The STEAM Journal

Volume 3
Issue 2 *Standing Still*

Article 8

December 2018

Design for STEAM: Creating Participatory Art with Purpose

Nick Kamienski
James Madison University

Nicole M. Radziwill
James Madison University

STEAM is a bi-annual journal published by the Claremont Colleges Library | ISSN 2327-2074 | http://scholarship.claremont.edu/steam

Design for STEAM: Creating Participatory Art with Purpose

Abstract
Innovation is simultaneously reflected in the variety and diversity of art. Over the past century, art forms have progressed along a continuum from static to dynamic, and then to interactive and participatory. The therapeutic value of creating and engaging in all of these art forms has also been identified. Furthermore, educators have recognized the profound value of art and design within the context of scientific and technical learning, and STEAM (science, technology, engineering, art, and math) has emerged as an educational philosophy with a strong base of support. This paper defines and articulates participatory elements of STEAM projects, and provides guidance for how to design art installations for learning that are fully participatory. To do this, we 1) present emerging social and organizational models that align with STEAM, and then 2) develop a design framework for creating new participatory art that meets the goals of STEAM learning.

Author/Artist Bio
Nick Kamienski graduated from the Department of Integrated Science and Technology (ISAT) at James Madison University in 2015 with a B.S. and is currently employed at CTI Consultants as a Field Inspector. Nicole Radziwill is an Associate Professor in the Department of Integrated Science and Technology (ISAT) at James Madison University (JMU) in Harrisonburg, Virginia. She is a Fellow of the American Society for Quality (ASQ) and is a Certified Six Sigma Black Belt (CSSBB) and Certified Manager of Quality and Organizational Excellence (CMQ/OE). She has a Ph.D. in Quality Systems, and her research uses data science to explore quality and innovation in cyber-human production systems. She is one of ASQ's Influential Voices and blogs at http://qualityandinnovation.com.

Keywords
design, innovation, participatory art, interactive art, STEAM, pedagogy

Cover Page Footnote
This project is the result of an undergraduate senior capstone project at XXX University. We are grateful to the many professors who were involved in providing incremental help and feedback along the way.

Design for STEAM: Creating Participatory Art with Purpose

Nick Kamienski & Nicole M. Radziwill

Introduction

Advancements in science and technology have routinely been expressed through art, creating a symbiotic relationship between the advancement of all three. Furthermore, scientific discovery leads to the development of new technology, and the creation of new art. STEAM (science, technology, engineering, art, and math) captures this dynamic interplay and helps raise awareness of its existence. But art has evolved from being static, to dynamic, to interactive, and finally to participatory. (Hu, 2013) Static art is unchanging, while dynamic art transforms based on environmental factors without user interaction. Interactive forms change based on the viewer's behavior and control of sensory input and only finds its final form as a consequence of that interaction (Kluszczynski, 2010).

Participatory art breaks down conventional notions of the viewer and artifact, facilitating interactivity that ultimately *becomes* the artistic experience, and demonstrating how cooperation and critical reflection contribute to value creation. This study provides a "Design for STEAM" canvas that incorporates guidelines, heuristics, metrics, and models to build agile learning environments from participatory art.

Background and Literature Review

Changes brought upon by rapid advancements in technology and globalization have increased the need for interdisciplinary approaches in education to stay competitive, leading to the rise of STEM (Science, Technology, Engineering and Mathematics) programs. But STEM does not always help students cultivate the creativity needed to solve complex problems. (Land, 2013) STEAM bridges this gap, studied as early as Yakman (2006) who has since trained teachers to implement STEAM globally (STEAM Education, 2016).

Engagement in STEAM

STEAM teaching should facilitate inquiry, encourage engagement, and challenge limitations. Artistic engagement in STEM encourages learners to interpret the material based on personal experience, thus increasing the value and intrinsic enjoyment of learning. (Land, 2013) It also supports customization and support of unique needs. (Connor et al., 2014) Creative exploration allows students to experience interrelationships between topics that are otherwise obscured, so STEAM learning fosters a more meaningful approach that empowers individual autonomy. It aligns with the social constructivist pedagogy, which emphasizes the pursuit of shared meaning. Through social construction of knowledge, learners can explore new ideas, pursue emerging paths, and reflect on how learning helps people fit into new social and professional roles. (Benton & Radziwill, 2011) Social construction of knowledge breaks down the conventional roles of teacher and student, and creates a network of empowered learners (Radziwill, Benton & Moellers, 2015). Active learning thus creates a personally relevant learning experience that *leverages* the aptitude inequality by encouraging collaboration as a means to grow, as interaction results from participation. (Kluszcynski, 2010; Zhao & Chen, 2013) Engagement is an ongoing process that increases stakeholders' desire to participate due to a renewed sense of agency.

(Marcum, 2013) The balance of participation, engagement, and agency leads to meaningful learning experiences in STEAM education.

Therapeutic Value of Art

Creating and engaging with art can improve health and wellness -- a balance of the whole person, which includes body, mind and spirit. (Hacker, 2012) To experience art means to *know* or to *reconnect with* a small part of oneself. Typically, therapeutic value emerges when art engages the sense of spirit, leading to a deeper personal understanding of self, others, or the environment. Finding purpose can clarify self-identity, enhance empowerment, and improve mental health and social inclusion. (Hacking et al., 2008) The Mental Health Foundation (2011), exploring the needs of the elderly who often suffer from social disconnectedness, discovered that participatory art can help them update their sense of self with positive attributes and improve their status and reputation in social groups. When artistic engagement has been applied as a treatment, studies (e.g. Stuckey, 2010) show that it can remedy stress, depression, and chronic illness. Virtual reality research (e.g. Rothbaum et al., 1995) also supports these findings.

Social and Organizational Models

Power structures have been long associated with competition and disengagement. But since the 1990's, new management concepts have emerged including transformation, experiential empathy, and co-creation of value (prosumerism) to enhance personal agency and co-ownership over competition. Transformation is a change in the fundamental nature of an organization, and is typically associated with discontinuous, high-impact improvements (Hacker, 2012) It requires purposeful change, catalyzed from within the changing systems, and is demonstrated when people start living according to new values (Joy, 2010).

Effective growth through transformation sometimes requires major shifts -- a *co-evolution* of staff, customers, and stakeholders – and always requires learning. These efforts are typically systematic and empowering. Change is simultaneously acknowledged by the learner, the individuals in the learning community, and even friends or family that the learner interacts with on a daily basis. (Henderson, 2002) Transformation shifts identities.

According to McGrath (2014), the idea from the early to mid-1900's of *organization as machine* is also shifting. By the 1990's, executives realized that managing knowledge was critical, and the concept of *organization as complex system* emerged. As a living organism, capabilities could be generated, shaped, and expanded. As intelligent systems gain traction we are once again at a crossroads where organizations must create complete and meaningful *experiences*. To do this, empathy is prerequisite. Humans thriving occurs by sharing ideas and cooperating to achieve shared goals, not by selfish hoarding of resources and power or eliminating competitors (Waal, 2009) – and traditional organizational models can *inhibit* empathy via the manufactured need to compete. These models are summarized in Table 1.

Organization	Purpose	Comparable Art Form
Organization as a **machine**	Create efficiency, consistency, and predictability	Static or dynamic
Organization as **collective knowledge**	Understand the environment and solve problems	Interactive
Organization as **experience factory**	Create complete and meaningful experiences	Participatory

Table 1. Organizations compared to types of art.

According to Heimans & Timms (2014), executive leadership is shifting as well -- from command and control to "new power" -- an open and participatory style, most effective when

knowledge and resources are allowed to flow freely. This represents the shift from competition and dominance to participation and collaboration, and is evident in the rise of crowdsourcing and increased promotion of co-ownership in design. (Howe, 2006)

Co-creation of value can also occur between the organization and its customers, strengthening alignment between company goals and customer needs. (Payne, 2007) This requires dynamic capabilities and personalization. (Prahalad, 2004) When value is jointly generated through mutually beneficial dialogue and exchange (Vargo, 2008), blurring the boundaries between producers and consumers (Ritzer, 2010), organizations can become more adaptable and resilient. (Payne et al., 2008)

The Agile Organizing Framework (AOF) can also inform STEAM artifact design. (Benton & Radziwill, 2011) AOF promotes social creation of knowledge through engagement and experience, reducing inequality in student abilities through active learning environments, and growing knowledge through inquiry-based problem solving and ongoing reflection. Based on AOFs key principles (Vidgen & Wang, 2009), STEAM efforts should promote collective mindfulness and active team-based learning, change management should accommodate differences in how quickly adaptation occurs, and student autonomy should be honored. The learning environment should provide material and help the learner create new learning paths.

Methodology and Results

This study applied *design science* to create a "Design for STEAM" canvas by: 1) identifying a structure by studying **Design for X** (DfX) tools, 2) exploring guidelines associated with **Participative and Participatory Design**, and 3) conducting an **Affinity/Pareto Analysis** to identify success factors based on Radziwill et al. (2015). The final step, extracting applicable

guidelines and heuristics from the literature review, is covered in Section 4 with the canvas.

Design is a process that separates professions and trades from the sciences (Glasser, 1976) and aligns problems with appropriate solutions. Outcomes include material artifacts, remedies, improvements, strategies, and plans that can generate new knowledge and catalyze innovation. (Vaishnavi & Kuechler, 2004). Design can also be used for optimization, because insights lead to a richer understanding of how a system can function according to its purpose. *Design science* formalizes the creation of artifacts to solve design problems (Hevner, 2004; Anderson et al., 2011). Design for X (DfX) tools can be used to improve quality, reduce costs, and enhance productivity and efficiency (Eastman, 2012). These include Design for Manufacturing and Assembly (DFMA), Design for Sustainability (DfS), and Design for Reliability (DfR). They share common elements that help establish a sense of purpose and an emphasis on shared goals: **guidelines and heuristics**, **checklists**, **metrics**, **methods**, and **mathematical models** (Chiu & Okudan, 2010).

Participative design focuses on quality and process improvement by breaking down bureaucracy in favor of more democratic processes. Participatory design, in contrast, is more like co-creation of value or prosumerism because it involves customers and/or stakeholders in the design process. Proponents of participative design argue that tapping into the full mental capacity of the workforce is the key to quality improvement, but these efforts fail when responsibility is not truly shifted. An entrenched hierarchy prevents the self-management necessary to foster democratic decision making. (Emery, 1995) For optimal success, participative design says that who *does* the work should *design* the work. Participative design and participatory design are both broadly motivated by enhancing agency. They both expose the necessity for individual empowerment and inclusion through engagement, leading to better results. (Holmlid, 2012)

The Explanatory Sequential mixed methods approach was used to identify, rank, and evaluate the critical elements for scaling. (Figure 2). A group of 12 students and faculty who had built participatory art projects using technology gathered to create an affinity map. (Figure 3) The prompt was: "What factors influence the success of a participatory art project as it is being scaled from idea to broad availability?" They arranged factors into themes, and weighted them with scores from 1 (low importance) to 10 (high importance). Pareto analysis (Figure 4) highlighted the "vital 20%" of key factors, drawn from goals emerging from design philosophy, logistical concerns, and fitness for use. (Radziwill & Simmons, 2012) Takeaways were: 1) a **default activity** should be defined, with opportunities for sub-activities, 2) a **social element** should be integrated to encourage participation and self-reflection *beyond* the time and spatial bounds of the experience, 3) a **data collection element** should be integrated at the end to foster reflection, and 4) a **feasibility** check should be performed to make sure that the designed experience can support the volume of participants expected (e.g. personnel, materials, energy requirements).

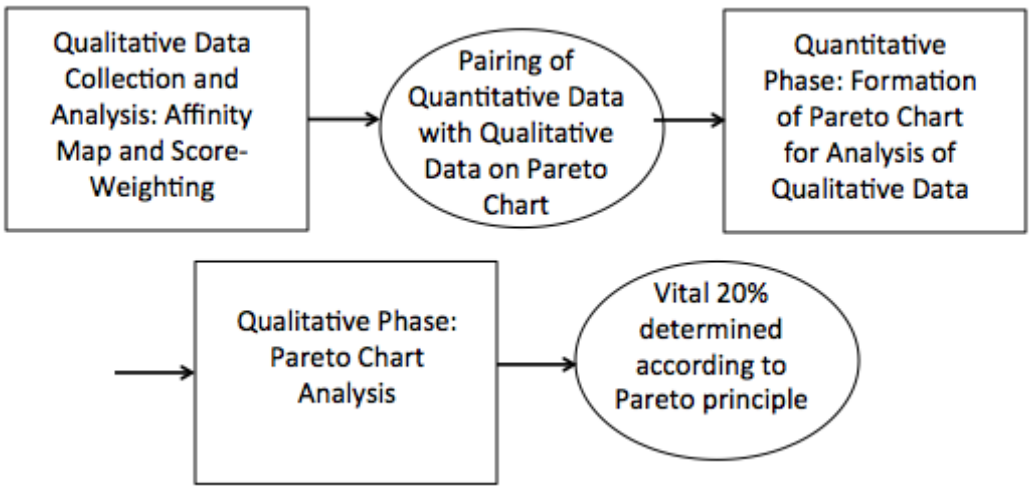

Figure 2: Explanatory Sequential Design approach.

Affinity Diagram of Features and Factors Necessary and Desired to Scale Participatory Art

Level of fitness for end use		Large-scale logistical concerns		Goals Emerging from Design Philosophy		Support		Known Need for Improvement		User experience	
Data acquisition technology	3	Consensus on final dimensions	3	Simple social platform to encourage long-term participatory engagement	5	Management of data acquired from acquisition	2	Pedagogical benefits are clearly expressed by art artifact	6	Possibility of saving digital media snippet to reflect on past participatory experience	2
Consensus on a permanent location of the artifact	4	Durability testing of the scaled-up, final structure	4	Catalyze critical reflection of self-identity through participation	6	Knowledge diffusion of the artifact among possible initial adopters	3	Purposeful incorporation of disparaged groups	4	Ability for user to adjust technical aspects of the tool for educational purpose	4
Prosumer approach at identifying lateent needs	5	Normal energy usage calculations	3	Default activity defined and prominently displayed to guide inexperienced users to participate	7	Knowledge of similar projects in academia	2	Introduction of flexibility in function to increase adaptive potential	5		
Identification of barriers to engagement or social interaction	5	Look into feasibility of sizing needed for scaled-up technical components	5	Critical exerecise to foster refelection on the experience directly after participating	7	Financial or organizational support from a third party that believes in the goals of the project	5				
		Research into possible better technological tool alternatives	4								
	17		19		25		12		15		6

Figure 3: Affinity map used in the first stage of analysis

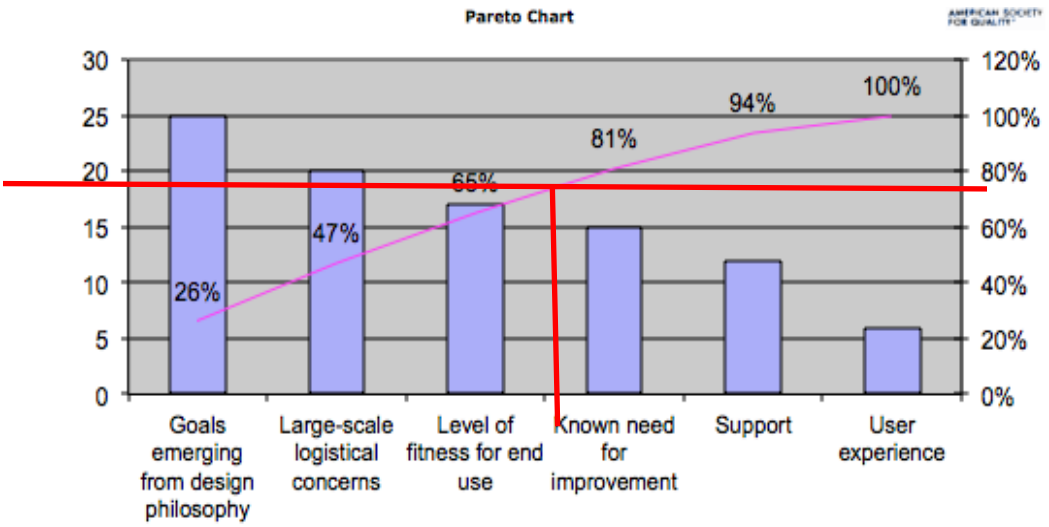

Figure 4: Pareto analysis

Integration of Elements into "Design for STEAM"

Participatory art for STEAM should:

- Create unique, meaningful experiences balancing participation, engagement, and agency
- Stimulate self-inquiry, raise questions about how the individual sees him or herself
- De-emphasize competition and dominance in favor of co-creation
- Strengthen self-identity by enabling individual creative exploration
- Be emergent: art finds its final form only after dialog between consumer/prosumer
- Honor personal agency for the co-creator/participant
- Adapt to their changing needs and level of understanding
- Provide opportunities for pursuing new knowledge and deepening existing knowledge.

We organized these into design heuristics using Simon's (2010) principles for participatory art (Table 1). Engagement metrics for each element should go beyond participation and capture the changes and transformations that occur as a result of participating in an experience. Tseng (2012) surveyed 95 organizations and recommended: percent of participants satisfied with experience, growth of sponsorship or donations as result of experience, proportion of new programming, percent of participants who report an enhanced image of the collaborators or contributors, and frequency of repeat participation.

Participants can also be asked to list which aspects they enjoyed the most, and why; whether the experience enhanced their knowledge, interest, or appreciation; whether knowledge or understanding of foreign cultures was enhanced, whether they experienced beauty and awe; and whether they would return.

	Heuristics		
	Empower Individuality	**Convey Knowledge Clearly and Concisely**	**Foster Valuable Social Interactions Between Participants**
Collaborators & Creators	• Make visitors feel they are owners of their own experience • Promote activities that require reflection on self-identity	• Establish clear criteria for rules of engagement • Option of participation very clear to individual	• Support continuous feedback and contributions • Get in the mindset of the institution (culture) • Solicit community engagement
Contributors	• Provide many optional individual actions that can lead to social experience • Create opportunities for visitors to add work that is useful to the institution	• Profile-making activities • Scaffolding activities so that the experience itself determines final results	• Incorporating personalization techniques for social discussion • Motivating interpersonal discussion around an object
Co-Creators	• Create activities where data analysis activities are open to visitors	• Serve custom content through a platform	• Ensure exhibition activities aren't too prescriptive

Table 1. Strategies for Participatory Design Using Simon's Models and Heuristics.

Creative data acquisition can be embedded within the experience itself, for example, determining the proportion of visitors who leave a contribution (e.g. a response to a guided question left on a public board for others to see). It can be combined with other goals, for example, encouraging visitors to help keep a museum clean by depositing their entrance passes in bins that correspond to survey questions, or "filling out a survey item" by walking through a labeled door or opening (Simon, 2010). Another idea is to gauge a participant's positivity (Fredricksen, 2009) before and/or after the experience. Integrating these findings, Design for STEAM (Table 2) is proposed to facilitate planning, foster engagement, establish inquiry-based and active learning, and cultivate new power models that demonstrate empathy and catalyze the free flow of ideas. Although important, feasibility and models (e.g. cost reduction, optimization of engagement) were not explored. These could be addressed in future research to enhance the value of the canvas.

1. Identify Default Activity ● What is the primary experience you want co-creators/participants to have? ● What do you want co-creators/participants to *leave behind*… to create, improve, or expand? ● What questions do you want your experience to stimulate for your co-creators/participants?	**2. Identify Sub-Activities** ● What activities could the co-creator *choose* to become engaged in *after* being exposed to the default activity? ● How will co-creators know those choices are available? How will they make the decision to engage in the sub-activity, or return to the main activity?
3. Define Value Propositions ● What specific benefits will be part of the experience? ○ For Collaborators/Creators ○ For Contributors ○ For Co-Creators/Participants ● What benefits would you like to provide after participants reflect on the experience? ○ For Collaborators/Creators ○ For Contributors ○ For Co-Creators/Participants	**4. Select Metrics/Develop Data Collection** ● What data can you collect to ensure that value is delivered? ○ From/about Collaborators/Creators ○ From/about Contributors ○ From/about Co-Creators/Participants ● What data can you collect to monitor and catalyze *intellectual* growth? ● What data can you collect to monitor and catalyze *personal* growth?
5. Explore Social Features ● How can you help participants connect with each other, during and after the experience? ● Can you leverage pre-existing social connections to enrich the experience? ● How can you use social connections to catalyze intellectual growth? ● How can you use social connections to catalyze personal growth?	**6. Explore Personalization Features** ● How can you adapt the experience to an individual's expectations? ● How can you adapt the experience to an individual's preferences (e.g. social, sensory environment)? ● What additional information can you capture to provide a more customized experience? ● How will you disclose to co-creators what information is being stored/used to customize the experience for them (informed consent)?

Table 2. "Design for STEAM" Canvas

References

Anderson, J., Donnellan, B., & Hevner, A. (2011). Exploring the Relationship between Design Science Research and Innovation: A Case Study of Innovation at Chevron. *Practical Aspects of Design Science,* 116-131. doi:10.1007/978-3-642-33681-2_10

Benton, M. C., & Radziwill, N. M. (2011). A Path for Exploring the Agile Organizing Framework in Technology Education. *IEEE*, 131-134. doi:10.1109/AGILE.2011.51

Chiu, M. C., & Okudan, G. E. (2010, January). Evolution of design for X tools applicable to design stages: a literature review. *ASME 2010 International Design Engineering Technical Conferences and Computers and Information in Engineering Conference* (pp. 171-182). American Society of Mechanical Engineers.

Connor, A. M., Karmokar, S., Whittington, C., & Walker, C. (2014). Full STEAM Ahead: A Manifesto for Integrating Arts Pedagogics into STEM Education. *International Conference On Teaching, Assessment and Learning (TALE), 2014,* 319-326. doi: 10.1109/TALE.2014.7062556

Creswell, J. W. (2015). *A Concise Introduction to Mixed Methods Research*. USA: SAGE Publications.

Eastman, C. M. (2012). *Design for X: Concurrent engineering imperatives*. Springer Science &

Business Media.

Emery, F. (1995). Participative design: Effective, flexible and successful, now! *The Journal for Quality and Participation, 18*(1), 6. Retrieved from http://search.proquest.com/docview/219143329?accountid=11667

Fredrickson, B. (2009). Positivity. Harmony Press.

Glaser, R. (1976). Components of a Psychology of Instruction: Toward a Science of Design. *Review of Educational Research, 46*(1), 1-24. Retrieved from http://www.jstor.org/stable/1169916

Hacker, S. (2012). Change Ability: Individual transformation is the key to organizational improvement. *Quality Progress*.

Hacking, S., PhD, Secker, J., PhD, Spandler, H., PhD, Kent, L., Cert Ed, & Shenton, J. (2008). Evaluating the impact of participatory art projects for people with mental health needs. *Health & Social Care in the Community, 16*(6), 638-648.

Heimans, J. & Timms, H. (2014). Understanding "New Power." *Harvard Business Review*. Retrieved from https://hbr.org/2014/12/understanding-new-power.

Henderson, G. (2002). Transformative Learning as a Condition for Transformational Change in

Organizations. *Human Resource Development Review, 1*(2), 186-214. doi:10.1177/15384302001002004

Holmlid, S. (2012, September). Participative; co-operative; emancipatory: From participatory design to service design. In Conference Proceedings ServDes. 2009; DeThinking Service; ReThinking Design; Oslo Norway 24-26 November 2009 (No. 059, pp. 105-118). Linköping University Electronic Press.

Howe, J. (2006). The Rise of Crowdsourcing. *Wired Magazine,* (14).

Hu, J., Wang, F., Funk, M., Frens, J., Zhang, Y., Van Boheemen, T., Rauterberg, M. (2013). Paticipatory Public Media Arts for Social Creativity. *International Conference on Culture and Computing*.

Joy, L. (2002). Individual and Societal Transformation: The Connection. *Quaker Institute for the Future*. Retrieved from http://www.quakerinstitute.org/wp-content/uploads/2010/04/joyTransformation.pdf

Kluszczynski, R. (2010). Strategies of interactive art. *Journal of Aesthetics and Culture, 2*.

Land, M. (2013). Full STEAM Ahead: The Benefits of Integrating the Arts Into STEM. *Procedia Computer Science, 20*, 547-552. doi:10.1016/j.procs.2013.09.317

Manney, P. (2008). Empathy in the Time of Technology: How Storytelling is the Key to Empathy. *Journal of Evolution and Technology, 19*(1), 51-61. Retrieved from http://jetpress.org/v19/manney.htm.

Marcum, J. W., PhD. (2013). Engagement Theory. Retrieved from http://jameswmarcum.com/engagement-theory/

McGrath, R. (2014). Management's Three Eras: A Brief History. *Harvard Business Review*. Retrieved from https://hbr.org/2014/07/managements-three-eras-a-brief-history/.

Mental Health Foundation. (2011). An Evidence Review of the Impact of Participatory Arts on Older People. *Mental Health Foundation*.

Payne, A., Storbacka, K., & Frow, P. (2008). Managing the co-creation of value. *Academy of Marketing Science,* (36), 83-96. doi:10.1007/s11747-007-0070-0

Prahalad, C. K., & Ramaswamy, V. (2004). Co-creation Experiences: The Next Practice in Value Creation. *Journal of Interactive Marketing, 18*(3). doi:10.1002/dir.20015

Radziwill, N. M., & Benton, M.C. (2016). Design for X (DfX) in the Internet of Things (IoT).

Radziwill, N. M., Benton, M. C., & Moellers, C. (2015). "From STEM to STEAM: Reframing What it Means to Learn," *The STEAM Journal*: Vol. 2: Iss. 1, Article 3. DOI:

10.5642/steam.20150201.3

Radziwill, N. M. & Simmons, R. (2012). Quality Tools for Problem Solving. *Quality and Innovation*.

Ritzer, G., & Jurgenson, N. (2010). Production, Consumption, Prosumption: The nature of capitalism in the age of the digital 'prosumer'. *Journal of Consumer Culture, 10*(1), 13-36. doi:10.1177/1469540509354673

Rothbaum, B., PhD, Hodges, L., PhD, Kooper, R., Opdyke, D., Williford, J., & North, M. (1995). Effectiveness of computer-generated (virtual reality) graded exposure in the treatment of acrophobia. *The American Journal of Psychiatry*, *152*(4), 626-628. http://dx.doi.org/10.1176/ajp.152.4.626

Simon, N. (2010). *The Participatory Museum*. CreateSpace (Amazon) Publishing.

STEAM Education. (2016, March 13). Georgette Yakman's Professional Biography - Short. Retrieved from http://steamedu.com/wp-content/uploads/2014/01/GYakmanProBioShort13Mar2016.pdf

Stuckey, H., & Nobel, J. (2010). The Connection Between Art, Healing, and Public Health: A Review of Current Literature. *American Journal of Public Health, 100*(2), 254-263.

Tseng, S. (2012). Current Practices and Trends in the Use of Key Performance Indicators in the Arts. Changing the Game: Strategic Thinking for Creative Organizations. Cultural Leadership Summit, Hong Kong. Retrieved from http://www.hkaaa.org.hk/uploads/hkaaa/201207/20120703_154848_H2OoBBvxY0_f.pdf

Vargo, S., Maglio, P., & Akaka, M. A. (2008). On value and value co-creation: A service systems and service logic perspective. *European Management Journal, 26*(3), 145-152. doi:10.1016/j.emj.2008.04.003

Vidgen, R., & Wang, X. (2009). Coevolving systems and the organization of agile software development. Information Systems Research, 20(3), 355-376.

Waal, F. B. (2009). *The age of empathy: Nature's lessons for a kinder society*. New York: Three Rivers Press.

Williams, R. (2009). Are We Entering the Age of Empathy? *Psychology Today*. Retrieved from https://www.psychologytoday.com/blog/wired-success/200910/are-we-entering-the-age-empathy.

Zhao, J., & Chen, Z. (n.d.). *Participation and Interaction: The Theory and Practice of China's Diplomacy*. World Scientific.