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Science Cafés: Exploring Adults' Motivation to Learn Science in a Community Space

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Abstract

Science Cafés create open, public forums to promote the exchange of ideas between science experts and the public. This study explored Science Café attendees' interest in science content, and motivational factors in attending events as well as documenting what attendees did with the information presented at an event through the means of a survey ($n = 124$) and interviews ($n = 17$). The *Synthesized Elements for Informal Learning Experiences at Science Cafés* represents a merged perspective of informal learning environments, based on self-determination theory and the contextual model of learning. The synthesized elements (*endogenous* and *ecological*) may provide an explanation of the public's motivation in attending Science Café events. Based on survey and interview data, the majority of participants reported *endogenous elements* (knowledge and learning; fulfills personal needs) as motivational factors to attend Science Café events. Additionally, attendees stated *ecological elements*, such as social interactions, with other attendees and science experts were significant motivational influences to attend events. Survey and interview respondents cited they share and discuss the information gained from a Science Café event with others in their social network (e.g., family members, friends, and colleagues). This information may inform best practices in connecting the community to science experts in order to share scientific endeavors and documenting the profound effect science has on the public.

Keywords Motivation · Informal science education · Adult learning · Science cafés

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Introduction

The Science Café movement serves to bridge the communication gap between science and society. Science Café events provide opportunities for science experts to share scientific research and advances through an open dialog with the public. During the early 1990s, the Science Café movement (café scientifique) was launched in France, spreading quickly to England, then to the USA shortly thereafter. By the beginning of the twenty-first century, the phenomenon of Science Cafés had spread worldwide (Clery 2003). Science Cafés have been described as having multiple purposes that include engaging the public in the work of scientists and researchers, informing citizenry, allowing for public discourse about scientific research, and encouraging social learning in an informal learning environment (Dijkstra 2017). By projecting science into the public arena, Science Cafés promote conversations that can present not only the findings of scientific research, but also the implications and consequences of science (Norton and Nohara 2009). Furthermore, because Science Café events are a growing phenomenon with the goal of connecting science to the public, there is a need to explore the contextual factors, such as motivation, through the lens of self-determination theory and the contextual model of learning, to better understand attendee participation habits, interests, and attitudes related to science (NAS 2018). The purpose of this study was to examine the motivational factors, such as *personal interest*, *fulfilling personal needs*, or *social interactions*, that influence individuals to attend a Science Café and to understand what attendees do with the information they obtain at an event. By exploring participant motivation, this study seeks to provide context as to why individuals are attending these public events and to inform the design and implementation of informal science education opportunities in the public arena to support diverse engagement. The research questions for this study are described below:

Research Questions

Research question 1: What *motivational factors* are shared by individuals who attend Science Café events?

Research question 2: What do individuals *do with the information or knowledge* presented at a Science Café event?

Informal Science Environments and Adult Learning

Learning is a multi-dimensional process that is not limited by age. For adults, learning is often the result of circumstance, culture, or choice. During the course of a lifetime, motivation and interest in learning are ever evolving, with opportunities either facilitating or limiting the choices an individual makes when seeking new knowledge (NAS 2018). It occurs in a variety of formal and informal settings that can extend existing interests and promote novel ideas, such as Science Cafés. Science Cafés have the potential of influencing participants' science knowledge and interests throughout their life span. In general, people spend more time in informal educational settings than in traditional classrooms (Falk et al. 2007; Falk and Needham 2013). Traditional or formal settings focus on cognitive outcomes and are limited in opportunity based on age, educational goals, and background. Conversely, informal environments have a greater potential to influence cognitive development and a broader range of outcomes (National Research Council 2009). These outcomes may include learning across age spans (lifelong), learning across a broad range of settings and experiences (life-wide), and

learning through interactions in culture and society (life-deep) (National Research Council 2009). When given an opportunity, adult learners will pursue activities they find of interest and utility, especially when they are "important to their sense of competence and well-being" (National Academies of Sciences, Engineering and Medicine 2018, p. 199). Experiences in informal learning environments are important in building interest in, understanding of, and appreciation for science (National Research Council 2009). Focusing on science, informal science environments are defined as "any science learning that takes place outside the school wall" (Ramey-Gassert 1997, p. 433). Common informal science learning environments can be museums, botanical gardens, local and national nature parks, making and tinkering spaces, and many others. Interestingly, attendance of informal science learning opportunities appears to be greatest outside of formalized schooling ages and has the additional benefit of "… developing positive science-related attitudes, emotions and identities" (National Research Council 2009, p. 294; Falk and Storksdieck 2010). Science Cafés are informal science environments for the public as these events do not take place within traditional *school walls* but do support science learning and engagement between audience members and science experts.

Science Cafés

The Science Café movement is just one type of informal science learning environment, and as such, exploring the public's interest and motivation in attending is important to investigate for fostering science learning. Although Science Cafés take a variety of formats, these events often include one or two speakers who present a short presentation on their work, followed by a period of audience participation in which questions are asked and discussions occur (Grand 2014). The organization of Science Café events serve as a stage for public participation in science. They are often low in cost and management because a location, such as a restaurant or café, a science expert, and an audience are generally the only requirements for a Science Café to exist (Nielsen et al. 2015). Furthermore, the goal of a Science Café is to help foster a deeper connection to a science concept in a more formalized format while still maintaining a relaxed, voluntary atmosphere (Navid and Einsiedel 2012).

Science Cafés, as an adult learning experience, can be valuable in helping learners reframe existing ideas, engage in new concepts, stimulate interest, build new knowledge, and increase one's comfort level within a culture of science. Likewise, Science Cafés have been utilized as a model to introduce STEM and STEM careers to young women or as a gateway to build relationships between schools, students, and their parents (Bazilio et al. 2016; Robinson 2017). In the 2010 NAP publication, *Surrounded by Science: Learning Science in Informal Environments*, the authors suggest presenters at a Science Café were able to connect with the audience in a way that "personalizes science and provides authenticity" (National Research Council 2010, p. 12). Not only did the Science Café stimulate the audience to consider the impact of science on their daily decision-making processes but "38% of participating scientists report that their involvement in the program changed the way they present their work to the public" (National Research Council 2010, p. 11). Following engagement with the public, the presenter was more knowledgeable about the public's motivation to apply scientific discovery to their lives. The audience, furthermore, grew in their application of scientific principles. Both outcomes could be considered scientific literacy gains.

There are few studies providing an understanding of the characteristics and affordances of those who attend Science Cafés. Norton and Nohara (2009) explored a series of Science

Cafés conducted by graduate students over a 4-year period in Japan, designed to provide training to scientists in public communication. The researchers identified a range of Science Café settings including a one-way communication model with a single speaker, a panel-type format that included experts with different viewpoints, and discussion of events based on issues that encouraged audience participation. The results of this study centered on the methods facilitated by the presenters to engage the audience further such as stage-acting (a fictitious science character), experimental demonstrations, or well-planned discussion elements to develop the desired conclusion. Although this study focused on presenters' development, clear appreciation of the skills of multimodal communication, science ethics, and time relevancy of science presentation occurred. Secondly, Navid and Einsiedel (2012) researched Science Café presentations conducted in five different areas across Canada in a 3-year period. The specific research questions related to prior knowledge and perception of synthetic biology, response to presentation, and attitudes of Science Café format. The researchers found attendees visited Science Café events because of a desire to learn more about the topic. These results indicated that attendees perceived the science presentations were informative and interesting and resulted in a greater understanding of synthetic biology. Additionally, Dijkstra and Critchley (2016) compared the risk perceptions of nanotechnology between two adult groups: individuals who have attended a Science Café and individuals who have not attended a Science Café. The findings suggested that individuals who attended Science Café events to learn about nanotechnology were more positive than the individuals who did not attend the Science Café event. A comparison of Danish and Japanese Science Café events revealed some cultural differences in how audience members participated; however, Science Cafés, even in different locations around the world, are easily adaptable to most environmental contexts (Nielsen et al. 2015). Lastly, an evaluative research study measured self-confidence in knowledge and understanding of public health topics as explored in a Science Café setting in which the self-confidence scores increased over time (Ahmed et al. 2014). Overall, the previous studies highlight the affordances of Science Cafes, including scientific literacy, public science promotion, and interactions between the public and the science expert. Because they are primarily attended by those who already have confidence and an interest in science, one constraint to Science Cafes is their inability to reach a broad segment of the population (Dijkstra 2017). This limitation would suggest a need to address the existing gap in the research that seeks to understand participants' motivation to attend Science Café events to better understand how to potentially reach a broader segment of society.

Despite the marked variety of study methodologies in Science Café utility, affordances, and characteristics, there is a clearly discernable potential for Science Café events to have a broad impact on the public's knowledge of and attitude toward science. According to the National Academies of Sciences, *How People Learn II*, research is needed to examine contextual factors that influence lifelong learning, such as motivation. In other public events that are designed to support scientific discourse between the community and science experts, motivation to learn about science topics as well as personal interest and attitudes regarding science may guide individuals to participate in these events and support scientific literacy (Bonney et al. 2016; Spoel et al. 2008). By examining motivation in a context where participants are engaging in science learning, discourse, and in which they feel like they "belong…[and] have a sense of purpose," our study seeks to elucidate the factors that contribute to Science Café participation (National Academies of Sciences, Engineering and Medicine 2018, p. 133).

Theoretical Frameworks

Most of the research directed at learning science has been in the K-12 classroom setting. Consequently, a theoretical foundation for understanding learning in informal settings has not yet been developed. "Despite the increasing prevalence of public engagement events for science-related issues, the current research on public engagement event evaluation lags behind" (Rose, Brossard, Scheufele and Heisler 2017, p. 254; Falk and Needham 2013). Yet free-choice, informal learning environments, including Science Cafés, are a growing phenomenon that serve an important role in contributing toward public understanding of science. To better understand the motivational experiences of Science Café attendees, two theoretical perspectives, self-determination theory and the contextual model of learning, serve as the foundational foci to investigate and document the experiences of Science Café attendees.

Self-Determination Theory

Self-determination theory (SDT) is a model to illuminate the motivations of people who chose to participate in learning opportunities (Deci and Ryan 2000). The constructs of SDT may explain the motivations of people who attend Science Café events with three constructs: competency, relatedness, and autonomy. Competence is the ability for one to master the challenges experienced in the environment and consequently, affect that environment. Relatedness describes how people connect with others, including developing a sense of belonging and security while interacting with others. Autonomy, the final component, involves freedom and choice in how individuals participate in learning experiences (Deci and Ryan 2000). SDT suggests that individuals will seek out opportunities that will fulfill these fundamental needs and facilitate growth. People will pursue activities, which allow them to interact with their environment, participate in things they find interesting, and "move toward personal and interpersonal coherence" (Deci and Ryan 2000, p. 230). Applied to the context of Science Café events, SDT suggests that attendees are making an autonomous choice about their learning environment and, as such, are more likely to develop competence in learning science.

Contextual Model of Learning

Another perspective to consider in exploring the experiences of attendees at Science Cafés is Falk and Dierking's (2000) contextual model of learning (CML) that describes learning in a museum environment. This framework identifies three contexts of informal learning experiences: personal (prior experiences and attitudes), sociocultural (social interactions with others), and the physical context (learning environment). CML is one of the several theories suggested by the National Academy of Sciences in understanding learning in informal settings (National Research Council 2009). While the constructs defined in CML are targeted toward museum experiences, they may apply to other informal learning environments, including Science Cafés. The physical context in a Science Café is varied by venue and organization; however, there are many commonalities in a broad range of settings. Science Cafés are situated in facilities that promote social interaction and have a perceived informal atmosphere.

Synthesizing the Elements for Informal Learning Experiences at Science Cafés

When SDT and CML are compared, there are significant parallels in these two frameworks to provide insights on free-choice environments (see Table 1). To document Science Café attendees' perceived interest, motivation, and learning at an event, we designed a synthesized, merged perspective (titled: *Synthesized Elements of Informal Learning Experiences at Science Cafés*) for this investigation (see Table 2).

Endogenous Elements

The personal context factors identified in CML are related to the constructs of competence and autonomy as identified critical needs within SDT. We would propose that these three constructs (personal context, competence, and autonomy), collectively, are *endogenous* elements, relating to attendees' intrinsic drive to attend Science Café events. Although competence is not specifically paralleled in the personal context of CML, successful mastery of learning is often an outcome of prior knowledge, interest, and motivation (National Academies of Sciences, Engineering and Medicine 2018). Endogenous elements in the proposed hybrid model include motivations and expectations of attendees, their prior knowledge, interest and beliefs brought to an event, and the autonomy, or choice and control they have in choosing to attend events and which events to attend.

Ecological Elements

Social learning theory is one of the foundational components for both SDT and CML (Falk and Storksdieck 2005; Ryan and Deci 2000) and includes factors that relate to learning through social experiences. Sociocultural learning theory has origins in Vygotsky's social development

Table 1 Application of frameworks to Science Café experiences

	Model and construct descriptions	Application to Science Cafés
Self-determination theory (Deci and Ryan 2000)	*Autonomy* – defined as choice and control; involves being free to choose experiences and activities based on one's interests, desires, and identity *Competence* – mastery within one's environment; the ability to have a positive effect on one's surroundings and in turn, be positively affected by it *Relatedness* - social connectedness; to foster positive relationships with others	*Autonomy* – attendees' choice to attend any or all events based on interests, desires, identity *Competence* – whether the attendees feel that they are enriched by the experience *Relatedness* - the social connections made when attending Science Cafés and the relationships that develop
Contextual model of learning (Falk and Dierking 2000)	*Personal context* - motivation, expectations, interests, prior knowledge and beliefs, choice; factors that relate to one's intrinsic desires *Social context* - within and facilitated interactions; connections made with others that facilitate positive relationships *Physical context* - orientation, design, reinforcing experiences; interactions with the museum environment that help one grow and learn	*Personal context* – attendees choose to attend events based on interests, desires, identity; includes personal enrichment *Social context* –the social connections made when attending Science Cafés and the relationships that develop *Physical context* – an informal atmosphere that is perceived as enjoyable and facilitates social interaction

Table 2 Synthesized elements of informal learning experiences at Science Cafés

Synthesized elements	Factors	Description
Endogenous elements	Intrinsic factors including motivations and expectations, prior knowledge, interest, and beliefs that are facilitated by choice.	Constructs related to internal motivation and the desire for personal growth and knowledge.
Ecological elements	Social interactions among individuals that build interdependent relationships and the environment in which they occur.	Constructs that foster interdependent relationships of participants, including attendees, speakers, and organizers, and how those factors are facilitated by the setting of the event.

theory, which recognizes that human activities, such as learning, occur in a social context (Lemke 2001). Social learning theory, as a foundation of both theories, relates to learning in SDT in the construct of relatedness, or the need for individuals to make connections with others through social experiences. CML recognizes the importance of interactions both with others in a social group and with experts.

Although SDT does not specifically address the setting in which learning occurs, CML is generally applicable to learning in museum environments. The CML framework recognizes that learning is situated, and the research and description primarily apply to learning in museum settings. The environment or setting itself in a Science Café relates to a venue and format for interaction, whether it is a tavern, coffee shop, or restaurant, and the way in which interactions between attendees and speakers are facilitated. These factors can be thought of as part of the ecosystem of a Science Café. The format of the specific event is a factor as Science Cafés provide varying opportunities for interaction with their speakers (Dijkstra 2017). Therefore, we propose that these elements are *ecological* in nature as they reference interdependent relationships in the environment in which they occur, making connections between individuals in a community of learners. In the synthesized elements, ecological factors would include interactions of participants in a Science Café, and how those factors are facilitated by the setting of the event.

The *Synthesized Elements of Informal Learning Experiences at Science Cafés* are rooted in social learning theory (Grusec 1992), merged from both foundational theories (SDT and CML), and based on the components of the two theoretical frameworks. The elements of each framework are unique in perspective and inform our research, but the parallels between the frameworks provide a means to compile each of these perspectives into a meaningful understanding of attendees' motivation in attending Science Cafés. This research seeks to understand the experience of Science Café attendees by synthesizing these two different perspectives as a foundational lens for investigation.

Methodology

In this study, we documented individuals' motivation to attend Science Café events and what individuals do with the information or knowledge presented at a Science Café event by administering an online questionnaire and conducting interviews with attendees. Designed as a mixed-methods study approach, we surveyed 124 adult attendees in the Southeastern USA then subsequently interviewed 17 adults who attended at least one Science Café event within

the past year (Creswell and Clark 2017). The questionnaire and interview protocols were designed for participants to describe their experiences in attending Science Cafés by asking questions related to motivation and interest in attending Science Cafés as well as how the information or knowledge presented during the event may be used by the attendees. The purpose of this methodological approach was to document the questionnaire's responses in relation to the study's research questions and further explore in-depth, interviewees' motivations in attending Science Café events. Permission to obtain research data was granted by a university institutional review board (IRB). All Science Café attendees were invited to participate in the survey and interview portions of the study, and consent forms for participation were available as mandated by the IRB. Questionnaire data were collected by Qualtrics®, an online survey and questionnaire program, and downloaded onto a computer (password protected and locked in a protected room) into data files, such as Excel. Interview data (audio recordings, transcripts, and coding) were also contained on a password-protected computer.

Study Context

This study reported adult participants' (18 years or older) experiences in attending Science Cafés in the Southeastern USA. The three Science Café locations in this study are often organized as having one or two speakers present related talks (30 min to an hour) on their science-related work or research located within a restaurant. Generally, the talks occurred during weekday evening hours. The audience can ask questions to the speaker, and these questions may facilitate discussions about science topics during the Science Café event. During this study, scientific topics shared and discussed at Science Café events varied by venue, but such talks typically include new discoveries in astronomy, medicine, genetics, ecology, and physics.

Questionnaire Protocol

An online questionnaire was developed based on a review of the literature of informal learning experiences related to learning, motivation, and interests of adults participating in community-based informal science events. The questionnaire was reviewed by a panel of three science education researchers for validity, piloted, and revised before administering the questionnaire. The survey was piloted with four adults who were not part of the study to document readability of the questionnaire items and length of time to complete the questionnaire to support the revision of the questionnaire. These adults were selected to review questionnaire items as they were representative of the demographics (age, gender, location, and education level) of those who attend Science Café events in this study. The questionnaire solicited information about Science Café attendee demographics, educational background, attendance behaviors, motivation to attend Science Café events, perceived benefits of attending Science Café events, and documented what Science Café attendees do with the information or knowledge gained once they leave an event. The questionnaire protocol (22 total questions) included open-ended response questions asking the participant to share motivational factors (specific influences or elements that motivates individuals) and what they do with the knowledge or information gained after attending an event. Specific items in the questionnaire targeted information aligned to the study's research questions such as motivation factors to attend science cafés (*Why do you attend Science Cafés?*) and what they do with the knowledge or information gained after attending an event (*How do you benefit in attending Science Cafés? What do you*

do with the information you learn at a science café?). All Science Café attendees were invited to participate in the survey. At the end of the survey, participants were asked to supply contact information (email address and telephone number) if they were willing to be interviewed about their specific experiences in attending science café events.

Questionnaire Participants

The online recruitment request, sent to Science Café organizers in the Southeastern USA region to be distributed to their Science Café organization, invited participants to share their experiences in attending Science Cafés "...to better understand the community of participants and their interest in Science Cafés". The questionnaire participants ($n = 124$) were adults (18 years of age or older) who attended at least one Science Café event during the past year (26% attended 1 event; 31% attended at least 2 events; 42% attended at least 4 events; 1% preferred not to answer). Of the study's 124 respondents, 60% were female and 40% were male. The majority of Science Café attendees identified as Caucasian (83%) and held college degrees (84% of Science Café attendees have a 4-year degree or higher). Seventy-two percent of Science Café attendees who completed the online questionnaire were 41 years of age or older (mean age = 52).

Interview Protocol

The interview protocol questions were designed in an open-ended, semi-structured format to document the motivations, what happens with knowledge or information gained at an event, and demographics of Science Café attendees. The questions were informed by the literature on Science Cafés, motivation (SDT), and informal learning experiences (CML) relating to adults' interests, sociocultural motivations, and physical context of the informal science event. Specifically, the interview protocol was designed to capture participants' motivation by asking questions related to their experiences at Science Cafés. The interview protocol consisted of sixteen questions that were reviewed by three science education researchers with experience in informal science learning contexts to address validity. During the review, the created questions were aligned to the review of literature, research questions, and the synthesized elements by the panel, evaluated by two adults (who were not participants in the research) to explore the connection and discernment of the interview questions, and revised the interview questions for clarity by the panel. Specific questions directed at interviewees included (1) *Why do you attend Science Cafés?* (2) *What do you like best and least about them?* (3) *What do you think are the benefits of attending Science Café's?*, and (4) *What would be your ideal Science Café experience?* Additional follow-up questions were asked as necessary to encourage interviewees to elaborate on their initial responses. Science Café attendees who completed the survey were asked to share contact information if willing to be interviewed about their Science Café experiences, and those attendees who agreed to share their contact information were selected for an interview. Interviews were conducted by phone and audio-recorded with electronic recording devices. Interviews lasted approximately 20 min.

Interview Participants

Interview participants were recruited from those who completed the online questionnaire (described above). Science Café attendees who were interested in participating in the interview

shared their contact information (email and telephone number). The interviews were conducted by telephone and were scheduled at the convenience of the participants. The telephone interviews were audio-recorded and transcribed. There were 17 interviewees: 47% females and 53% males. The mean age of the interviewees was 55 (median = 57). The majority of interviewees indicated they were Caucasian (82%) while the other participants indicated the following: 1 Asian, 1 Hispanic, and 1 preferred not to answer. Most of the interviewees (94%) had at least a 4-year degree.

Questionnaire and Interview Analysis

Open-ended questionnaire items and interview responses designed to capture participants' experiences in attending Science Cafés were analyzed using the two-cycle coding method described by Saldaña (2015). The first cycle of coding used the structural coding method, which, according to Saldana, is suited for use with open-ended survey items. In this coding method, research questions drive the first round of coding which is concept based, then "collected together for more detailed coding and/or analysis" (p. 98). The codes identified by the researchers and described connections to the community, curiosity of the science topic, importance of learning, intellectual stimulation, networking, personal interest in science, and social engagement. Codes were developed to document what Science Café attendees did with the knowledge of information after event centered on challenging their own personal views of the science topic, fueled personal research, and sharing the new knowledge with others in their social network. Once the codes were established, analysis of the questionnaire and interview data along with the coding process was implemented and identified common elements and themes from the interviews. During the second round of coding, a theoretical coding approach was implemented, aligning initial codes to the synthesized elements: endogenous and ecological. According to Saldaña (2015), this approach can be used to apply "pre-existing theories in different contexts or social circumstances" (p. 251). Initial codes were integrated to build and elaborate on the existing theoretical constructs identified as the basis of this study and subcategories were defined. To discover more about what participants did with the knowledge or information gained at a Science Café event, codes were categorized that aligned with the synthesized elements (endogenous and ecological): share or discuss with others; catalyst for personal growth or development; reflection; and nothing or very little. To better understand participants' motivational factors, the following categories were synthesized based on endogenous and environmental elements: knowledge and learning; fulfills personal need; social interactions, Science Café environment and location; and science process. During the second round of coding, researchers worked collaboratively to resolve any differences in categorization during analysis. The theoretical coding process provided coherence and relevance to the analysis as categories were generated and refined (Thornberg and Charmaz 2014). Finally, descriptive statistics were used to document the demographic data of the questionnaire and interview participants.

The questionnaire open-ended responses were read and reread by three researchers. Inter-rater agreement was established between the three raters as 94%. Frequency counts and percentages of responses for each code were calculated. For the interview analysis, transcripts were generated from interviewee audio files for each interview and were analyzed. Interview data were reviewed and coded by two researchers. An inter-rater reliability agreement was established at 95%. The codes and themes created during the questionnaire and interview data review were summarized and connected to each research question. Specific quotes from the

interviews were selected and featured in the "Results" section and the "Discussion" sectionS14 to address the research questions and alignment to the synthesized model.

Results

The results are reported by research question for the questionnaire and the interview responses of Science Café attendees. The *Synthesized Elements for Informal Learning Experiences at Science Cafés* factors were aligned to thematic findings.

Research Question 1: What Motivational Factors Are Shared by Individuals Who Attend Science Café Events?

Questionnaire Results

Participants ($n = 124$) were asked to respond to the question that elicited the reason or motivation in attending Science Cafés, such as the specific question *Why do you attend Science Cafés?* Participants were allowed to provide more than one answer. Thematically, the majority (65%) reported learning and gaining information or knowledge was a significant motivational factor in attending Science Café events. Participants also noted that social interactions (30%) with other attendees at Science Café events as well as fulfilling a personal need (38%) were motivational influences in attending Science Café events. Only 15% of participants stated that the environment or atmosphere of a Science Café event encouraged attendance and 12% of participants indicated learning about science process (i.e., process of science relating to science literacy, nature of science, application of science) as an inspirational factor for attendance (see Table 3). Overwhelmingly, the questionnaire responses indicated that *endogenous elements* (described as internal cause or origin) as motivational factors to attend Science Café events were shared by most participants. *Ecological elements* were cited secondarily as factors related to motivation in attending Science Café events.

Interview Results

Interviewees ($n = 17$) responded to the questions (described above) by indicating that they felt these events provided intellectual stimulation in general, provided an experience in which they could learn something new, or provided an opportunity for social interaction.

Interview—Endogenous Elements

Forty-seven percent of interviewees shared intellectual stimulation in terms of a basic need. One interviewee discussed the importance of intellectual stimulation, "I want something that is going to challenge me to think and challenge me to process what they are saying." Embedded in this theme are the concepts of curiosity and the importance of learning for personal growth. One respondent explained, "I have developed a lot more curiosity about things, having attended these [Science Cafés] than I typically had before…(the) Science Café has really, kind of gotten me to enjoy a lot of other things; being more curious and doing more reading...The Science Cafés have really been very eye opening." One attendee's response extended the importance of intellectual stimulation beyond a personal need and felt that this is

Table 3 Motivational factors to attend Science Café events

Synthesized elements	Code	Description of code	Example participant responses	Science Café attendees (%, *n*)
Endogenous elements	Knowledge and learning	This theme includes participants' responses indicating gaining *information* and *knowledge* or *learning* more about a science topic as motivational factors.	"Learning about new science. Learning how to present science. Getting excited about science."	65% ($n = 80$)
Endogenous elements	Fulfills personal need	Participants reporting *fulfills personal need* as a motivational factor indicated obtaining personal fulfillment, sustaining an active mind, and broadening horizons.	"I get exposed to new information and new areas of research. I find Science Cafés really inspiring. I get encouragement for my own studies and research."	38% ($n = 47$)
Ecological elements	Social interactions	*Social interactions* describe participants' responses revolving around socializations, discussion, connections, and interactions with *like-minded* or *intelligent* people.	"…making contact with real people who are doing scientific and theoretical work; there is also a social benefit, just mingling, hearing other people, having conversations."	30% ($n = 37$)
Ecological elements	Science Café setting	This theme includes participants' responses indicating that the Science Café environment and location were motivational factors.	"I like the casual atmosphere." "The relaxed, low-pressure atmosphere."	15% ($n = 18$)
Endogenous elements	Science process	Science process describes participant responses relating to science literacy, how science works, nature of science, and the application of science.	"…to see different ways that you can be a scientist, and what science looks like."	12% ($n = 15$)

a value that should be shared by all members in a community. He commented, "I'm a big believer that knowledge about anything is good and makes people a better citizen or better people regardless of what the knowledge is about."

The majority of interviewees cited the opportunity to learn something new as an important motivator for attending Science Cafés, although they talked about this purpose using different language. Some attendees discussed how they enjoyed learning new information that provided a broader understanding of familiar topics. When asked *what was the major benefit of attending Science Cafés*, one participant commented, "For me, the primary is the educational part, learning new stuff. My mind just likes to soak up new information. I've been that way all my life." Some interviewees attended because of existing, personal interests: "I'm really interested in environmental science and ecology and looking at climate change and understanding what we're doing to our environment and ways that we could lessen our impact or better our impact." Other attendees indicated Science Cafés exposed them to new ideas that they were previously unaware of: "I learned about robotics in agriculture…I wouldn't have known about it otherwise. That was pretty cool." Regardless of whether it was to learn more about a current field of interest, a previously unknown field, or new research in new fields, most attendees reported that an innate desire to learn was one of the motivating factors for attending Science Cafés.

Interview—Ecological Elements

Ecological factors were reported by the attendees as an important motivational factor in attending Science Cafés. Majority of the interviewees (82%) discussed the importance of social interactions as a reason for participating in these events. The various codes that were generated during the analysis most often could be summarized as community building, networking, socializing with people who have common interests, and broadly interacting within a social context. Comments related to community building and the environment include thematic comments such as, "You get to meet people you would not meet in other contexts. You see them again and again in the same place and you form a kind of comradery." Some attendees view Science Cafés as an opportunity to network. As one interviewee explained, "Part of my job is to connect people. If somebody needs something, or somebody needs to talk to somebody, I use that as part of my network in trying to connect people." One common theme that emerged is that attendees found that Science Cafés gave them an opportunity to connect with people who had "like interests." One interviewee stated attending Science Cafés gave her an "opportunity to talk to other people who usually are pretty collegial and science supportive."

Research Question 2: What Do Individuals Do with the Information or Knowledge Presented at a Science Café Event?

Questionnaire Results

A major area of interest in this research was to document what attendees do with what they learn at Science Cafés. The majority (54%) share and/or discuss the information gained from a Science Café event with others (e.g., family members, friends, colleagues). Additionally, 40% of participants ($n = 50$) stated a specific catalyst for personal growth or development, indicating that as a result of their attendance at a Science Café event, the attendee will actively

participate in experiences such as research and reading about the information shared at the event. Furthermore, 17% of participants responded either they do nothing or very little with the information shared at the event or participate in personal reflection of the information presented at a Science Café event (see Table 4).

Interview Results

The interview question "What do you do with the information you learn at the Science Café?" was specifically geared toward learning what impact, if any, participation in these events has on attendees. This research question informs how the information learned at a Science Café might shed more light on motivations to return to future Science Café events. Thematic analysis of the interviews showed that both endogenous and ecological elements were implied in how attendees acted on what they learned at Science Cafés.

Interview—Endogenous Elements

In terms of endogenous elements, interviewees reported that they perceived the information they learned at a Science Café was valuable for personal satisfaction. When asked what he does with the information learned at a Science Café, one interviewee responded with, "It comes by as second nature. It's just like asking a musician why does he or she go to other musicians' concerts. It is a similar kind of thing. After a while a part of you would like to keep the curiosity and stay up to date with science." One-third of interviewees stated that they would, "do some follow up reading," or "do a little more research often after a Science Café to find some more articles about it." Sometimes attendees just "think about" what they learn and possibly reference it later. Just learning new information seems to have intrinsic value. One of the attendees explained, "It's kind of just background information in the back of my head and for me it's about serendipity. I don't know when it will come up to be useful."

An important outcome of the data analysis that emerged was that five of the interviewees (29%) felt that attending a Science Café challenged their preconceptions. One attendee stated that, "it exposes me sometimes to perspectives I had not considered," while another reported, "it's thought provoking and challenges your point of view." Whether they followed up with research, faced new perspectives, or just held on to the information they learned, for many of these interviewees, it was obvious they valued learning new information, which is not only a motivator for attending, but a tangible outcome as well.

The final themes that emerged from the interview analysis relate to the endogenous elements synthesized in our data. The themes that are considered here relate to specific outcomes in which attendees use the information they learn for personal growth in some way. Four of the interviewees (24%) took some sort of specific action that was inspired because of information they learned at a Science Café. One interviewee summarized, "I feel like I've really been made more aware of those things and it's important that people understand we can make some changes and we can impact things." A related outcome can be considered personal growth through civic responsibility, either individually or collectively. This includes the importance of thinking critically about important issues, or how information learned at a Science Café can influence public policy. One interviewee felt better informed about science issues and explained, "I think since most science is publicly funded, when you learn about what is being done with your money, that's makes you a better citizen. You're participating in a democracy. It's nice to know that your tax dollars are supporting something worthwhile."

Table 4 What do participants do with the information gained from a Science Café event?

Synthesized elements	Code	Description of code	Example participant responses	Science Café attendees (%, *n*)*
Ecological element	Share or discuss with others	This theme includes participants' responses indicating that they share and/or discuss the information with others such as family members, colleagues, and friends.	"Live tweet it if it's relevant to my audience." "I use the information to start discussions with friends and classmates, and I tell my family about what I learned."	54% ($n = 67$)
Endogenous element	Catalyst for personal growth or development	Participants reported actively pursuing additional research, reading, and applying the new information gained.	"Sometimes it prompts further reading or I'll make a lifestyle change if that is relevant, other times it may spark an idea for one of my own projects."	40% ($n = 50$)
Endogenous element	Reflection	*Reflection* describes participants' responses describing personal contemplation, deliberation, and questioning.	"After "too much plastic is not fantastic" I am more likely to dispose plastic carefully and pick up plastic trash when I find it."	14% ($n = 17$)
	Nothing or very little; no follow-up action	This theme includes participants' responses indicating there was little to no follow-up action.	"It was nothing practical."	14% ($n = 17$)

*Some Science Café attendees reported more than one factor

Interview—Ecological Elements

One of the most common themes that emerged in the interview data was that most often attendees shared what they learned with others after leaving the Science Café. More than half (59%) discussed using the information they learned in conversations with others after the events. One teacher explained, "I'll share that through social media or with my friends or share with my students at school." An older attendee reported, "Now that I'm retired, I'm just participating in discussions with other friends...but the information is going to be recycled one way or another." Another attendee explained that he likes to share, "the information out there and let other people know that there are issues and what's being done and what the research is." Some interviewees stated the information they learn helps them be more prepared for social discussions. As explained by one interviewee, "I learned a lot about different things that I have used in my arguments and discussions with people." Sharing information, an ecological element, appears to be one of the primary outcomes of participation in a Science Café.

Discussion

The results of this study are limited based on several factors including the location of the Science Café events, the attendees who participated in the survey and interview as they self-selected to participate in the study, and demographics of those attendees which may not be representative of all attendees or individuals who live in the regions that these Science Café events were hosted. As such, generalizability of these results to the general population may be limited in scope. However, based on questionnaire and interviewee volunteer status, demographics of participants, and participant location, it is imperative that the results and interpretations of this study are limited to the prospective research question and participant demographic boundaries. Although the questionnaire and interview protocols were designed based on a review of literature within motivation and informal learning contexts as well as reviewed by a panel of experts within these fields, the findings are not necessarily generalizable to other Science Cafés as other Science Cafés may have different formats, presentation topics, community diversity, and needs. Additionally, future research should be conducted to explore the synthesized elements developed from the data collected in this study, including the comparison of documented elements with other Science Café events or other informal science education opportunities as well as the development and validation of survey items designed to capture participants' motivational factors. Possible future analysis concerning the utility of information learned at Science Cafés by area educators could bring insight into information networks and science discourse.

Previous research investigating Science Café events primarily focused on scientific knowledge and affordances and constraints of these events citing Science Cafés are conducive in connecting science to the general public (Navid and Einsiedel 2012). This study focused on participants attending Science Café events shared motivational factors and what they do with the information gained from a Science Café event to add a deeper understanding of the factors that motivate individuals to attend events within this field of informal science education research. The questionnaire and interview responses indicated that personalized factors, such as *endogenous elements* and social-environmental factors describing *ecological elements* were primary reasons in attending Science Café events. The information shared from the questionnaire and interview data enables Science Café and other informal science education organizers

to understand why public members in the community are seeking science learning experiences. This information aligns to the broader impact of this study as Science Café events support attendees' autonomous choices to explore their personal interests related to science. Science Cafés may serve as an avenue for the learning of science through informal contexts which potentially could assist in creating a sense of community and safety among the public (National Academies of Sciences, Engineering and Medicine 2018). Furthermore, documenting the motivational factors helps explain the value of Science Cafés as learning experiences. Because Science Cafés tend to require few resources to host, it appears that the opportunities to foster motivation through social engagement and alignment to personal interests and not necessarily the specific location (defined here as a traditional, formal space for informal learning) are the determining factors for public engagement in science.

Endogenous Elements

Endogenous elements were defined in this paper as factors that are of internal origin related to motivation in attending Science Café events and were designed from three constructs (personal context, competence, and autonomy) associated with SDT and CML. Based on the questionnaire and interview responses, majority of participants cited endogenous factors as being their primary motivational indicators. Falk and Storksdieck (2010) suggest that informal learning experiences or free-choice learning opportunities may support intrinsic motivation of individuals to learn or explore science topics. Science Café events, as they are informal in nature and can be considered free-choice regarding participation, enable ease of access for the public to engage in science-related activities in the community.

Similar trends were noted for the responses collected to document what participants did with the information gained at a Science Café event. Questionnaire responses indicated that individuals *reflected* on the information or use the information as a *catalyst for personal growth or development*. Interviewees shared that attending Science Café events enabled them to *challenge their views of science* or participate in post-attendance activities that usually were described as *reading* or *research* as well as general *references*. Science Cafés may support a continuous, lifetime growth of interest in science and motivation to attend science-related community events for the public. Choosing to engage in these activities relates specifically to the factors of *autonomy* and *competency*. This motivational behavior has been documented in other informal science-related activities or groups such as museums, science hobbyists, and citizen scientists (Martin et al. 2016; Author 1a 2017; Author 1b 2018).

Ecological Elements

Social factors as defined in SDT and CML frameworks describe the importance of communication and sharing of ideas within a learning community to support motivation and utilization of information after a science-related event. *Ecological elements* specifically relate to the constructs of *relatedness* (SDT) and the *social context* (CML). These ideas note that social interactions of individuals within a shared community of learning may support the continued motivation and interest. Within the context of Science Cafés, ecological elements describe the importance of social interactions that revolve around the opportunities of discussion, connections, and interactions with like-minded individual or experts at Science Café events as indicated by the questionnaire responses. Interviewee responses described *social interactions* as *community building* opportunities, *networking*, and *sharing common interests* as evident in

the description of SDT (Deci and Ryan 2000; Deci et al. 1991). The social or community aspect of Science Café events creates opportunities and experiences for the public to engage in multi-directional sharing of science. In response to the connection of ecological factors and what participants do with the information obtained at a Science Café event, majority of questionnaire participants stated they shared and discussed the scientific information from the Science Café event with other individuals in their social network such as family members, colleagues, and friends. Building the capacity for social engagement in informal science-related communities may support continued or renewed interest in science for the public.

Science Cafés enable the community to participate in science by supporting the flow of science information between science experts and the audience. The motivational appeal of Science Cafés from the public's perspective revolves around reinforcing personal interest in science and the social interactions between attendees and other attendees, attendees and their personal or professional networks, and attendees and science experts. Furthermore, the location and environment create a relaxed atmosphere in which individuals can share information and ask questions in a safe place. For Science Café and other informal education organizers, understanding the specific needs of the community will aid in the design and implementation of similar events. As shared in previous studies, the description of Science Cafés as being appealing to community members was because of the informal nature in communicating science (Nielsen et al. 2015). This idea relates to the motivational factors described by questionnaire and interview participants in this study, as Science Café attendees shared being able to interact in a safe environment that stimulates their personal interest is important to their science learning.

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