubting whether they *could* be successful throughout the ESPP program. Students shared their knowledge through applying skills individually, which in turn contributed to the group's working experience. Morgan and Theo, who built the PVC pipe "organ" mentioned here, made up one of several combinations of students that formed and reformed small working teams that worked on different aspects of the ESPP, depending on the students' ideas and their perceived need for the specific skills that each student could bring to the task. The students brought application of skills to a group level where skills were shared across disciplines throughout the project.

Students' reports of what they learned through the ESPP revealed that they gained new and concrete STEAM practices. These skills ranged from a shift in perspective on the value of repurposing materials to understanding how to apply theory to practice in engineering and teaching. Through practicing various skills through application, the students were conscious of how they developed their thinking processes (see Figure 7 and Table 4).

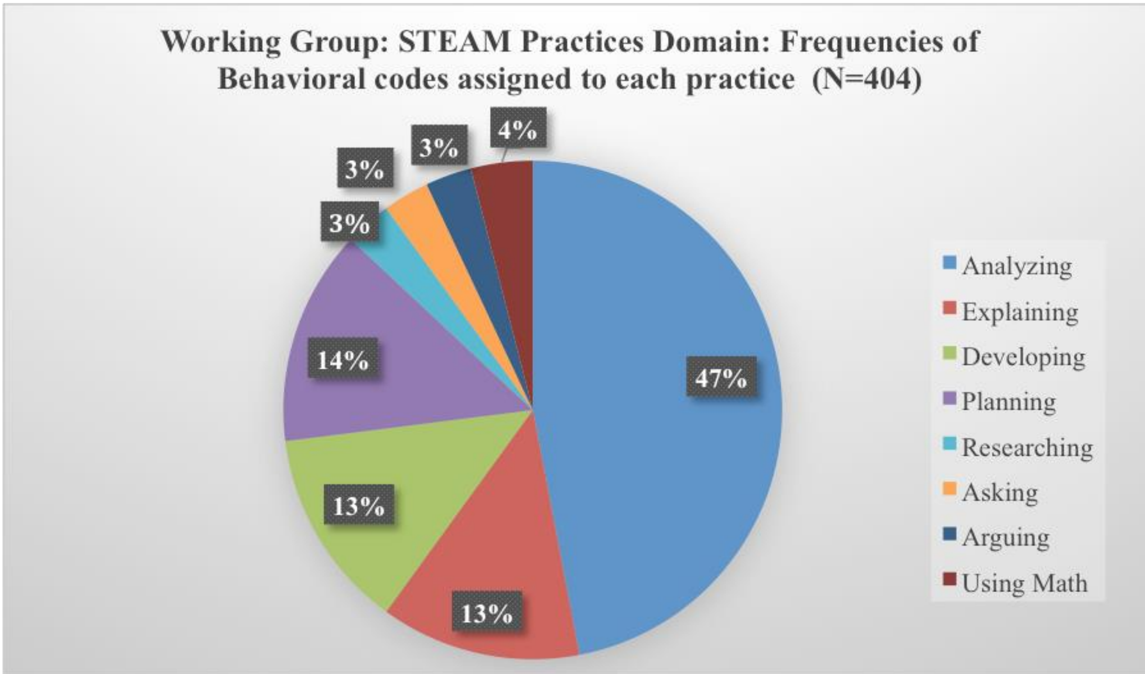

Figure 7. Total instances of STEAM Behavioral codes assigned to each STEAM practice.

Interview data: STEAM practices

Table 4

Transcriptions of Interview Data Regarding STEAM Practices: Organized Thematically.

Theme	Comments
Evidence-based Decision making	*Aria* (Visual Art): I chose materials based off the concept of form and function. How would the shape, material, or flexibility of a material react to an alteration to induce sound? How would we be able to secure the parts together so that they wouldn't fall apart in use, or be blown away in weather? What materials could we use that wouldn't be attractive to thieves? How safe can we make this material for children? These were the sort of questions I was asking myself and my peers while choosing materials. *Gavin* (Materials Engineer): I chose the materials by first thinking about what kind of conditions that they would have to endure. The

	thermal properties of the material would be very important due to the nature of being situated outside. If the material conducted heat well, it would not be adequate for use during the summer. I also did not want the material to be too brittle or dense. I tried to keep thermal and mechanical properties in mind at all times. *Theo* (Music Education): I found that I could visualize my future designs and plans by experiencing, by touching, listening and playing with the materials. Through this process, I began designing many small pieces to add to our overarching structure. Instead of passively thinking and planning, I began to contribute through action. *Tom* (Mechanical Engineering): The building process was very effective! It was helpful to be able to try out ideas with the materials in front of us and assess the musical qualities of the instrument as well as how difficult it was to put together.
Goal-oriented Thinking	*Aria* (Visual Art): The building process was effective in my experience, because it was very experimental. The plans or models we established beforehand never held back the creative process, and they definitely helped create new avenues for building. *Morgan* (Music Education): Throughout the first year and a half of the "EcoSonic" project, I was highly involved, researching pre-existing projects and playgrounds, testing out building materials, and eventually actually building different playground instruments from sketches that I had made. *Theo* (Music Education): The PVC Pipe Organ was one of the pieces that we wanted the structure to feature. For this instrument, Morgan and I had to calculate the length each PVC piece would be to get a certain pitch (roughly equal tempered A=440). After using math to plan the length of each PVC piece, I had to learn a new skill for this project: using power tools. *Tom* (Mechanical Engineering): It was rewarding to be able to work directly with materials so that I could come up with an idea, test the idea, and then iterate the design until it either worked or it was clear it

was a lost cause. To be able to cycle through the entire engineering process in the same day was eye opening. As an engineering student, most of my coursework deals with theory and computer simulations; it was refreshing, to say the least, to be able to work with my hands as part of the design process.

Quantitative data: Likert scale question

As part of the questionnaire, the students were asked, "Please rate on a scale of 1-5 (1 = never used; 2 = Rarely Used; 3 = Sometimes Used; 4 = Often Used; 5 = Almost Always Used) how much you used the following STEAM practices during the design and building process". Answers to this question showed the students' self-perceptions of the skills used in completing the ESPP. The graph below indicates student scores for each category of STEAM practices. The numbers on the *y* axis represent the average percentages of reported STEAM practices use (see Figure 8).

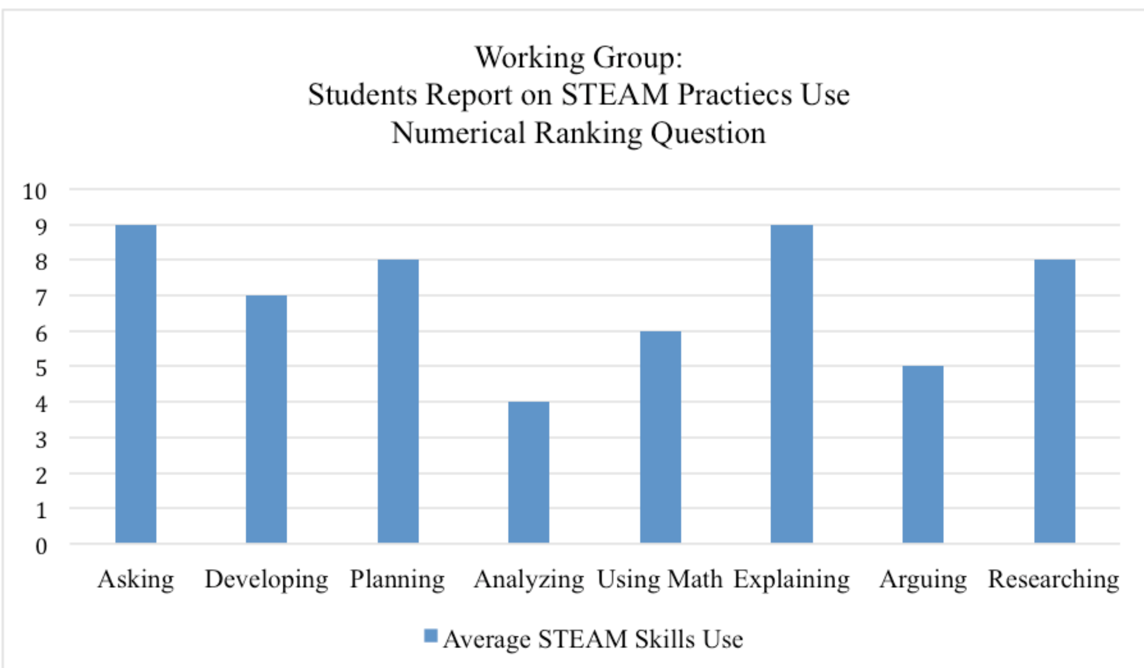

Figure 8. The graph shows the working group's ratings of STEAM practices in answer to a Likert scale question.

Playing groups

Overview

The playing groups reported mainly on cognitive skills, followed by social-emotional skills, with STEAM practices a distant third. The small amount of reporting on STEAM practices seemed logical since the students focused on making music rather than on building the structures. Note that the Cognitive skills domain accounts for more than half of the codes found in the data (see Figure 9 and Table 5).

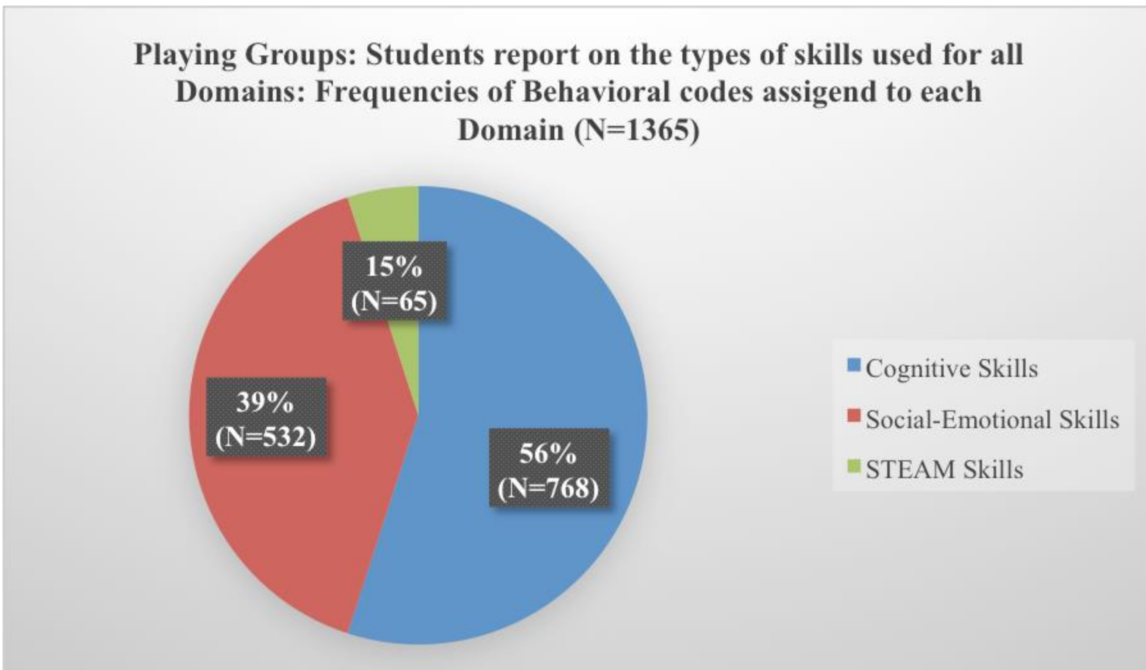

Figure 9. Overview of Playing Groups, frequencies of coded instances within responses. Data comprised interview transcripts, videos of student work, and researcher observational notes.

Table 5

Playing Groups: Frequencies of Coded Instances Within Responses for Each Domain.

Participant Group	Domain	N	%	Skills and Practices	N	%
Playing	Cognitive	768	56	Embodied Thinking	279	36
				Deep Play	195	26
				Perceiving	138	18
				Patterning	132	17
				Abstracting	24	3
	Social-Emotional	532	39	Cooperation	157	30
				Engagement	156	29
				Creativity	149	28
				Confidence	70	13
	STEAM	65	15	Analyzing	50	77
				Developing	15	23
Total number of codes for all Domains = 1365						

Cognitive skills domain

The primary focus on cognitive skills aligns with the improvisatory nature of playing the instruments, shown in the emphasis on "embodied thinking" and "deep play" (see Figure 10). We presented the instruments without any instruction about how to play them to preserve the experimental quality inherent in every aspect of the ESPP program. When discussing their approach to the instruments, the playing groups captured the feeling of playing in an unfamiliar context. Their descriptions of the experience revealed the conscious choices they made as the playing developed, which seem to indicate a meta-cognitive perspective during improvisation (see Table 6).

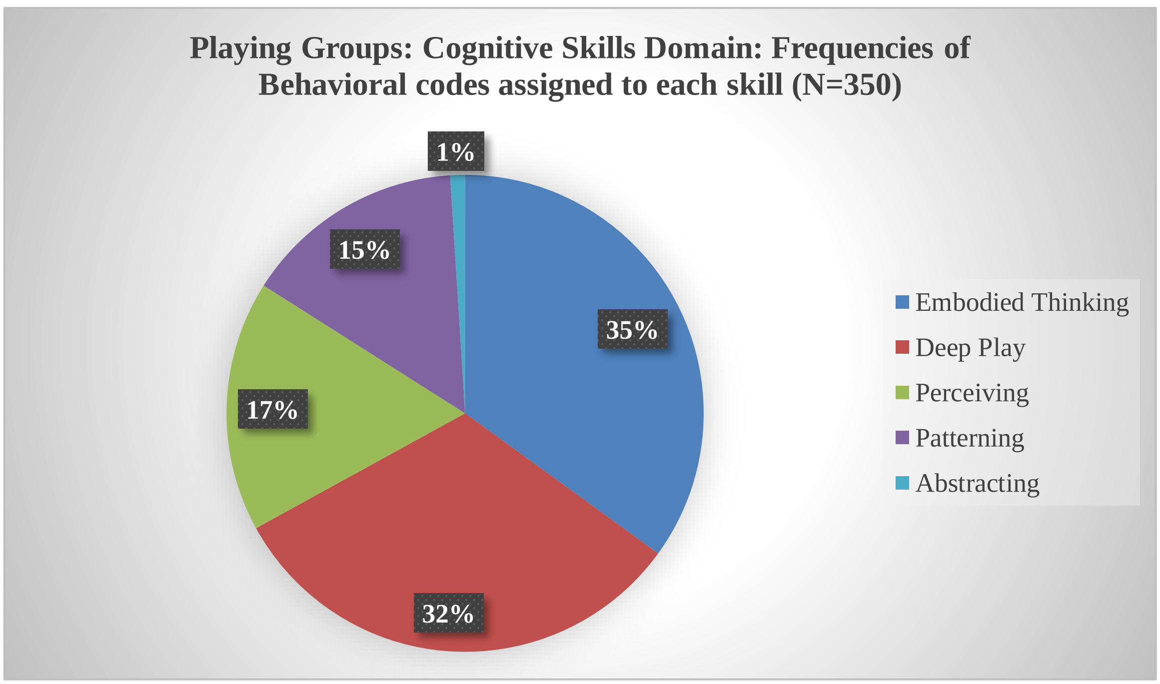

Figure 10. Total instances of Cognitive Behavioral codes assigned to each Cognitive skill; *Modeling* and *Synthesizing* are missing.

Interview data: Cognitive Skills

Table 6

Transcriptions of Interview Data Regarding Cognitive Skills, Organized Thematically.

Theme	Comments
Approaching the Instruments	In a sense when you have a traditional instrument you have predisposed information beforehand like we see performers holding it a certain way we see how they bow it – so we have some kind of information about how it's supposed to be played traditionally. But here you can just experiment. By playing these non-conventional instruments you can put yourself more in the mindset of anything can be a musical sound. Like you didn't really know what they were until you started playing them. And then you made the connection to a real instrument that they were a lot like and then and that was a cool part about it. I really enjoyed being able to just approach both structures with no idea how they worked. It made me feel like I was in elementary school again. Being able to figure out how these things worked by hitting them was awesome. It was easy! You could use your imagination. And one of the drums was like you just gave it a good whack and it made a good noise. I enjoyed seeing how other people used the instruments and the different sounds they could make. You could use your background information about what you know about the instrument. But also, you really did not get stuck on that. You could take it as some sort of tool and try to experiment with it whichever way you could.
Discovery process	I wanted to try everything out just to see what everything sounded like – like the different timbres of each of the things.

	So, I kind of just took a step back and watched other people explore to see what they had discovered. Every little spot on it could be a new discovered timbre or a new discovered way of playing. It really opened my eyes to other timbres and unique instruments. For the first play through where people were getting used to what the instruments are it was people's self-discovery of what the instrument sounds like and what makes them think. And I noticed with a lot of people, after I had started the beat and people started jumping on, they went to instruments that they had spent the most time on and had started to play around with the most. Once everyone gravitated towards what they enjoyed to play, that's when everyone started to do a little more improvisation on those instruments as well.
Musical form and Function	I thought it was really neat to see people piece together how to make music out of what was given to them. I really enjoyed at the end when people started making rhythmic patterns and more people kept jumping in. It was interesting trying to find pitch. That made it a mentally stimulating exercise. Another one of the cool parts is that I wasn't afraid to be with the music – because even if somebody made a starting pattern you still got to put in your own custom part. So, it was fun.

Social-emotional skills domain

The playing group turned toward the interpersonal aspects of playing music in their reports on using social-emotional skills. Codes in this domain fell into groups of skills that indicated social play (see Figure 11). The students' reporting focused on the following: concern with wanting to add to the group experience through consideration of the sounds they produced, noticing the moments when the group improvisation cohered, the collaborative nature of the instruments, and listening to and observing their peers to help them contribute to the improvisation (see Table 7).

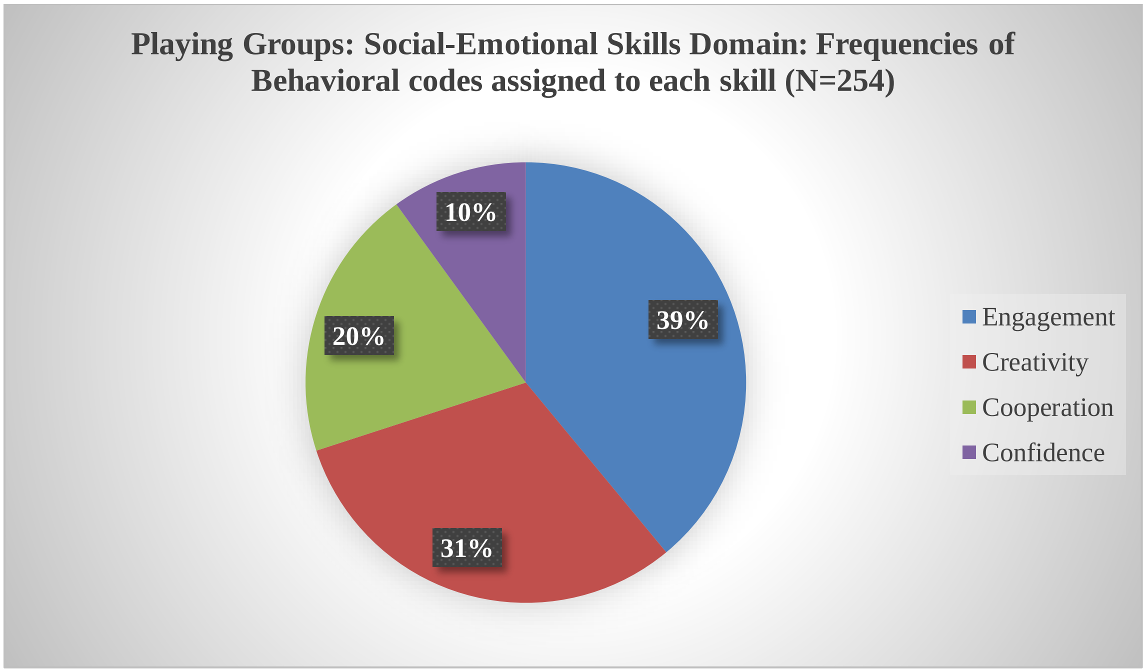

Figure 11. Total instances of Social-Emotional Behavioral codes assigned to each Social-Emotional skill. *Accomplishment*, *Belonging*, *Discipline*, *Intrinsic Motivation*, *Perseverance*, and *Teamwork* are missing.

Interview data: Social Emotional Skills

Table 7

Transcriptions of Interview Data Regarding Social-Emotional Skills, Organized Thematically.

Theme	Comments
Sense of Community	I had to take steps back and pause and observe and listen to what other people were doing because if I was clashing, then I felt I wasn't helping the overall performance. I would sometimes be more self-indulgent and that's fun, but it's not fun when it's overtly destructive in comparison to what other people are doing.

	I really enjoyed how effortlessly collaborative this experience was. If a friend had a groove going, I would do something to work off of them or vice versa. It showed, at least to me, how intrinsically collaborative music is. The music strongly depended on the sense of community playing the instruments. The first stage was experimentation and then collaboration to form musical ideas. It was a mind-blowing experience! For me it felt different than playing your own instrument with other people. Whereas we were all playing this one giant instrument. It kind of made me feel like we were more together. I thought it was interesting that we were all facing each other. That makes it easier to make eye contact, you see movements, you can use that. It's also a little bit more fun, you smile at each other if you like what you're doing. That was interesting. It was really cool how effortlessly collaborative it was. If one of your friends had a groove going then you'd be like, "Oh, I'll do this that goes along with them." And then maybe it will catch on. But even then, there were points where me and Daniel were doing things across the room that were working together. Sometimes you forget that music is inherently collaborative and that it's meant to be and that was really cool to see that. It was only fun when we played together.
Listening and Communication	Communicating with the other musicians was an interesting experience. After a couple of minutes, we were able to establish a steady pattern, with some improv mixed in. We all ended together by just means of musical communication. I found it interesting how at first everyone was doing their own thing and trying everything out, and by the end everyone was playing together and going off each other. I found it interesting that a clear groove developed after a few minutes,

	without a leader, and the groove and tempo changed throughout. We got a groove going on. At first it was just kind of like something was there but it wasn't defined yet. But after more people came in, we got a more defined groove going and we started communicating more.
Musical Development through Social Connection	Initially when everyone first started going over to these instruments, everyone was still playing at once but it was everyone playing for themselves to get the sound that they wanted to get out of each part, like the PVC or to hear the water jugs. But the second time when everyone started coming together and actually working together, to make a communal sound, that's when it actually started to be more appeasing to people to want to join in and participate. In the beginning, it was tough because there was so much going on that I didn't really know what to do. I kind of just took a step back and watched other people explore to see what they had discovered. And then went and did what I saw was cool and then thought oh that's cool, maybe I'll try that. So, I got a picture of what was going on. It took Ari to start a groove to encourage myself and others to build on top of that. He inspired me! I didn't really feel comfortable with becoming creative until Ari started becoming creative by himself, which takes a good bit of confidence to do that in front of everyone else. When everyone was sitting down you have that social pressure to sit down as well. Even I was a little nervous. But when he started playing that confidence and willingness to experiment just got me back up there. Ari presented a structure that felt more comfortable for us that we're used to – we clung onto that and made it our own. So, it goes to show that if a teacher starts having confidence in a structure they're presenting, the students are more likely to follow through and become more cohesive with that.

STEAM practices domain

Within the STEAM domain, student responses were coded into two practices groups: *Analyzing* and *Developing* (see Figure 12). While there were a small number of responses coded to STEAM practices, we report on the data here to suggest how elements of a scientific approach may underlie the music making. Students' remarked on the form and function of the music they played and how they used these structural elements to understand how the improvisation unfolded (see Table 8).

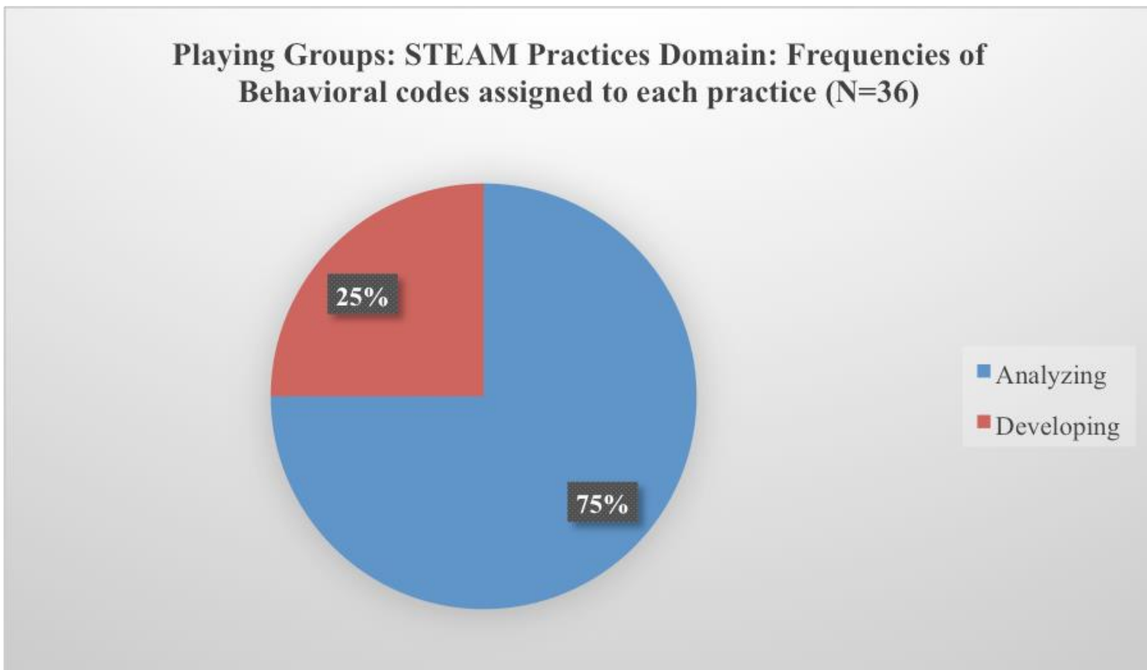

Figure 12. Total instances of STEAM Behavioral codes assigned to each STEAM practice: *Asking*, *Planning*, *Using Math*, *Explaining*, *Arguing*, and *Researching* are missing.

Interview data: STEAM Practices

Table 8

Transcriptions of Interview Data Regarding STEAM Practices, Organized Thematically.

Theme	Comments
Experimentation With sound	I noticed that the first time that I played, everyone was just experimenting. It didn't really matter whether any sort of beat or pitch clashed with anything because we were just playing, we were learning

	and discovering. And then a couple minutes later we would get into a groove and it was super fun. And then when I went to play again, I was a little more conscious, like, "Ok, now I understand how this works." For kids or for anyone who wanted to try it I think the first instinct wouldn't necessarily be, "Oh, I'm going to compose a piece." It's just, "Oh, what sound does this make?" and then going from there it would become that musical entity. I wanted to try everything possible. I went around to each instrument to see how each one sounded. And then eventually I made a more reactive improvisation with other people, rather than playing as an individual. I went from asking myself, "How does this sound?" to, "How does this sound with everybody else?" and, "How can we make music out of it?"
Musical analysis	From a compositional standpoint, a lot of music starts with discovery and really listening and analyzing and discovering what exactly does what. Obviously at first, I didn't know what was going on because I was trying to test out, "What noise does this make?" Then eventually people were coming together and that could be the start of a form. And then when people started trickling off and going into other things it's just another section of a composition. If I knew we were making one piece, I would be like, all right, what can I find that's a pattern. What instruments are being played the same way in terms of trying to find a groove? I always go back to that. It sounded like an actual drum beat, like something you would hear in an improv drum solo. You could tell that there was a clear beat to it, which is easier to fit in other forms of improvisation around it.
Testing the Instruments	For me it was just trying to figure out or wanting to figure out how the instruments made the sounds. Like why some things were attached to other things and why they're in certain places. I wanted to try everything out just to see what everything sounded like – like the different timbres of each of the things. I just wanted to try everything I could.

A lot of them you had to find the sweet spot to get the right sound you wanted. It was a little more experimental than regular instruments.

I feel like every little different aspect was not like a normal classical, what you would consider to be a typical instrument. Every little spot on it could be a new discovered timbre or a new discovered way of playing. It was just really interesting adding that in as we were all playing together.

That barrel drum, I didn't think that was going to have that much resonance, that much bass. That's a sound that percussionists would kill for! And it's just like there – it's just in a barrel. So, it was just really cool because I was just like, now I want this.

Quantitative Data: Playing groups Likert scale questions

The playing groups were asked to rate the following statements on a scale from 1-5, with 1 being *none of the time* and 5 being *all of the time* (see Figure 13):

- I understood how to use these structures.
- I was confident while using these structures.
- I was comfortable participating in the improvisation.
- I enjoyed the experience.
- The music I made depended on what others did.

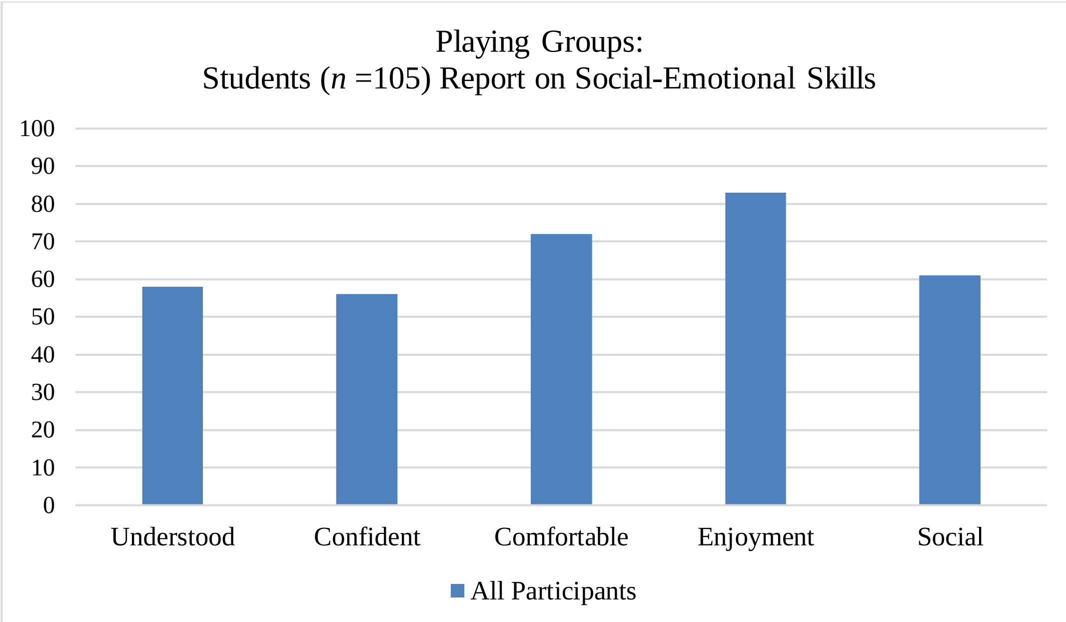

Figure 13. Frequencies of student reporting on social-emotional skills use with a rating of 4 (most of the time) or 5 (all of the time).

Answers to these questions were cross tabulated with each other to determine relationships among them. Using Pearson two-tailed correlation testing, we found the following: students who reported that they understood how to play the structures showed higher confidence levels (r(105) = .419, p. = .001) and were more apt to connect musically with others (r(105) = .275, p. = .023); there was a positive correlation between confidence levels, higher levels of comfort with the structures (r(105) = .395, p. = .001), and higher levels of enjoyment while playing them (r(105) = .393, p. = .001); students who reported feeling comfortable playing the structures were apt to have higher levels of enjoyment (r(105) = .490, p. = .001) and interact more with their peers during music making (r(105) = .266, p. = .029).

We also became interested in the relationship between social-emotional skills and the following yes/no questions (see Figures 14-15):

- Have you ever improvised before?
- Is improvisation part of your training as a musician?

For the first question, the results below contain graded responses, ranging from just a basic understanding of how improvisation works, to feeling confident in one’s improvisation skills, to being a comfortable improviser, to improvising for enjoyment as a part of one’s personal musical practice, to feeling confident enough to improvise in a social musical setting (for example, in a jazz combo).

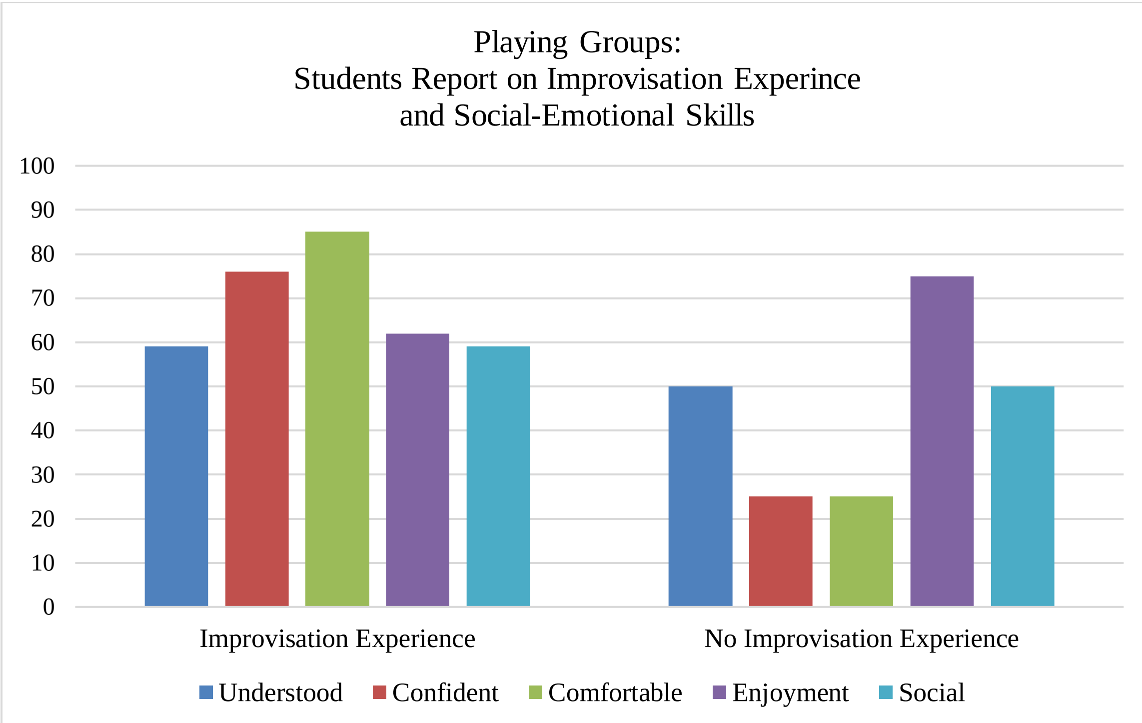

Figure 14. Cross tabulations of student reporting on improvisation experience and social-emotional skills

Cross tabulations of participants' reports on improvisation experience and measures of social-emotional skills use showed moderate to significant differences between the two groups; every measure except *enjoyment* gained with experience (see Figure 12). Pearson two-tailed testing showed a positive correlation between students who reported having improvisation experience and their confidence about playing the structures (r(105) = .245, p. = .044).

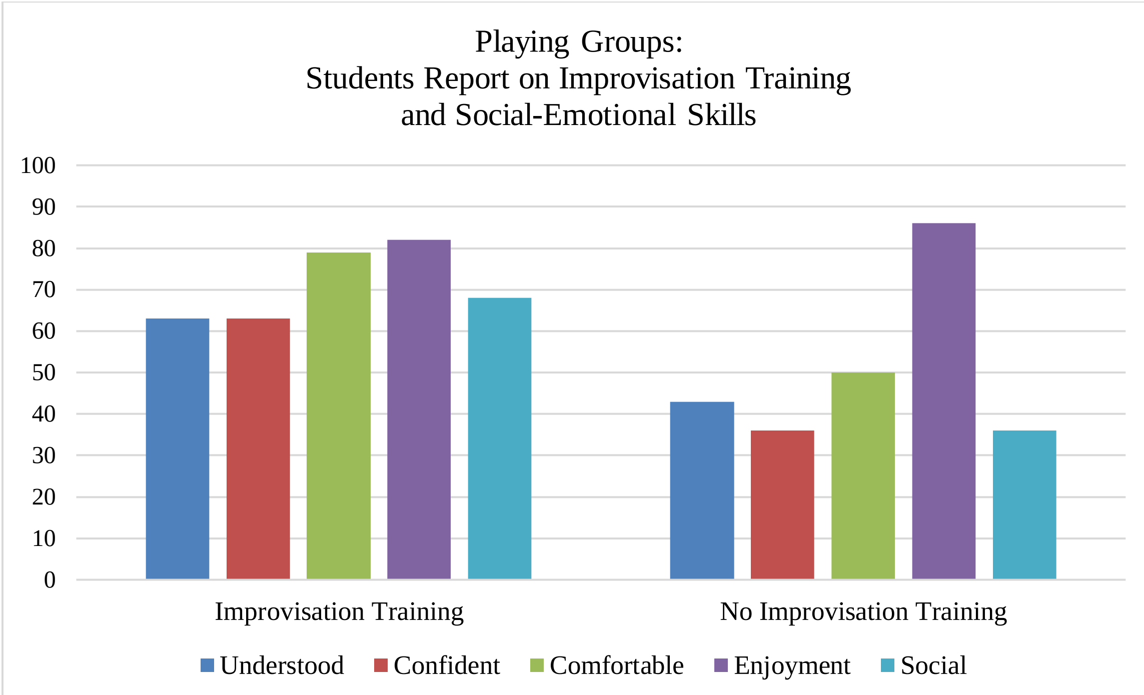

Figure 15. Cross tabulations of student reporting on improvisation training and social-emotional skills

Cross tabulations of participants' training in improvisation and social-emotional skills showed significant differences, again except for *enjoyment*, which was slightly higher with the *no training* group (see Figure 13). The Pearson test revealed positive correlations between improvisation training and whether participants understood how to play the structures ($r(105) = .241$, $p. = .047$), as well as whether they responded to their peers musically while playing ($r(105) = .288$, $p. = .017$).

Discussion and conclusions

Overall, the results show that the EcoSonic Playground Project design and building curriculum was effective in providing the students with a co-equal integrated arts project that utilizes certain STEAM, cognitive and social-emotional skills. Both the working and playing groups drew on previous skills and knowledge from all three domains in their approach to building and playing the ESPP instruments.

Both participant groups used skills across domains to work successfully through the various stages of the ESPP program. Their varied perspectives on the project illustrate how each group of students approached working through challenges with the particular types of skills and knowledge that came from their training and areas of interest. While the working group, out of necessity, focused more on using STEAM practices, both groups showed greater focus on both cognitive and social-emotional skills. Both groups used STEAM practices as a matter of course: the working group in all aspects of building the instruments and the playing groups in their analysis of musical form and function while listening and creating music.

Research shows that developing cognition relies on consistent and constant skills practice to make knowledge permanent (Cowan, 2001; Egan & Schwartz, 1979; Sweller & Cooper, 1985). However, deep skills practice may be embedded in projects that transcend subject boundaries and that have potential for immersive learning. This approach allows the learner to develop understanding in context, which then may become more meaningful; the learner uses and practices skills as a matter of necessity to complete an assignment that has real-life applications.

Throughout this study, the working group used the same skills repeatedly to help them build a structure that would function as intended and be useful. Students in the playing groups reported cyclical participation in creating the music: They moved into and away from the playing to allow themselves time to listen, process, and then contribute to the music. This process allowed them to practice their skills from a purely musical perspective. In addition, the intensity of the short-term playing experience seemed to produce similar results when compared to the long-term building experience. For example, quantitative results for the playing groups corroborated the close connection between social-emotional and cognitive skills, with students' ability to approach a new challenge successfully stemming from feelings of confidence and competence.

Both student reports and researcher observations of the students' work and playing showed that the challenges we provided encouraged them to use skills within and across the STEAM, social-emotional, and cognitive domains of learning. The students were conscious of the skills they brought, used, and developed through the ESPP program. Every student, regardless of participant group, experienced a sense of agency through immediate feedback that showed them how every action they performed had a profound influence on the development of their structural and musical creations. They became comfortable with the unexpected.

While the analysis of student reports organizes their experiences from different perspectives, in real time the students' use of skills and practices happened immediately and simultaneously. For the working group, development individually and as a group occurred over time as an aggregate of smaller steps toward new knowledge. In addition, the students were aware that they were transitioning as learning beings from a state where their set of individual knowledge and skills separated each of them from the group to a state where they became a cohesive group with shared knowledge and skills. In their self-analysis, the students acknowledged that working through the ESPP with its inherent challenges and frustrations taught them how to meet these challenges and to succeed because of them.

The social-emotional and cognitive skills developed and learned through our co-equal integrated model provided us with concrete evidence that this teaching model works. As both groups of students reported and as we observed, their most intensive learning happened in the social realm where the skills they practiced and developed were those most likely to translate into other real-life contexts. These include collaboration, cooperation, adaptation, creative problem solving, critical thinking, negotiating, contributing, risk taking, and listening.
The researchers also observed that the ESPP helped the students to reorient their thinking about, and approach to, a complex project. We deliberately created the program to allow the students to both become self-reliant and to rely on each other to complete it successfully. As the students worked through the various engineering, design, and musical challenges, they drew on skills indiscriminately and used them wherever necessary; boundaries or even subjects did not exist. Allowing the freedom to draw on and use diverse skills encouraged meaningful learning in the context of the project. The students also discussed applications of their new knowledge and skills to contexts outside of the ESPP.

Finally, the cross-pollination of STEAM, social-emotional, and cognitive skills shows the strength of the curriculum design. Our students seamlessly combined knowledge and experience from both realms as they worked through the project, only remarking on different types of skills when asked. Due to the immersive nature of the program, we waited until our students finished their work or playing before calling attention to various aspects of their approach. As much as possible, we did not want to influence their experience.

Given the range of skills we observed being used, applied, and developed over the course of the ESPP, we concluded that further study of co-equal arts/STEM integration as applied to our program is warranted for future iterations with more diverse student groups. Implementing a balanced curriculum that encourages students to draw on diverse and cross-disciplinary sets of skills appears to facilitate successful outcomes.

Based on our experiences with this pilot study, we have substantially redesigned the ESPP program to become more streamlined and adaptable to diverse contexts. More recently, we have brought the ESPP into a range of programs and schools with culturally diverse populations and have worked with students ages 3-12 years. Our experience with each of these projects has allowed us to develop further the ESPP architecture and curriculum. We are presently analyzing data from these projects and hope to show supporting evidence for the effectiveness of our co-equal integrated STEAM curriculum in more diverse contexts as well as applications for integrated learning beyond the ESPP program.

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Appendix A

Questionnaire given to and received from all working group participants in pilot program.

The EcoSonic Playground Project: Questionnaire

1. What were your impressions of the building project when we first started working together?

2. How did your impressions change over time if they changed?

3. Please rate on a scale of 0-10 (0= did not use; 10=used extensively) how much you used the following skills during the design and building process (please write your answer on the line given):

    - Asking questions and defining problems: _______

    - Developing and using models: _______

    - Planning and carrying out investigations: _______

    - Analyzing and interpreting data: ________

    - Using mathematics and computational thinking: _______

    - Constructing explanations and designing solutions: ________

    - Engaging in argument from evidence: ________

    - Obtaining, evaluating, and communicating information: ________

4. How did you choose the materials to make the instruments you designed?

5. How was the process of building effective or ineffective in your experience?

6. Describe your level of engagement with the project – what kept you coming back to work with us?

7. The EcoSonic Playground is an inquiry-based, skills-based curriculum, meaning that we look to solve a larger problem through project work grounded in STEAM practices that our students have already learned. In this case, the problem we're solving is local sustainability and the project used to solve the problem is the EcoSonic Playground.

Please tell us:

1. How effective your experience was in helping you to develop your skills and knowledge further.
2. How effective the project will be in helping to solve the problem (we are aware that as of now, our impact will be small because we're still in the experimental stages).

Appendix B

Survey given to all participants in the playing groups.

The EcoSonic Playground Project Experience Survey

<u>Demographics</u>:

What is your age?

What gender do you consider yourself?

1. M
2. F
3. Fluid

What is your major? (The younger participants did not answer this question.)

1. Performance
2. Sound Recording Technology
3. Music Studies (Music Education)
4. Music Business
5. Other

What is your primary instrument?

1. Winds
2. Strings
3. Percussion
4. Brass
5. Voice
6. Piano

Do you consider yourself a composer?

1. Yes
2. No
3. I compose some but don’t consider myself a composer

<u>Experience</u>:

Which structure did you play?

1. Cube
2. Drum Set
3. Both

On a scale from 1 to 5, with 1 being none of the time and 5 being all of the time, please tell us following:

I understood how to use these structures.

Scale: 1 2 3 4 5

I was confident while using these structures.

Scale: 1 2 3 4 5

I was comfortable participating in the improvisation.

Scale: 1 2 3 4 5

I enjoyed the experience.

Scale: 1 2 3 4 5

The music I made depended on what others did.

Scale: 1 2 3 4 5

Has playing on these structures changed how you define "musical instrument?"

1. Yes
2. No

Have you ever improvised before?

1. Yes
2. No

Is improvisation part of your training as a musician?

1. Yes
2. No

Would you consider these structures to be musical instruments?

1. Yes
2. No

Open ended:

Is there anything else you would like to tell us about your experience here today?

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