RESEARCH BRIEF 7

Open Portfolio Project

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Open Portfolio Project: Research Brief 7

SURVEY OF MAKERSPACES, PART II

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Makerspaces in the National Educational Landscape

As reflected in the prior research brief ("Survey of Makerspaces, Part I"), makerspaces are involved in offering a host of educational activities to a diverse range of youth. Today, policymakers, academics, and a number of educators find resonance with the larger Maker Movement and its potential to transform and extend existing educational efforts (Peppler & Bender, 2013). However, little is known about whether and to what extent makerspaces themselves align with such larger educational initiatives, including the STEM (science, technology, engineering, and mathematics), STEAM (Arts + STEM), and standards-based movements in education. This brief summarizes the responses to several sections of a broader survey (see Appendix B for a full copy of the survey) that was sent out widely to Maker Education Initiative youth-oriented sites and allied institutions and is the second part of a three-part series summarizing the survey results. The focus of this research brief is on how makerspaces align their organizations and programming, as well as the key skills and practices they attempt to cultivate in their spaces.

A Survey of Broader STEM Education Initiatives

We sought to better understand the extent to which makerspaces were aware of and aligned with the national educational initiatives in **Table 1**, listed in order of most prevalent to least well aligned and/or known among makerspaces.

TABLE 1: List of National Educational Initiatives and Percentage of Makerspaces Indicating Alignment

EDUCATIONAL INITIATIVE	PERCENTAGE OF SITES THAT INDICATE ALIGNMENT		
	YES	NO	NOT FAMILIAR
Science, Technology, Engineering, and Mathematics (STEM)	94%	6%	0%
STEM + Art = STEAM	89%	9%	2%
Technology Education	79%	9%	13%
Media Education	57%	15%	28%
21st-Century Community Learning Centers (21st CCLC)	51%	11%	38%
Next Generation Science Standards (NGSS)	49%	21%	30%
Career and Technical Education (CTE)	40%	31%	28%
Common Core State Standards (CCSS) in Mathematics	38%	36%	26%
Common Core State Standards (CCSS) in Language Arts	38%	43%	19%
Information and Communications Technology (ICT)	34%	26%	40%
100kin10	4%	34%	62%

The results indicated that 100% of the participating sites were well aware of the larger STEM movement, and the vast majority (94%) agreed that it was well aligned with the goals and offerings of their site. Further, the STEAM movement followed in a close second place, with 89% of sites stating that their sites and makerspace programming aligned well with this initiative. Additionally, a majority of sites reported aligning with Technology Education (79%), Media Education (57%) and 21st-Century Community Learning Centers (21st CCLC, 51%). Additionally, just under a half of the sites said that their spaces and programming seemed well aligned to the Next Generation Science Standards (49%) and larger Digital Integration Initiatives (49%). The remainder of the educational initiatives that we polled participants on seemed to resonate with less than half of the sites. However, some of these trends may be explained in large part because of the vast number of sites that were unaware of these initiatives.

Makerspaces and Next-Generation Science Standards in Science and Engineering

Nationally, there is a growing recognition of the Maker Movement's potential to transform how and what people learn in STEM fields. As President Obama stated in his remarks on the Educate to Innovate campaign:

> *I want us all to think about new and creative ways to engage young people in science and engineering, whether it's science festivals, robotics competitions, fairs that encourage young people to create and build and invent—to be makers of things, not just consumers of things* (Obama, 2009).

This orientation toward personal fabrication rather than blind consumerism is also seen as empowering people not just to seek out jobs in STEM or other creative fields, but to make their own jobs and industries, depending on their interests and the emerging needs they see in a rapidly changing society (Kalil, 2010). As such, we're seeing a growing number of makerspaces emerging in schools of engineering and computer science, encouraging a new studio-based approach to traditional STEM disciplines marked by open-ended approaches to learning, rather than traditional approaches that minimize hands-on instruction and more process-based types of learning experiences.

While the data in Table 1 indicates that just under half of the sites found general alignment with the Next Generation Science Standards (NGSS Lead States, 2013), another third of the respondents were not yet aware of the initiative, given that the standards are relatively new. Consequently, we sought to better understand whether and to what extent there was alignment with the core Scientific and Engineering Practices advocated in the standards. Importantly, these practices include: (1) defining problems (for engineering); (2) developing and using models; (3) planning and carrying out investigations; (4) analyzing and interpreting data; (5) using mathematics and computational thinking; (6) designing solutions (for engineering); and (7) engaging in argument from evidence, among others that applied more generally to science.

We then asked sites to reflect on the most recent month of their programs and how frequently their youth actively participated in each of the targeted practices (see **Table 2** for a full summary of results). In general, we found that the practices most aligned with fields of engineering were the most frequently reported and seemed to resonate with more than 40% of makerspaces. Such practices included problem definition and planning and carrying out investigations, as well as designing solutions to a specified problem or task. What was somewhat surprising in the results was how rarely sites cultivated mathematics and computational thinking practices, especially given the dominant role that computer programming plays in traditional maker activities. However, when relating back to the types of making and available tools described in Brief 1 ("A Networked Vision for Sharing and Documenting"), it does follow that few of the reported maker activities actually engage or necessitate coding. This mirrors the difficulties in creating coding communities among a host of prior efforts that are being addressed through

TABLE 2: Frequency of Sites Reporting Engagement in NGSS Science and Engineering Practices

	NEVER	1–2 TIMES PER MONTH	ONCE PER WEEK	MULTIPLE TIMES/WEEK
Define problems to investigate.	6.4%	21.3%	23.4%	**48.9%**
Develop and use models.	19.1%	38.3%	12.8%	29.8%
Plan and carry out investigations.	10.6%	29.8%	14.9%	**44.7%**
Analyze and interpret data related to their project.	25.5%	36.2%	17.0%	21.3%
Use mathematics and computational thinking.	4.3%	**40.4%**	31.9%	23.4%
Design solutions to a specified problem or task.	4.3%	12.8%	38.3%	**44.7%**
Engage in argument from evidence.	23.4%	**36.2%**	17.0%	23.4%

Note: *Bolded percentages indicate the modal or most common response.*

		NEVER	1–2 TIMES PER MONTH	ONCE PER WEEK	MULTIPLE TIMES/WEEK
THINK CREATIVELY	Elaborate, refine, analyze and evaluate their own ideas in order to improve and maximize creative efforts.	4.3%	27.7%	19.1%	**48.9%**
WORK CREATIVELY WITH OTHERS	Develop, implement, and communicate new ideas to others effectively.	2.1%	21.3%	25.5%	**48.9%**
	Be open and responsive to new and diverse perspectives; incorporate group input and feedback into the work.	8.5%	10.6%	27.7%	**51.1%**
	View failure as an opportunity to learn; understand that creativity and innovation is a long-term, cyclical process of small successes and frequent mistakes.	6.4%	14.9%	23.4%	**55.3%**
Note: *Bolded percentages indicate the modal or most common response.*					

		NEVER	1–2 TIMES PER MONTH	ONCE PER WEEK	MULTIPLE TIMES/WEEK
COMMUNICATE CLEARLY	Articulate thoughts and ideas effectively using oral, written, and nonverbal communication skills in a variety of forms and contexts.	8.5%	17.0%	19.1%	**55.3%**
COLLABORATE WITH OTHERS	Assume shared responsibility for collaborative work, and value the individual contributions made by each team member.	4.3%	17.0%	29.8%	**48.9%**
Note: *Bolded percentages indicate the modal or most common response.*					

TABLE 3 (TOP): Frequency of Sites Reporting Engagement in 21st-Century Creativity and Innovation Skills

TABLE 4 (BOTTOM): Frequency of Sites Reporting Engagement in 21st-Century Communication and Collaboration Skills

a number of new initiatives by Code.org and others.

Makerspaces and 21st-Century Skills

Based on our initial fieldwork and interviews, we wanted to acknowledge that makerspaces cultivate more than just STEM-related competencies and practices. Seeking to better articulate these understandings, we leveraged the work from the Partnership for 21st Century Learning (P21). P21 established a set of 21st-century knowledge and skills targeted at U.S. K–12 education, which can be accomplished by what is described as fusing the 3Rs (i.e., including traditional school subject areas like reading and mathematics) with the 4Cs, which include critical thinking, communication, collaboration, and creativity and innovation. We examined a selection from across the areas of learning and innovation skills in the P21 framework, including (1) creativity and innovation, (2) communication and collaboration, and (3) critical thinking and problem solving, as well as (4) life and career skills.

Learning and Innovation Skills: Creativity and Innovation

P21 identifies "creativity and innovation" as one of the core learning and innovation skill sets, which is well aligned with the Maker Movement and the works created by makers—ranging from fanciful steampunk works to the practical types of innovations used in hydroponics. Within the P21 creativity and innovation framework, we targeted four practices that we thought well aligned with the kinds of individual and collaborative capacities cultivated through making, including (a) elaborating, refining, analyzing, and evaluating ideas in order to improve and maximize creative efforts; (b) developing, implementing, and communicating new ideas to others effectively; (c) being open and responsive to new and diverse perspectives, incorporating group input and feedback into the work; and (d) viewing failure as an opportunity to learn, understanding that creativity and innovation is a long-term, cyclical process of small successes and frequent mistakes. **Table 3** displays the degree of resonance that sites felt with each of these four targeted practices, with nearly 50% of sites stating that they cultivate all four skills multiple times per week, demonstrating a high degree of alignment between this set of 21st-century skills and the goals and aims of the surveyed makerspaces.

Learning and Innovation Skills: Communication and Collaboration

Making oftentimes involves large and ambitious group projects that necessitate close collaboration and clear communication with peers and adults. This emphasis on communication and collaboration is another core area of the P21 framework. For the purposes of our survey, we identified two of the many areas of communication

and collaboration to see how well they resonated with makerspaces, including (a) articulating thoughts and ideas effectively using oral, written, and nonverbal communication skills in a variety of forms and contexts and (b) assuming shared responsibility for collaborative work and valuing the individual contributions made by each team member. **Table 4 (previous page)** displays the frequencies sites reported for each of these two targeted skills. Again, about half of the sites stated that they cultivated both targeted communication and collaboration skills multiple times per week, demonstrating a high degree of alignment between this set of 21st-century skills and the goals and aims of the surveyed makerspaces.

Learning and Innovation Skills: Critical Thinking and Problem Solving

Makers engage in interest-driven projects, encountering new and unique problems and necessitating innovative solutions. As such, we targeted two key areas of the P21 critical thinking and problem solving framework in our survey, including (a) using systems thinking to analyze how parts of a whole interact with each other to produce overall outcomes in complex systems and (b) solving different kinds of non-familiar problems in both conventional and innovative ways. The vast majority of sites reported cultivating systems thinking one or more times each week, as well as solving problems multiple times per week.

Life and Career Skills

Lastly, the P21 framework targets long-term life and career skills, seeking to address the need for youth to flexibly adapt to the changing demands of the workplace in the 21st century. We targeted two of the five areas of life and career skills outlined in the P21 framework, including flexibility and adaptability as well as initiative and self-direction. Within each of these areas, we targeted three to four areas that we thought pertinent to makerspaces, including (a) adapting to varied roles, jobs responsibilities, schedules and, context; (b) working effectively in a climate of ambiguity and changing priorities; (c) incorporating feedback effectively; (d) dealing positively with praise, setbacks, and criticism; (e) utilizing time and managing workload efficiently; (f) monitoring, defining, prioritizing, and completing tasks without direct oversight; and (g) going beyond basic mastery of skills and/or curriculum to explore and expand one's own learning and opportunities to gain expertise. Each of these skills

TABLE 5 (TOP): Frequency of Sites Reporting Engagement in 21st-Century Critical Thinking and Problem Solving Skills

TABLE 6 (BOTTOM): Frequency of Sites Reporting Engagement in 21st-Century Life and Career Skills

		NEVER	1–2 TIMES PER MONTH	ONCE PER WEEK	MULTIPLE TIMES / WEEK
USE SYSTEM THINKING	Analyze how parts of a whole interact with each other to produce overall outcomes in complex systems.	12.8%	17.0%	**42.6%**	27.7%
SOLVE PROBLEMS	Solve different kinds of non-familiar problems in both conventional and innovative ways.	6.4%	17.0%	27.7%	**48.9%**
Note: *Bolded percentages indicate the modal or most common response.*					

		NEVER	1–2 TIMES PER MONTH	ONCE PER WEEK	MULTIPLE TIMES / WEEK
FLEXIBILITY AND ADAPTABILITY	Adapt to varied roles, jobs responsibilities, schedules and context.	4.3%	29.8%	31.9%	**34.0%**
	Work effectively in a climate of ambiguity and changing priorities.	6.4%	23.4%	21.3%	**48.9%**
	Incorporate feedback effectively.	4.3%	17.0%	**42.6%**	36.2%
	Deal positively with praise, setbacks and criticism.	2.1%	14.9%	34.0%	**48.9%**
INITIATIVE AND SELF-DIRECTION	Utilize time and manage workload efficiently.	6.4%	12.8%	21.3%	**57.4%**
	Monitor, define, prioritize and complete tasks without direct oversight.	4.3%	25.5%	19.1%	**51.1%**
	Go beyond basic mastery of skills to explore and expand one's own learning and opportunities to gain expertise.	6.4%	25.5%	31.9%	**36.2%**
Note: *Bolded percentages indicate the modal or most common response.*					

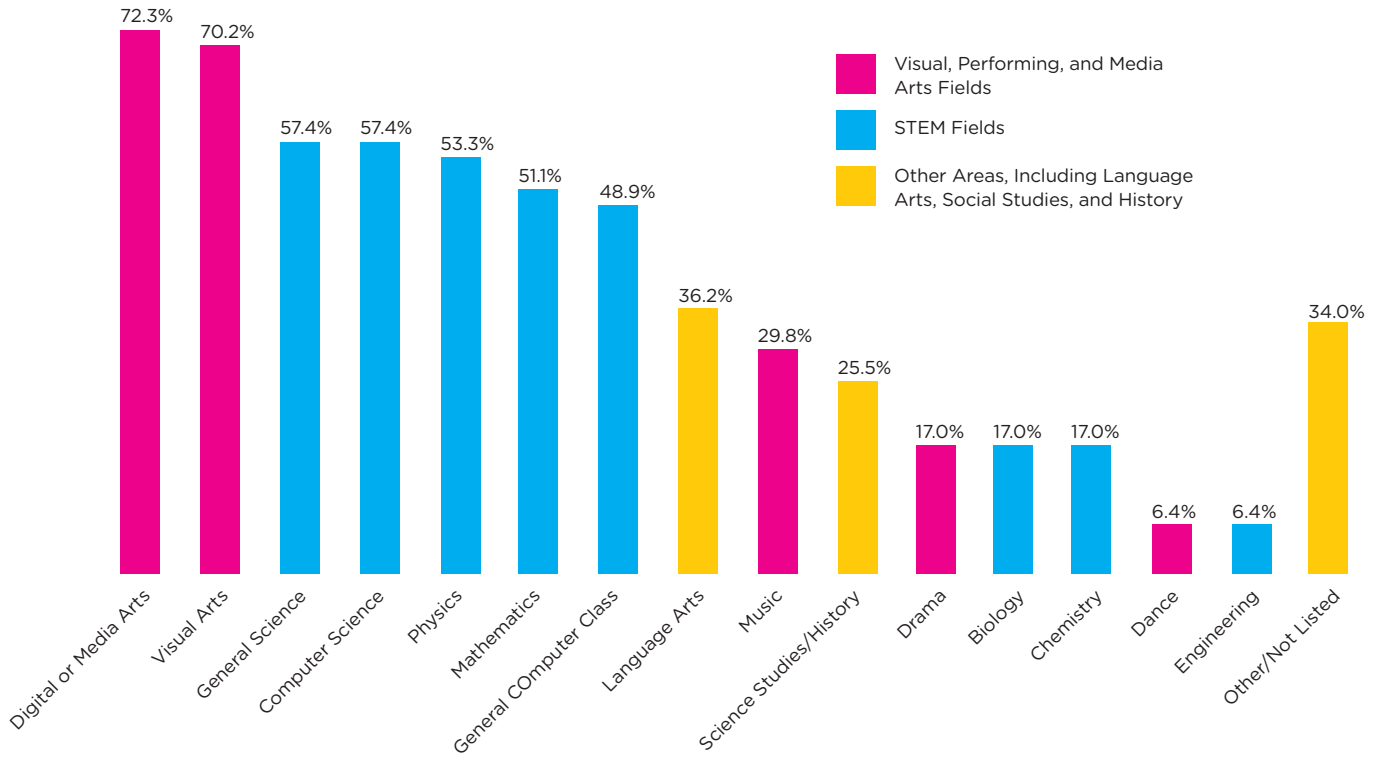

FIGURE 1: Makerspaces were asked that if their sites or programming were hypothetically to be offered during the school day, which subject areas would be offered. The percentages reported per subject are shown here.

was again reported by 50% or more of makerspaces as occurring one or more times each week. It is important to note that these skills stand in stark contrast to many educational spaces that value routine and rote memorization.

Making and Alignment with Traditional Subject Areas

To better identify where makerspaces situate in the current educational landscape, in a hypothetical scenario, we asked makerspaces that if their programs were offered in a school context, which subject areas or disciplines would most likely be offered. More than 70% of the sites replied that they would be situated in the digital, media, or visual arts, with a close second cluster found in STEM fields with sites citing general science, computer science, physics, or mathematics **(Figure 1)**. This mirrors the responses in Table 1, where sites most often replied that they would situate maker programming in STEAM and/or STEM education initiatives. In addition, sites also stated that their programming aligned with general computer class, language arts, music, social studies/history, drama, biology, chemistry, dance, and engineering as well as other areas not listed on the survey. The relatively small number of connections to engineering, we believe, is related to the fact that explicit engineering classes are currently less common in K–12 schools. The other areas that were not listed as part of our survey but noted by less than three of the respondents included: library research, practical art (which incorporates visual and digital arts with math and science), STEAM studio, innovation/tinkering time, vocational and crafting technologies, other STEM courses, technology education, robotics, world languages, media literacy/studies, stress management, and shop class/wood shop. Collectively, the survey responses paint a picture that making connects across all areas of the curriculum and is seen as particularly aligned to the arts and certain STEM fields. This aligns well with much of the public conversations about the potential of the Maker Movement to increase the STEM pipeline but also place an emphasis on the role of the arts in making.

Conclusion

Key questions that often swirl around making and learning relate to the ambiguity of making's benefits. Stakeholders, educators, parents, and administrators ask good questions, seeking evidence of its positive impact and alignment with necessary academic standards. Those who bring making into educational programming—and then proceed to transform the learning experience because of it—speak not only to the connection between making and numerous subject areas but also to the "soft," non-cognitive skills that are developed. These skills are the 21st-century skills

highlighted here that makerspaces report engaging in: creativity and innovation, communication and collaboration, critical thinking and problem solving, and adaptability. While a clear limitation of the current work is that these are all self-reports by site administrators, the results identify key areas and general framing that deserve further research to confirm and uncover the extent to which these practices and skills are cultivated.

In addition to associating closely with NGSS standards and a wide variety of traditional academic subject areas, it is perhaps most interesting that makerspaces connect to those 21st-century skills. The large, interest-driven, collaborative projects that makers engage in require the development of such skills. Coupled with the design and creation of a portfolio—which necessitates time for reflection, opportunity for clear expression of youth voice, and a showcase of abilities—making is helping to prepare youth for any life or career pathway.

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