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Integrating the Arts and STEM for Gifted Learners

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This study investigates the process of identifying high-quality lessons for gifted learners that integrate the arts with science, technology, engineering, and mathematics (STEM) fields. These STEAM lessons have the potential to develop deep thinking, as well as develop creativity and visual–spatial skills that are necessary in the STEM disciplines. Lessons were solicited from teachers through their involvement in national organizations, and 61 lessons were analyzed and reviewed by experts in the arts and STEM fields, as well as master teachers. High-quality lessons provided deep content knowledge in both STEM and arts fields, connections across content areas, specific criteria for assessment, and collaborations between teachers and between students. The findings from this study will be used to further define the evaluation process for STEAM lessons designed for gifted learners and to develop professional development opportunities for teachers of the gifted.

Keywords: arts integration, gifted curriculum, mixed methods, STEAM, STEM

As business leaders call for greater creativity and deep thinking among today's workforce and recent policy changes place a greater emphasis on the Fine Arts in public schools (Every Student Succeeds Act [ESSA], 2015–2016), there has been a growing movement to provide curricula that more deeply integrates the arts. Specifically, STEAM initiatives, which add "arts" into the traditional STEM (science, technology, engineering, and mathematics) fields, promise the deepening of curricula the provision of richer educational experiences for students and increasing of capabilities in the sciences and engineering (e.g., Gettings, 2016). This trend has increasing significance for the gifted population of students, because they are more able to make connections across disciplines due to their increased intellectual and academic capabilities (e.g., Anderson, 2014) and gifted programs are often designed to develop critical and creative thinking skills (e.g., Renzulli & Reis, 2000). This article outlines arts integration as a strategy that has the potential to have particular significance for gifted learners. This article seeks to explore the ways in which STEAM-focused lessons for gifted learners can be evaluated and best practices can be identified. Specifically, our research questions are as follows:

1. How can researchers use a rubric to identify effective practices in STEAM lesson plans?
2. What properties of quality STEAM lesson plans do expert reviewers identify?

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BACKGROUND

Arts Integration and STEAM

Arts integration is not a new endeavor; it has long been a favored (e.g., Holzman & Byrne, 1978), if not a controversial, approach to curriculum. When art is used primarily to teach another discipline, research has demonstrated achievement gain, particularly for low-performing students (e.g., Hardiman, Rinne, & Yarmolinskaya, 2014). However, this approach fails to address the deep learning that can occur when instruction integrates the arts and STEM fields with meaningful content. This integration can be conceptualized as a spectrum (e.g., Drake, 2007). On one end is a disciplinary approach, in which content areas are taught independent of each other. This may also occur with some connections being apparent, for example, when a STEM lesson happens to apply to the arts (e.g., light and color in physics). Moving toward greater integration, in a multidisciplinary approach, connections are made across content areas, and in an interdisciplinary approach, instruction focuses on those areas in which overlap occurs between content areas. This can occur, for example, when science is integrated into an art curriculum or when art is integrated into a science curriculum. Finally, in transdisciplinary approaches, the intersection of disciplines is complete and taught with its own conceptual framework, epistemology, and practices (Marshall, 2014). Though the transdisciplinary approach is heralded by many as the goal for curricula, this project includes lessons that tend more toward an interdisciplinary approach, in which the domains remain largely separate but instruction occurs at the intersection, incorporating meaningful content from both disciplines.

Many studies have investigated the implementation of arts integration in schools. When surveyed, teachers largely had positive views of arts integration (e.g., Duma, 2014; May & Robinson, 2016; Pruitt, Ingram, & Weiss, 2014). Teachers also perceived social and cognitive or academic growth among students when engaged in interdisciplinary arts lessons (Duma, 2014. May & Robinson, 2016). For example, students were more engaged in school with more positive peer relationships (Duma, 2014). As students become more actively engaged in meaningful curriculum through arts integration, they display growth in noncognitive domains. In addition, in the cognitive domains, when arts were used to make meaning across disciplines, students demonstrated significant growth in higher level thinking (Pruitt et al., 2014).

STEAM, as it refers to the integration of the arts with the STEM fields, is relatively new to the field of education. However, it relies upon previous work in arts integration; this project seeks to develop a framework in which to evaluate lessons that teach STEAM content. That is, this project is specifically related to the intersections in discipline of the arts and sciences. Evidence has shown the social, cognitive, and academic benefits of arts integration for students overall, and this research builds on these findings by exploring approaches to evaluating STEAM lessons.

Rubrics and Evaluation of Lesson Quality

In addressing questions of evaluation of STEAM lesson quality, there has been little research done on the evaluation of lessons. However, the fields of science and art education have both developed rubrics and guidelines for the evaluation of high-quality lessons in their fields. These rubrics tend to elucidate best practices for teachers and curriculum that are aligned to particular standards or objective outcomes, such as the Achieve EQuIP rubrics aligned to the Common Core State Standards and the Next Generation Science Standards (Achieve, 2017). The rubrics and evaluation measures from these sources informed the current study as a basis for the inclusion of the basic parts of the rubric but were found to be too prescriptive and aligned too specifically to sets of standards to be broadly applied to the STEAM integration lessons for the study.

STEAM and Gifted Students

Within the gifted population, there has been relatively little systematic investigation into the effectiveness of STEAM lessons or of arts integration to increase progress toward educational goals, such as achievement, attitudes, or school engagement. However, many authors have explained methods and strategies to further integrate the arts for gifted learners, through retrospectives about practice (e.g., Barilla & Brown, 2015) and specific guides for teachers (e.g., Smutny, 2002). These guides provide examples, primarily at the multidisciplinary level, encouraging teachers to have students paint pictures about literary events, create theater pieces from short stories, or examine properties of light in historical paintings (Smutny, 2002). Alternatively, discussion-based methods, such as Paideia Seminar, have been suggested as ways to integrate the arts into gifted classrooms (Ayers & Tay, 2016). In addition, there have been many successful projects to identify the artistically talented and provide instruction for them across disciplines. One such program targeted rural children from underserved populations (primarily from Native American and Hispanic backgrounds; DeLeon, Argus-Calvo, & Medina, 2010), demonstrating successful arts integration programs for artistically talented students from underrepresented populations. Another project focusing on rural students, ProjectARTS, included community-based art education and an emphasis on authentic assessments (Clark & Zimmerman, 1997); this project also demonstrated positive outcomes as a result of arts integration for gifted students from rural populations. However, there remains a need for more studies investigating arts integration with gifted learners.

In looking at STEM curriculum for gifted learners, there is some evidence that incorporating the arts and creativity can be beneficial. For example, a study in Turkey demonstrated that arts and science enrichment centers increased scientific literacy among academically talented learners (Komek, Yagiz, & Kurt, 2015). In another study, successful professionals in STEM fields were surveyed and the results showed the importance of hobbies in the arts that develop visual–spatial capacities and imagination that are relevant to endeavors in engineering, mathematics, and the sciences (Root-Bernstein, 2015). Although these activities were not part of a formal school curriculum, this research demonstrates the importance of the arts in science professions.

Though *arts integration* is a long-standing term, STEAM is relatively new. However, research has shown favorable perceptions among teachers for this approach (Park, Byun, Sim, Han, & Baek, 2016). In addition, the use of STEAM lessons is hypothesized to contribute to the “de-siloizing of the content” and lead to aesthetic learning and student engagement (Gettings, 2016, p. 10). Gettings (2016) critiques current educational practices that artificially divide content and instead purports strategies such as STEAM to teach content that intersects traditional disciplines. It also has the potential to develop creative problem solving, individual learning, and social responsibility (Rolling, 2016) by engaging students in high-level thinking and synthesizing meaningful content across disciplines. The hands-on and creative processes of engineering, which are closely linked to many of the skills in the arts, have also been emphasized as an important component of gifted curriculum (e.g., Mann, Mann, Strutz, Duncan, & Yoon, 2011). The visual–spatial abilities that are necessary for both engineering and many arts disciplines are often overlooked in gifted identification and curricula (e.g., Anderson, 2014). Based on the foundational research regarding arts integration, this project seeks to further refine our knowledge, particularly with regard to the intersections of arts and STEM disciplines in the curriculum.

METHODS

This study was conducted by the Innovation Collaborative, a nonprofit group that is dedicated to the intersection of the arts, sciences, and humanities within learning contexts. Through connections with member organizations, including the National Association for Gifted Children, the National Art Education Association, and the National Science Teachers Association, STEAM lessons were solicited from teachers nationwide through an online submission system (see Appendix A). Specifically, the national organizations sent e-mails, posted to social media, and included in newsletters information regarding the project and inviting members to submit STEAM lessons to the online system. Submissions were then evaluated using a rubric that incorporated facets of STEAM and arts integration principles (see Appendix B). A panel of experts, including professors and leaders in the fields of arts and science education, along with practitioners who have previously been highly successful in delivering STEAM instruction, evaluated each lesson, including both qualitative and quantitative data. Each lesson was evaluated by three reviewers: one arts content expert, one science content expert, and one practitioner expert. The content-area reviewers had high levels of experience with all levels of the content either working at the university level, serving on curriculum or standards committees for national organizations, or holding leadership positions in national organizations. The reviewers also provided data specifically regarding the efficacy of the rubric. This study used a mixed-methods approach to answer the research questions.

Instrumentation

Rubric Development

Because this study is largely exploratory in nature, one of the goals was to begin the development process of a rubric to evaluate STEAM lessons. Based on the existing literature regarding arts integration (specifically the elicitation of deep thinking skills and the value of meaningful content) and the input from leaders in the fields of art and science education, a rubric with five criteria (General Pedagogy, Thinking Skills, Assessment, Arts Content, and STEM Content) was developed for preliminary use. Each of these criteria was evaluated on a 3-point scale, including Developing, Proficient, and Exceptional, with a description for each level. These guidelines were designed to incorporate best practices for gifted learners, including the integration of high-level thinking and engagement with complex ideas.

Lesson Plan Submission

Based on the areas identified in the rubric, the research team developed a lesson plan submission form. This form not only included areas for a typical lesson plan (e.g., objectives, standards, procedures) but also included an area for teachers to provide information about arts and STEM integration, thinking skills, and evidence of success. This submission form was available online, through the use of Qualtrics software.

Data Analysis

To answer the first research question (How can researchers use a rubric to identify effective practices in STEAM lesson plans?), both quantitative and qualitative data were used. Specifically analyzing the reviewer ratings on the rubric, bivariate correlations between individual scores and interrater reliability (intraclass correlation coefficient [ICC]) for each criterion were calculated. The means scores and descriptive statistics are reported, along with the comparisons between the reviewers.

To add to these analyses of data to answer research question 1, the qualitative data regarding the reviewers' comments about the rubric were analyzed. Using a grounded theory approach, the text of the reviewers' feedback regarding the effectiveness and validity of the rubric was read, codes were developed, and through this process themes were identified. These data then informed the findings regarding the development of the rubric to evaluate the lesson plans.

To answer the second research question (What properties of quality STEAM lesson plans do expert reviewers identify?), qualitative data, in the forms of both the text of the lesson submission and the comments from the expert reviewers, were examined. For this stage of the analysis, a subset of high-quality lessons was identified based on the weighted average scores. The lessons were then placed into five quality levels (see Table 1). The lessons in the highest group were then examined. Each lesson was read and coded by an independent member of the research team and the objectives and procedures were summarized and coded by content areas. Finally, the reviews for each lesson were read and coded by the research team. From these codes, themes were developed across lessons and these themes were summarized and findings were discussed.

DATA SOURCES

Sample

A total of 61 complete lessons were submitted and evaluated by the expert reviewers. The teachers submitting lessons represent an experienced and geographically diverse

TABLE 1
Quality Levels

	N	*M*	*SD*
Level 1 (1.0–1.5)	15	1.26	0.18
Level 2 (1.5–2.0)	14	1.78	0.16
Level 3 (2.0–2.5)	22	2.21	0.11
Level 4 (2.5–3.0)	10	2.82	0.18

sample; see Table 2. The majority of teachers had more than 15 years of experience (*n* = 47) and had obtained at least a master's degree (*n* = 48). Most of the teachers reported that their primary role was as a classroom teacher (*n* = 49) in a neighborhood public school (*n* = 37; see Table 3). The majority of teachers taught in the visual arts (*n* = 43), but a significant proportion also taught science (*n* = 14). Few teachers taught English/language arts (*n* = 8), music (*n* = 2), performing arts (*n* = 2), or engineering and design (*n* = 4).

The lesson plans submitted also represented diversity (see Table 4). Lessons were designed for all grade levels: primary and elementary (*n* = 28), middle (*n* = 16), and secondary (*n* = 20) grades. The majority of lessons were multiday units (*n* = 51), with a few 1- to 2-day lessons (*n* = 7) and year- or semester-long curricula (*n* = 2). Overall, teachers reported students utilizing many thinking skills in the lessons, with all types of thinking skills (including finding problems, generating ideas, abstracting, synthesizing, creating, responding, reflection, and changing perspectives) reported by over half of the lessons submitted. The teachers also reported using informal assessments (*n* = 42), projects with rubrics (*n* = 49), and observations (*n* = 40) more than traditional assessments (*n* = 10) and written responses (*n* = 25). The lessons were aligned to a variety of standards, including Common Core Standards (*n* = 23), National Core Art Standards (*n* = 34), Next Generation Science Standards (*n* = 23), and various state standards (*n* = 24). Over the 3-month period during which the online submission system was open, a group of teachers submitted a robust sample of lessons.

TABLE 2
Demographic Data Regarding Teachers

	N	*Percent*
Geographic location		
Northeast (CT, MA, NH, NJ, NY, PA, RI)	13	21.3
Midwest (IA, IL, KS, MI, MN, MO, OH, SD)	13	21.3
South (FL, GA, MD, NC, TN, TX, VA)	19	31.1
West (AK, CA, MT, NM, OR, WA)	12	19.7
Years teaching		
0–5 years	5	8.1
6–10 years	9	14.5
11–15 years	11	17.7
16–20 years	18	29.0
20 or more years	18	29.0
Highest degree earned		
Bachelor's degree	12	19.4
Master's degree	45	72.6
Doctoral degree	3	4.8
Total	61	100.0

TABLE 3
Demographic Data Regarding Teaching Assignment

	N	*Percent*
School type		
Public (neighborhood)	37	59.7
Public (magnet)	4	6.5
Public (charter)	4	6.5
Private	7	11.3
Higher education	8	12.9
Role		
Teacher	49	80.3
Higher education professor	5	8.2
Professional development	4	6.6
Other (artist in residence, librarian, student)	3	4.9
Grade levels taught (select all)		
Pre-kindergarten	5	8.2
Kindergarten	17	27.4
First grade	19	30.6
Second grade	20	32.3
Third grade	18	29.0
Fourth grade	20	32.3
Fifth grade	19	30.6
Sixth grade	18	29.0
Seventh grade	16	25.8
Eighth grade	19	30.6
Ninth grade	13	21.0
Tenth grade	13	21.0
Eleventh grade	15	24.2
Twelfth grade	14	22.6
University/college	4	6.6
Content taught (select all)		
Classroom/generalist	3	4.8
English/language arts	8	12.0
Science	14	22.6
Mathematics	5	8.1
Social studies	3	4.8
Visual arts	43	69.4
Music	2	3.2
Performing arts	3	4.8
Foreign language	2	3.2
Engineering/design	4	6.4
Total	61	100.0

Note. Total may not equal 58 for each category, because teachers could select all that apply.

RESULTS

Research Question 1: How Can Researchers Use a Rubric to Identify Effective Practices in STEAM Lesson Plans?

To answer the first research question, both qualitative and quantitative data were collected. First, the expert reviewer scores were analyzed across all lesson plans submitted.

TABLE 4
Lesson Plan Submissions

	N	*Percent*
Duration		
One- to 2-day lesson	7	11.3
Multiday (multiweek) unit	51	88.5
One semester	1	1.6
One year	2	3.2
Grade level(s)		
Pre-kindergarten–primary (K–2)	7	11,4
Elementary (2–4)	9	14.8
Upper elementary (4–6)	12	19.6
Middle grades (6–9)	16	26.2
Secondary (9–12)	11	18.0
Advanced (11–12)	9	14.8
All grade levels	1	1.6
Lesson plan content (select all)		
Visual arts	54	87.1
Music (vocal or instrumental)	9	14.5
Theater	6	9.7
Dance	7	11.3
Media arts	19	30.6
Other arts (art history, painting, sculpture)	8	12.9
Earth sciences	16	25.8
Life sciences	23	37.1
Physical sciences	19	30.6
Social sciences	13	21.0
Other sciences (weather, environmental)	10	16.1
Mathematics	22	35.5
Engineering	25	40.3
Technology	32	51.6
History/civics	13	21.0
English/language arts	28	45.2
Foreign language	5	8.1
Other (religion, service learning, careers)	7	11.5
Thinking skills utilized (select all)		
Finding and clarifying problem	44	27.4
Acquiring information	49	79.0
Generating ideas	47	75.8
Abstracting	36	58.1
Transforming and synthesizing	46	74.2
Comparing and contrasting	45	72.6
Selecting and evaluating best ideas	41	66.1
Creating	57	91.9
Responding	45	72.6
Reflection and metacognition	46	74.2
Changing perspectives	37	59.7
Other (imagination, collaboration, social)	9	9.7
Assessments (select all)		
Informal assessments	42	67.7
Traditional assessments	10	16.1
Written responses	25	40.3
Product/project with rubric	49	79.0
Observational	40	64.5
Other (discussions, self-assessment)	16	25.8
Standards used		
Common Core Standards	23	37.1
National Core Art Standards	34	54.8
Next Generation Science Standards	23	37.1
Other (e.g., state standards)	24	38.7

Then these scores were used to model the components with regression analyses. Finally, the reviewers' comments were analyzed qualitatively.

Analysis of Reviewer Scores

The results of the comparisons of the reviewers' scores indicate that each type of reviewer (i.e., arts, STEM, and practitioner) contributed a unique perspective to the overall ratings of the lessons. This analysis was conducted to compare scores across reviewer types and between criteria. The bivariate correlation matrix (see Table 5) shows that the reviewers tended to rate lessons similarly across criteria (range: 0.375–0.764), and there was less agreement between reviewers on the same criteria (range: 0.184–0.495). All of the correlations within a reviewer type and across criteria were statistically significant at the $p < .001$ level. Thus, the reviewers' evaluations of lessons were consistent; there was less agreement across reviewers.

The reliability analyses indicate similar findings; see Table 6. As a measure of interrater reliability, the average measure ICC for each criterion between three reviewers ranged from fair to good (range: 0.448–0.719; Cicchetti, 1994). The lowest agreement between reviewers was on the thinking skills criterion, ICC(2,3) = 0.448. The remaining average measure ICCs can be classified as good (general pedagogy, ICC [2,3] = 0.660; STEM content ICC[2,3] = 0.448; arts content ICC[2,3] = 0.719; and assessment ICC[2,3] = 0.677; Cicchetti, 1994).

Of the remaining variables, lessons scored the highest on general pedagogy (M = 2.17; SD = 0.61) and lowest on assessment (M = 1.98; SD = 0.55), with scores on thinking skills (M = 2.23; SD = 0.51), arts content (M = 2.12; SD = 0.62), and STEM content (M = 2.02; SD = 0.65) in the middle. In comparing the average scores across types of reviewers, art experts scored the lessons the lowest (M = 1.95; SD = 0.66) and practitioner experts the highest (M = 2.32; SD = 0.64, see Table 7).

Analysis of Rubric Development

In the text-based analyses of the reviewers' comments regarding the effectiveness of the rubric, eight themes emerged (see Table 8). Reviewers found the rubric "appropriate" and "useful." For areas of improvement, reviewers indicated a need for a criterion to evaluate the "quality of writing," "the inclusion of the humanities," and "proficiency of integration of the concepts of STEAM." In addition, the reviewers recommended greater detail or examples be provided within the rubric and a level of criteria to indicate that the lesson was missing or provided "insufficient level of detail" for sections of the rubric. Similarly, reviewers also indicated a need for greater discrimination between levels.

TABLE 5
Correlations Between Reviews

	1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*13*	*14*	*15*
Art reviewer															
1. General pedagogy	*1.0*														
2. Thinking skills	*.718***	*1.0*													
3. STEM content	*.670***	*.619***	*1.0*												
4. Arts content	*.641***	*.639***	*.377***	*1.0*											
5. Assessment	*.575***	*.511***	*.435***	*.573***	*1.0*										
Science/math reviewer															
6. General pedagogy	**.307***	.176	.306*	.351**	.178	*1.0*									
7. Thinking skills	.242	**.217**	.309*	.266*	.263*	*.660***	*1.0*								
8. STEM content	.224	.095	**.403****	.093	.162	*.670***	*.544***	*1.0*							
9. Arts content	.323*	.233	.192	**.436****	.246	*.589***	*.450***	*.395***	*1.0*						
10. Assessment	.316*	.197	.354**	.320*	**.267***	*.745***	*.561***	*.763***	*.585***	*1.0*					
Practitioner reviewer															
11. General pedagogy	**.346****	.187	.231	.316*	.263*	**.485****	.266*	.489**	.387**	.387**	*1.0*				
12. Thinking skills	.214	**.184**	.231	.163	.142	.309*	**.244**	.383**	.278*	.345**	*.681***	*1.0*			
13. STEM content	.356**	.185	**.489****	.022	.275*	.361**	.242	**.445****	.102	.193	*.648***	*.588***	*1.0*		
14. Arts content	.458**	.340**	.393**	**.495****	.394**	.349**	.164	.224	**.452****	.383**	*.764***	*.600***	*.485***	*1.0*	
15. Assessment	.261*	.066	.296*	.088	**.372****	.356**	.190	.374**	.324*	**.474****	*.656***	*.633***	*.640***	*.694***	*1.0*
16. Final score	.657**	.495**	.575**	.691**	.592**	.729**	.551**	.711**	.602**	.780**	.673**	.480**	.474**	.640**	.556**

Note. Italics indicate correlations from the same reviewer. Bold indicates correlations for the same criterion between reviewers.
*Significant at $p < .05$. **Significant at $p < .001$.

TABLE 6
Reliability

	M (SD)[a]	ICC[2,3]
General pedagogy	2.17 (0.61)	0.660
Thinking skills	2.23 (0.51)	0.448
STEM content	2.02 (0.65)	0.712
Arts content	2.12 (0.62)	0.719
Assessment	1.98 (0.55)	0.677

[a]Mean score is on a 3-point scale.

TABLE 7
Descriptive Statistics of Reviewer Scores

	M	*SD*
Art reviewer		
General pedagogy	2.02	0.73
Thinking skills	2.16	0.73
Science/math content	1.95	0.82
Arts content	1.85	0.83
Assessments	1.72	0.79
Overall score	1.94	0.65
Science/math reviewer		
General pedagogy	2.14	0.79
Thinking skills	2.48	0.65
Science/math content	1.91	0.82
Arts content	2.34	0.77
Assessment	2.03	0.77
Overall score	2.05	0.65
Practitioner reviewer		
General pedagogy	2.36	0.78
Thinking skills	2.48	0.65
Science/math content	2.19	0.80
Arts content	2.34	0.77
Assessment score	2.20	0.79
Overall score	2.32	0.64
Overall mean	2.11	0.51
Final score	1.98	0.55

Research Question 2: What Properties of Quality STEAM Lesson Plans Do Expert Reviewers Identify?

To answer the second research question, the top lessons, as identified by the rubric, were analyzed. These analyses included data from both the text of the lessons and from the reviewers' feedback and notes.

Analysis of Exemplary Lessons

Of the nine lessons rated in the exemplary category, three of these were designed for middle grades, three for elementary, two for primary, and one for all levels (see Table 9). No high school lessons were included. The primary teaching responsibilities of the teachers include art, engineering/design, general classroom, and science. Most of the lessons addressed the visual arts (n = 8), one addressed dance, and one of the visual arts lessons also included music. For STEM disciplines, there was diversity of content areas, including life and physical sciences, engineering, and mathematics. In addition, two lessons integrated language.

TABLE 8
Reviewers' Comments Regarding Rubric

Theme	*N*	*Representative Quote(s)*
Appropriateness of rubric: Comments in this theme indicated that the rubric was good, appropriate, or useful.	3	"Appropriate for this lesson" "The rubric content is useful"
Areas for improvement: Quality of writing: Comments in this theme indicated that the rubric needed an additional section to score the quality of the writing in the lesson plan.	3	"There should be a section on the quality of the writing"
Areas for improvement: Criteria for insufficient information: Comments in this theme indicated that there was a need for an additional level to indicate that the author did not include sufficient information.	3	"I do not think "Developing" means something was not done or addressed"
Areas for improvement: Include humanities: Comments in this theme indicated that in addition to the arts and sciences, humanities should be added as an area for integration.	3	"We need to include the Humanities in our interdisciplinary thinking"
Areas for improvement: Differentiated scores: Comments in this theme indicated that the reviewer wished for more nuanced score choices, expanding from three to more than three levels.	4	"This is one in where I might have wanted more score points than three"
Areas for improvement: Greater detail: Comments in this theme indicated that there was a need for greater detail in the descriptions within the rubric.	5	"Perhaps some explanations or exemplars to the rubric are required"
Areas for improvement: Integration of content: Comments in this theme indicated that there needed to be an additional criterion that evaluated the lesson's ability to integrate the content areas.	2	"It would be helpful for there to be a section that includes the proficiency of the integration of the concepts of STEAM into a unit"
Need for instruction or practice: Comments in this theme indicated that the rubric was more useful with practice.	3	"As I use the rubric, it becomes easier to navigate"

TABLE 9
Lesson Summaries

Lesson Title	*Grade Level(s)*	*Content Area(s)*	*Brief Description*
Cellular Ceramics	Middle grades	Visual Arts Life Sciences	Students observe cells through a microscope and then create ceramic cell tiles.
Creating an Acoustical Garden	Elementary	Visual Arts Music Physical Sciences	Students create musical instruments using clay.
3-D Mixed-Up Animals	Elementary	Visual Arts Life Sciences Language Arts	Students use texture and pattern to create collages of animals, write about their animals, and then convert to sculptures using a 3D printer.
Art in Motion: Kinetic Sculpture	Middle grades	Visual Arts Engineering	Students create sculptures based on engineering principles and design process.
Integrating with Ipcar	Primary grades	Visual Arts Life Sciences Math	Using informational text, and following an artist study, students create collages of animals, based on the style of Ipcar. Connections to geometry are made in the lesson.
Collaborative Construction: Building Bridges	Middle grades	Visual Arts Engineering Physical Science	Students use the design process to build bridges, which include both aesthetic and structural components for evaluation.
Understanding Physical Properties of Matter through Science/Art Connections	Primary grades	Visual Arts Physical Science	Students use visual arts and science concepts to explore the properties of matter, including the production of artwork, scientific investigations, and presentations to the group.
K–12 Imagine Mars	All levels	Visual Arts Language Arts Physical Science	In collaboration with partner institutions, these sets of lessons engage students in using drawing to understand science concepts. Students create 2D and 3D models to solve problems that might occur on Mars.
3rd Grade Dancing through Science	Elementary	Dance Life Science Physical Science	Students choreograph original dance pieces to demonstrate understandings in the science curriculum.

This diversity demonstrates that the high-quality STEAM lesson identified in this project spanned development levels, specific STEAM content area, as evaluated by expert reviewers.

Analysis of Reviews of Quality Lessons

Finally, the text of the reviews for the high-quality lessons was examined and eight themes were identified; see Table 10. These themes were identified across reviewers from all disciplines and across several lessons.

Collaboration Across Teachers

Reviewers identified that high-quality lessons included the cooperation of more than one teacher, across disciplines. For example, "Integrated lesson with teachers working together as collaborators across the curriculum" (science reviewer). Most often this collaboration included teachers from various disciplines (e.g., art and science). For some lessons, it also included more than one teacher from the same discipline (e.g., elementary art teachers).

Criteria for Assessment

Regarding assessment, reviewers indicated that high-quality lessons were explicit in how they evaluated and assessed student performance, including alignment to objectives and content standards. For example, "I love the connections to the criteria on the rubric" (practitioner reviewer). This also indicated that the teachers were able to articulate their assessment plan and align the assessment to their objectives, indicating a thoughtful and reflective process to their curriculum development.

Connections Between Content Areas

It is not surprising that high-quality STEAM lessons identified by our reviewers also included deep connections between content areas. These comments ranged from interdisciplinary to transdisciplinary approaches in the lessons. For example, "This lesson does a nice job of integrating art with natural and man-made materials" (science reviewer). Although this area was not directly measured by the rubric, the reviewers indicated that the integration of these meaningful content areas was highlighted in the highest rated lessons.

Deep Thinking

Reviewers also commented on the deep thinking skills that were elicited by many of the lessons. This took several forms within the lessons. Some comments required deep understanding of a content area, as in "This requires deep understanding of art content and design" (art reviewer). Others focused on the objectives and assessment of projects,

TABLE 10
Lesson Review Themes

Theme	*Description*	*Quote(s)*
Collaboration across teachers	This theme indicates that there were meaningful collaborations between teachers across content areas.	"Integrated lesson with teachers working together as collaborators across the curriculum" (science reviewer)
Criteria for assessment	This theme indicates the inclusion of specific criteria linked to the assessment within the lesson.	"I love the connections to the criteria on the rubric" (practitioner reviewer)
Connections between content areas	This theme indicates a deep connection between content areas.	"This lesson does a nice job of integrating art with natural and man-made materials" (science reviewer)
Deep thinking	This theme indicates ways in which deep thinking was elicited from students.	"This requires deep understanding of art content and design" (art reviewer) "Thinking skills reflected in the objectives … suggest the addition of a teacher-made product rubric including Thinking Skills" (science reviewer) "Multiple learning methods to allow for students' various learning modes" (art reviewer) "By asking students to demonstrate knowledge in a new media, the students must think deeply about the content area" (science reviewer)
Student reflection	This theme indicates the opportunities for student reflection within the lessons.	"[The lesson] included opportunities for reflection and revision" (science reviewer) "Multiple points on student engagement/self-led discovery" (art reviewer)
Creativity/imagination	This theme indicates the importance of creativity or imagination within the lessons.	"Unique art lesson using art content and inspiration without copying style but encouraging original thought" (art reviewer) "Students have some creative freedom" (teacher reviewer)
Student success	This theme indicates ways in which the reviewers noticed opportunities for student success.	"Students have many opportunities to be successful and a variety of ways to show what they have learned through art" (teacher reviewer) "This unit addresses all learners" (teacher reviewer)
Student collaboration	This theme indicates ways in which the reviewers noted collaboration among students.	"Good use of social constructivism" (teacher reviewer)

as in "Thinking skills reflected in the objectives … suggest the addition of a teacher-made product rubric including thinking skills" (science reviewer). Some included the multiple approaches to the instructional strategies, as in "Multiple learning methods to allow for students various learning modes" (art reviewer). Finally, others addressed the skills required in translating understanding across media, "By asking students to demonstrate knowledge in a new media, the students must think deeply about the content area" (science reviewer).

Student Reflection

Similarly, many of the high-quality lessons also included opportunities for students to reflect on their own progress and learning. This is related to a specific thinking skill, and metacognition is often cited as an important skill for self-regulated learning and assessment (e.g., Dinsmore & Wilson, 2016). Reviewers noted that one lesson "included opportunities for reflection and revision" (science reviewer) and another lesson contained "multiple points on student engagement/self-led discovery" (art reviewer).

Creativity/Imagination

Another deep-thinking skill that was noticed in several lessons by reviewers was the capacity for lessons to engage students in using creativity and imagination. For example, "Unique art lesson using art content and inspiration without copying style but encouraging original thought" (art reviewer) and, in another lesson, "Students have some creative freedom" (teacher reviewer). In addition to the deep thinking in the previous theme, this theme relates specifically to the divergent thinking that was elicited by the lessons.

Student Success

Reviewers also noted that the high-quality lessons had opportunities for students to be successful, addressing the needs of a variety of learners. For example, "Students have many opportunities to be successful and a variety of ways to show what they have learned through art" (teacher reviewer) and "This unit addresses all learners" (teacher reviewer). This theme related to how the teacher supported diverse students to be successful in the lessons.

Student Collaboration

Finally, many of the high-quality lessons had opportunities for students to collaborate with each other. Even when projects were completed individually, many of the high-quality lessons included components in which students worked together in critiques, brainstorming, or reflective activities. For example, "Good use of social constructivism" (teacher reviewer).

DISCUSSION

These results indicate the promise of this exploratory study for informing future research and the development of criteria for STEAM lessons. Although these lessons were not necessarily developed specifically for gifted learners, they are particularly suited for curricula designed for gifted learners, allowing for greater critical and creative thinking and the synthesis of ideas across disciplines. Specifically, these findings can help researchers develop and refine future instruments, identify high-quality STEAM lessons, and inform curricula for gifted learners in STEM fields.

Use of Rubric to Identify Effective Practices for STEAM Lessons

Related to the first research question, this study demonstrated the need for greater refinement and additions to the rubric used to evaluate STEAM lessons. In particular, future rubrics should include greater detail, relying less on the expertise of the reviewer and providing examples and/or descriptions for each criterion. Additionally, the rubric should allow for greater differentiation of scores, including scale points that provide for more nuances in scoring. In addition, there should be a scale point for insufficient information or not included, because some of the lessons did not address parts of the rubric. Although there was detail included about the fidelity of the lesson to art content areas and STEM content areas, reviewers would have liked to have been able to score the other content areas as well, including the humanities. Additionally, some reviewers indicated that there should be an additional criterion to measure the extent to which the content areas were integrated. This addition would align with the research regarding the nature of integrated curricula (e.g., Drake, 2007; Marshall, 2014). Finally, in future research, materials to train the reviewers and allow time for practice should be included.

Properties of Quality STEAM Lessons

Among the l0 lessons with the higher quality scores, there were no lessons written specifically for high school students. This may be due to the greater difficulty for high school teachers to collaborate and work across disciplines. The predominance of the visual arts in these lessons also indicates the overall trend for STEAM lessons to be more focused on the visual arts. However, experts in the musical and performing arts have also been involved in the STEAM movement, and the lessons using these areas demonstrate this trend as well.

In developing guidelines or recommendations for high-quality STEAM lessons, the themes identified by the reviewers could be used. For example, the themes regarding deep thinking, student reflection, creativity, and assessment all represent areas of lesson planning and curriculum that have long been documented as critical for success. The theme regarding the opportunities for all students to be successful could be further expanded to detail best practices for including gifted students, as well as students who have special needs or twice-exceptional students. Although collaboration, between both teachers and students, is not a necessary element for a successful STEAM lesson, it certainly should be noted that many successful lessons rely on the expertise of multiple teachers and the social aspects of students working together. Future research and professional development projects should work to define best practices in these regards as well.

Implications for Gifted Learners

The high-quality lessons identified in this study demonstrated key components for gifted learners, specifically, ways in which teachers of the gifted can best implement STEAM lessons into their curriculum. As stated by previous research, attention to the arts within STEM curricula for the gifted can provide educational benefits (e.g., Komek et al., 2015; Mann et al., 2011). When developing STEAM lessons, teachers of the gifted should be encouraged to collaborate with other teachers to ensure that meaningful content from both the arts and STEM fields is incorporated and integrated. In addition, specifically for gifted learners, deep thinking should occur at the intersection of these fields. Finally, the lessons should incorporate opportunities for creativity, imagination, and student reflection.

Limitations

Because this is an exploratory study, there are several limitations. Primarily teachers self-selected to participate in this study, submitting their highest-quality lessons to be evaluated. Therefore, the lessons included in the analyses are not representative of the quality of lessons across the country. In addition, there was relatively low interrater reliability across disciplines; therefore, further research should be conducted to develop more refined evaluation guidelines. Relatedly, the sample population is overrepresentative of art teachers compared to teachers from other disciplines. Thus, the results regarding effective practice may not fully include when arts are integrated into a science curriculum (as opposed to science integrated into art lessons). Finally, the findings may be due to the low levels of variability within the sample. With a larger and more diverse sample, there might be differences in lesson quality depending on teachers' experience and education level.

SCHOLARLY SIGNIFICANCE

This study has several aspects of scholarly significance, including both implications for research and practice. The study can inform future studies on STEAM instruction for gifted learners, providing methodologies to evaluate high-quality lessons and further refinement of the rubric. This research also demonstrates the unique perspectives of the various members of the review team, and future research might investigate the use of differentiated rubrics for the various areas of expertise. This study also has significance for classroom practice of teachers of the gifted and will be used to formulate recommendations for these teachers. This is of particular concern for gifted audiences, because gifted curriculum has historically focused on the development of critical and creative thinking and the connections across content areas.

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APPENDIX A: LESSON PLAN SUBMISSION FORM

Innovation Collaborative: Effective Practices Lesson Plans

Background Information:

Name: (Last, First)
Email Address:
School Name:
School District:
State:

Years Teaching:	Highest Degree:
□ 0–5 years	□ Associates
□ 6–10 years	□ Bachelor's (BA, BFA, etc.)
□ 11–15 years	□ Master's (MA, MAT, MEd, MFA, etc.)
□ 16–20 years	□ Doctoral (PhD, EdD, JD, etc.)
□ 20+ years	
Primary Role:	School Type:
□Classroom Teacher	□Public School (Neighborhood)
□Inclusion/Pull-out Teacher	□Public School (Magnet)
□Administrator	□Public School (Charter)
□Other: ____________	□Private School
	□Parochial School
	□Other: ____________

Grade level(s) that you currently teach: (check all that apply)

□Pre-Kindergarten	□ 4th	□9th
□Kindergarten	□5th	□10th
□ 1st	□6th	□11th
□2nd	□7th	□12th
□3rd	□8th	□Other: ____________

Content Area(s) of current teaching assignment: (check all that apply)

□ General Classroom (all subjects)	□ Art (Visual)
□ English/Language Arts	□ Music (Instrumental/Choral)
□ Science(s)	□ Performing Arts (Theater, Dance, etc.)
□ Mathematics	□ Foreign Language
□ Social Studies	□ Other: ____________

Lesson Overview

Lesson Plan Title: (25 words or less)

Description: (75 words or less)
Duration of Lesson:
□Warm-up Activity/Mini-Lesson
□1–2 Day Lesson
□Multi-day Unit
□Other: ____________
Target Grade Level of Lesson:
□Pre-kindergarten/Primary (PK–2nd grade)
□Elementary (2nd–4th grade)
□Upper Elementary (4th−6th grade)
□Middle Grades (6th–9th grade)
□Secondary (9th–12th grade)
□Advanced (11th–12th grade)
□Other: ____________
Curricular Areas: (check all that apply)

□ Visual Arts	□Earth Science	□ Mathematics
□ Music (Vocal and Instrumental)	□Life Science	□ Engineering
□ Theater	□Physical Science	□ Technology
□ Dance	□Social Sciences (Psychology, Sociology, etc.).	□ History/Civics
□ Media Arts	□Science (Other): ____________	□ English Language Arts
□Arts (Other): ____________		□ Foreign Language
		□ Other: ____________

Please describe how the content area(s) are represented and integrated:

Arts: (50 words or less)	Sciences/Math: (50 words or less)	Humanities: (50 words or less)	Other: (50 words or less)

Lesson Plan
List the lesson objectives, big ideas, and/or essential questions below: (100 words or less)
Which discipline standards were used in this lesson? (Check all that apply)
□Common Core Standards (http://www.corestandards.org/read-the-standards/)
□National Core Arts Standards (http://www.nationalartsstandards.org/)
□Next Generation Science Standards (http://www.nextgenscience.org/next-generation-science-standards)
□Other: ____________
List the specific standard(s) used in this lesson:
Example: NGSS MS-PS1-1. Develop models to describe the atomic composition of simple molecules and extended structures.
List the materials needed for the lesson:
Procedures/Instruction:
Describe (in detail) how this lesson was implemented, including the steps or order of the lesson.
Lesson Assessment
How did you evaluate/assess students in this lesson? (check all that apply)
□Informal
□Traditional test/quiz
□Essay or written response
□Product or Project with a rubric
□Observations
□Other: ____________
Describe your assessment procedures:
Based upon your assessments, explain your students' successes here. (You can consider the overall findings and/or antidotal examples.)

Lesson Details

Which *thinking skills* were elicited from students in this lesson? (check all that apply; see last page for definitions)

□ Finding/Clarifying the problem	□ Transforming/ Synthesizing	□ Responding
□ Acquiring necessary information	□ Comparing/ Contrasting	□ Reflection/ Metacognition
□ Generating ideas	□ Selecting/Evaluating best ideas	□ Changing Perspectives
□ Abstracting	□ Creating	□ Other:______

Please describe how you think this lesson was successful and/or why it represents best practices:

Thank you for your time!

APPENDIX B: THINKING SKILLS EXPLANATIONS

K–12 Effective Practices: Higher Level Thinking Skills

In most high-quality, effective lessons, it is typical to focus on one or two of these higher level thinking skills:

- Finding/clarifying a problem—*Students identify and then refine the problem.*
- Acquiring necessary knowledge—*Students locate and find relevant background information from meaningful and reputable sources.*
- Generating ideas—*Students brainstorm or list many ideas, sometimes the focus is on creative or unusual thoughts (creative thinking)*.
- Changing perspectives—*Students think about content and concepts in different ways or from different points of view.*
- Abstracting—*Students explore theoretical concepts and/or make generalizations from concrete experiences.*
- Transforming and Synthesizing—*Students modify and adapt ideas and content and/or combine disparate ideas together to form new conceptualizations.*
- Comparing/Contrasting—*Students explore similarities and differences between ideas, experiences, or content.*
- Selecting the best idea(s)—*Students select the idea(s) that solve the problem in a novel way, using a set of criteria.*
- Creating—*Students design, build, or invent something new based on what the student has learned or background knowledge*.
- Responding—*Students view other people's work or important concepts, knowing what to look for and how to make meaning. They see how the work or concepts connect to other subjects or their own lives and use criteria to evaluate the work.*
- Other ______________________________________

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