

**Professional Development Opportunities
for Informal STEM Learning Professionals**
A Symposium for NARST 2020
(conference cancelled)

Presenters: Martin Storksdieck, Jill K. Stein, Rebecca D. Swanson, Lynn Uyen Tran, Preeti Gupta, Ardice Hartry, Danielle B. Harlow, Ron Skinner, Sinead Brien, and Micaela Balzer

Abstract: In order to engage visitors, guests, participants or audiences in positive STEM learning experiences, informal learning institutions need professionals who understand how to design for and facilitate engaging activities. Initial professional training for informal STEM educators, and subsequent ongoing professional learning create considerable challenges. There is a need for providing informal STEM educators with pathways to professionalization that guarantee high quality educators who can support successful informal STEM education. In this symposium, we propose to share research on key aspects of training and developing informal STEM learning professionals, including a framework to identify and support job competencies and knowledge gaps, results of a study on museology programs, as well as multiple models for ongoing professional development. Our intent is to share an overview of the state of the field and current tools and programs for supporting this population of education-focused professionals, while also providing an opportunity to debate and discuss next steps in the field around standards and expectations and related opportunities for ongoing professional learning.

Symposium Statement of Problem

There is a rising acknowledgment in both research and practitioner settings, over the last 15 years, that people learn about science, technology, engineering, and math [STEM] not only in school classrooms, but also in informal settings such as museums, aquariums, botanical gardens, after-school programs, summer camps, and in the course of everyday lives (Falk & Dierking, 2012; Feinstein & Meshoulam, 2014; National Research Council [NRC], 2009; Rennie, 2014). Key to the quality of out-of-school time STEM learning are the informal STEM learning [ISL] professionals who design and facilitate visitor experiences (NRC, 2015; Peter, 2009).

ISL professionals often enter the field through a variety of pathways that do not include formal training in best practices of teaching and learning in general, and even less so in “teaching” or learning in informal or out-of-school settings or in free-choice learning (Tran, 2008; Sacco, 2013). Those entering the field of informal STEM learning not only come from a wide array of professional backgrounds, but also have few opportunities for pursuing a formal trajectory towards professionalization of the field (Tran, 2019). Opportunities for professional growth have often been limited to short-term trainings and workshops, shadowing/apprenticing, conferences and other professional meetings, and a small number of undergraduate and graduate courses and degrees that tend to be limited to museum and museum-like settings. Rare are institutional support mechanisms for the type of long-term, reflective, situated professional growth models that support deep and sustained learning opportunities in a profession (Ash, Lombana, & Alcalá, 2012; Swanson, 2018; Tran, 2019)

There is a robust lineage of research on the benefits of professional development for education professionals who teach in formal (e.g., K-12, post-secondary) contexts (Desimone, Porter, Garet, Yoon, & Birman, 2002; Luft & Hewson, 2014), but far less research focusing on professional development opportunities for informal STEM professionals (Ash & Lombana, 2012;

Bevan & Zanthadouki, 2008; NRC, 2015, Peter, 2009; Tran, 2019). While being cautious about claiming that what is beneficial for formal education professionals also applies to ISL professionals, the relative lack of research in this area indicates a need to identify, provide, and study professional development models for this emerging class of professionals.

In order to engage visitors, guests, participants or audiences in positive STEM learning experiences, informal learning institutions need professionals who understand how to design for and facilitate activities that “engage”, i.e., that are enjoyable as well as educational (Packer, 2006). While a growing body of research (NRC, 2009) is beginning to suggest best or evidence-based practices in out-of-school STEM learning (NRC, 2015), there is little evidence that professionals benefit from this knowledge. While there are a variety of programs that provide initial training for museum professionals (Tran, 2019), far fewer opportunities exist for training professionals more generally in the field of informal or free-choice (STEM) education. Providing quality opportunities and professional trajectories to support the professional development needs of this population is nonetheless an important aspect of supporting and developing quality out-of-school time programs (NRC, 2015). Initial professional training for teachers, and subsequent ongoing professional learning create considerable challenges (NASEM, 2015), yet becoming and remaining an informal science or STEM educator may pose even bigger problems: expectations for creating highly engaging, yet educationally valuable experiences are high, while remuneration and working conditions are generally not comparable to those of school teachers. Still, there is a high need for providing informal science educators with pathways to professionalization that guarantee high quality educators who can support successful informal STEM education (NRC, 2015).

In this symposium, we propose to share research on key aspects of training and developing ISL professionals, including a framework to identify and support job competencies and knowledge gaps, results of a study on museology programs, as well as multiple models for ongoing professional development. Our intent is to share an overview of the state of the field and current tools and programs for supporting this population of education-focused professionals, while also providing an opportunity to debate and discuss next steps in the field around standards and expectations and related opportunities for ongoing professional learning.

Symposium Structure

Each topic, representing current work in the field of professionalization of ISLs and described in detail in subsequent sections of this proposal, will be briefly presented by a panel member (10 minutes or less). Following these short presentations, we will facilitate a panel discussion (30 minutes or more) on current and future goals for this area of research and practice. The panel discussion will be moderated, and there will be ample opportunity for audience participation in the discussion.

Panel Member Topics

1. Measuring Professional Advances in ISL: Framing the Discussion
2. The Role of Museology Programs for Creating New ISL professionals
3. Transforming the Field Towards Professional Learning
4. Training the Next Generation of Informal Educators Through a Museum-University Research Practice Partnership
5. Shifting Teaching Practices of Informal STEM Educators in an Online Collaborative Professional Learning Community

6. Supporting Equitable Teaching Practices Through Research Practice Partnerships: Insights into the Practice of Sharing Authority

Panel Member Topic 1 - Measuring Professional Advances in ISL: Framing the Discussion

Authors: Martin Storksdieck, *Oregon State University*

Nancy Staus, *Oregon State University*

Professionals in Informal Science Learning (ISL) enter the field through a variety of pathways that may not include training in informal STEM learning (Tran, 2008; Sacco, 2013), and may not be fully aware of the large body of work that exists in informal or free-choice (STEM) education (e.g., Falk & Dierking, 2019; NASEM, 2018; NRC, 2009; 2015). In response to this problem, over the last three years, a team of ISE professionals under the leadership of the Association of Science-Technology Centers developed an evidence-based informal STEM learning Professional Framework, based on a structured empirical process that reveals what professionals in science centers, science and natural history museums or children’s museums actually do when performing their job-related tasks. The goal was to create a Professional Framework that professionals and institutions could use as a tool for individuals, institutions, and organizations to understand, plan, and advance their professional capacity in the field of informal STEM learning. Individuals can use the framework to assess their current competencies and to identify the competencies they want to develop. Institutions can use the framework to plan professional development for staff or develop job descriptions.

The Framework represents four domains of competencies: two centered on understanding the ways institutions work in the ISL field (Institutional Operations and Institutional Impact), and two domains focused on the various ways individuals work within institutions (Job Specific Expertise and General Expertise). Each domain includes four core competencies and illustrates how each competency might develop across the continuum of a career. For example, in the Institutional Impact domain under the core competency “Audiences”, Level 1 (early) professionals are expected to “Identify intended and achieved outcomes for my area of work that align with an understanding of visitors”, Level 2 (middle) professionals are expected to “Identify intended and achieved outcomes for my institution that align with an understanding of my community and of the ISL field”, and Level 3 (advanced) professionals are expected to “Advance the aspirations of outcomes that align with an understanding of society and the ISL field.” Another example: One competency (Structure) within the Institutional Operations domain progresses from “Understand and navigate the organizational structure of my institution” to “Influence and shape the structure and operation of my institution” and finally “Create or contribute to organizational structures that are effective within the ISL field”.

Feedback on the use and usefulness of the Framework from ISE professionals from a national survey and a series of focus groups revealed the need for specific examples of the domains and competencies, and moreover, clear indicators on when those competencies are being reached. “Performance indicators” would be needed for self-assessment and supervisor reviews, but could also inform university-based training programs or ongoing learning opportunities. In this conversation we will provide examples of performance indicators, and will discuss the inherent tensions that arise when broad descriptors of competencies are reduced to indicators and associated measures. Just as when guidance for “what will be on the test” runs the risk of narrowing the enacted curriculum to test-performance enhancing exercises, providing indicators for professional growth may be misconstrued as implicit curriculum or misinterpreted as the only

way to progress in ISE. We will provide alternative concepts that balance the demand for indicators with the need for flexibility in understanding performance in ISE.

***Panel Member Topic 2 - The Role of Museology Programs for Creating New ISL Professionals:
Results of a Nationwide Study.***

Authors: Jill Stein, *JKS Consulting*
Mika Cohen Jones, *independent consultant*

Overview - Commissioned by the University of Washington's Museology Graduate Program, a landscape study of museum studies graduate programs and the museum field more broadly was conducted by JKS Consulting, from September 2017 to June 2018 (Stein & Cohen Jones, 2019). The study aimed to better understand the overall alignment between museum studies graduate programs and the needs of museum institutions, the overall value of a museum studies degree, and the critical issues facing museum studies programs and the museum field as a whole. While not specifically limited to ISL professionals, results from the study provide insights into issues related to training informal learning professionals, broadening participation in the field, and addressing critical issues in society more broadly.

Methods - The study consisted of four phases as follows: 1) an online survey with a subsample of graduate programs in museum studies, museology, and closely related fields (n=25), which surveyed program directors around each program's purpose, goals, and mission; curriculum focus; size and breadth of the program; and information around the students applying to and attending the program ; 2) an online survey of museum leaders (n=93), followed by a subset of semi-structured, qualitative interviews (n=15), which together aimed to better understand the skills and knowledge areas seen as important for different museum professions, as well as level of career (early/mid-career vs. advanced), and the unique value of a museum studies graduate degree compared to other possible pathways into the museum field; 3) an online survey of program alumni from 2006-2013 (n=53), which focused specifically on important skills and knowledge areas gained from the program, the value of the degree in their professional pathways, and recommendations for strengthening the program; and 4) an expert review from thought leaders in museums, society, and learning that gathered insights and implications of the study results for the future of the museum field.

Key findings - Looking across the study components, several critical issues emerged as most essential for the museum field, and graduate programs in particular, to address in order to remain vital and relevant. First, the landscape study suggested that practical, hands-on job experience prepares emerging professionals better than an academic degree alone; and that a museum studies degree is not perceived as essential for success as a museum studies professional. Curricular emphases on practical skills and job/internship experience, critical thinking skills, and content-specific knowledge contributes to the value of a museum studies degree. Second, the study suggested that there is growing concern around disparities between the cost of graduate school and the potential salaries offered in the museum field, as well as a shortage of jobs in comparison to the number of graduate students entering the museum field. These disparities are seen as part of the reason for a lack of diversity in museum programs and in the field more broadly, as this gap is particularly likely to impact lower income communities. Finally, the ability to communicate the relevance of museums, engage with diverse audiences, and innovate new funding and development models is viewed as critical for the museum studies field to move forward.

Panel Member Topic 3 - Transforming the field towards professional learning

Authors: Lynn Uyen Tran, *University of California, Berkeley*

Preeti Gupta, *American Museum of Natural History*

Ardice Hartry, *University of California, Berkeley*

Rosalind Nava, *University of California, Berkeley*

Catherine Halverson, *University of California, Berkeley*

Informal educators work at the interface among the objects within the organization's collections and the cultural, conservation, historical, and scientific knowledge embodied by those objects and the visiting public (Tran, 2008). This work is expansive, e.g., support youth, interact with visitors, and teach teachers. Their collective effort broadens the scope of their organization's reach and grow the organization's social capital in its local community and beyond its physical footprint (Tran, Gupta, & Bader, 2019). In short, informal educators hold a significant role within an organization, and their professional growth should be a valued priority.

The tradition for this professional growth, however, has tended towards activities like shadowing, one-off trainings, and individual conferences. Those new to the profession are trained by shadowing seasoned staff; they observe and imitate what is done and how to do it. Sometimes, educators have opportunity to attend a professional conference or workshop. Unfortunately, it is not affordable for all staff to participate together and regularly, leaving some feeling isolated and unable to deepen their professional practices. For those who get to attend, these experiences typically stand alone, leaving educators with the burden to apply and transform their practice without colleagues from their organization. This tradition tends to take a deficit perspective of the educators and treat the expense as burdensome (Tran et al., 2019). A Program was designed to challenge this tradition in our field (Tran, Werner-Avidon, & Newton, 2013); a tradition that does not reflect what is known about how people learn (NASEM, 2018) or how to transform practice (Zeichner & Liston, 2014)

This Program is a professional learning program designed for organizations to adopt and implement themselves, rather than rely on outside experts to come on-site or sending select individuals out to participate. The community learns about learning together, and in the process shape the language and meanings by which they do and talk about their work to support visitors' experiences. The intention is to inculcate habits and routines for professional learning among educators, and instill this mindset into the community's culture. By professional learning, we refer to the educators' ongoing learning about their practice to increase their expertise and skills, and is valuable for improving practice regardless of the profession (Webster-Wright, 2009). It involves reflective practice.

With funding from the National Science Foundation, we made access to the Program more broadly available across the U.S. This accessibility included: offering 42 workshops for 452 educators from 265 organizations in 39 states across the U.S. from 2016 to 2019, low to waived workshop fees, travel stipends as needed, copy of the curriculum, and a variety of ongoing technical support. Our collective focus was to prepare and support educators attending our workshops to use the Program at their institutions after the workshop, and in turn, ignite shift towards professional learning.

In this paper, we reframe analysis from our evaluation and annual reports to consider: *what does it take to transform the field towards professional learning?* Using dissemination of the Program as the common experience, we address this question with analysis and triangulating data from a variety of sources: post workshop and delayed post workshop surveys (for participant

perspectives), applications (for institutional demographics), annual reports (for perspectives from across the Program), and interviews and observations from five case study sites (for deeper and vertical perspectives). We argue the need for changing this tradition is not unique to the Program; efforts for making effective professional learning programs can only go so far as educators' and institutions' willingness to engage in ongoing learning. This need for change is ever more important when we consider how to bring equity and inclusion into educators' practice.

Panel Member Topic 4 - Training the next generation of informal educators through a museum-university research practice partnership

Authors: Danielle Harlow, *University of California, Santa Barbara*

Ron Skinner, *MOXI, The Wolf Museum of Exploration + Innovation*

The [University] and [a new STEM museum in the Western United States] have developed and implemented a practice-based training program for informal science educators through a Research-Practice Partnership (RPP) (Coburn, Penuel, & Geil, 2013). The museum is an interactive space to engage visitors of all ages in constructing understanding of STEM topics through active engagement in the processes and practices of STEM. The design of the museum's exhibits were informed by the theory of constructivism (Driver et al., 1994) and the Next Generation Science Standards (NGSS Lead States, 2013), and the exhibits were intentionally designed to allow for multiple modes of interaction and to have multiple entry points, allowing for productive open-ended experiences for a wide range of learners, from pre-schoolers through college graduates. However, facilitating such open-ended exhibits is challenging.

To enable learning experiences that engage museum visitors in STEM practices requires facilitation, which requires floor staff with the appropriate expertise. Research on how museum staff are trained to guide learning is limited but emerging (King & Tran, 2017; Ash & Lombana, 2012). Training varies considerably across institutions and typically includes observations, shadowing, and trial and error (Allen & Crowley, 2017). Despite museum leadership expressing goals of increasing visitor-centered participatory experiences, didactic instruction based on acquisition-based theories of learning is more common, even after training (Allen and Crowley, 2017; Sanford & Sokol, 2017). This is not surprising. Facilitating STEM learning in ways that support visitors in constructing their own understanding is difficult, especially since science educators may be working simultaneously with children and adults of a range of ages, backgrounds, and goals.

When this museum opened in 2017, the stakeholders in this collaboration set out to develop both a facilitation model that fit the goals of engaging visitors in STEM practices and a training program to fill the need of a stable floor staff of highly trained informal educators. We refer to our model of facilitation as *Practice-based Facilitation*, which is a set of pedagogical strategies and ideas developed to support learning in this museum in ways that engage visitors in STEM practices (*Practice-based Learning*) (see Harlow & Skinner, 2019). Our 15-month training program both prepares floor staff to implement this model of facilitation and prepare them for professions in museum education.

This program has two complementary components: 1) Certificate in Informal STEM Education awarded through [the university's] professional certificate program, and 2) 20 hours a week as paid floor staff at this museum. Our program is implemented through a cohort model (approximately 10 participants/year) that begins each summer and continues through the following summer. The coordinated coursework and work on the museum floor provides an opportunity for

the participants to immediately apply and reflect on new practices and strategies learned in their coursework while working directly with visitors on the floor at the museum in their work facilitating exhibits, running program carts, working in the makerspace, implementing field trip programs and museum outreach.

The coursework each quarter is focused on a project that is completed on the floor. Together these projects provide a range of experiences and artifacts that build the [program participants'] professional portfolio and help them identify aspects of informal science education they are most drawn to. Projects include developing expertise around facilitating a specific exhibit and developing a facilitating guide for implementing practice-based facilitation at that exhibit, developing and testing more structured curriculum for the maker space or program carts, conducting an evaluation of visitor experience, and a capstone project related to their own professional goals. Collectively, these projects require learning and applying a range of topics related to both formal and informal STEM education, including constructivist learning theory, STEM content, the Next Generation Science Standards (NGSS), learning across age ranges (including NGSS progressions, early childhood, and adult learning), disability awareness and Universal Design for Learning (UDL), research and evaluation, classroom management, public speaking, responsive teaching, informal science education and ecosystems of learning.

Panel Member Topic 5 - Shifting Teaching Practices of Informal STEM Educators in an Online Collaborative Professional Learning Community

Author: Rebecca D. Swanson, *Tufts University*

This research focuses on shifting teaching practices of informal STEM educators [ISEs] teaching in summer STEM camps. ISEs who teach seasonally or part-time have even greater logistical barriers to participation in professional learning than do those who work year-round or more regularly for institutions. Such barriers include widely varied work schedules, lack of common location, and lack of funding. The challenges in scheduling learning opportunities for this group of ISEs typically results in single-day or single-week trainings that include mainly didactic lecture-style instruction focused on providing imminently needed classroom management skills and content knowledge, with little or no opportunities for instructors to reflect on previous teaching experiences or for new instructors to have access to more experienced ISEs in the program (Bevan & Dillon, 2010; NRC, 2015; Peter, 2009; Tran & King, 2007).

The context of this professional development work is an *online, synchronous professional learning community*. This small community of summer STEM camp instructors (N=7) was embedded in a larger university-affiliated STEM program organization based in the western United States, which hires over 60 instructors each year, most of whom work for this institution only during during the summer camp season. Participants met bi-weekly in 1.5-hour long meetings with a researcher/facilitator for the three months leading up to the start of summer camps. The meetings took place in a virtual environment, using Google Hangouts and other Google Suite tools. The topics of the professional development meetings were developed based on a combination of participants' stated needs and the researcher/facilitator's prior experience developing PD for this informal STEM organization and other teacher PD contexts. Data sources include pre-, post-, and follow-up interviews, teaching observations, and recordings of the five PD meetings.

Evidence of the benefits and productivity of this online synchronous model of professional development include instructors shifting the focus of their stated needs from dissemination and sharing of classroom management techniques towards deeper pedagogical reasoning around

teaching practices over the course of time, and particularly in the ways that they drew on the varied professional strengths and experiences of the other members of this community. We saw ISEs taking up teaching practices identified as productive for learning in informal STEM environments (NRC, 2015), including increased focus on youth-centered talk, implementation of youth-centered activities, and supporting curriculum design with pedagogical reasoning. This model of professional development, because of its low barriers to participation, is one that has promise in serving ISLs, particularly those working in seasonal or irregular positions.

Panel Member Topic 6 - Supporting equitable teaching practices through research practice partnerships: Insights into the practice of sharing authority

Authors: Sinead Brien, *Michigan State University*
Micaela Balzer, *Impression 5 Science Center*
Betsy Mappilaparampil, *Impression 5 Science Center*
Angela Calabrese Barton, *University of Michigan*
Won Jung Kim, *Michigan State University*

Problem - Informal science learning environments have been lauded as holding potential to engage youth in STEM more than school science (e.g., Falk, Dierking, & Semmel, 2013) and to support minoritized youth to identify with STEM. However, researchers have shown how a confluence of dominant institutional cultures and social and economic exclusion can combine to produce inequitable practices that exclude rather than engage youth of color in these spaces (e.g., Dawson 2014). Thus, from an equity point of view, developing equitable ISL practices is a critical project.

Using a critical justice framework of consequential learning (Jurow & Shea, 2015) we explore the efforts of one set of Research+Practice Partnerships [RPP], which has focused on engaging with ISL professionals in participatory design based research to support the professional learning and practices of ISL educators. In this paper, co-authored by researchers and practice partners, we report on how one ISL educator, Addison, teaching in a collaborative program involving a science center and community center serving predominantly low-income youth of color, sought to collaboratively study and reflect upon her pedagogical practices related to sharing and restructuring authority with her students. We define the practice of sharing authority as more than giving students the opportunity to be an expert/authority in the traditional epistemological sense, but also giving up the centrality of that epistemology and supporting new forms of authority that bridge and/or challenge traditional forms (Dimick, 2012). Our research questions include: What practices does the educator engage in that support sharing authority with youth? How does the educator adapt her practices to meet the needs of the youth in an ISL space that is new to her?

Methods - Our RPP includes university, science center, community partners and youth in a mid-sized Midwestern city. Within this RPP, we collaboratively studied ISL moments that support equitable and transformative informal STEM experiences for youth of color, and sought to translate our insights into programmatic and pedagogical practices. Our RPP work is grounded in participatory design-based research (Bang & Vossoughi, 2016) that foregrounds the practices of building humanizing relationships across settings/time; positioning youth, community members and educators as experts towards re-distributing power; and situating design work in local context. All data were co-generated, and include: reflective dialogues of ISL practice, audio/video/written records of practice, educator/student interviews, and educator/student work. Data were co-analyzed using a consequential learning framework. Based on this analysis, the practice of

sharing/restructuring authority was enacted most frequently and in a variety of ways, so we focused the analysis in this paper on the ways Addison shifted her practice of sharing authority across the two program iterations.

Findings - We report on how Addison noticed and responded to youths' assertions of authority during the first semester-long iteration of the program by changing her curriculum to better serve these youth in the second iteration. In the first iteration (Forensic Science), Addison implemented a set curriculum made up of individual lessons that built toward a final project. These lessons were meant to teach youth the needed forensics techniques that they could apply to process a crime scene and solve the crime in the final project. During the forensics program, Addison employed two approaches to sharing authority: Positioning youth as teacher helpers and Listening. This listening practice was supported by our RPP through reflective dialogues between researchers and Addison about how youth were responding to the program. Addison listened to what youth wanted in the program, stating "...the question I was asked every single time a kid walked in was 'are we making anything today?'.... Instead of doing experiments, I think we need to tailor to maker activities . . . that was my inspiration for this session. Addison brought this design challenge to our RPP where we collaboratively reflected on youths' expectations for the STEM program and how she could honor youths' interests through changes in her curriculum. The changes Addison made in the program supported five new ways of sharing authority which she enacted in the second iteration of the program: listening to and valuing youth contributions, valuing youth work, fostering an environment where youth taught youth, providing opportunities to choose material, and positioning youth as experts and problem-solvers.

[1] The term minoritized, vs. minority, indicates that an individual's minoritized status is a function of how that individual is positioned within society, rather than an inherent descriptor or trait. The term 'minority' is increasingly recognized in critical scholarship as an inaccurate reflection of demographics in many communities in the U.S. where individuals of color and lower-income individuals represent the majority of the population (Bishop, 2011).

Contribution

This panel of researchers and their projects studying ISL professionals offers a unique opportunity to discuss key aspects of current and future opportunities for supporting this demographic of science education professionals. Specifically, this collection of work will provide an overview of the state of the field and will provide insight into models of professional development that are research-practice partnerships and build on situated contexts for ISL learning. We believe that this opportunity for discussion and reflection will not only contribute to science education as a whole, by drawing attention to the strengths of ISL professionals, but will particularly be of interest to NARST attendees studying informal STEM learning across the many contexts available to STEM learners.

References

- Allen, L. B., & Crowley, K. (2017). From acquisition to inquiry: Supporting informal educators through iterative implementation of practice. In P. Patrick (Ed.) *Preparing Informal Science Educators* (pp. 87-104). Columbus, GA: Springer International Publishing.
- Ash, D. B., & Lombana, J. (2012). Methodologies for Reflective Practice and Museum Educator Research. In *Putting Theory into Practice: Tools for research in informal settings* (pp. 29-52). SensePublishers.

- Ash, D. B., Lombana, J., & Alcalá, L. (2012). Changing practices, changing identities as museum educators. In *Understanding interactions at science centers and museums* (pp. 23-44). SensePublishers.
- Bang, M., & Vossoughi, S. (2016). Participatory design research and educational justice: Studying learning and relations within social change making. *Cognition and Instruction, 34*(3), 173-193
- Bevan, B., & Dillon, J. (2010). Broadening views of learning: Developing educators for the 21st century through an international research partnership at the Exploratorium and King's College London. *The New Educator, 6*(3-4), 167-180.
- Bevan, B., & Xanthoudaki, M. (2008). Professional development for museum educators: Unpinning the underpinnings. *Journal of Museum Education, 33*(2), 107-119.
- Bishop, R. (2011). Education leaders can reduce educational disparities. In *International handbook of leadership for learning* (pp. 1069-1081). Springer, Dordrecht.
- Coburn, C. E., Penuel, W. R., & Geil, K. E. (2013). Research-practice partnerships: A strategy for leveraging research for educational improvement in school districts. *New York, NY: William T. Grant Foundation.*
- Dawson, E. (2014). "'Not Designed for Us': How Science Museums and Science Centers Socially Exclude Low-Income, Minority Ethnic Groups." *Science Education, 98*(6): 981-1008.
- Desimone, L. M., Porter, A. C., Garet, M. S., Yoon, K. S., & Birman, B. F. (2002). Effects of professional development on teachers' instruction: Results from a three-year longitudinal study. *Educational evaluation and policy analysis, 24*(2), 81-112.
- Dimick, A. S. (2012). Student empowerment in an environmental science classroom: Toward a framework for social justice science education. *Science Education, 96*(6), 990-1012.
- Driver, R., Asoko, H., Leach, J., Scott, P., & Mortimer, E. (1994). Constructing scientific knowledge in the classroom. *Educational researcher, 23*(7), 5-12.
- Falk, J. H., Dierking, L. D., & Semmel, M. (2013). *Museum Experience Revisited*. Walnut Creek, CA: Left Coast Press.
- Falk, J.H. & Dierking, L.D. (2019). *Learning from Museums*, 2nd Edition. Lanham, MD: Rowman & Littlefield.
- Feinstein, N. W., & Meshoulam, D. (2014). Science for what public? Addressing equity in American science museums and science centers. *Journal of Research in Science Teaching, 51*(3), 368-394.
- Harlow, D. B., & Skinner, R. K. (2019). Supporting Visitor-Centered Learning Through Practice-Based Facilitation. *Journal of Museum Education, 44*(3), 298-309.
- Jurow, A. S., & Shea, M. (2015). Learning in equity-oriented scale-making projects. *Journal of the Learning Sciences, 24*(2), 286-307.
- King, H., & Tran, L. (2017). Facilitating Deep Conceptual Learning: The Role of Reflection and Learning Communities. In P. Patrick (Ed.), *Preparing Informal Science Educators* (pp. 67-85). Columbus, GA: Springer International Publishing.
- Luft, J. A., & Hewson, P. W. (2014). Research on teacher professional development programs in science. *Handbook of research in science education, 2*, 889-909.
- National Academies of Sciences, Engineering, and Medicine (2015). *Science Teachers' Learning: Enhancing Opportunities, Creating Supportive Contexts*. Washington, DC: The National Academies Press. <https://doi.org/10.17226/21836>.

- National Academies of Sciences, Engineering, and Medicine (2018). Learning Through Citizen Science: Enhancing Opportunities by Design. Washington, DC: The National Academies Press. <https://doi.org/10.17226/25183>.
- National Research Council (2009). Learning Science in Informal Environments: People, Places, and Pursuits. Washington, DC: the National Academies Press
- National Research Council (2015). Identifying and Supporting Productive STEM Programs in Out-of-School Settings. Washington, DC: The National Academies Press. <https://doi.org/10.17226/21740>.
- NGSS Lead States. (2013). Next Generation Science Standards: For states, by states. Retrieved from <https://www.nextgenscience.org/>
- Packer, J. (2006). Learning for Fun: The Unique Contribution of Educational Leisure Experiences. *Curator: The Museum Journal* 49 (3): 329-344.
- Peter, N. (2009). Defining Our Terms: Professional Development in Out-of-School Time. *Afterschool Matters*, 9, 34-41.
- Rennie, L. J. (2014). Learning science outside of school. *Handbook of research on science education (Vol. 2)*, 120-143.
- Sacco, K. 2013. Graduate school: A pathway to a science center career. *Dimensions*, July/Aug.
- Sanford, C., & Sokol, V. (2017). Professional Development: Targeted On-the-Job Trainings. In P. Patrick (Ed.), *Preparing Informal Science Educators* (pp. 289-310). Columbus, GA: Springer International Publishing.
- Stein, J., and M. Cohen Jones (2019). University of Washington Museology Graduate Program Landscape Study. Technical Report: JKS Consulting, Corvallis, OR.
- Swanson, R. D. (2018). *Boundary Crossings Between Professional Communities: Designing Online Collaborative Learning Opportunities for Informal Stem Educators*. School of Education Graduate Theses & Dissertations. 104. https://scholar.colorado.edu/educ_gradetds/104
- Tran, L. U. (2008). The work of science museum educators. *Museum Management and Curatorship*, 23(2), 135-153.
- Tran L. U., Werner-Avidon, M., & Newton, L. R. (2013). Successful professional learning for informal educators: What is it and how do we get there? *Journal of Museum Education*, 38(3), 333-348.
- Tran, L. U. (2019). The how and why of Reflective Practice for Science Museum Professionals. *Chapter in The Reflective Museum Practitioner: Expanding Practice in Science Museums*.
- Tran, L. U., Gupta, P., & Bader, D. (2019). Redefining Professional Learning for Museum Education. *Journal of Museum Education*, 44(2), 135-146.
- Webster-Wright, A. (2009). Reframing professional development through understanding authentic professional learning. *Review of Educational Research*, 79(2), 702-739.
- Zeichner, K. M., & Liston, D. P. (2014). *Reflective Teaching: An Introduction* (2nd ed.). New York, NY: Routledge.