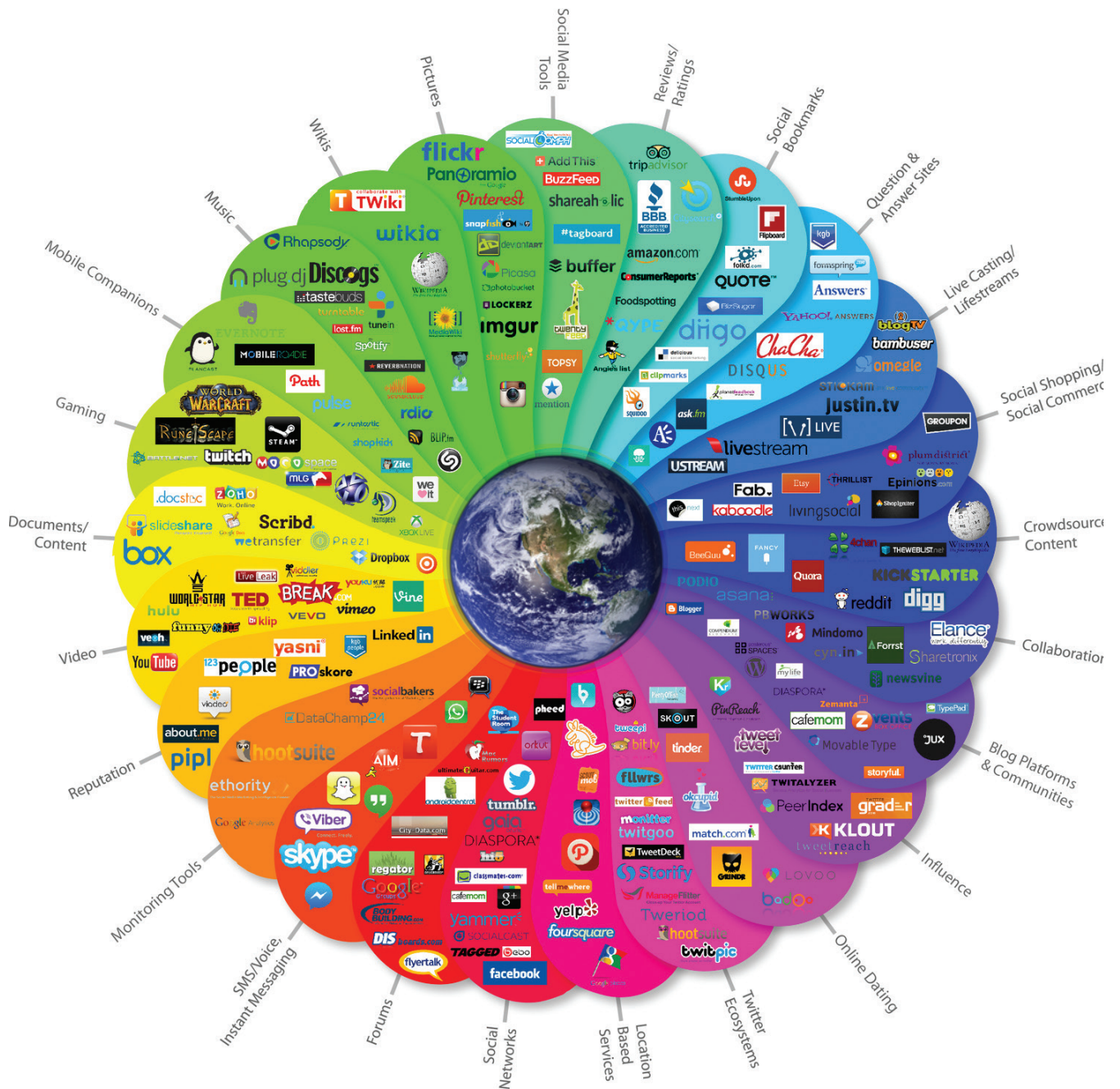


# Affinity Spaces for Informal Science Learning: Developing a Research Agenda

Report of Workshop held July 6 & 7 at Games+Learning+Society 2015





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## Table of Contents

Introduction	4
What is an Affinity Space?	5
Why Does Affinity Space Research Matter Today?	7
Summary of Literature Review	8
Current Trends in Informal Science Education Research	9
Workshop Presentations on Related Themes and Research	11
Social Media	11
Participatory Culture and Connected Learning	12
Identity	14
Children Online	15
Workshop Discussion and Recommendations for Research	16
Theme 1. Equity and Diversity	16
Theme 2. Interest	17
Theme 3. Identity	17
Theme 4. Literacy	18
Theme 5. Methodology	19
Recommendations	20
Funding Opportunities	21
Appendices	22
Workshop Agenda	23
Participant Directory	24
Literature Review	32
References	42



## Introduction

With support from the National Science Foundation's Science Learning+ initiative, Twin Cities Public Television (TPT), in St. Paul, MN, in collaboration with a team of researchers in the US and the UK organized a workshop with the title *Affinity Spaces for Informal Science Learning: Developing a Research Agenda*. Our goal was to develop and refine a set of concepts and issues that will guide future investigations into how participation in online affinity spaces can promote and enable informal science learning. The workshop took place on July 6th and 7th, 2015, ahead of the Games+Learning+Society conference in Madison, Wisconsin. The agenda and the attendees are included in the appendices.

Generally, an affinity space is a place – virtual or physical – where informal learning takes place, where people are drawn together because of a shared interest or engagement in a common activity (Gee, 2004). Such spaces encourage the sharing of knowledge or participation in a specific topic, and informal learning is a common outcome. In the workshop and in this report, the emphasis is on virtual or online affinity spaces, while acknowledging that online and offline spaces can be connected to good effect.

A sizeable body of research has explored affinity spaces in computer games, the arts and other creative endeavors, but there is very little research on the novel potential of affinity spaces to advance informal science or STEM learning<sup>1</sup>. With the explosive growth in the use of digital platforms and social media today, particularly among youth, it is an exciting time to investigate the unique affordances of these spaces.

This report is designed to be a resource for anyone interested in exploring affinity spaces and informal science learning. Our goal is to not only introduce informal science education researchers and practitioners in informal science education to current affinity space research, but also to present the many interesting research questions identified and discussed in the workshop.

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<sup>1</sup> STEM is the commonly used acronym for science, technology, engineering and math. Throughout this report, references to science learning may be understood to include the other subjects in STEM as well, but for simplicity, "science" is used in the text except when used in cited references.

## What is an Affinity Space?

Affinity spaces were first defined by James Paul Gee (Gee, 2004; Gee, 2005) as a way to understand how spaces – physical, virtual, and blended ones – provide opportunities for individuals through their communications within groups to develop affinity for a topic, such as media objects (e.g., games such as *The Sims*, media fandom such as *Star Trek*) and for practices (e.g., knitting, car repair, or gourmet cooking) (Duncan & Hayes, 2012, p. 7). Gee emphasized the metaphor of “space,” not “community,” in contrast to Lave and Wenger’s (1991) influential “communities of practice” concept. This distinction clarifies that what is important for understanding learning are the affordances of the environment, and that participation within affinity spaces is a much more fluid endeavor than is typically attributed to membership in a “community” (Duncan & Hayes, 2012, p. 9).

Two-way interactions, discussions, and sharing content are defining features of affinity spaces. An interactive online service that offers rich content but does not permit free exchange of ideas and allow users to contribute content does not qualify as an affinity space. The content in an affinity space is mutable, not fixed. It evolves through the social interactions and practices that take place in the space.

Affinity spaces can have a number of formal features, although a given space may not embody all of them (Gee, 2004):

1. Common endeavor, not race, class, gender, or disability, is primary.
2. Newbies and masters and everyone else share common space.
3. Some portals are strong generators, i.e., participants create new content, works, projects.
4. Content organization is transformed by interactional organization.
5. Both intensive and extensive knowledge are encouraged.
6. Both individual and distributed knowledge are encouraged.
7. Dispersed knowledge is encouraged.
8. Tacit knowledge is encouraged and honored.
9. There are many different forms and routes to participation.
10. There are lots of different routes to status.
11. Leadership is porous and leaders are resources.

At the workshop, in his introductory remarks, James Gee discussed how the affinity space concept has evolved and underscored these features:

*An affinity space is not merely an interest-driven group. Passion brings people to affinity spaces and passion is the important part. It is beyond interest. Affinity spaces have the potential to kindle what begins as a small interest into a passion.*

*Affinity spaces are not about individual intelligence, but collective intelligence. These spaces exist because the participants have an affinity for something, not because of race, class, or gender. If someone is there for a moment they are in it. Beginners and professionals can all participate. There is no gatekeeping.*

*Roles are flexible; sometimes you teach sometimes you learn. Standards are internal and indigenous; there are no top-down standards. Moderation is contested and negotiated. In some spaces, one has to earn the right to have opinions. Others are very nurturing. Affinity spaces are fluid by definition. Affinity spaces can go in and out of existence. They are prone to emergent results. They are squishy. They do not have well-defined boundaries.*

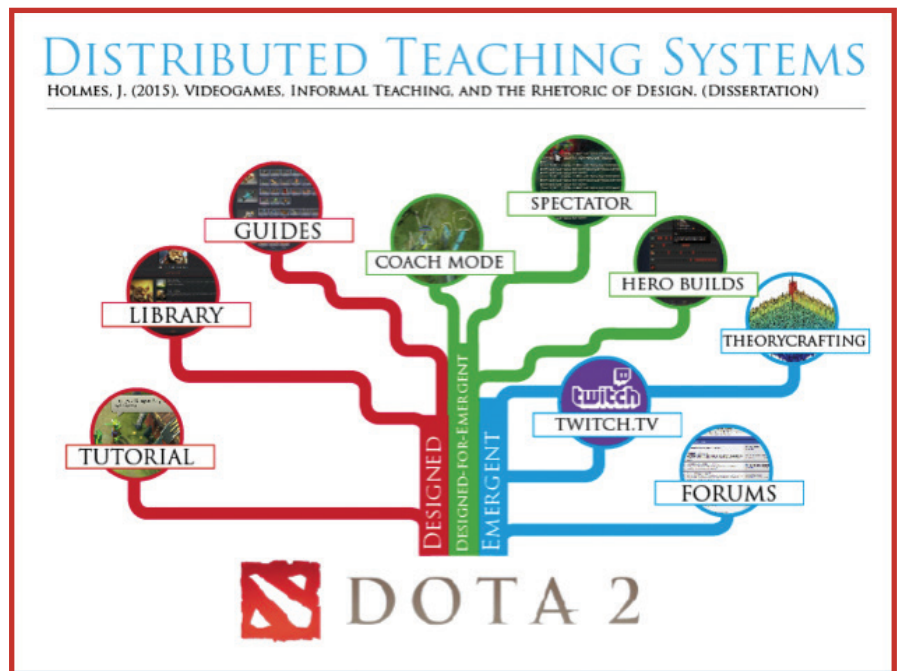
Affinity spaces are increasingly linked to other affinity spaces, as in the affinity spaces linked to the multiplayer online battle game *Dota 2*, illustrated in the accompanying figure<sup>2</sup>.

Not only does passion tend to spawn new connections between existing affinity spaces as users identify fresh links, it also encourages the creation of new user-generated spaces. This adoption, adaption and addition of spaces creates a dynamic ecosystem that reflects shared passion at any one time. As *spaces of spaces*, affinity spaces are rich distributed teaching and learning systems.

There are a number of established examples of online science-related affinity spaces worth further study, although there is no comprehensive catalogue. Many affinity spaces form among science hobbies, such as astronomy, birding, making,

gardening, and beekeeping. Other examples are Reddit's subreddit on science, [reddit.com/r/science](http://reddit.com/r/science); the affinity spaces tied to the programming language Scratch, [wiki.scratch.mit.edu/wiki/Scratch\\_Community](http://wiki.scratch.mit.edu/wiki/Scratch_Community) (Resnick, 2012; Fields et al., 2013); and question and answer sites such as StackExchange, [stackexchange.com](http://stackexchange.com).

There are numerous citizen science forums, such as those in Zooniverse, [zooniverse.org/talk](http://zooniverse.org/talk), Eyewire, [www.forum.eyewire.org](http://www.forum.eyewire.org), and Foldit, [fold.it/portal/forum](http://fold.it/portal/forum). A growing body of research is exploring the dynamic social dimension of these citizen-science affinity spaces (Curtis, 2015; Jennet et al., 2013). Other examples of science-related space include the growing number of sites on climate change, such as [realclimate.org](http://realclimate.org) and [climate-debate.com](http://climate-debate.com). Finally, the growth of medicine and healthcare-related online forums, termed "peer-to-peer" or "online health communities" are the focus of a growing body of relevant research (Centola, 2013; Wentzer & Bygholm, 2013; Vennik et al., 2014; Fox, 2013.)



<sup>2</sup>Graphic courtesy of Jeffrey B. Holmes, Arizona State University

<sup>3</sup>Nathan Allan, the editor of Reddit/r/science, participated in the workshop and expressed interest in collaborating with researchers. He may be contacted through Reddit.

## Why Does Affinity Space Research Matter Today?

Any contemporary effort to engage youth in informal science learning experiences must consider that young people today spend much of their lives online. Aided by the convenience and constant access provided by mobile devices, especially smartphones, 92% of teens in the U.S. report going online daily — including 24% who say they go online “almost constantly,” according to a recent study from Pew Research Center (Lenhart, 2015). Usage is not limited to youth: young adults (ages 18 to 29) are the most likely to use social media – fully 90% do. Usage among those 65 and older has more than tripled since 2010 when 11% used social media. Today, 35% of all those 65 and older report using social media, compared with just 2% in 2005 (Perrin, 2015).

A survey of informal science providers in the UK by John Falk was commissioned by the Wellcome Trust as part of the Science Learning+ initiative. Falk articulated an *ecological approach*, comparing the system of informal science education to a managed forest. Like a forest, with its large numbers of individual species interacting in multiple interconnected webs, the informal science education community has many distinct “species” interacting to seek broad improvements in scientific literacy and achievement (Falk et al., 2012).

Scholars of digital media have recognized a comparable ecosystem of intersecting technologies:

*Rather than dealing with each technology in isolation, we would do better to take an ecological approach, thinking about the interrelationship among different communication technologies, the cultural communities that grow up around them, and the activities they support (Jenkins, 2006).*

This ecological approach has commonalities with the work of Jenkins and others, in their studies of “participatory culture,” which identifies the distinctive practices that distinguish the unique power of informal learning. Such educational experiences are often experimental, innovative, responsive to short-term needs, and give their participants complete mobility to move in and out of the learning process.

Although the Wellcome Trust study identifies the category of “electronic media” as one of the more important “species” in its informal science learning “forest,” the study does not acknowledge the degree to which digital media increasingly acts as a conduit for the interconnections among the different species or education providers. A decade of research has established that today’s digital, participatory culture and the online affinity spaces within it function as highly engaging and personally rewarding learning spaces.

Affinity spaces have the ability to engage millions of learners in informal science education, and may have unique potential of reaching underserved populations who may have limited access to conventional sources of informal science learning yet are active users of the internet. Developing a research agenda to learn how these spaces can involve both adults and youth in experiences across the entire spectrum of science, technology, engineering and math (STEM) promises to reveal new ways to reach new audiences and enrich the entire ecosystem of informal science learning.

## Summary of Literature Review

A preliminary literature review was conducted in preparation for the workshop, to identify the questions that are explored in current research, to highlight emerging themes and discussions in the literature, and to note gaps and avenues for future research. The workshop generated many additional ideas and references to other published research, which are included at the end of this report.

Five common themes and concerns related to affinity spaces and informal science learning emerged from the research reviewed:

1. Equity,
2. Interest,
3. Identity,
4. Literacy, and
5. Methodology.

These five themes are discussed later in this report as a structure for the questions generated in the workshop. The full literature review is included in the appendices.



Image courtesy of Mark Pegrum, [e-language.wikispaces.com](http://e-language.wikispaces.com)





## Current Trends in Informal Science Education Research

The premise of informal science learning is that virtually all people of all ages and backgrounds engage in activities that can support science learning in the course of daily life. The recent National Science Foundation AISL solicitation support of informal science learning offers a definition that, significantly, specifically includes digital media:

*Almost any environment can support informal science learning, such as a home, a museum, a library, a street, a virtual or augmented reality game. Information networks, mobile media, and social networks transform educational possibilities and create opportunities for seamless learning environments.* (National Science Foundation, 2015).

Significantly, most science learning takes place outside of traditional schooling. Average Americans spend less than 5 percent of their life in classrooms, and an ever-growing body of evidence demonstrates that most science is learned outside of school (Falk & Dierking, 2010). Informal learning environments are, in principle, accessible to all learners, and evidence suggests they have particular potential for supporting learners from non-dominant groups (National Research Council, 2009).

In recent years, the National Academy of Sciences has produced a number of important documents on informal science or STEM education, beginning with *Learning Science in Informal Environments* (LSIE), a consensus document that summarized over 2000 studies. *Surrounded by Science* is a subsequent companion publication, illuminating the research presented in LSIE for a broad audience of practitioners and researchers.

LSIE described informal science learning as a complex ecosystem, a theme that has been taken up by other researchers (Falk, 2012) acknowledging that learning happens across a broad spectrum of experiences, in and out of school, with families, groups, and communities. They include:

- Designed settings, such as schools, clubs, museums, and youth programs;
- Naturalistic settings, such as city parks, waterways, and forests and deserts;
- People and networks of people, such as practicing science professionals, educators, enthusiasts, hobbyists, and business leaders who can serve as inspiration and role models; and
- Everyday encounters with science, such as on the internet, on television, on the playground, or during conversations with family members and other young people.

LSIE also identified six strands of science learning, whether in or out of school. They reflect increasing levels of engagement with science and the development of a science identity. As people – whether adults or children – engage more deeply in science, they will:

1. Experience excitement, interest, and motivation to learn about phenomena in the natural and physical world.
2. Come to generate, understand, remember, and use concepts, explanations, arguments, models, and facts related to science.
3. Manipulate, test, explore, predict, question, observe, and make sense of the natural and physical world.
4. Reflect on science as a way of knowing; on processes, concepts, and institutions of science; and on their own process of learning about phenomena.
5. Participate in scientific activities and learning practices with others, using scientific language and tools.
6. Think about themselves as science learners and develop an identity as someone who knows about, uses, and sometimes contributes to science.

A recent report, *Identifying and Supporting Productive STEM Programs in Out-of-School Settings* (National Research Council, 2015), looks more closely at informal science learning and includes a number of themes that would be relevant to exploring affinity spaces and informal science learning, with specific recommendations for action and research:

- Understand the local conditions for community programs that support science learning: *Build a map and bridge the gaps.*
- Design programs to achieve access, equity, continuity, and coherence: *Connect young people to opportunities to learn.*
- Support the use of creative and responsive approaches to evaluate the success of programs at the individual, program, and community levels: *Support innovative evaluation approaches.*
- Increase the professionalization of out-of-school program leaders and staff: *Provide professional development.*
- Strengthen the science learning infrastructure: *Build an infrastructure that will last.*
- Invest in research to improve our understanding of science learning in out-of-school programs: *Explore how science learning ecosystems work.*

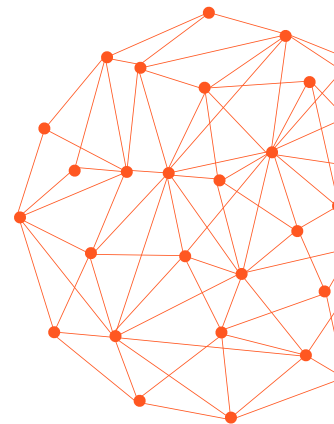
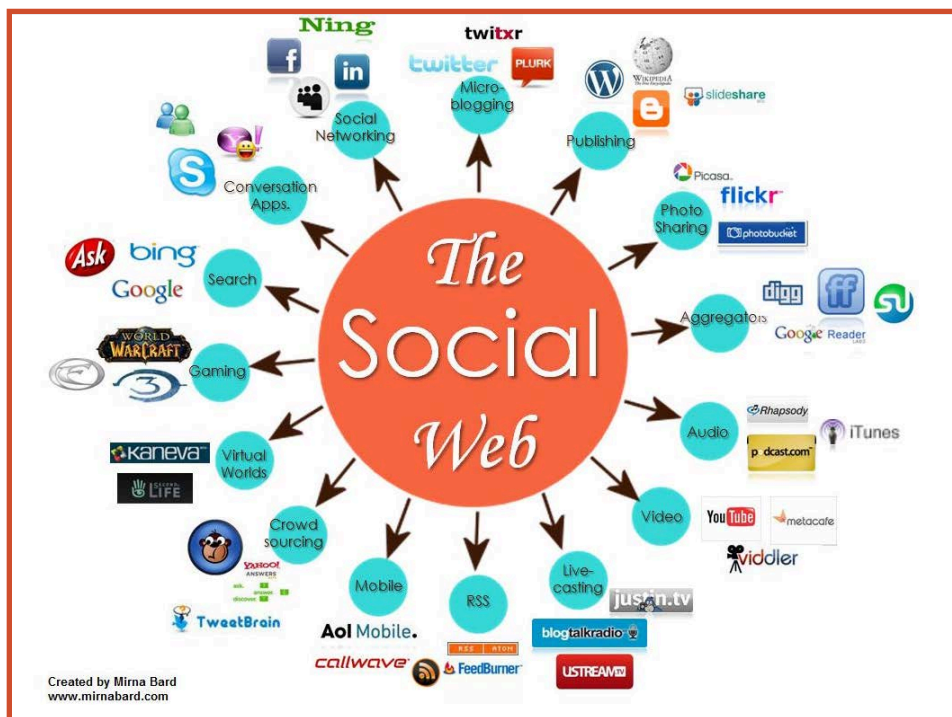
In addition to the NRC reports, the CAISE organization, the Center for the Advancement of Informal Science Education, provides a rich collection of research, evaluations and reports on many dimensions of informal science education on its website, [informalscience.org](http://informalscience.org).


## Workshop Presentations on Related Themes and Research

Following the introductions to affinity spaces and informal science learning, workshop participants gave brief presentations on their research in related areas, to provide a richer context for the discussion of the themes identified above. Affinity spaces exist within the larger domains of social media, participatory culture and connected learning. Jayne Lammers, June Ahn, Cliff Lampe, and Sonia Livingstone presented brief overviews of these domains. (See appendices for brief biographies of the participants.) A major research theme that cuts across both affinity spaces and science learning is the question of identity, how it is defined and how it develops in affinity spaces and comparable settings. A second cross-cutting research theme that is becoming increasingly important is how young children are using online services and spaces. Workshop participants Ben DeVane and Deborah Fields reviewed research in these areas. These presentations are summarized below and illustrate both the great range of research taking place in these domains and the variety of research methods employed. For brevity, only key ideas are presented here. Readers are encouraged to seek out the related papers and background research, which are cited in the text and included in the references section.

### Social Media

The Pew Internet and American Life Project, [pewinternet.org](http://pewinternet.org), has documented the dramatic growth of social media use in recent years. All social media has some common features: the content is user-generated; there are direct user-to-user interactions; and there are bundles of applications, in seemingly unlimited breadth and diversity.





The increasingly sophisticated combination of inexpensive hardware and powerful software creates affordances that permit different genres of social media and different user experiences. The lens of affordances has been effectively employed by researchers in recent years to understand the diverse ways people use social media tools to accomplish different goals, and the potential of social media to generate new ways of communicating and understanding information (Treem & Leonardi, 2012).

Social media research has produced some consistent findings: use is heterogeneous, just as in affinity spaces, varying across a broad spectrum of ages, expertise and interest. On one end of the spectrum, users may “lurk;” at the other end, they may fully engage. This pattern of use continues to follow a 90-9-1 rule: 90% of users are lurkers (i.e., read or observe, but don’t contribute); 9% of users contribute from time to time; and 1% of users participate a lot and account for most contributions. Researchers have mapped these patterns of use to personality types, with outcomes mirroring use (Hughes et al., 2012). For example, loneliness and depression are more associated with lurking; active users feel more connected to friends.

One measure of the impact of social media on users is social capital, the benefits users receive from their social relationships. Cliff Lampe, with Nicole Ellison and Charles Steinfield, examined the development of social capital on Facebook in 2007 (Ellison, et al. 2007), and more recently June Ahn and colleagues examined how teens develop social capital on social network sites (Ahn, 2012).

An underlying question in social media research is the degree to which the design and/or uses of social media are reconfiguring core dimensions of communication – identity, trust, publicity, accountability, authenticity, privacy, intimacy, participation, equality, and more – in addition to learning (Livingstone, 2015).


In the context of informal science education, the relationship between social capital and science learning has been explored in formal settings with educators and in teacher professional development (Baker-Doyle et al., 2011; Seaman, 2013; Wilson 2013), but not to a significant degree in *student* learning (Greehow, 2011; Veletsianos & Navarrete, 2012). While there are many studies of learning online from websites and other forms of media, learning in online social media – including affinity spaces – has had little attention and offers many opportunities for meaningful research.

### **Participatory Culture and Connected Learning**

Participatory culture, noted earlier as a component of today’s digital ecosystem, is a relevant foundation for explorations of affinity spaces.

*A participatory culture is a culture with relatively low barriers to artistic expression and civic engagement, strong support for creating and sharing one’s creations, and some type of informal mentorship whereby what is known by the most experienced is passed along to novices. In a participatory culture, members also believe their contributions matter and feel some degree of social connection with one another.*  
(Jenkins, 2009 p. xi)

The implications for out-of-school learning and literacies generally – not only science literacy – are informed by sociocultural theorists, such as Kress, Lankshear and Knobel, as well as Gee. These theorists understand learning and literacy in broad terms as the acquisition and enactment of new identities, practices, social relationships, and forms of meaning-making, tied to particular social and cultural contexts (Duncan & Hayes, 2012).



Digital media, participatory culture and real-world learning combine in “connected learning,” a phenomenon explored extensively by researchers in the Digital Media + Learning Hub, at [dmlhub.net](http://dmlhub.net). This organization’s 2013 report, *Connected Learning, an Agenda for Research and Design* by Mimi Ito and colleagues, presents a broad and compelling synthesis of research into connected learning and its capacity to leverage the power of modern digital media to “address the gap between in-school and out-of-school learning, intergenerational disconnects, and new equity gaps arising from the privatization of learning.” While online opportunities are a cornerstone of connected learning, the framework is not limited to online learning, but “taps the opportunities provided by digital media to more easily link home, school, community and peer contexts of learning; support peer and intergenerational connections based on shared interests; and create more connections with non-dominant youth, drawing from capacities of diverse communities” (Ito et al., 2013).

Recent research has also explored the links between creating real-world DIY projects – media production, making, crafting, e-textiles, etc. – and sharing them online (Kafai & Peppler, 2011; Kafai et al., 2014). Because such activities are interest-driven, they often lead to personal enjoyment, curiosity about unexpected gaps in knowledge, concern regarding a subject matter, and choices to pursue activities that help an individual solidify their identity, life goals, or self-improvement over a longer-term (Edelson & Joseph, 2004).


A series of ethnographic studies of youth engagement with digital media, the Digital Youth Project, gathered a collection of ethnographic studies and identified two primary genres of participation: interest-driven and friendship-driven (Ito et al., 2010). Affinity spaces are by definition interest-driven, where participants can engage with others who share their interests, regardless of geographical or age-related boundaries. By contrast, friendship-driven genres of participation primarily take place in social media sites but may also be a significant factor in participation in affinity spaces.

Participatory and interest-driven online groups, ranging from online video production, fan fiction writing groups, and gaming groups, offer contexts where young people can connect with peers and mentors who share their passions. They receive feedback and guidance, hone teamwork, and disseminate their work to a broader public (Ito et al., 2009; Thomas & Brown, 2011).

Jayne Lammers at the University of Rochester, with collaborators Jen Scott Curwood and Alecia Marie Magnifico, have examined interest-driven behaviors of adolescents and the development of literacies related to *The Sims* video games, *The Hunger Games* novels, and the *Neopets* online game. Their research identifies and illuminates many salient features of modern affinity spaces and provides new insights into the development of contemporary literacy skills in adolescents.

Their work also reveals opportunities and constraints of online affinity space research. Established affinity spaces often have multiple entry and exit points and separate domains, as in the *Dota 2* example noted earlier, and these are constantly evolving. This presents both an opportunity and a challenge to researchers. Conducting ethnographic research with subjects who are dispersed geographically requires new protocols. Many affinity spaces become platforms for the creativity of their members, and these artifacts can be a rich resource for research. However, given the ephemeral nature of many sites, persistent access to these artifacts is a further challenge (Lammers et al., 2012).

A core part of interest-driven opportunities is the blending of adults, peers, and mentors. Unlike online social platforms like Facebook or text messaging, interest-driven activity (whether online or off-line) is often intergenerational in nature with fellow hobbyists, leaders, experts, and mentors of all ages (Ito et al., 2009). The presence of caring adults who are tied into areas of authentic interest has the potential to reorient a young person’s identities, and academic and economic opportunities in the longer term.



June Ahn and his colleagues in the College of Information Studies at the University of Maryland are part of a design-based research initiative to explore connected learning and science education. They describe their focus as “life-relevant science learning” and create experiences that help learners identify and explore the potential roles such experiences can play in science learning. They have developed a social media application, ScienceKit, to promote children’s scientific inquiry.

Their research explores three key dimensions of science learning: identity, interest and literacy (skills and knowledge). They have followed students in an afterschool program for three years, documenting and correlating the behaviors of students with growth in these three domains. Case studies, which apply detailed methods and models for research that could be applied to other dimensions of affinity spaces and science learning, are presented in detail in their publications (Ahn, 2015; Bonsignore, et al., 2014; Yip, et al., 2013).

## Identity

Research into the development of identity permeates research in learning generally, and is also a theme in science learning research (Bell, 2012; Bevan, 2013; Martin, 2004). Much of this scholarship has taken the view that learning is in part a process of identity transformation, of assuming new modes of being and doing in the world (Lave, 1992). *Learning Science in Informal Environments* enumerates several theoretical perspectives that researchers have employed to study the development of a learner’s identity, and numerous studies have examined identity formation in real-world informal science learning spaces such as museums and after-school programs (Feder et al., 2009). However, there has been relatively little research into identity and science learning in *online* environments.

By contrast, learning and identity have been extensively explored in the context of games and related affinity spaces – in some cases with specific reference to science learning – and this research provides a useful model for informal science learning research in online spaces (Fraser et al., 2014; Dodge et al., 2008). The workshop included a presentation by Constance Steinkuehler and Sean Duncan of their study of how participation in online affinity spaces surrounding the popular game *World of Warcraft* fostered the development of scientific habits of mind, including research, sharing hypotheses, proposing models, gathering data across multiple trials, and debating results (Steinkuehler & Duncan, 2008).

Focusing specifically on identity, Kurt Squire, Ben DeVane and colleagues explored identity development in the games *Grand Theft Auto* and *Civilization* and in the affinity spaces surrounding these games (DeVane et al., 2008). DeVane conducted a 3-year ethnographic study of how a young player developed his social identity in the game, research that provides a model for how a learner’s social identity is constructed and negotiated through social interactions in a game/affinity space. He explores how his subjects in affinity spaces take on certain behaviors, belief systems, and forms of self-expression, in order to participate, thereby demonstrating how identity is intimately linked to how participants learn (DeVane, 2014).

## Children Online

As younger children increasingly engage in online experiences, particularly in different forms of social networking, researchers are exploring the implications for education as well as personal and social development. A 2012 report by Deborah Fields and Sara Grimes, *Kids Online, A New Research Agenda for Understanding Social Networking Forums*, identified significant gaps in current research, including when and how children begin using the internet, the significance of the home setting, the variety of platforms, and the increasing role of user-generated content (Grimes & Fields, 2012).

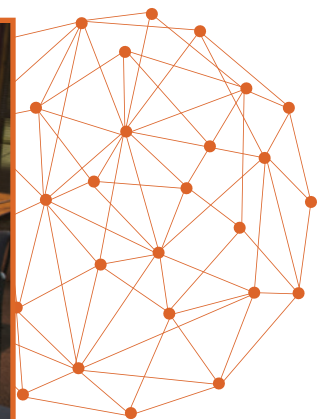
Fields and Grimes are currently conducting a 3-year analysis of sites that encourage the creation and sharing of media by children. Their preliminary review documents the features of over 100 different sites in this category (Grimes & Fields, 2015).

With more and younger users engaging in online activities, the issue of online safety has become a prominent theme of research. In a report on a seminar held on 12-14 February 2015 at the London School of Economics and Political Science, Sonia Livingstone and colleagues write

*While digital engagement is rapidly spreading throughout the world, this fast-paced, widespread growth often occurs far ahead of any understanding of what constitutes safe and positive use in digital contexts... This environment presents challenges for safeguarding children as their use of digital devices often precedes an effective rights framework or challenges existing laws when applied to the digital environment.*

A significant body of European research, much of it focused on issues of online safety, is collected by EU Kids Online, a multinational research network that seeks to better understand the role of the internet in children's lives. Recent results are published online at: [lse.ac.uk/media@lse/research/EUKidsOnline/Home.aspx](http://lse.ac.uk/media@lse/research/EUKidsOnline/Home.aspx), with a collection of recent papers listed at [lse.ac.uk/media@lse/research/mediaWorkingPapers/home.aspx](http://lse.ac.uk/media@lse/research/mediaWorkingPapers/home.aspx).

The organization produced an exhaustive and illuminating examination of CYP internet use and related risks, which documented factors that affect online safety, such as socio-economic stratification, regulatory framework, technological infrastructure and the dominant educational systems. (Lobe & Livingstone, 2011).



## Workshop Discussion and Recommendations for Research

Participants in the workshop iteratively brainstormed key themes that emerged in the presentations and discussions. These conversations reinforced the importance of the five major themes identified in the review of current literature on informal science or STEM learning. The questions raised in discussions are not unique to affinity spaces. In many instances, the research questions discussed in the workshop have been explored in other settings, but not in the domain of affinity spaces and informal science learning.

### Theme 1. Equity and Diversity

**How do we attract underrepresented groups (including women and members of different ethno-cultural and racial groups) to science learning and science careers? What role can affinity spaces play?**

Broadening participation among groups typically underserved in science learning has become a mantra of the informal science education community and a cross-cutting theme in much informal science education research. Equity in science learning has broad societal concerns, reflected in calls to invest in the science and engineering education of underrepresented groups because science and engineering labor needs can no longer be met by recruiting among traditional populations. (Schweingruber et al., 2012).

In a series of interviews with informal science education practitioners, Falk and colleagues found that despite expressing concern about attracting diverse groups, providers could cite few examples of best practices in “addressing the needs of disadvantaged communities and engaging them with science” (Falk et al., 2012, p. 5).

Many authors cited in our literature review highlighted a lack of equity in access to learning opportunities as a motivator and context for their work (Ahn et al., 2013; Subramaniam, Ahn, Fleischmann, & Druin, 2012; Falk et al., 2012; Bell et al., 2009; Fenichel & Schweingruber 2010). These authors situate the disparities in informal learning opportunities not only within the field of education, but also in the context of globalization, noting that students in the US and UK have underperformed on international surveys of science learning, and that both regions are experiencing shortages of graduates entering STEM-related careers.

The increased use of smartphones for internet access in minority communities, and their increasing reliance on smartphones for health information, educational, content, job-seeking, etc. (Anderson, 2015; Turner-Lee et al., 2012), suggests that these communities may also engage with science content online in ways they do not engage with real-world informal science education institutions. Patterns of smartphone use to access affinity spaces by minority communities is an important area for further study.

How do we make an intervention that can both connect learning & honor learners' desires to keep spaces separate?

Affinity spaces can make society more equitable by creating space for everyone to "matter" ??



## Theme 2. Interest

**What sparks a person's interest in science generally, or in informal STEM activities, more specifically? What sustains their involvement over time?**

Discovering an interest in a science activity is the first of the six strands of informal science learning discussed in the National Research Council reports by Bell et al., (2009) and Fenichel and Schweingruber (2010). Generally, interest has repeatedly been found to have a powerful influence on learning. (Hidi & Renninger, 2006). Interest-driven learning crosses boundaries between school and out-of-school and is embedded in social relationships, communities and leisure activities. (Azevedo 2013; Barron 2006; Rahm 2014). Within this research, interest is closely linked with motivation, which is a significant research theme in current research into affinity spaces, cited earlier in this report. Social affinity spaces offer a powerful opportunity to participate in interest-driven activities and deserve deeper investigation relative to science learning.

## Theme 3. Identity

**How do we encourage people to engage with science, to feel competent, and potentially to see themselves as scientists? Or beyond informal science, how do people identify with the groups and activities in which they participate?**

Identity is another of the six strands of informal science learning outlined in the NRC reports by Bell et al., (2009) Fenichel and Schweingruber (2010). For the informal science education community, identifying with science "includes the learner's sense that he or she can do science and be successful in science", which can involve a sense of belonging to either a community or a science-related activity (Fenichel & Schweingruber, 2010, p. 93).

What do online affinity spaces offer in terms of identity development and learning? Abundant research on participatory culture and social networking, noted earlier in this report, provide useful models for research into practices of self-presentation and the fluidity of identity development afforded by online spaces can impact science learning.

Even as informal science learning in physical contexts has noted the importance of identity formation to learning, affinity spaces, as open, voluntary and often pseudonymous arenas, offer a new arena for understanding how people try on new identities related to STEM. Further research on affinity spaces and science learning could examine how over *time* learners experiment with and take on new affiliations with science knowledge and practices; how learners make connections between their lifeworlds and science learning – their interests, professions, activities, and personal relationships; and how learners' social positions in an affinity space shape their engagement with science learning.

## Theme 4. Literacy

**Which resources and literacies enable individuals to participate in informal science learning?  
Which factors can affect digital literacy and participation in online affinity spaces?**

The concept of literacy was a constant background theme in the workshop conversations, from general concepts of literacy and its ties to affinity spaces in the work of James Paul Gee, to literacy in fan spaces in the work of Jayne Lammers, to digital literacy generally, and finally to scientific literacy, which the National Research Council summarizes as a primary goal of STEM education, “increasing scientific literacy among all young people, supporting life-long interest and engagement with STEM.”

The school of “New Literacies” points to how rapidly learning and meaning-making are evolving in today’s world of rapid technological change. (Knobel & Lankshear, 2007). Some scholars are even more aggressive, for example, Hodson ties the scientific literacy in the 21st century to the development of learning experiences that encourage social change and activism (Hodson, 2002). Literacy today can be more participatory, more collaborative and distributed. Gee points out that participants in this new form of literacy actively seek peers in affinity spaces at the intersection of language and technology, in what he terms a “situated-sociocultural” approach (Gee, 2010). The work of Jayne Lammers in the ethnographic study of the fansite devoted to *The Sims* is a model for such research (Lammers, 2012).

Research over the past three decades has explored the development of scientific literacy broadly, with emphasis on creating a scientifically literate public. The NSF has published Science and Engineering indicators since 1993 ([nsf.gov/statistics/seind/](http://nsf.gov/statistics/seind/)). Numerous researchers have written extensively on the value and the development of scientific literacy, including analysis of learning outside of school (Feinstein, 2011; Liu, 2009; Miller, 1998; Miller, 2004). However, there are few recent studies that explore the effect of new technologies, social media or affinity spaces on the development of scientific literacy generally, although there is increasing work in climate change communication and related scientific literacy, and the numerous forums on climate change offer fertile ground for further research (Schäfer, 2012).



## Theme 5. Methodology

### Which methodological approaches are appropriate to studying and understanding different types of participation and learning in informal affinity spaces?

Though Lammers, Curwood, and Magnifico (2012) outlined methodological concerns for understanding participation and learning in affinity spaces, there was no consensus during the workshop on the most effective methodological approaches to take to further our understanding of informal science learning in affinity spaces. Yet participants agreed that the variety of methodological approaches – from “big data” analytics to online ethnographic approaches – offer a robust set of opportunities for the future understanding of informal science learning in affinity spaces. One common concern was the study of learning over time in affinity spaces and the potential of affinity spaces to help sustain the science interests of youth typically underserved by traditional informal science education.

Which approaches to affinity spaces might yield not only deeper understanding of learning in affinity spaces, but might help to provide guidance for informal STEM institutions on ways to interface with these spaces? One thread that addressed both the longitudinal interests of the workshop participants and the potential to better unify affinity space research with the goals of STEM learning institutions was Fields and Kafai’s (2009) “connective ethnography” (also elaborated in Pellicone & Ahn’s, 2015, study of *Minecraft* affinity space use). This approach, which explicitly acknowledges that online participation can be made more intelligible and consequential by connecting learning in online spaces to face-to-face participation in communities and institutional education, was seen as potentially valuable moving forward. Connective ethnographic approaches might be usefully employed to better elaborate how the online participation of learners in virtual spaces are consequential within participants’ material, face-to-face interactions and participation in institutions of learning.

Are interesting affinity spaces the same as instructional spaces?

Connecting virtual and “real.” How do kids connect affinity spaces in STEM?

What aspects of STEM are interesting to young people?  
It must be relatable, applicable to their everyday lives.

## Recommendations

With the dramatic increase in the use of online social spaces today, there is a pressing need to develop a research agenda that explores informal science learning in these spaces. Over the past decade, numerous research agendas have been developed by the informal science education community for settings such as museums or maker spaces yet there is no comparable agenda for online informal science learning that might capitalize on the power of affinity spaces. (See [informalscience.org/research/research-agendas](http://informalscience.org/research/research-agendas).)

In the workshop, after extended discussions of the many questions that stem from the five themes outlined above, the following set of five primary research directions emerged. They refine the general questions identified in the literature review, incorporate ideas raised in the workshop, and reflect existing research in both informal science learning and research into affinity spaces:

**Equity and Diversity:** What affordances of affinity spaces can impact science learning in underrepresented communities? What meta-skills or prior experiences are relevant for a science affinity space? How do users develop those skills?

**Interest:** What draws people to participate in science-themed affinity spaces and what sustains their interest and continuing participation? What role does inappropriate or “transgressive” online behavior play in engagement?

**Identity:** What contributions can participation in science affinity spaces make to the science identity of users, specifically youth? How would such findings impact the design of new affinity spaces?

**Literacy:** How can offline and online informal science affinity spaces be connected to each other and to other real-world science learning environments? How can such linked affinity environments contribute to science literacy? How do participants in affinity spaces navigate between teaching and learning roles, and differing levels of expertise and experience? What affordances of affinity spaces promote such experiences?

**Methodologies:** The workshop presentations summarized in this report include many useful examples of research strategies, including ethnographic studies as well as qualitative and quantitative approaches. The references cited throughout this report provide additional details about these methods. Repeatedly, however, participants stressed the need for longitudinal approaches, particularly with underserved youth.

As a primary step to address these questions, discussions repeatedly raised the need for a comprehensive inventory of existing science-related affinity spaces, their characteristics, and their affordances. Such an inventory should include both emergent and designed spaces; i.e., those that emerge outside of educational institutions and those that are intentionally designed by such institutions. What are the different types of science-related spaces and what are their common or unique characteristics? How are issues of moderation and the accuracy of science content managed? The survey by Grimes and Fields mentioned above offers a useful template (Grimes & Fields, 2015).

**Affinity spaces are complex and powerful informal education systems, and offer a largely untapped resource for informal science learning. More research is needed to understand the potential impact of existing science affinity spaces and to understand what design choices might increase the impact on informal science teaching and learning. It is the hope of this project’s principal investigators and workshop participants that the recommendations and the information gathered here will encourage researchers to explore the profoundly valuable learning opportunity science affinity spaces can provide.**

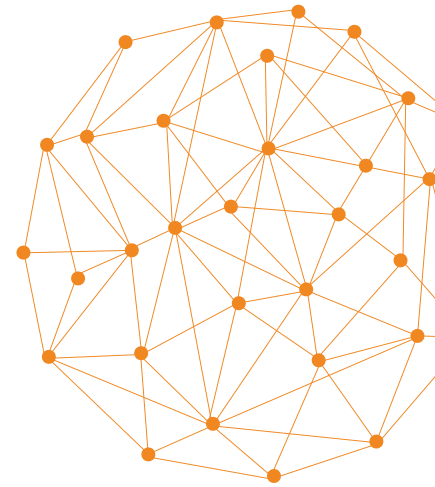
## Funding Opportunities

The partnership between the National Science Foundation and the Wellcome Trust, Science Learning +, [wellcome.ac.uk/funding/science-learning](http://wellcome.ac.uk/funding/science-learning), supported this workshop and several other similar forums exploring informal science learning. They are listed at [nsf.gov/news/news\\_summ.jsp?cntn\\_id=133508](http://nsf.gov/news/news_summ.jsp?cntn_id=133508) ([bit.ly/sciencelearningplus](http://bit.ly/sciencelearningplus)).

A second round of funding opportunities were announced in March, 2016, [http://www.nsf.gov/publications/pub\\_summ.jsp?WT.z\\_pims\\_id=505240&ods\\_key=nsf16548](http://www.nsf.gov/publications/pub_summ.jsp?WT.z_pims_id=505240&ods_key=nsf16548) ([bit.ly/slplus2016](http://bit.ly/slplus2016)).

Other programs at the NSF offer research funding as well, including

- Advancing Informal STEM Learning (AISL) research strands, [nsf.gov/funding/pgm\\_summ.jsp?pims\\_id=504793](http://nsf.gov/funding/pgm_summ.jsp?pims_id=504793) ([bit.ly/AISL16](http://bit.ly/AISL16));
- Cyberlearning and Future Learning Technologies, [nsf.gov/funding/pgm\\_summ.jsp?pims\\_id=504984](http://nsf.gov/funding/pgm_summ.jsp?pims_id=504984) ([bit.ly/cyberlearning](http://bit.ly/cyberlearning)) and
- STEM + Computing Partnerships (STEM+C) [nsf.gov/funding/pgm\\_summ.jsp?pims\\_id=505006](http://nsf.gov/funding/pgm_summ.jsp?pims_id=505006) ([bit.ly/stemc16](http://bit.ly/stemc16)).



Does  
Designing  
on Affinity  
Space take  
away something  
special about  
Affinity Spaces?

WHAT SUSTAINS  
PARTICIPATION  
IN A.S.'s?

What existing  
spaces might  
STEM content  
be injected to?  
or thinking about  
Worth new audiences  
for existing  
resources?



## Appendices

**Workshop Agenda**

**Participant Directory**

**Literature Review**

**References**



## Workshop Agenda

### Day 1 – Monday, July 6, 2015

- 7:30 - 8:30 Breakfast
- 8:30 - 8:45 Welcome & Overview (Richard Hudson)
- 8:45 - 9:30 Participant Introductions (All)
- 9:30 - 10:00 Framing: Affinity Spaces Research (Jim Gee & Sean Duncan)
- 10:00 - 10:30 Framing: Informal STEM Education (Martin Storksdieck)
- 10:30 - 10:45 Break
- 10:45 - 11:30 Small Groups: Themes from Literature Review & Research Questions (All)
  - 1. Equity and Diversity
  - 2. Interest
  - 3. Identity
  - 4. Literacy
  - 5. Methodology
- 11:30 - 12:30 Report Out: Key Research Questions (Carlton Reeve)
- 12:30 - 1:30 Lunch – Scientific Habits of Mind (Constance Steinkuehler, Sean Duncan)
- 1:30 - 2:15 Interest-Driven/Connected Learning Research (Jayne Lammers, June Ahn)
- 2:15 - 3:00 Social Media Research (Cliff Lampe, Sonia Livingstone)
- 3:00 - 3:15 Break & “Sorkin” Walkabouts: Theme “What’s still missing in our discussions?”
- 3:30 - 4:15 Identity in Online Spaces (Ben DeVane, Debbie Fields)
- 4:15 - 4:30 Other Topics & Perspectives to Consider (Carlton Reeve)
- 4:30 - 5:30 Brainstorm Proposal Concepts in Small Groups
- 5:30 - 6:30 Break
- 6:30 - 9:00 Dinner at Cooper’s Tavern, about 15-min walk from hotel.

### Day 2 – July 7, 2015

- 7:30 - 8:30 Breakfast (All)
- 8:30 - 9:00 Brainstorm Proposal Concepts in Small Groups, continued.
- 9:00 - 9:30 Report Out: Proposal Concepts
- 9:30 - 10:00 Discussion: Affinity Spaces & STEM Learning Research Methods (Duncan, moderator).
- 10:00 - 10:15 Break
- 10:15 - 11:00 NSF/WELLCOME TRUST Research Funding Opportunities (Ellen McCallie, Remote)
- 11:00 - 11:30 Phase II Proposal Ideation continued - Small Groups (All)
- 11:30 - 12:30 Reporting Out & Next Steps (Hudson, Reeve, Duncan)
- 12:30 - 1:30 Lunch

### End Workshop

## Participant Directory

(Affiliations as of July 2015)



### June Ahn\*

Assistant Professor, iSchool and College of Education, University of Maryland, College Park

June's core research interest is in understanding how technology and information can enhance the way we learn and deliver education. He approaches his studies from two primary lenses: (1) through design-based research to understand how technology and new media can be used to enhance how people learn in new ways; and (2) through studies that try to understand the socio-technical configurations that arise from the combination of technology, education settings (formal and informal), and people - and how these socio-technical systems could lead to improved social/ educational outcomes. He has led NSF-funded projects including studying how after-school programs, new media, and science fiction storytelling could engage inner-city youth in engaging with STEM; understanding how open education communities such as the Peer-2-Peer University function to create learning opportunities; the design of large-scale alternate reality games to engage teenagers in STEM learning; and the use of online and blended learning in K-12 public school systems.



### Nathan Allen

Moderator, Reddit Science

Nate is a synthetic organic chemist at the ANGUS Chemical Company, and the Science AMA Series coordinator and moderator in /r/science of reddit.com, which receives 2.5 million unique readers per month. The Reddit science forum provides a digital space for discussions about recent, peer-reviewed scientific publications, putting the forum (along with /r/AskScience) on the front line of the science-public interface. On these pages, scientists and nonscientists can connect through discussions on everything from subatomic particles to interstellar astrophysics. Importantly, it provides the same window for those who are not scientists, who do not regularly talk with PhDs, and who may be unfamiliar with how science is discussed by scientists. In essence, it is a window into the Ivory Tower.



### Flávio Azevedo

Assistant Professor, Dept. of Curriculum & Instruction, University of Texas - Austin

Flávio's research focuses primarily on theorizing the nature of short- and long-term interests in STEM disciplines, and designing learning environments that are truly engaging to students. This has led him to investigate learning and interest-based participation in settings as diverse as classrooms, after-school programs, and hobby practices (model rocketry and amateur astronomy). Intersecting with this central research focus, other research interests include the use and creation of technical representations and the way these mediate knowing and learning; the discourse and practices of engaged participation in STEM classrooms; and social justice issues in STEM education.

\* Member of Steering Committee





**Leema Berland**

Assistant Professor, Dept. of Curriculum & Instruction, University of Wisconsin-Madison

Leema earned her PhD in the Learning Sciences from Northwestern University in 2008. Prior to joining the WI faculty, she was an assistant professor in STEM education at the University of Texas at Austin. She is currently a Principal Investigator on the NSF-funded project “Fostering Pedagogical Argumentation: Reasoning with and About Student Ideas” and Co-Principal Investigator on the NSF-funded project “Supporting scientific practices in elementary and middle school classrooms.” Her work focuses on supporting and understanding student engagement in the scientific practices and on helping teachers do the same.



**Tilly Blyth** (Online Participant)

Keeper of Technologies & Engineering and Lead Curator of Information Age Gallery, National Museum of Science & Industry (London)

Tilly is Keeper of Technologies and Engineering at the Science Museum in London and Lead Curator of the Information Age gallery. She studied Physics at Manchester before migrating to the social sciences, with postgraduate degrees in Science Policy and the Sociology of Technology. Her studies in the construction of consumer need for new technologies lead to innovative online projects for Channel 4, Sky, the BBC and the Science Museum. Her research includes analyzing the economic and cultural legacy of the BBC Microcomputer for NESTA and creating a mobile application to geolocate historical collections. Tilly is a member of the advisory board for the British Library on the Oral History of British Science and has acted as external examiner for Anglia Ruskin University. She lives in North London with her husband and three daughters.



**Douglas Clark**

Associate Professor, Dept. of Teaching & Learning, Vanderbilt University

Doug’s research investigates the learning processes through which people come to understand core science concepts. This work focuses primarily on conceptual change, explanation, collaboration, and argumentation. His research often explores these learning processes through the design of digital learning environments and games. Doug is the principal investigator on the SURGE and EGAME grants from the National Science Foundation and the EPIGAME grant from the Department of Education. These grants explore designs for integrating the rich intuitive understandings players develop through popular game-play mechanics with explicit formal understandings that players can apply and transfer. Doug is also a co-principal investigator on the CTSiM, an NSF grant exploring the integration of argumentation, modeling, and programming to support science learning.



**Ben DeVane\***

Assistant Professor, Educational Psychology, University of Iowa College of Education

Ben earned his PhD in curriculum and instruction from the University of Wisconsin, where he was witness to the founding of the Games, Learning, and Society research initiative. His research seeks to understand how young people learn about science inquiry and computational thinking with games and digital media. His work has been funded by the National Science Foundation, and published in peer-reviewed academic journals like the *International Journal of Learning and Media*, and *Games and Culture*. His chapter on identity, titled *Whither Membership? Identity and Social Learning in Affinity Spaces*, appears in *Learning in Video Game Affinity Spaces* (Duncan, Hayes 2014).



**Marie Domingo**

Producer / Project Manager, Twin Cities Public TV

Marie is a Producer on the PBS Kids series, *SciGirls*, and the Project Director for the Educational Media to Advance Computer Science (EMACS) project. In addition to her years of experience producing documentaries and educational media content for grades K-12, she is an adjunct professor of Cinema Production at the Minneapolis Community and Technical College. Marie also serves on the board of *TVbyGirls*, a non-profit dedicated to using media tools to develop girls' leadership skills, and she coaches Girls in Engineering Math and Science (GEMS) and First Lego League (FLL) robotics teams.



**Sean Duncan** (co-PI)

Assistant Professor, Center for Research on Learning & Technology, Indiana University

Sean's research focuses on collaboration and play in informal learning environments, with a primary emphasis on gaming, game design, and gaming culture. He is a research scientist in IU's Center for Research on Learning and Technology, where he directs the Playful Culture Lab. Intersecting with digital media and learning research, Sean investigates *informal learning in interest-driven learning communities*, looking at the forms of collaborative learning, design thinking, and complex reasoning that are part and parcel of engagement with media. His work crosses the learning sciences and literacy studies, incorporating perspectives that value the out-of-school forms of learning that are embedded in digital media use. Sean studies *games* – not just educational technologies, or digital simulations – as media, cultural practice, and as engaging contexts for play. Play is a driving framework for his work, both investigating play as instantiated in games (digital, cardboard, and otherwise) as well as play as a framework for understanding self-motivated, interest-driven learning.



### **Noah Weeth Feinstein**

Associate Professor in the Departments of Curriculum & Instruction and Community & Environmental Sociology, University of Wisconsin-Madison

Noah's work explores the value of science in the social and political lives of non-scientist citizens. He is interested in identifying and developing social mechanisms through which scientific institutions and practices can make societies more, rather than less, democratic, and he believes that some of those mechanisms are educational in nature. His current and recent projects focus on public engagement with science among parents of recently diagnosed autistic children, the contribution of learning (writ large) to climate change adaptation, the impact of changing scientific practices on scientist outreach, the relationship between science education and sustainability, and the need for museums and science centers to forge better connections with their diverse communities.



### **Deborah Fields\***

Assistant Professor, Instructional Technology & Learning Sciences, Utah State University

Deborah's research focuses on the relationship between learning and engagement at the intersections of kids' lives, those places where home, school, friends, family, and community connect. These interests have guided her studies in virtual worlds and STEM education in and across classrooms, clubs, and digital social environments. In 2013 she recently published a book with MIT Press on kids' online play: *Connected Play: Tween Life in a Virtual World*. Related, she recently co-authored a critical review of children's participation in social networking sites for the Joan Ganz Cooney Center. Current interests include breaking down stereotypes about who can create with digital media by creating educational opportunities to design with sewable electronics or the popular programming environment, Scratch. This interest carries over into the growing phenomenon of child-generated digital content in online environments, focusing on what this development means for children's cultural rights, learning opportunities, and industry best practices.



### **James Gee**

Regents Professor and Mary Lou Fulton Presidential Professor of Literacy Studies, Arizona State University

James is a member of the National Academy of Education. His book *Sociolinguistics and Literacies*, first published in 1996, was one of the founding documents in the formation of the "New Literacy Studies", an interdisciplinary field devoted to studying language, learning, and literacy in an integrated way in the full range of their cognitive, social, and cultural contexts. He formulated the idea of an "affinity space" in 2004 in *Situated Language and Learning: A Critique of Traditional Schooling*. His book *An Introduction to Discourse Analysis* brings together his work on a methodology for studying communication in its cultural settings, an approach that has been widely influential over the last two decades. His more recent work deals with video games, language, and learning. *What Video Games Have to Teach Us about Learning and Literacy* argues that good video games are designed to enhance learning through effective learning principles supported by research in the Learning Sciences. His most recent books include *Good Video Games and Good Learning: Collected Essays on Video Games, Learning, and Literacy* (2013), *The Anti-Education Era: Creating Smarter Students through Digital Learning* (2013), and *Unified Discourse Analysis: Language, Reality, Virtual Worlds, and Video Games* (2015).



### **Alex Halavais**

Associate Professor, School of Social & Behavioral Sciences, Arizona State University

Alex is an associate professor of social technologies in the School of Social and Behavioral Sciences at Arizona State University, where he researches ways in which social media change the nature of scholarship and learning, and allow for new forms of collaboration and self-government. He has published articles and book chapters on how social media relate to social change, as well as a book introducing the social role of search engines. He is the interim director of the MA in Social Technologies. He previously served as the president of the Association of Internet Researchers and as the technical director of the Digital Media and Learning Hub at the University of California. His most recent book was *Search Engine Society* (Polity, 2008), and he is working on a book tentatively titled *All Seeing*.



### **Richard Hudson (PI)**

Director of Science Production, National Productions, Twin Cities Public Television (TPT)

Richard is the Director of Science Production at TPT, Twin Cities Public Television, the PBS affiliate in St. Paul, MN. For over 30 years, he has specialized in the creation and production of signature science TV series and websites for children and adults including *Newton's Apple*, the longest-running family science series on public television, *DragonflyTV*, seven seasons of authentic inquiry-based investigations, and *SciGirls*, a new TV series, website and outreach effort to engage more girls in STEM subjects. As part of TPT's expanding presence on the web, he also led the development of *Sparticl*, a new online STEM service for teens at [www.sparticl.org](http://www.sparticl.org). In longer-form documentaries, he was TPT's Executive Producer of the NOVA documentaries *Hunting the Edge of Space*, on the 400-year history of the telescope, and *Absolute Zero and the Conquest of Cold*, on the history of low-temperature research. For his contributions to science learning, he received the prestigious Faraday Award from the National Science Teachers Association.



### **Jayne Lammers\***

Assistant Professor, Warner School of Education: Teaching & Curriculum, University of Rochester

Jayne directs the secondary English teacher preparation program. Prior to joining the Warner School in 2011, she taught graduate and undergraduate literacy education courses. She has also taught English/language arts/reading at the secondary (grades 6-12) and postsecondary (college composition) levels. Her research explores adolescents' literacy learning, especially in online environments. She engaged in a two-year virtual ethnography to study young women's digital media creations with *The Sims* video games. Her current project is a case study of adolescent writing in three contexts: school-based writing, fan fiction posted in an online community, and personal creative writing. As a result of her research, Jayne aims to help shape literacy classrooms into spaces where online/offline and in-school/out-of-school boundaries get blurred and students are designing literacies that prepare them for 21st century futures.



**Cliff Lampe\***

Associate Professor, School of Information, University of Michigan

Cliff is an associate professor in the School of Information. Previously, he spent six years as an assistant professor in the College of Communication Arts and Sciences at Michigan State University. He researches the social and technical structures of large scale technology mediated communication, working with sites like Facebook, Wikipedia, Slashdot and Everything2. He has also been involved in the creation of multiple social media and online community projects, usually designed to enable collective action. One of Cliff's core values is combining top quality research with community engagement.



**Sonia Livingstone\***

Professor, Department of Media & Communications, London School of Economics & Political Science

Sonia is a full professor in the Department of Media and Communications at LSE. She teaches master's courses in media and communications theory, methods, and audiences and supervises doctoral students researching questions of audiences, publics and youth in the changing digital media landscape. She is author or editor of nineteen books and many academic articles and chapters. She has been visiting professor at the Universities of Bergen, Copenhagen, Harvard, Illinois, Milan, Oslo, Paris II, and Stockholm, and is on the editorial board of several leading journals. She is a fellow of the British Psychological Society, the Royal Society for the Arts, and fellow and past President of the International Communication Association, ICA. Sonia has received honorary doctorates from the University of Montreal and the Erasmus University of Rotterdam. She was awarded the title of Officer of the Order of the British Empire (OBE) in 2014 'for services to children and child internet safety.



**Darren McRoy**

Community Manager, Zooniverse, Adler Planetarium (Chicago)

Darren serves as a liaison to the Zooniverse community and assists with strategic content for projects. Zooniverse provides opportunities for people around the world to contribute to real discoveries in fields ranging from astronomy to zoology. It is the largest online platform for collaborative volunteer research and home to the internet's largest, most popular and most successful citizen science projects. Darren is leading the rebuild of the Zooniverse Talk discussion system to expand opportunities for members of the Zooniverse community to communicate with each other. He is a 2010 graduate of Northwestern University's Medill School of Journalism. His diverse online communications experience includes serving as the Community Relations and Communications Coordinator for the Winnetka, IL public schools and working as a Field Editor for the news service, Patch.com, writing articles, managing multiple social media accounts, and supporting a team of bloggers.



**Lisa Quirke**

Independent Research Consultant, PhD University of Toronto

Author, Literature Survey for Affinity Spaces & STEM Learning Workshop

Lisa is a qualitative researcher and consultant based in Toronto, Canada. She holds a PhD in Information Studies from the University of Toronto and conducts research on the information practices of youth. Her work has examined the information needs, leisure and online practices of refugee youth, revealing new insights for researchers and policymakers into the potential role of leisure activities in bolstering mental health and the building of social capital among newcomers. She is a collaborator on a new Canadian initiative, The Kids' DIY Media Project, to strengthen understanding of (DIY) media creation among children, including online communities such as Scratch.



**Carlton Reeve** (co-PI)

Senior Lecturer, School of Media, Design & Technology, University of Bradford and Director, Play With Learning, Inc.

In a digital media career spanning nearly 20 years, Carlton has created and commissioned educational multiplatform content for all ages. His Ph.D. is in game-based learning, user-centered design and evaluation. His academic background provides a robust framework for continuing media production that includes award-winning television programs, websites and games for organizations including the BBC, Channel 4 and the United Nations. He has led and managed multi-disciplinary teams, subcontractors and external agencies on multi-million pound projects. As well as ongoing production, Carlton shares his expertise through teaching, training and research publications.



**Constance Steinkuehler**

Associate Professor in Digital Media, University of Wisconsin-Madison and Co-Director, Games+Learning+Society (GLS)

Constance is an Associate Professor in Digital Media at the University of Wisconsin-Madison and co-directs the Games+Learning+Society (GLS) center at the Wisconsin Institute of Discovery and chairs their annual GLS Conference. Her research is on cognition and learning in commercial entertainment games and games designed for impact. In 2011-2012, she served as Senior Policy Analyst in the White House Office of Science and Technology Policy (OSTP) where she advised on national initiatives related to games. Policy work included the coordination of cross-agency efforts to leverage games toward national priority areas (e.g. childhood obesity, early literacy, STEM education) and the creation of new partnerships to support an ecosystem for more diversified innovation in commercial and non-commercial games. She also played a central role in recent meetings through the Vice President's office on videogames and violence. Constance's current research interests include neuroscience and games (particularly in the areas of attention and emotional and social well-being), learning analytics (informal scientific reasoning, problem-solving, and the role of failure), and mixed methods (game community discourse and literacy).



### **Martin Storksdieck**

Director, Center for Research on Lifelong STEM Learning / Oregon State University

Before becoming the Director of the Center for Research on Lifelong STEM Learning in June 2014 Martin served as the Director of the Board on Science Education (BOSE) at the National Research Council (NRC) of the National Academy of Sciences. As the BOSE Director he oversaw studies that address a wide range of issues related to science education and science learning, and provide evidence-based advice to decision-makers in policy, academia and educational practice. His prior research focused on what and how we learn when we do so voluntarily, and how learning is connected to our behaviors, identities and beliefs. This includes the role of personal perspectives in science learning, and how connections between school-based and out-of-school learning can create and sustain lifelong interest in science, but also learning itself. His research also focused on the role of science-based professionals and science hobbyists in communicating their passions to a broader public. Martin also directs NRC's Roundtable on Climate Change Education.



### **Kelly Sutphin-Borden**

Director of Education, Zooniverse, Adler Planetarium (Chicago)

Kelly holds a BA in anthropology (focusing on historical archaeology) from the State University of New York at Binghamton and an MA in Public Archaeology at University College London. She began her career as a museum educator at the Lake County Discovery Museum. After working for the Museum of Science and Industry and Chicago Public Schools she came to the Adler Planetarium in 2009 to oversee summer camp and field trip programs. In 2012 Kelly moved to the Citizen Science department as the Citizen Science Education Lead. In that capacity she oversees teen programs at the Adler and the educational efforts of the Zooniverse online citizen science platform.

## **SCRIBES**



### **Lucas Cook**

Graduate Student, Center for Research on Learning & Technology, Indiana University

Lucas is a doctoral student in the Learning Sciences Program at Indiana University. His research interests include learning through games, learning through collaboration and competition, speedrunning, and online game streaming through Twitch.tv and other related services. He comes to IU after teaching in Washington DC public charter schools for two years.



### **Joey Huang**

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Joey (Chu-Jen) is a doctoral student in Indiana University's Learning Sciences program. Her research interests include affinity spaces, informal learning, and learning through social media. In particular, she is interested in developing creative and innovative learning environments. She recently drew her research interests into a triangle shape with respect to three aspects – computational thinking, constructionism settings/spaces, and cultural variation. As a member of the *Playful Culture Lab*, she is expecting to leverage her research interests to develop and cooperate provocative learning elements in terms of informal learning settings.



## Literature Review

### **Affinity Spaces for Informal Science Learning:**

**Written by Lisa Quirke for  
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### **Introduction**

This literature review examines the existing research on informal science education, online affinity spaces and interest-driven learning as part of an initiative exploring the potential for STEM (Science, Technology, Engineering and Math) learning in online environments. The goals of this review are the following: to identify the research questions being explored in current research; to highlight emerging themes and discussions in the literature; and to note gaps and avenues for future research. It is our hope that this literature review will serve as a jumping-off point for more debate and research on these topics, in particular on the potential for collaborative, participatory, interest-driven and social practices seen in online environments to support informal STEM learning.

In order to achieve these goals, yet keep this review focused and bounded, we began with the following key resources on informal STEM learning:


- “Analysing the UK Science Education Community: The contribution of informal providers” by the Wellcome Trust foundation (Falk et al., 2012)
- “Learning Science in Informal Environments” by the US National Research Council (Bell, Lewenstein, Shouse, & Feder, 2009)
- “Surrounded by Science”, also by the US National Research Council (Fenichel & Schweingruber, 2010).

Though these resources offer detailed perspectives on the initiatives, frameworks and research objectives of informal science educators, none deeply explores online environments or these spaces’ potential to support informal STEM education. To better understand online environments, we reviewed research on online participatory culture (i.e., Burgess & Green, 2009; Jenkins, 2006a; Jenkins, 2006b), in particular those studies that focused on online affinity spaces (i.e., Gee, 2005; Lammers, Curwood, & Magnifico, 2012; Hayes & Duncan, 2012) as well as resources that specifically documented the digital practices of youth (i.e., Grimes & Fields, 2012; Ito et al., 2010; Lehnart, 2015). A third body of research, which sits at the intersection of and unites both informal STEM learning and online participatory culture, is interest-driven learning, in particular the types of learning taking place in online environments (i.e., Lemke, Lecusay, Cole, & Michalchik, 2015).

As we reviewed the findings of these studies, five common themes and concerns emerged: equity, interest, identity, literacy, and methodology. This review examines these themes and highlights examples from the literature that illustrate researchers’ and practitioners’ questions about each. First, however, we will briefly define key terms in this review, namely informal science learning and affinity spaces.

Informal science learning consists of science-related activities and experiences pursued outside of the formal education system. Bell et al. (2009) define this type of learning as learner-motivated, personal, voluntary,





collaborative and open-ended. They also highlight informal science learning as leading “to further inquiry, enjoyment, and a sense that science learning can be personally relevant and rewarding” (Bell et al., 2009, p. 11). Fenichel and Schweingruber (2010) categorize settings for informal science learning into three types: *everyday informal environments*, which can include watching TV, reading, searching online, playing games, speaking to others and volunteering; designed environments, including museums, planetariums, zoos, aquariums, and science centres; and programs, including organized after-school activities.

Affinity spaces are in-person, virtual or blended spaces in which people gather to pursue shared interests (Gee, 2005). Developed as an alternative to the concept of “communities of practice” (Lave & Wenger, 1991), affinity spaces focus on interactions taking place in a specific space rather than conceptualizing members as belonging to a defined community (Gee, 2005). These spaces, which can include online games, message boards and fan-fiction websites, tend to focus on a “common endeavour” and involve many ways in which learners – including a range from novices to experts – can participate (Gee, 2005, p. 225). Lammers, Curwood, & Magnifico (2012) highlight the ways in which the affinity spaces concept has evolved in response to new online practices, including the prominence and pervasiveness of social networking sites.

Though it may appear at first glance that informal STEM learning and the concept of affinity spaces have little in common, they are strongly linked both by the potential for learning, and by the interest-driven nature of activities in both spaces. Despite noting online resources as environments for informal science learning, as above, the informal science community appears to treat these places as single and isolated experiences: visiting a website to look for a specific piece of information, for example, or using a virtual tool as part of a museum exhibit. The nature and potential of online learning in affinity spaces is far richer than this, however, as virtual worlds, games and fan-based activities online can act as third spaces that foster not only deep engagement with learning, but also practices of scientific thinking. As Steinkuehler and Duncan (2008) found in their study of *World of Warcraft*, participants in online discussion forums actively collaborated, constructed knowledge, tested models and debated various explanations in their game-based play – all valuable skills in scientific endeavours. This review, therefore, attempts to bring online, interest-driven learning environments into dialogue with the approaches and concerns of the informal STEM community, with the hope that rich and varied potential avenues for future STEM affinity spaces research can be identified.

The next five sections of this review outline the themes identified in the literature. The first and most prominent theme that emerged in the research was equity and diversity.

### **Theme 1: Equity and Diversity**

Equity and diversity was a topic seen throughout the various literatures in this review, but raised as a central concern in the informal STEM community, with questions such as:

**Question:** *How do we attract underrepresented groups (including women and members of different ethno-cultural and racial groups) to STEM learning and STEM careers?*

For practitioners in the informal STEM community, equity was an issue for those interested in attracting more diverse socioeconomic status, racial and ethnic groups to science programs, museum exhibits and other public venues for STEM learning. As Fenichel and Schweingruber (2010) explain, the informal science community has not always been successful in ensuring equal access to learning opportunities: in fact “striving for equity in science education has often resulted in attempts to provide better access to opportunities already available to dominant groups”, which often “privilege the science-related practices of middle-class whites” (p. 120). Despite expressing concern for equity, however, Falk et al. (2012) note that there is little evidence upon which practitioners can base decisions in programming. In their review of literature on informal STEM learning, the authors found gaps both in research and in terms of models of service provision for

underserved groups (Falk et al., 2012). They highlighted significant research gaps, in particular, regarding the “learning or engagement with science of women, minority ethnic groups or adults (Falk et al., 2012, p. 37). In follow-up interviews with informal STEM education providers, the authors found that despite expressing concern about attracting diverse groups, providers could cite few examples of best practices in “addressing the needs of disadvantaged communities and engaging them with science” (Falk et al., 2012, p. 5). The authors go on to highlight that gaps in research by informal STEM providers are likely to persist as institutions often study only users, not those underserved by their programs; as Falk et al. (2012) note, “it would appear that only the individuals that participate in the most conspicuous informal venues get studied” (p. 40).

Issues of equity and diversity were not raised only the context of informal STEM program attendance, but also in relation to broader societal concerns, specifically regarding access to informal STEM learning, education and economic well-being. Many authors cited in this review highlighted a lack of equity in access to learning opportunities as a motivator and context for their work (Ahn et al., 2013; Subramaniam, Ahn, Fleischmann, & Druin, 2012; Falk et al., 2012; Bell et al., 2009; Fenichel & Schweingruber 2010). These authors situate the disparities in informal learning opportunities not only within the field of education, but also in the context of globalization, noting that students in the US and UK have underperformed on international surveys of science learning, and that both regions are experiencing shortages of graduates entering STEM-related careers. Shortages of STEM professionals, in particular among populations such as women, and racial and ethnic minorities, were also noted.

In her reflection on the state of research in informal science learning, Rahm (2014) discusses equity and diversity as central concerns in the field. What is needed, she proposes, is not just a focus on issues of access and diversity, but “a much more nuanced approach that ensures the physical, cognitive, and social inclusion of all learners in science activities” (Rahm, 2014, p. 401). Rahm cites the absence of deeper discussions of race and power in the field of informal science learning, and cautions that “catchwords” such as accessibility and empowerment can be used to “stand in and diverge the discourse away from others centering on race and power” (Rahm 2014, p. 401). This point raises the question of whether or not researchers and practitioners, instead of focusing on encouraging women, ethnic and racial minorities and other underrepresented groups to engage with STEM learning and careers, also need to examine the systemic barriers preventing individuals from taking up these opportunities. The complexity of barriers and inequalities experienced by those at the intersection of identities can also be seen in Alper’s (2014) MacArthur Foundation report on digital youth living with disabilities. Alper’s (2014) report notes, for example, that families of children with disabilities who were also from immigrant backgrounds experienced more difficulties accessing health coverage than those from non-immigrant backgrounds (p. 11).

**Question:** *What does diversity look like in different online communities?*

While the informal science education community works to better understand issues of diversity in STEM learning, researchers studying online participatory culture have documented features of diversity in online environments. In Gee’s (2005) work on affinity spaces, for instance, he describes them as places in which “people relate to each other primarily in terms of common interests, endeavours, goals or practices, not primarily in terms of race, gender, age, disability or social class” (p. 225). He contrasts these online spaces with typical classrooms, which are generally segregated by age, skill and grade level, and where “race, class, gender and disability are often much more foregrounded than they are in an affinity space” (Gee, 2005, p. 230). An additional element of diversity is added through the participation of people from a range of skill levels, from novices, right up to experts. The nature of affinity spaces is such that forms of participation are varied, which creates opportunities for engagement for anyone interested in taking part.

## Theme 2: Interest

In addition to equity and diversity, a second prominent theme that emerged in the literature was interest. In the informal STEM literature, the following questions were posed:

**Questions:** *What sparks a person's interest in learning, generally, or in informal STEM activities, more specifically? What sustains their involvement over time?*


Interest is discussed throughout the informal STEM learning literature as the key motivator for participation in science learning. For this reason, discovering an interest in a science activity is the first of six strands of informal science learning discussed by both Bell et al. (2009) and Fenichel and Schweingruber (2010). Despite the importance of interest to STEM learning in informal settings, however researchers in this field appear to have little certainty about how interest is created or sustained.

The role of interest in learning has also been studied in other, non-STEM related context. In her research on interest and self-sustained learning among adolescents, Barron (2006) notes that sustained interest can be motivated by one's activities, experiences and social networks. Inspiration for learning can come from a variety of sources, including the "activities of other people, conversations, books, computer programs, projects or assignments" (p. 200). In her study, Barron (2006) found that interest-driven learning crossed boundaries; participants took up some interests at school and continued their learning in home and community contexts, while in other instances their interests originated at home or with friends, and were continued in school.

Similar to Barron's findings on the context-based and boundary-crossing nature of interest-driven learning, Rahm (2014) also discusses the importance of contextual approaches in examining the lived experiences, motivations and social connections of learners. In her reflections on the state of research in informal STEM education, Rahm (2014) notes that learning is best "understood as embedded in rich social relationships, as driven by personal interests or community concerns grounded in students' lives and communities" (p. 397). Rahm (2014) goes on to encourage a shift in the informal STEM field, moving from the study of informal science, to the study of learners and learning. Research in this area should ask "What are the overall goals of engagement with science that drive participation?" Rahm (2014) notes, as "rarely is science literacy the primary or end goal that drives engagement" (p. 398). If science literacy is not often the main goal of engagement with informal science learning, what other goals motivate learners? And are there any common motivational traits shared by interest-driven learning in STEM that are also seen in affinity spaces?

**Question:** *What motivates people to take part in affinity spaces?*

Motivation can be found in the "rich social relationships" Rahm describes, in particular the opportunities for socializing offered by online spaces. In their study of children playing science games in the virtual world of Whyville, Kafai and Giang (2007) found that participants were drawn to Whyville by social interaction, such as chatting and sending messages to other users; science games, by comparison, were mostly completed by players to obtain in-game currency. In their research on fan-fiction sites and online games, Lammers et al. (2012) found that socializing activities "are a central part of getting people into the space on a regular basis" (p. 49), and that social media are "now an intrinsic part of participating in affinity spaces" (p. 55). Shared social connections online are not just motivating for users, but can also be beneficial to their learning and their lives: research has shown that social media and the connections that learners form with one another can rich sources of information (Donath & Boyd, 2004), bridging social capital, and can bolster psychological well-being (Steinfeld, Ellison, & Lampe, 2008). In their work on connected learning, Ito et al. (2013) also emphasize the importance of social support, digital media and the connections that these technologies and associated



online (or offline) spaces enable learners to foster with others. Ito et al.'s (2013) connected learning framework highlights features of online spaces such as interactivity, the potential for self-expression, and the opportunity for exposure to broader and more diverse cultures and bodies of knowledge, as central to learning.

In addition to opportunities for socializing, fun can be a key motivation for participation in interest-driven learning environments. As Lemke (2015) notes, informal learning communities “aim to improve motivation, engagement, and enjoyment”, and focus on “the drivers of learning more than on the learning of specific content” (p. 86). It is a natural fit, therefore, that researchers studying interest-driven learning online have explored spaces such as online gaming communities and fan communities (i.e., Squires, 2011; Steinkuehler & Duncan, 2008; Duncan & Hayes, 2012). Engaging and playing with others who are just as passionate about a specific topic can be deeply motivating, allowing participants to find authentic audiences for their work (Lammers et al., 2012). As the next section discusses, self-presentation, identity and informal learning are interconnected in various ways.

### **Theme 3: Identity**


Identity was discussed in different ways throughout the literature as a factor influencing participation and engagement with interest-driven learning.

**Questions:** *How do we encourage people to engage with science, to feel competent, and potentially to see themselves as scientists? Or beyond informal science, how do people identify with the groups and activities in which they participate?*

The informal STEM field explores issues of identity to try to better understand the relationship between learners' self-perceptions and their engagement with science. Research in this area is grounded in concerns regarding broader societal issues, including low levels of public literacy regarding science, low science test scores among students, and a lack of participation by underrepresented groups in informal science learning activities or STEM careers (Ahn et al., 2013; Subramanian et al., 2012).

Identity is one of the six strands of informal science learning outlined by Bell et al. (2009) and Fenichel and Schweingruber (2010). In addition to the other strands, which include excitement and interest in science, “understanding scientific knowledge, engaging in scientific reasoning, reflecting on the nature of science, [and] increased comfort with the tools and practices of the scientific community”, the authors include “identifying with the scientific enterprise” as the sixth and final strand (Fenichel & Schweingruber, 2010, p. 103). It is worth noting that while the other strands were developed to apply to science learning in formal educational settings, the first and last strand – interest and identity – were developed solely for informal settings; interest and identity, therefore, are the motivators that drive voluntary engagement with science.

For the informal STEM community, identifying with science “includes the learner’s sense that he or she can do science and be successful in science”, which can involve a sense of belonging to either a community or a science-related activity (Fenichel & Schweingruber, 2010, p. 93). This kind of affiliation with science, however, does not result from a single experience or museum visit, as Fenichel and Schweingruber (2010) note, and would instead “usually require extended time frames of involvement with a program or community” (p. 94). The type of community involvement referenced in informal STEM learning echoes existing theoretical approaches to learning in groups, in particular situated learning theory (Lave & Wenger, 1991). Identity development is key to situated learning, as learners participate and become connected to communities of practice; this, in turn, allows for the “development of an identity which provides a sense of belonging and commitment” (Handley, Sturdy, Fincham, & Clark, 2006, p. 642).



Though belonging may be fostered through learning as part of a community of practice, Handley et al. (2006) highlight the limitations of this conceptualization, noting “one could argue that the site for the development of identities and practices is not solely within a community of practice, but in the spaces between multiple communities” (p. 650). Singular and stable identities may also be assumed within the communities of practice approach, despite the fact that “individuals are likely to participate in multiple communities during their lifetime – each with distinct practices and identity structures” (Handley et al., 2006 p. 650). Gee’s (2004) work on affinity spaces also resists the assumed homogeneity of the notion of community, and instead emphasizes the multiple trajectories of participation available to learners.

What do online spaces offer in terms of identity development and learning? Research on participatory culture and social networking sites in particular provide insight into practices of self-presentation and the fluidity of identity development afforded by online spaces. Social networking sites offer opportunities for individuals to create profiles, display their social connections (Donath & Boyd, 2004), and share their media preferences (Burgess & Green, 2009). In their study of YouTube, Burgess and Green (2009) note that ‘favouriting’ videos is “an act both of self-expression and identity performance” as these choices are “published as markers of personal taste and implicitly communicate recommendations to other users” (p. 46). The fluidity of these identities is key for youth, in particular, as Ito et al. (2010) highlight, explaining that “many youth craft multiple media identities that they mobilize selectively depending on context” (p. 37).


Some participants use online spaces to find authentic audiences for their writing or art, or test out new identities; Greenhow and Robelia’s (2009) youth participants, for example, used MySpace to “present themselves and get feedback” (p. 132). Other youth revel in the ability to participate and learn anonymously. As Ito et al. (2010) found, youth seeking specialized information or resources online may “lurk” on forum pages, an activity that allows them to “look around and, in some cases, dabble or mess around anonymously” (p. 56). The anonymity of these spaces allows participants to learn “without having to risk displaying their ignorance” (Ito et al., 2010, p. 56).

What is clear from the discussions of identity development in the literature reviewed is the predominance of sociocultural approaches, which understand learners and their practices within the broader contexts of their lives, communities and cultures. This approach includes ecological theories of development (Bronfenbrenner, 1979), which emphasize that “the intellectual, knowledge-focused domain cannot be isolated from the domain of social identity”, and shift the focus from individual learners “in isolation to culturally variable participation structures” (Bell et al., 2009, p. 41). The next theme of this review, literacy, expands on the notion of social and contextual constraints and their effects on opportunities for informal learning.

#### **Theme 4: Literacy**

**Questions:** *Which resources and literacies enable individuals to participate in informal science learning? Which factors can affect digital literacy and participation in online affinity spaces?*

The theme of literacy is one that unites the others in this review, including equity, interest and identity. When considering a lack of participation in informal STEM learning by underrepresented groups, as discussed in the first theme of this review, it is important to reflect on the resources and literacies that enable youth to participate in these activities. The same thinking applies to questions about how to help individuals develop an interest in science, or engage with and identify with scientific endeavours. In this fourth section, the theme of literacy is discussed, including some of the factors that can constrain or enable participation in informal learning.




If learning is embedded in students' lives, contexts and communities, as Rahm (2014) notes, then barriers they experience in their lives can also present barriers to participation in informal learning. Challenges learners face stemming from racism, sexism, or discrimination based on ethnic background or disability may limit the opportunities for participation and learning that may take place as a result. Class is also a factor, as families from higher socioeconomic statuses may be able to offer their children more support for informal learning opportunities, for example through science programs or memberships to local museums, or access to mentors in STEM careers. Access to online resources can also be greatly affected by factors such as class, gender, race and ethnicity, as Hargiattai (2010) found in her study of the Internet skills of young people. Despite the fact that her sample consisted of a relatively privileged group – college students – she found that participants who were male, white, Asian-American or had high levels of parental education were more likely to have higher skill levels of Internet use, and were more likely to engage in a more diverse set of online activities (Hargiattai, 2010). Hargiattai is therefore careful to caution us against assuming that all youth, despite growing up surrounded by digital technologies, have the same sets of skills or experiences. Context and community can greatly shape one's facility in the use of digital technologies, but also – and more importantly – one's ability to benefit from resources online.

Another thread in the literature discusses the notion of science literacy. What does it mean to be scientifically literate? And which definitions of science are informal science educators promoting with their exhibits, programs and activities? The research in this review not only calls for a greater level of science literacy among the general population – a need that Steinkuehler and Duncan (2008) refer to as “urgent” in the United States (p. 530) – but also among the informal science community, as Falk et al. (2012) note that many practitioners may hold outdated or overly simplistic concepts of what science is.

In their work on scientific thinking among participants in virtual worlds, Steinkuehler and Duncan (2008), note that the formal educational system has “done a poor job at fostering the right habits of mind in our schools” (p. 530). They emphasize that science learning should be thought of not just as specific content and facts to be imparted to students, but instead as a process or set of practices – ways of thinking that can be cultivated in online environments. In their study of online discussion forums in *World of Warcraft*, Steinkuehler and Duncan (2008) discovered that participants engaged in many practices such as collaboratively constructing knowledge and testing models relating to facets of gameplay. In analyzing participants' discussions, the authors noted that their practices – including using data, building on others' ideas, and referencing outside sources - matched many of the benchmark criteria for scientific literacy created by the American Association for the Advancement of Science (Steinkuehler & Duncan, 2008). While the discussions in their study evidenced habits of reflection and scientific thinking among participants, Steinkuehler and Duncan (2008) note that future research would be needed to determine whether or not it is game forums that foster these attitudes toward knowledge, or whether they “tend to attract individuals with a more nuanced stance toward knowledge” (p. 541).

In addition to the issues of scientific literacy and access to online resources discussed above, another relevant form of literacy could involve social capital, or the information and resources contained in a person's social network. As Greenhow and Robelia (2009) found in their study of students from low-income families, “knowing how to cultivate and use a supportive network of people, information and resources” can be extremely valuable to youth, in particular for those experiencing life transitions, as these resources can help to boost self-esteem and social belonging (p. 129). In their report on learning in media-rich environments, Lemke et al. (2015) emphasize the importance of social skills - including an ability “to build relationships and negotiate social networks” (p. 92) - as key to facilitating learning. To be able to learn effectively, students must



not only have know-how, but also “know-who”, or an understanding of who in their network can help them to meet a need (Lemke et al., 2015, p. 92). Researchers studying social networks emphasize the importance and utility of information gleaned from weak ties, or people whom “one knows in a specific and limited context” (Donath & Boyd, 2004, p. 11). Those with smaller and less diverse networks, therefore, may be at a disadvantage, as weak ties can be especially “good sources for novel information” (Donath & Boyd, 2004, p. 11).

In his conceptualization of participatory culture, Jenkins (2006a) is careful to note that “not all participants are created equal [...] some consumers have greater abilities to participate in this emerging culture than others” (p. 3). A key question in this review, therefore, could be the following: if online affinity spaces and other environments can foster potential for learning in deep, interest-driven ways, then what are the implications of gaps in access to digital literacy and opportunities for participation in online spaces between different groups and individuals?

The next and final theme of this review examines the methodological questions explored in the literature, including debates regarding the best approaches for studying informal STEM learning and participation in affinity spaces.


## **Theme 5: Methodologies**

**Question:** *Which methodological approaches are appropriate to studying and understanding different types of participation and learning in informal spaces?*

Methodology was discussed in many of the articles in this review, as researchers highlighted the challenges of studying and assessing participation and learning in informal settings.

For the informal STEM education community, documenting and assessing learning is an ongoing challenge, made more complex by not only the nature of informal science learning, but also by the lack of a common approach across the field. Assessing informal science learning in “practical, evidence-centred ways” can be difficult when this learning involves activities that are entirely self-directed, episodic, and take place in diverse institutional and everyday settings ranging from science centres to living rooms and backyards (Fenichel & Schweingruber, 2010, p. 103). Bell et al. (2009) note the informal STEM community’s struggles with theoretical and conceptual framings for understanding science learning, and call for a “common language and common constructs” for research and assessment (p. 55). Adding to these challenges are diverging opinions within the informal STEM community on the issue of standardized assessment tools. While some practitioners fear that standardized methods of assessment could inhibit the diversity of learners’ experiences and ways of interacting with science, others note that adopting a common framework for assessment could lay the groundwork for more equity in opportunities in science learning by helping to identify gaps in the field and areas for potential improvement (Fenichel & Schweingruber, p. 111).

Researchers studying learning and literacy practices, including those exploring online affinity spaces, also document the challenges of selecting and implementing appropriate theoretical and methodological approaches. In order to capture the diverse levels of analytical richness in their studies of online literacy practices, Steinkuehler et al. (2005) draw on various fields of study to include approaches such as activity theory, distributed cognition and phenomenology. They outline various methods that can help to document the meanings of literacy and practices among participants, including think-aloud protocols, interviews and discourse analysis (Steinkuehler et al., 2005). To study literacy as place, Steinkuehler et al. (2005) emphasize



that ethnography may be most appropriate; this approach can include methods such as participant observation, the collection of documents, interviews with informants, and the analysis of transcripts from chats and message boards. Studies of this type are complex and time-intensive, as researchers must invest significant effort to recruit and conduct participant observation in these settings (Lammers et al., 2012; Steinkuehler et al. 2005). Steinkuehler et al. (2005) note that familiarizing themselves with changing gameplay and gaining access to different groups and segments of a community “can require months of online participation” on the part of participant observers (p. 8).

Further research challenges emerge when considering the constantly evolving nature of online environments: Lammers et al. (2012) highlight that the “instability and impermanence” of online spaces can make data collection difficult (p. 44). In addition to the disappearance of sites, new portals of affinity spaces can be created at any time, which may require researchers to account for and consider these new avenues for participation (Lammers et al., 2012). The changing nature of online participation over time necessitates a shift in – or expansion of – our understanding of the concept of affinity spaces. As Lammers et al. note (2012), online environments have evolved significantly since Gee (2004) first proposed the concept of affinity spaces: for this reason, the extensive involvement of social networking sites in the activities of online fan and gaming communities, for example, must be taken into account by researchers.

Researchers interested in capturing the effects of learning taking place in various informal spaces over time advocate for an increased use of longitudinal study designs. In her study on interest-driven learning among teens, Barron (2006) notes that as interests cross boundaries and are taken up over time in different contexts, “longitudinal data should be collected” (p. 201). In their report on informal learning in media-rich environments, Lemke et al. (2015) echo this call, highlighting that a longitudinal approach can “attend to multiple time scales [...], following changes and gains from the inception of a project and documenting the processes by which desirable outcomes occur in addition to the outcomes themselves” (p. 90).

While Steinkuehler et al. (2005) advocate for qualitative methods as most useful for understanding the meaning of online practices to participants, other researchers also recommend data mining and other large-scale data collection strategies to document evidence of learning in informal environments (Kafai & Giang, 2007; Lemke et al., 2015). Mixed-methods approaches, for example combining interview and survey data (Steinfeld et al., 2008), may also be key to future research in this area.

Researchers not only need to attend to the appropriate methods and data analysis strategies, but also to the broader contexts of their participants’ activities. As Steinkuehler et al. (2005) note, the nuances of meaning associated with the practices under study should be seen “within their indigenous contexts of use” (p. 1). The environments in which data are collected should be as close as possible to the context in which participants experience these phenomena; for this reason, findings regarding science learning and games conducted in classroom settings (Kafai & Giang, 2007), for example, may not always illustrate the elements of intrinsic motivation that are key to understanding informal and interest-driven learning.



## Conclusion and Future Directions

This review of the literature examined the research questions and gaps in research at the intersection of informal science learning, interest-driven learning and online affinity spaces. In addition, it outlined five themes found in the literature:


- Equity and Diversity
- Interest
- Identity
- Literacy
- Methodology

Many avenues of future research can be seen in this review, including the following questions and topics which represent gaps in existing research:

- women and ethno-racial minorities' engagement with science (Falk et al., 2012)
- the best practices in providing science learning opportunities to underrepresented communities (Falk et al., 2012)
- the interest and needs of non-users of informal STEM programs (Falk et al., 2012)
- the extent of differences of web-use skills among different populations in the broader public (Hargiattai, 2010)
- methods of assessment that can attend to both outcomes for individual learners and group-level learning (Lemke et al., 2015)
- how to balance the diverse needs and interests of learners at various skill levels
- how to support positive identity work in science inside the classroom (Rahm, 2014) – or outside the classroom
- how literacy skills, self-identity and the nature of online communities affect learners' experiences and the development of their future aspirations (Ahn et al., 2014)
- how interest in a topic – like science - is sustained (Falk et al., 2012), as well as the role that identity development plays in sustaining interest among learners (Barron, 2006)
- the literacies and practices of young children in online environments (Grimes & Fields, 2012)
- how assessments of informal learning can take into account the cultural and social contexts of communities and institutions that both support and constrain the activities under study (Lemke et al., 2015)
- how bridging spaces can be created between school and home to foster academic learning (Steinkuehler & Duncan, 2008), and how diverse digital literacies learned in other settings can be brought into and valued in academic settings (Greenhow & Robelia, 2009)
- and whether or not in-depth assessments of learning in existing affinity spaces for children, such as Scratch, a coding language for kids (i.e., Kafai, Fields, & Burke, 2010), can support our understanding of the possibilities for informal STEM learning online.

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