Routledge
Taylor & Francis Group

International Journal of Science Education, Part B
Communication and Public Engagement

ISSN: 2154-8455 (Print) 2154-8463 (Online) Journal homepage: http://www.tandfonline.com/loi/rsed20

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To cite this article: Elysa N. Corin, M. Gail Jones, Thomas Andre & Gina M. Childers (2017): Characteristics of lifelong science learners: an investigation of STEM hobbyists, International Journal of Science Education, Part B, DOI: 10.1080/21548455.2017.1387313

To link to this article: http://dx.doi.org/10.1080/21548455.2017.1387313

INTERNATIONAL JOURNAL OF SCIENCE EDUCATION, PART B, 2017
https://doi.org/10.1080/21548455.2017.1387313

Characteristics of lifelong science learners: an investigation of STEM hobbyists

Elysa N. Corin [a], M. Gail Jones[a], Thomas Andre[b] and Gina M. Childers[a]

[a]STEM Education Department, North Carolina State University, Raleigh, NC, USA; [b]College of Education, Iowa State University, Ames, IA, USA

ABSTRACT

STEM hobbies are free-choice activities through which participating individuals may develop sophisticated STEM knowledge and expertise. To date, research into STEM hobbies and hobbyists has examined hobby groups by subject area. Missing from this body of work is research that examines the development and participation in different types of hobbies by age, ethnicity, and gender of participants. This research, part of a larger series of investigations of American adult STEM hobbyists, aims to fill that gap. Surveys were completed by 2,838 respondents from ten different STEM hobbies (astronomy, beekeeping, birding, electronics/robotics, environmental monitoring, falconry, gardening/horticulture, home brewing, model building, rock/fossil collecting). Results showed that there is great variation between STEM hobby groups across multiple variables and divergent descriptive profiles emerged for each group. Results also showed that, in several groups, more than half of the adult hobbyists reported first participating in their hobby during their youth. This study illustrates how crucial childhood experiences are to encouraging lifelong explorations in STEM and provides information about the types of experiences hobbyists reported as being influential to their hobby-related learning and development. This information may be used by educators and organizations to design programs to support current and future hobbyists.

ARTICLE HISTORY
Received 8 January 2017
Accepted 28 September 2017

KEYWORDS
Informal education; public engagement; free-choice learning; survey; hobby

Introduction

A growing body of evidence has demonstrated that Americans learn a substantial portion of their science knowledge from experiences that take place outside of school hours, and after their years of formal education are complete (Bell, Lewenstein, Shouse, & Feder, 2009; Falk & Dierking, 2010). The National Research Council Report, *Learning Science in Informal Environments: People, Places, and Pursuits* (Bell et al., 2009), highlighted the importance of informal learning environments on the science learning of children and adults, including the potential to bolster Americans' understanding of science on a national scale. As the content, tools, and techniques of science are ever-changing, staying well-informed requires a lifelong commitment and is especially necessary if individuals are to participate in science policy discussions and decision-making. To meet the goal of staying well-informed, science learning is often engaged in as a voluntarily leisure endeavor that extends beyond formal, in-school experiences (Falk, Donovan, & Woods, 2001; Rennie, 2014).

CONTACT Elysa Nicole Corin encorin@ncsu.edu STEM Education Department, North Carolina State University, CB 7801, Raleigh, NC 27695-7801, USA

Dr. Corin and Dr. Childers conducted this research while affiliated with North Carolina State University. Dr. Corin is now a researcher with the Exploratorium in San Francisco, California and Dr. Childers is a researcher at the University of North Georgia in Dahlonega, Georgia.

Some researchers contend that adult free-choice learning experiences are the single greatest contributor to the science knowledge of adults, though they concede that insufficient data exist to demonstrate this conclusively (Falk & Dierking, 2010).

Regardless of whether the free-choice learning experiences of adults is the greatest source of their science knowledge, it is clear is that after their years of compulsory schooling have ended, American adults continue to learn about STEM (Science, Technology, Engineering, and Mathematics) topics through a diversified array of free-choice avenues, including: visiting museums, zoos, science centers, and parks; participating in educational programs and activities; and consuming media including educational television and radio programs (Bell et al., 2009; Corin, Jones, Andre, Childers, & Stevens, 2015; Falk et al., 2001; Falk & Dierking, 2010; Rennie & Williams, 2006). Some adults also pursue STEM hobbies, another endeavor that may lead to the learning of sophisticated science concepts and skills (Bell et al., 2009; Corin et al., 2015; Liu & Falk, 2014).

Hobbies, a word whose meaning has evolved as much as the character of the activities it refers to, have been enjoyed as an American leisure activity since the nineteenth century (Gelber, 1999) though Americans had been engaging in science avocationally since at least the century prior (Knowles, 1977). In the decades since the nineteenth century hobbies have evolved from activities engaged in to prevent idleness, a socially approved pastime termed *productive leisure*, into activities pursued earnestly for their own enjoyment and intellectual benefit (Gelber, 1999).

To date, research into STEM hobbies and STEM hobbyists has examined hobby groups by subject area; there have been studies on amateur astronomers (Azevedo, 2013b; Berendsen, 2005; Hite, Jones, Andre, Childers, & Corin, 2016; Yocco, Jones, & Storksdieck, 2012), amateur astronomers and model rocket builders (Azevedo, 2005, 2011), amateur astronomers and birders (Corin et al., 2015; Jones, Corin, Andre, Childers, & Stevens, 2016), birders (Cordell, 2004; Cordell & Herbert, 2002; Eubanks, Stoll, & Ditton, 2004; Hvenegaard, 2002; Robinson, 2005; Robinson, 2008; Scott, Baker, & Kim, 1999), gardeners (Cheng, Patterson, Packer, & Pegg, 2010), home brewers (Murray, 2009; 2011; Murray & O'Neill, 2015), koi keepers (Liu, 2012), and model rocket builders (Azevedo, 2013a), among others. Indeed, hobby-specific clubs and organizations have been observed across many subject areas (Liu & Falk, 2014). These hobbyist studies reflect diverse research perspectives and have utilized a range of methodologies to pursue unique lines of inquiry. Researchers have explored hobbyists' motivations to engage in a STEM hobby (Eubanks et al., 2004; Hvenegaard, 2002; Jones et al., 2016; Murray & O'Neill, 2015; Scott et al., 1999). Other studies have focused on the benefits of participating in a STEM hobby including satisfaction and enjoyment (Cheng et al., 2010; Murray & O'Neill, 2015; Scott et al., 1999), opportunities to socialize (Cheng et al., 2010; Jones et al., 2016; Murray & O'Neill, 2015; Scott et al., 1999), opportunities to learn (Berendsen, 2005; Cheng et al., 2010; Jones et al., 2016; Liu, 2012; Murray & O'Neill, 2015), among others. Some studies have also found that STEM hobbyists are visible in their communities as a resource of STEM knowledge and expertise, engaging in outreach to members of their communities (Corin et al., 2015; Gibbs & Berendsen, 2006; Yocco et al., 2012). Other researchers have explored barriers to participating in STEM hobbies. For example, Robinson's (2005, 2008) work focused on the experiences of African American birders and identified several impediments including social pressures, economic pressures, and a lack of role models. Other work has reported on the experiences of minority members of the amateur astronomer community (i.e. female and/or non-Caucasian hobbyists) and the challenges they identify including concerns about personal safety, isolation/lacking peers and mentors, and inadequate access to resources (Hite et al., 2016).

Missing from this collection of work is a national study of American STEM hobbyists where the respondent's hobby is included as a variable for comparison along with demographic and hobby-related participation characteristics. This is important because we might expect that participation in leisure-time science activities would be open to all and accessed at rates that mirror a country's demographics. If variation is present, it is useful to differentiate between differences that are observed across all/most hobby groups and those which may be unique to particular interest groups. For example, it is likely that the characteristics of an individual with a physical science hobby could

be different from those of someone with a biological science hobby. This study aimed to fill that gap by collecting data from participants of 10 STEM-related hobbies and allowing comparisons to be made between groups.

Adult free-choice learning

The process of educating adults is distinct from educating children; adult learners are often characterized as being more self-directed and autonomous in their learning activities than children (Knowles, 1980; Pratt, 1998). Adult learners are also more likely than youth to consider their learning with regard to the immediacy of its application (Knowles, 1980). Adults often approach learning with a problem-centered or performance-centered frame of mind, perceiving education as the process of improving their ability to cope with problems they currently face (Knowles, 1980). Knowles (1980) contended that if we accept learning to be a lifelong process, K-12 schooling should be primarily concerned with developing skills of inquiry in students and adult education experiences should provide resources to learners and support interest-driven, self-directed learning.

Adult learners, including STEM hobbyists, are often interest-driven and choose to engage in learning activities they perceive will meet their educational needs (Knowles, 1980; Rennie & Williams, 2006). In discussing their model of interest development, Hidi and Renninger (2006) contend that interest is a psychological state that ' … in later phases of development, is also a predisposition to reengage content that applies to in-school and out-of-school learning and to young and old alike' (p. 111). While an individual's interests play an important role in guiding free-choice learning, external support, including support from others, is also crucial because without support from others interest development can become dormant, regress, or disappear (Hidi & Renninger, 2006). To support their hobby interests, STEM hobbyists engage in free-choice learning and seek out learning opportunities and support from many organizations in their communities including universities, museums, parks, and hobby clubs (Corin et al., 2015).

Hobbies as leisure

Pointing out that leisure is not necessarily the opposite of work, that one person's occupation can be another person's pastime (e.g. a car mechanic and a hobbyist who restores cars), Gelber (1999) provided three points to delineate leisure activities. First, leisure activities take place during time that is free from work, where *work* refers to income-generating activities as well as personal, familial, and home care activities. Second, leisure activities are voluntarily undertaken. Last, leisure activities are pleasurable. By this it may be understood that a leisure activity (e.g. a hobby) is less identified by what activity an individual engages in, and is more defined by the *why* and *when* an activity is undertaken. Explained simply, ' … leisure is a pleasurable activity, voluntarily undertaken, in non-work time' (Gelber, 1999, p. 7).

Stebbins (2001, 2011) promoted the idea that there were different types of leisure and that leisure activities could be categorized as *causal leisure* or *serious leisure*. Casual leisure is hedonic; it is an ' … immediately, intrinsically rewarding, relatively short-lived pleasurable activity requiring little or no special training to enjoy it' (Stebbins, 2001, p. 53). In contrast, serious leisure activities are challenging, complex and long-lasting (Stebbins, 2001). Participating in these activities may draw on specialized skills, knowledge, and/or expertise, and may require the participant to persevere (Stebbins, 2001). Stebbins (2001, 2011) outlined many possible rewards from participating in serious leisure, and noted that serious leisure activities offered participants an identity and an avenue to express their life interests by engaging them in complicated, absorbing, and satisfying activities. Prolonged, often lifelong, engagement in a STEM hobby is an example of a serious leisure pursuit that allows the hobbyist to explore a personal interest and adopt a hobby-related identity.

Leisure, access, and diversity

In the United States, individuals of different racial and ethnic groups participate in a broad range of leisure-time free-choice activities at different rates. Participation differences in the United States are observed between majority and minority groups, including African Americans and Caucasians (Cordell, 2004; Edwards, 1981; Floyd, Shinew, Mcguire, & Noe, 1994; Robinson, 2005; Shinew, Floyd, & Parry, 2004; Washburne, 1978) and Hispanics and Caucasians (Floyd & Gramann, 1993; Irwin, Gartner, & Phelps, 1990). Uneven participation in free-choice activities is also observed between subgroups of a minority community such as differences found within the Hispanic community (Fernandez, Shinew, & Stodolska, 2015; Floyd, Gramann, & Saenz, 1993). Leisure is perceived, accessed, and experienced in many ways within and between diverse communities; it is clear there is a range of preferences for and expressions of leisure.

Multiple hypotheses and frameworks have been put forward in attempt to explain these differences. Washburne (1978) presented two perspectives to explain African American underparticipation in outdoor free-choice activities. Washburne's marginality perspective posits that African Americans participate in these outdoor activities to a lesser extent than Caucasians due to the consequences of historical patterns of discrimination as well as limited socioeconomic resources. His ethnicity perspective, while acknowledging the influence of a history of marginality, also suggests the African American subculture includes unique leisure norms, value systems, and social organizations that influence participation. Multiple research studies have included marginality and ethnicity perspectives in their discussion of underparticipation of African Americans (Edwards, 1981; Floyd et al., 1994; Washburne, 1978) and Hispanics (Floyd et al., 1993; Floyd & Gramann, 1993; Irwin et al., 1990) in free-choice activities.

In a review published 20 years after Washburne's seminal article, Floyd (1998) highlighted several shortcomings of the marginality and ethnicity perspectives and called for the continued articulation of certain elements of the framework. Specifically, Floyd noted that while discrimination is often cited as a factor that accounts for lopsided participation in leisure settings, this area of research remains under conceptualized and understudied. He called for more work to investigate discriminatory factors and how they impact leisure choices. Sharaieveska, Stodolska, Shinew, and Kim (2010) investigated incidents of discrimination that Hispanic residents of two Chicago neighborhoods experienced in leisure settings. Study participants cited being verbally harassed, being stopped and searched by police, and being denied a service or given substandard service while participating in free-choice activities. Individuals responded to these experiences by withdrawing from or avoiding certain activities, participating in larger groups, and visiting 'protected sites' used by others of the same ethnic background (e.g. 'Hispanic parks').

Robinson, an African American birding hobbyist, ornithologist, and advocate for minorities in bird watching, highlighted specific obstacles to birding experienced by African Americans (Robinson, 2008). Participants in his research cited economic pressures, lack of role models, and social pressures including a desire to fit in. One respondent wrote

> … once a Black … person admits to being a "birder," they have broken with the image they are expected to maintain to belong to the Black [subculture], and have instead aligned themselves with the white majority. Being unique in a group you are otherwise expected to belong is very difficult. (Robinson, 2008, p. 47).

These experiences echo Washburne's marginality and ethnicity perspectives (1978). Robinson framed the lower level of African American participation in outdoor recreation activities, including birding, as a *don't loop*, explaining that if people do not know a birdwatcher personally they will be less likely to become a birder themselves as birders usually begin their hobby after being introduced to the activity by a friend or family member. Indeed, he found that African American birders were more likely to know other African American birders than African Americans who did not participate in birding, supporting his don't loop hypothesis (Robinson, 2008).

Recognizing that ethnic groups are not culturally monolithic, some researchers have also identified acculturation as a useful construct to inform discussions on differing levels of activity participation among Hispanics. Floyd and Gramann (1993) found that similarities between Mexican American and Anglo-American activity choices increased in concert with the extent to which the Mexican American subjects were acculturated. Christenson, Zabriskie, Eggett, and Freeman (2006) found family leisure to play an important role in the acculturation of Mexican-American youth. Highly acculturated youth, compared to bicultural youth, participated in more activities that took place in the outdoors and participated in more activities that were characterized as new, challenging, and different. Fernandez et al. (2015) asked Mexican participants about their participation in 32 outdoor activities, including bird watching, and found that while acculturation was an important predictor of participation in several activity categories, individuals who had greater access to parks were found to participate in all activity categories at higher rates while access to backyard spaces was not a significant predictor to participation in any category of activity. These themes of activity choice being shaped by one's environment, social network, and family are also found in Robinson's (2008) study of African American birders.

Aims of the present study

The literature review suggests that serious leisure activities afford a range of benefits to the practitioner, including cognitive and social benefits. American adults seek out opportunities during their leisure time to learn and engage in science, and many STEM hobbyists find that their hobby provides such experiences on an ongoing basis. Adult STEM hobbyists derive many benefits from their hobby including satisfaction, enjoyment, as well as opportunities to socialize, learn, and teach others about their hobby. While the benefits and affordances of STEM hobbies, specifically, and leisure, generally, are understood, it is of interest to the science education community to better understand how to encourage and support lifelong STEM interests like STEM hobbies among members of diverse communities. What influences and experiences do hobbyists report as beneficial to sparking their initial interest in their hobby and their continued development in their hobby? Do practitioners of different STEM hobbies report different influences as beneficial? Additionally, as the leisure literature describes the influence of race on activity participation, it is also important to understand how race intersects the engagement in free-choice STEM activities.

Prior investigations of STEM hobbies and hobbyists have typically treated hobbies separately by content area. The work reported here is part of a larger series of investigations (Corin et al., 2015; Jones et al., 2016) that explore the characteristics of STEM hobbyists and consider multiple hobby groups at once. This study was planned with the following research questions to explore how respondents from ten different STEM hobbies (astronomy, beekeeping, birding, electronics/robotics, environmental monitoring, falconry, gardening/horticulture, home brewing, model building, rock/fossil collecting) characterized their hobby development and participation.

How are hobby groups similar and different in:

- … their participants' demographic characteristics (including: race, gender, age, home environment, and education level)?
- … their participants' level of and length of hobby involvement?
- … the reported factors that influenced the development of the hobbyists' initial interest in their hobby?
- … the reported experiences that influenced the continued development of the participants' hobby?

From these results we consider implications for the science education community that may be used to encourage more STEM hobby and out-of-school science participation. The answers to these

questions may be used to inform a diverse range of education programs. Indeed, the more we understand about STEM hobbies and lifelong learning, the better we can design effective programs to promote science education and scientific literacy.

Methodology

The survey instrument

Development of the survey instrument was grounded in several theoretical frameworks including self-determination theory (Deci, Vallerand, Pelletier, & Ryan, 1991), the contextual model of learning (Falk & Dierking, 2000), sociocultural career theory (Lent, Brown, & Hackett, 1994), as well as work in the areas of identity (Carlone & Johnson, 2007; Gee, 2000; Hazari, Sonnert, Sadler, & Shanahan, 2010) and social constructivism (Veer & Valsiner, 1993; Vygotsky, 1978; Wertsch, 1979; 1985). Survey development was also informed by results from a previous exploratory study in which 107 astronomy and birding hobbyists were interviewed about their hobby-related experiences (Corin et al., 2015; Jones et al., 2016).

Survey questions were developed and reviewed by five researchers, piloted, and revised. Sixty-one questions were created to solicit information about hobbyists' demographics as well as their hobby development, involvement, motivation, career trajectory, educational experiences, and hobby-related interactions with others. The final survey was distributed through an online survey platform and took approximately 45 min to complete.

Participant recruitment

The researchers contacted local, state, and national hobby-related organizations in the United States and asked them to send announcements of the online questionnaire to their members. Hobbyists were subsequently informed of the research project by email, newsletter, and website post. Participants were also recruited through online hobby forums, and intentional and targeted recruitment efforts were undertaken to solicit participants from female and minority STEM associations. The specific hobbies chosen for the survey were selected because they represent a range of STEM interests (physical science, biological science, and engineering) and each have a relatively large body of practitioners in the United States. Four thousand and ninety-eight surveys were opened to the first page (the research consent form), and 2,838 surveys were filled out completely (69%). Incomplete surveys were eliminated and only those with complete responses were analyzed.

Participant characteristics

The survey was completed by hobbyists from ten STEM hobby groups: astronomy, beekeeping, birding, electronics/robotics, environmental monitoring, falconry, gardening/horticulture, home brewing, model building, and rock/fossil collecting (Table 1). A majority, 74% ($n = 2{,}095$) of survey respondents were male, 26% (743) were female. Most of the hobbyists, 93% (2,649), identified their race as white, not of Hispanic origin. The sample was 0.7% American Indian or Alaskan Native (20), 1.0% Asian or Pacific Islander (29), 0.7% black, not of Hispanic origin (21), 1.2% Hispanic (34), and 3.0% Other (85). The sample included participants from all 50 states and the District of Columbia. Figure 1 shows the geographic distribution of all hobbyists included in this study. Each marker represents the ZIP code identified by one or more hobbyists.

Table 1. Hobby groups.

Hobby	Sample Size	% of Total Sample
Astronomy	879	31.0
Model Building	377	13.3
Beekeeping	340	12.0
Home Brewing	259	9.1
Birding	251	8.8
Gardening/Horticulture	207	7.3
Rock/Fossil Collecting[a]	182	6.4
Electronics/Robotics	143	5.0
Environmental Monitoring[b]	104	3.7
Falconry	96	3.4

[a]'Rock/Fossil Collecting' category formed by combining the survey groups 'Rock/Mineral/Crystal Collectors' and 'Fossil Collectors.'
[b]'Environmental Monitoring' category formed by combining the survey groups 'Environmental Monitors' and 'Population Monitors.'

Limitations

Though great care was taken to recruit a wide range of participants through a variety of channels, it is possible the sampling overrepresented some groups and underrepresented others. In particular, the low percentage of racial and ethnic minorities included in our sample is striking. Efforts were made to corroborate this participation pattern with other data sources. Drawing from our conversations with STEM hobbyists, our discussions with other researchers, and our search of the published literature and governmental reports on outdoor leisure activity, we do believe that the imbalanced racial demographics found in our sample reflects the current landscape of STEM hobbyists in the United States. Several other studies have reported similar results demonstrating that people who identify their race as white, non-Hispanic, do participate in STEM hobbies in greater numbers and at greater

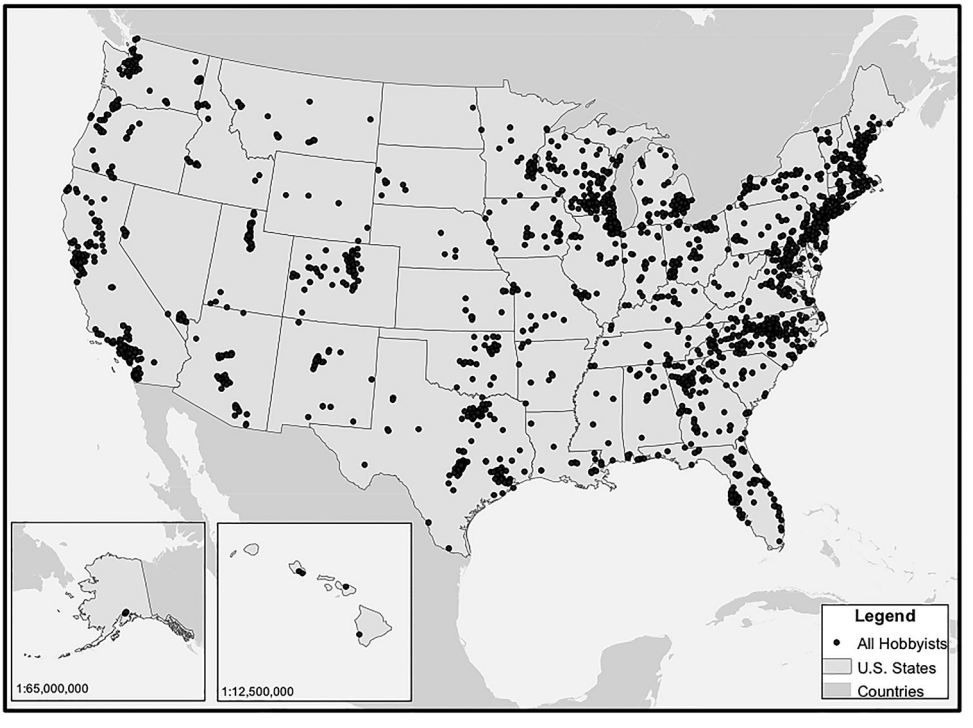

Figure 1. Location of all surveyed hobbyists by ZIP code.

rates than members of other demographic groups.[1] Additionally, other researchers of STEM hobbies choose not to include race in their reported sample demographics, their motivation for this omission being unclear.

Analyses

Twenty items from the survey were analyzed to address the four research questions. The data collected included ratio data (e.g. What is your age?), ordinal data (e.g. Did any of the following people or events influence the development of your initial hobby interests? – no influence, little influence, average influence, high level of influence, very high level of influence), and nominal data (e.g. Which of the following most describes your current home location? – urban, suburban, rural). Frequencies or measures of central tendency were calculated for each variable by hobby group. Tests of significance were conducted on the ordinal and ratio items. Table 2 lists all survey variables included in the analyses.

Kruskal-Wallis *H* tests were conducted to determine if there were significant differences in the responses from the 10 hobby groups for each of the continuous and ordinal dependent variables. Survey data met three of the assumptions to run a Kruskal-Wallis *H* test (Lund & Lund, 2013). The fourth assumption was violated: through visual inspection of a boxplot for each of the dependent variables, it was determined the distribution of scores was not similar for all hobby groups. Violations of the fourth assumption affected interpretation of the results, but did not prevent the Kruskal-Wallis *H* test from being applied. The null hypothesis was rejected in favor of the alternative hypothesis if the Kruskal-Wallis *H* test returned a $p < .05$. If the null hypothesis was rejected, indicating that at least one hobby group's mean rank score was significantly different from at least one other group's, post hoc tests were carried out to determine which hobby groups differed from each other. Pairwise comparisons between every pair of each of the ten hobby groups were performed using Dunn's (1964) procedure yielding 45 additional comparisons per dependent variable. The significance level was adjusted with a Bonferroni correction to reduce the chance of a Type I error; two hobby groups were subsequently

Table 2. Survey variables.

Variable	Survey Response Choices
Participant Characteristics	
Gender	Male, Female
Race/Ethnicity	American Indian or Alaskan Native, Asian or Pacific Islander, Black – not of Hispanic origin, Hispanic, White – not of Hispanic origin, Other
Age	Any age 18 years old and older
Home Environment	Urban, Suburban, Rural
Highest Education Level	Some High School or Less, High School, 2-Year College, 4-Year College, Masters, Ph.D.
Hobby Group	Astronomy, Beekeeping, Birding, Electronics/Robotics, Environmental Monitoring, Falconry, Gardening/Horticulture, Home Brewing, Model Building, Rock/Fossil Collecting
Start of Hobby	
Age When they First Participated in the Hobby	Any age
Development of the Initial Hobby Interest: Influence of Family, Friends, Significant Events, Teachers, Other Educators	No influence, Little influence, Average influence, High level of influence, Very high level of influence
Hobby Participation Characteristics	
Number of Years as Hobbyist	1–2 years, 3–5 years, 6–10 years, 11–20 years, 21+ years
Amount of Time Spent on Hobby	Less than 1 hour per week, 1–5 hours per week, 6–10 hours per week, 11+ hours per week
Development of the Hobby: Influence of Experiences in K-12 School, College, Museums/Science Centers, Clubs, Family Trips, Childhood Camp	None, Little, Some, A Lot

considered significantly different from each other if the difference was reported at $p < .001$. Hobby groups that were significantly different from seven or more of the other hobby groups were noted as 'distinct' in the data tables.

Results

Demographics of hobbyists

Race and gender of participants

Most of the participants in the 10 hobby groups identified as Caucasian (Table 3). The hobbies with the highest percentage of Caucasian respondents were birding (97%), falconry (97%), and home brewing (96%). Gardening was the hobby with the lowest percentage of members who identified as Caucasian, yet was still 91% Caucasian. Eight of the hobby groups included a majority of male respondents; hobbies with the highest percentage of males included model building (99%), home brewing (95%), and electronics/robotics (91%). Environmental monitoring was closely divided between male (52%) and female (48%) members. The hobbies with the highest proportion of female participants were gardening (74%) and birding (59%).

Age of participants

The age of survey participants ranged from 18 to 101 years old (Table 3). A Kruskal-Wallis H test determined there were significant differences in age by hobby group, $H(9) = 435.042$, $p < .0005$. Post hoc pairwise comparisons were performed with a Bonferroni correction to adjust for multiple comparisons. The post hoc tests determined the ages of the home brewers and the ages of the model builders were significantly different from all of the other hobby groups. Home brewers were significantly younger than hobbyists from other groups (mean age: 39.5, median age: 37, 50% of the sampled home brewers were between the ages of 31 and 47) and the model builders were significantly older than the other hobbyists (mean age: 61.0, median age: 63, 50% of the model builders in the sample were between the ages of 54 and 69).

Home environment of participants

The majority of participants from five of the hobby groups reported living in suburban environments: astronomy, home brewing, electronics/robotics, model building, and rock/fossil collecting

Table 3. Demographic characteristics of hobbyists.

	Ethnicity[a]	Gender[b]	Age[c]			Home Environment[d]		
Hobby	% Caucasian	% Male	Mean (SD)	Median	Distinct	% Urban	% Suburban	% Rural
Astronomy	91.8	85.4	55.2 (11.8)	57		16.6	61.4	22.0
Beekeeping	93.8	57.4	52.1 (11.5)	53		15.3	37.1	47.6
Birding	97.2	41.4	52.9 (15.6)	57		23.1	48.2	28.7
Electronics/Robotics	93.0	90.9	50.2 (15.3)	51		22.4	58.0	19.6
Environmental Monitoring	92.3	51.9	52.3 (14.6)	53		15.4	43.3	41.3
Falconry	96.9	82.3	50.9 (13.2)	53		17.7	27.1	55.2
Gardening/Horticulture	90.8	25.6	47.8 (13.5)	50		21.7	43.5	34.8
Home Brewing	96.1	94.6	39.5 (11.3)	37	*	23.2	59.5	17.4
Model Building	93.4	98.7	61.0 (11.9)	63	*	17.5	54.1	28.4
Rock/Fossil Collecting	92.3	63.7	54.5 (12.8)	56		22.5	52.2	25.3
Kruskal-Wallis Test	–	–	$H(9) = 435.042$, $p < .0005$				–	

Note: A hobby group will have an * in the 'Distinct' column if the group's responses are significantly different from seven or more of the other hobby groups at the $p < .001$ level.

[a]What is your ethnicity? (American Indian or Alaskan Native; Asian or Pacific Islander; Black, not of Hispanic origin; Hispanic; White, not of Hispanic origin; Other).

[b]What is your gender? (Male, Female).

[c]What is your age? (text entry).

[d]Which of the following most describes your current home location? (Urban, Suburban, Rural).

(Table 3). Three additional hobby groups had a large plurality of members who reported living in a suburban environment: birding (48%), gardening (44%), and environmental monitoring (43%). The hobby with the fewest percentage of members living in a suburban environment was falconry, with only 27% of members living in suburbia. The majority of falconers lived in a rural environment. Like the falconers, the beekeepers were most likely to report living in a rural environment (48%). A similar percentage of environmental monitors lived in suburban (43%) and rural environments (41%). Few sampled hobbyists reported living in urban environments, however, home brewing, birding, rock/fossil collecting, electronics/robotics, and gardening had the highest proportion of urban participants at just over 20%.

Education level of participants

Most hobbyists in eight of the hobby groups reported a 2-year or 4-year college degree as their highest educational level attained (Table 4). Of the remaining two groups, environmental monitors and gardeners, a Master's degree or a Ph.D. was most commonly reported as highest degree completed (51% and 49%, respectively). The hobbies with the highest percentage of members who reported attaining a high school degree or 'some high school or less' included falconry (16%) and model building (15%). A Kruskal-Wallis H test determined there were significant differences in education level by hobby group, $H(9) = 70.246$, $p < .0005$. Post hoc pairwise comparisons were performed, and though individual hobby groups were statistically different from one another, no hobby group or groups emerged as 'distinct' (significantly different from seven or more of the other hobby groups).

Hobby involvement

Age of participants when they participated in their hobby for the first time

Hobbyists were asked to report how old they were when they first participated in their hobby. Overall, 49% of hobbyists reported first participating in their hobby by age 18. The median age of the inception of the hobby for five of the hobby groups was reported to occur in childhood, by age 14: model building, gardening, rock/fossil collecting, electronics/robotics, and astronomy (Table 5). There were four hobbies where the median age of initial involvement fell in the twenties decade: falconry, birding, environmental monitoring, and home brewing. Indeed, 68% of hobbyists in the overall sample had participated in their hobby by age 30. Beekeeping was unique in that participants reported starting their hobby later in life (median: 44, mean: 43.1 years of age).

A Kruskal-Wallis H test determined there were significant differences in the age of the hobbyists when they first participated in their hobby: $H(9) = 628.968$, $p < .0005$. Post hoc pairwise comparisons

Table 4. Hobbyists' highest level of education attained.

	Education Level[a]		
Hobby	% High School or Less	% 2-Year or 4-Year College	% Masters or Ph.D.
Astronomy	9.5	51.7	38.8
Beekeeping	8.8	50.9	40.3
Birding	4.4	49.8	45.8
Electronics/Robotics	7.7	61.6	30.8
Environmental Monitoring	5.8	43.3	51.0
Falconry	15.6	47.9	36.4
Gardening/Horticulture	5.8	44.9	49.3
Home Brewing	7.3	57.9	34.7
Model Building	14.9	55.4	29.7
Rock/Fossil Collecting	10.4	45.6	43.9
Kruskal-Wallis Test		$H(9) = 70.246$, $p < .0005$	

Note: No hobby group was 'distinct.' (Where 'distinct' indicates a significant difference from seven or more of the other hobby groups at the $p < .001$ level.)

[a]What is your highest education level? (Some High School or Less, High School, 2-Year College, 4-Year College, Masters, Ph.D.).

Table 5. Participation characteristics of hobbyists.

	Age When Hobbyists First Participated in Hobby[a]			% of Hobbyists Involved With Their Hobby for Each Period of Years[b]					% of Hobbyists That Spend a Given Number of Hours/ Week Devoted to Their Hobby[c]				
Hobby	Mean (SD)	Median	Distinct	1–5	6–10	11–20	21+	Distinct	<1	1–5	6–10	11+	Distinct
Astronomy	22.8 (17.1)	14		24.3	15.2	17.3	43.1		9.2	57.7	21.6	11.5	
Beekeeping	43.1 (14.4)	44	*	67.8	17.1	6.8	8.2	*	18.8	59.7	16.2	5.3	
Birding	23.4 (15.7)	20		16.4	13.9	19.1	50.6		8.4	53.4	21.2	17.1	
Electronics/Robotics	20.1 (14.5)	14		22.4	15.4	11.9	50.3		4.9	48.3	26.6	20.3	
Environmental Monitoring	27.3 (17.8)	25		24.0	17.3	25.0	33.7		13.5	53.8	18.3	14.4	
Falconry	24.1 (13.5)	20		13.6	13.5	22.9	50.0		1.0	9.4	34.4	55.2	*
Gardening/Horticulture	16.4 (12.1)	12		17.3	14.5	23.7	44.4		5.3	56.5	27.5	10.6	
Home Brewing	29.4 (9.8)	27	*	53.7	21.6	16.6	8.1	*	12.4	68.3	15.8	3.5	
Model Building	15.6 (13.9)	10	*	6.9	8.8	11.4	72.9	*	1.9	36.3	33.4	28.4	*
Rock/Fossil Collecting	22.0 (17.0)	13		18.1	12.6	17.6	51.6		22.0	48.3	20.9	12.5	
Kruskal-Wallis Test	$H(9) = 628.968$, $p < .0005$			$H(9) = 632.474$, $p < .0005$					$H(9) = 347.422$, $p < .0005$				

Note: A hobby group will have an * in the 'Distinct' column if the group's responses are significantly different from seven or more of the other hobby groups at the $p < .001$ level.
[a]Approximately, how old were you when you first participated in your hobby? (text entry).
[b]How many years have you been involved with your hobby? (1–2 years, 3–5 years, 6–10 years, 11–20 years, 21+ years).
[c]How many hours per week do you devote to your hobby? (Less than 1 hour per week, 1–5 hours per week, 6–10 hours per week, 11+ hours per week).

showed beekeepers started their hobby at a significantly older age than all other hobby groups. The model builders were significantly different from eight groups, not significantly different from gardeners, and reported starting their hobby at the youngest age. The home brewers were significantly different from seven groups and first participated in their hobby in their late twenties on average, which is significantly younger than the starting age of beekeepers and significantly older than the starting age of six other groups (astronomy, birding, electronics/robotics, gardening, model building, rock/fossil collecting).

Length of hobby involvement

Individuals were asked to report how many years they had been involved with their hobby (Table 5). The majority of respondents in only two groups, beekeeping (68%) and home brewing (54%), reported being involved with their hobby for five years or less. In contrast, the hobby with the smallest proportion of new members (i.e. the group with the smallest percentage of respondents reporting to have been involved with their hobby for 1–5 years) was model building with only 7% of members being involved for 5 years or less. Half or more of the participants from five groups reported having been involved with their hobby for more than 20 years: model building, rock/fossil collecting, birding, electronics/robotics, and falconry. The majority of gardeners, astronomers, and environmental monitors reported being involved with their hobby for more than 10 years. A Kruskal-Wallis H test determined there were significant differences in the variable 'years involved with hobby' by hobby group, $H(9) = 632.474$, $p < .0005$. Post hoc pairwise comparisons were performed. Model building hobbyists indicated being involved in their hobby significantly longer than hobbyists from the other nine groups. Beekeeping and home brewing were found to be significantly different from the eight other hobby groups (but not significantly different from each other) with most of their members indicating they had been involved in their hobby for a relatively short period of time.

Amount of time participants reported engaging in their hobby

Hobbyists were asked to report how many hours per week they devoted to their hobby (Table 5). A Kruskal-Wallis H test determined there were significant differences in hobbyists' responses to this variable, $H(9) = 347.422$, $p < .0005$, and post hoc pairwise comparisons were performed. Falconers spent significantly more time per week participating in their hobby when compared with hobbyists from all other groups; the majority of falconers reported spending at least 11 hours per week on their hobby. Falconers were also unlikely (1%) to report spending less than an hour per week on their hobby. Model builders' responses to this question were significantly different from eight of the other hobby groups (not significantly different from electronics/robotics enthusiasts); model builders spent less time on their hobby than falconers yet more time than the respondents from the remaining seven groups. Most model builders (62%) reported spending 6 hours or more per week on their hobby and they were also unlikely to have members who spent less than an hour per week participating in their hobby (2%).

Beekeeping and home brewing were the hobbies with the fewest members who reported spending 11 hours or more per week participating in their hobby, at 5% and 4% respectively. The majority of home brewers, beekeepers, rock/fossil collectors, environmental monitors, astronomers, birders, gardeners, and electronics/robotics enthusiasts reported spending 5 hours or less on their hobby per week. Of these 8 hobbies, several had a notable percentage of members who spent less than one hour per week on their hobby (rock/fossil collectors: 22%, beekeepers: 19%, environmental monitors: 14%, and home brewers: 12%), perhaps indicating activities that do not require a large time commitment or prolonged periods of active engagement.

Development of initial interest in the hobby

Hobbyists were asked to rate the extent to which five different factors influenced the development of their initial interest in their STEM hobby (no influence, little influence, average influence, high level

Table 6. Factors that influenced the development of the initial hobby interest.

	Family[a]			Friends[b]			Significant Events[c]		
Hobby	% 'High' or 'Very High'	% 'No'	Distinct	% 'High' or 'Very High'	% 'No'	Distinct	% 'High' or 'Very High'	% 'No'	Distinct
Astronomy	29.3	27.4		29.2	23.4		55.0	11.8	*
Beekeeping	30.3	32.6		26.2	29.4		17.0	58.8	
Birding	43.0	21.9		42.2	17.5		11.6	49.8	
Electronics/Robotics	28.7	24.5		24.5	16.8		37.8	21.7	*
Environmental Monitoring	40.4	23.1		37.5	12.5		35.5	26.9	
Falconry	22.9	47.9		37.6	21.9		6.3	67.7	
Gardening/ Horticulture	64.7	5.8	*	36.8	11.6		15.5	37.7	
Home Brewing	30.9	25.5		59.5	8.9	*	1.6	78.0	*
Model Building	41.9	17.8		49.1	12.7		23.4	33.2	
Rock/Fossil Collecting	42.3	22.0		37.4	24.2		19.8	34.1	
Kruskal-Wallis Test	$H(9) = 170.452$, $p < .0005$			$H(9) = 146.848$, $p < .0005$			$H(9) = 744.410$, $p < .0005$		

Note: A hobby group will have an * in the 'Distinct' column if the group's responses are significantly different from seven or more of the other hobby groups at the $p < .001$ level.

[a]Did any of the following people or events influence the development of your initial hobby interests?-Family. (No Influence, Little Influence, Average Influence, High Level of Influence, Very High Level of Influence).

[b]Did any of the following people or events influence the development of your initial hobby interests?-Friends. (No Influence, Little Influence, Average Influence, High Level of Influence, Very High Level of Influence).

[c]Did any of the following people or events influence the development of your initial hobby interests?-Significant Events. (No Influence, Little Influence, Average Influence, High Level of Influence, Very High Level of Influence).

	Teachers[a]			Other Educators[b]		
Hobby	% 'High' or 'Very High'	% 'No'	Distinct	% 'High' or 'Very High'	% 'No'	Distinct
Astronomy	24.8	26.2		25.1	30.6	
Beekeeping	9.1	61.5	*	13.5	53.5	
Birding	29.1	33.1		33.9	29.1	
Electronics/Robotics	28.7	26.6		25.2	26.6	
Environmental Monitoring	36.6	21.2		46.1	13.5	*
Falconry	12.5	56.3		15.7	52.1	
Gardening/Horticulture	26.1	24.6		29.5	23.2	
Home Brewing	2.3	70.7	*	2.0	71.0	*
Model Building	10.4	37.7		9.9	40.8	
Rock/Fossil Collecting	21.4	37.4		23.6	33.5	
Kruskal-Wallis Test	$H(9) = 348.755$, $p < .0005$			$H(9) = 303.495$, $p < .0005$		

Note: A hobby group will have an * in the 'Distinct' column if the group's responses are significantly different from seven or more of the other hobby groups at the $p < .001$ level.

[a]Did any of the following people or events influence the development of your initial hobby interests?-Teachers. (No Influence, Little Influence, Average Influence, High Level of Influence, Very High Level of Influence).

[b]Did any of the following people or events influence the development of your initial hobby interests?-Other Educators. (No Influence, Little Influence, Average Influence, High Level of Influence, Very High Level of Influence).

of influence, very high level of influence). As reported in Table 6, a Kruskal-Wallis H test determined there were significant differences among hobbies in the distribution of responses for each of the five influence factors: family $H(9) = 170.452$, $p < .0005$; friends $H(9) = 146.848$, $p < .0005$; significant events $H(9) = 744.410$, $p < .0005$; teachers $H(9) = 348.755$, $p < .0005$; and other educators $H(9) = 303.495$, $p < .0005$. Post hoc comparisons were performed for each of the five variables between all pairwise combinations of hobby groups.

Responses to the five standalone questions above were compared to determine, within each hobby group, which of the five influences was rated the highest. Astronomy and electronics/robotics hobbyists rated *significant events* to have a *high* or *very high level of influence* on the start of their hobby to a greater degree than the other four variables. The influence of *teachers* was not reported as the highest influence for any hobby group, but *other educators* (e.g. museum educators) were reported to be the highest influence for environmental monitors. *Family* was rated by the highest percentage of

hobbyists involved with gardening, rock/fossil collecting and beekeeping to be the most influential of the five options. Similarly, *friends* were rated by the highest percentage of individuals involved with home brewing, model building and falconry. Similar percentages of birding hobbyists highly rated the influence of both family and friends.

When asked the extent to which each of the five influences impacted the development of their initial hobby interest, several patterns of group responses were unique. For example, the majority of gardeners rated family as having either a high or very high level of influence on the development of their initial hobby interest, and pairwise post hoc testing found that the response distribution was significantly different from all other hobby groups. The majority of members from every hobby group rated family as having *some influence* (very high, high, average, or little) on the development of their hobby interest. Friends were rated by the highest percentage of home brewing (60%) and model building (49%) hobbyists as having a high or very high influence in developing the initial hobby interest. Post hoc testing found home brewers to have rated this item higher than all other hobby groups and brewers' pattern of responses was significantly different from eight of the other hobby groups (excluding model builders). Most hobbyists from each group rated friends as having some impact on their interest development.

Participants from the following groups rated significant events to have had a high or very high influence at the three highest rates: astronomy (55%), electronics/robotics (38%), and environmental monitoring (36%). The majority of home brewers, falconers, and beekeepers as well as half of the birders rated significant events as having *no influence* on developing their initial hobby interest. Post hoc pairwise comparisons found the distribution of responses for astronomy was significantly different from all other hobby groups; the sampled astronomers credited significant events with sparking their initial hobby interest to a greater extent than any other hobby group. The electronics/robotics and home brewing groups were significantly different from eight of the other hobby groups. Electronics/robotics hobbyists' distribution of responses was significantly lower than the astronomers, significantly higher than 7 other hobby groups, and not significantly different from the environmental monitors. Home brewers rated significant events as having the lowest influence of any of the hobby groups; their response was significantly different from eight hobby groups, excluding falconers.

Environmental monitoring hobbyists (37%) reported teachers as having a high or very high influence on the initial interest development of their hobby at the highest rate. In contrast, the majority of hobbyists in the following groups reported that teachers had no influence on the development of their hobby interest: home brewing, beekeeping, and falconry. Post hoc testing found the home brewing group responded to the question about teacher influence in a significantly different way from eight of the other hobby groups; responses from the beekeeping group were significantly different from seven other groups. The home brewers cited teachers as less of an influence than all other groups, though the difference between home brewers and beekeepers was nonsignificant. The beekeepers rated the influence of teachers as lower than all other groups, after home brewers, and the difference with both home brewers and falconers was non-significant.

Environmental monitoring (46%) and birding (34%) were the groups with the highest percentage of members who indicated that other educators had a high or very high influence on the initial development of their hobby interest. Most home brewers, beekeepers, and falconers reported other educators had no impact on their interest development. The distributions of responses from environmental monitors and home brewers were distinct; environmental monitors ranked the influence of other educators significantly higher, and the home brewers ranked the influence of other educators significantly lower, when compared with the nine other hobby groups.

Development of the hobby

Hobbyists were asked to rate to what extent (a lot, some, little, none) the development of their hobby was influenced by six types of experiences (Table 7). Taking note of the hobbyists from each hobby

Table 7. Experiences that influenced the development of the hobby.

	Experiences in K-12 School[a]			Experiences in College[b]			Experiences in Museums/ Science Centers[c]		
Hobby	% 'A Lot'	% 'None'	Distinct	% 'A Lot'	% 'None'	Distinct	% 'A Lot'	% 'None'	Distinct
Astronomy	11.2	32.8		20.5	30.0		29.4	13.9	
Beekeeping	3.8	70.2	*	8.2	67.9	*	7.4	56.8	*
Birding	6.9	52.1	*	27.9	32.7		16.7	23.1	
Electronics/Robotics	14.7	28.9		35.7	18.9	*	14.7	29.4	
Environmental Monitoring	18.6	21.8	*	41.3	10.6	*	36.5	10.6	
Falconry	10.1	54.1		18.8	53.1		12.5	37.5	
Gardening/Horticulture	9.7	36.2		21.7	29.0		19.3	27.1	
Home Brewing	1.4	81.4	*	20.5	31.3		1.9	71.0	*
Model Building	8.4	35.8		14.9	36.3		15.1	27.3	
Rock/Fossil Collecting	10.6	39.9		20.3	40.1		35.7	11.0	
Kruskal-Wallis Test	$H(9) = 401.814$, $p < .0005$			$H(9) = 229.510$, $p < .0005$			$H(9) = 533.796$, $p < .0005$		

Note: A hobby group will have an * in the 'Distinct' column if the group's responses are significantly different from seven or more of the other hobby groups at the $p < .001$ level.

[a]To what extent was the development of your hobby influenced by any of the following? – Experiences in elementary, middle, and high school. (None, Little, Some, A Lot).

[b]To what extent was the development of your hobby influenced by any of the following? – Experiences in college. (None, Little, Some, A Lot).

[c]To what extent was the development of your hobby influenced by any of the following? – Experiences in museums/science centers. (None, Little, Some, A Lot).

	Experiences with Clubs[a]			Experiences on Family Trips[b]			Childhood Camp Experiences[c]		
Hobby	% 'A Lot'	% 'None'	Distinct	% 'A Lot'	% 'None'	Distinct	% 'A Lot'	% 'None'	Distinct
Astronomy	18.9	34.9		7.5	39.5		4.1	56.5	
Beekeeping	9.1	64.4	*	5.0	69.7	*	3.5	75.3	
Birding	12.0	46.2		21.5	21.9		8.8	48.6	
Electronics/Robotics	12.6	36.4		4.9	44.8		0.0	65.0	
Environmental Monitoring	20.2	32.7		31.7	21.2		15.4	32.7	*
Falconry	8.3	50.0		8.3	49.0		4.2	58.3	
Gardening/Horticulture	10.6	46.9		18.8	24.6		10.1	49.3	
Home Brewing	4.2	74.9	*	2.3	75.3	*	0.0	92.7	*
Model Building	17.2	32.4		9.5	36.6		1.1	67.6	
Rock/Fossil Collecting	22.0	33.5		31.9	22.0		2.7	56.0	
Kruskal-Wallis *H* Test	$H(9) = 214.567$, $p < .0005$			$H(9) = 419.762$, $p < .0005$			$H(9) = 244.094$, $p < .0005$		

Note: A hobby group will have an * in the 'Distinct' column if the group's responses are significantly different from seven or more of the other hobby groups at the $p < .001$ level.

[a]To what extent was the development of your hobby influenced by any of the following? – Experiences with clubs. (None, Little, Some, A Lot).

[b]To what extent was the development of your hobby influenced by any of the following? – Experiences on family trips. (None, Little, Some, A Lot).

[c]To what extent was the development of your hobby influenced by any of the following? – Childhood camp experiences. (None, Little, Some, A Lot).

group who reported the six experiences to have influenced their hobby development to any extent (i.e. influenced the development of the hobby a lot, some, or little), an interesting pattern emerged: the greatest positive response from each of the 10 groups clustered into just three experiences: *experiences in museums/science centers*, *experiences in college*, and *experiences on family trips*. The greatest percentage of environmental monitors[2] (89%), rock/fossil collectors (89%), astronomers (86%), model builders (73%), falconers (63%), and beekeepers (43%) indicated their hobby development was influenced by experiences in museums/science centers. The largest fraction of environmental monitors (89%), electronics/robotics enthusiasts (81%), and home brewers (69%) reported experiences in college to have influenced their hobby development. Experiences on family trips were cited by the largest proportion of birders (78%) and gardeners (75%) as influencing their hobby development. It is noteworthy that *experiences in K-12 school* was not the highest rated positive

influence for any group, especially as K-12 school experiences is the one category in which we might assume nearly all the hobbyists participated.

A Kruskal-Wallis H test was calculated for each of the six items (Table 7) and there were significant differences in the distribution of responses from the ten hobby groups for all six survey items: experiences in K-12 school $H(9) = 401.814$, $p < .0005$; experiences in college $H(9) = 229.510$, $p < .0005$; experiences in museums/science centers $H(9) = 533.796$, $p < .0005$; experiences with clubs $H(9) = 214.567$, $p < .0005$; experiences on family trips $H(9) = 419.762$, $p < .0005$, and childhood camp experiences $H(9) = 244.094$, $p < .0005$. Post hoc pairwise comparisons were performed.

Formal school experiences (K-12, college) were found to be influential to hobby development in some hobbies more than others. Environmental monitors rated the impact of K-12 school influences on their hobby development higher than all other hobby groups; monitors' mean rank score was significantly different than seven other hobby groups and not significantly different than astronomers and electronics/robotics hobbyists. The majority of hobbyists involved with home brewing, beekeeping, falconry, and birding rated the influence of experiences in K-12 schools as *none*. The lowest mean rank score, conveying low importance of K-12 experiences on hobby development, was from home brewers, followed by beekeepers; these two groups' distribution of responses were significantly different from the eight other groups and not significantly different from each other. Birders rated the importance of K-12 experiences to the next lowest degree; their responses were significantly different from seven groups, excluding falconry and rock/fossil collecting. The influence of experiences in college on hobby development was rated highest by environmental monitors, followed by electronics hobbyists; these two groups' mean rank score was significantly different from the eight other groups and not significantly different from each other. The majority of beekeepers and falconers also indicated that experiences in college had no influence on the development of their hobby. Beekeepers rated the influence of this item the lowest, and their distribution of responses was significantly different from all other groups.

Experiences in museums/science centers were rated as influencing hobby development *a lot* by about a third of the sampled environmental monitors, rock/fossil collectors, and astronomers. A majority of members from eight of the hobby groups reported museums/science centers to impact the development of their hobby to some extent. Of the remaining two groups, the majority of home brewers and beekeepers indicated experiences in museums/science centers had no effect on their hobby development; home brewers rated the importance of this influence lower than all other hobby groups, their distribution of responses was also significantly different from all other groups. Beekeepers rated the importance of this item to the next lowest degree, their responses were different from eight groups and not significantly different from falconers. Approximately one third of environmental monitors and rock/fossil collectors also reported that experiences on family trips influenced their hobby development a lot. Conversely, the majority of hobbyists involved with the home brewing and beekeeping groups also indicated experiences on family trips to have had no influence. Home brewers rated the importance of this item to their hobby development lower than all other hobby groups, followed by beekeepers; these two groups' distribution of responses were significantly different from the eight other groups and not significantly different from each other.

The majority of hobbyists from seven groups reported that *clubs* influenced their hobby learning to some extent. Half or more of the home brewers, beekeepers, and falconers indicated these experiences to have had no influence on hobby development. Home brewers' mean rank of this item was lower than all other groups and their responses were significantly different from eight of the other hobby groups (not significantly different from beekeepers). Beekeepers rated the importance of this item to the next lowest degree, and their responses were different from seven of the other groups (not significantly different from home brewers or falconers). *Childhood camp experiences* appeared to be the least influential of the six variables included in this analysis as the majority of participants involved with home brewing, beekeeping, model building, electronics/robotics, falconry, astronomy, and rock/fossil collecting reported camp experiences as having no influence on their hobby

development. Home brewers rated the importance of this item lower than all other hobby groups and post hoc pairwise testing found the brewers to respond to the question in a significantly different way from all other groups. The environmental monitors rated the influence of childhood camp experiences higher than the other groups, their responses were significantly different from seven other hobbies and not significantly different from gardeners or birders.

Discussion

The results of this study illustrate that there is significant variation between STEM hobby groups across multiple variables including the average age when hobbyists first participated in their hobby, influences that are reported as critical to the inception of the hobby, and experiences that hobbyists reported as important to their sustained hobby learning and development. By considering the constellation of variable values that describe the member characteristics of each group, divergent descriptive profiles emerged for each hobby group.

From childhood past retirement: model building as a lifelong pursuit

Model builders, in addition to having the highest proportion of male respondents, were significantly different from the other hobby groups in several ways. The narrative painted by model builders' responses pertaining to their age, the age they first participated in their hobby, as well as the number of years they reported being involved with their hobby was unique. Respondents reported first participating in their model building hobby at the youngest age, and half of the model builders reported their friends as an important and positive influence in the development of their initial interest in model building; four in ten reported family as having a similarly important influence. Considering that most model builders began their hobby in youth, it is then perhaps surprising that nearly seven in ten reported teachers and other educators to have had no or little influence on the development on the interest in model building. This may be due, in part, to the time period during which the model builders would have attended K-12 school. At the time of the survey, model builders were the oldest group of hobbyists in the sample. Corroborating the findings that they started their hobby at the youngest age and were the oldest group at the time of sampling, model builders also reported participating in their hobby for the greatest length of time compared with members of the other groups. There were also very few new members to the model building hobby (participating five years or less).

When asked about experiences that had influenced their continued development in their hobby, few model builders cited any one experience as influencing them strongly, though approximately two thirds of the model builders reported having been influenced (to any degree) by experiences in K-12 school, college, museums/science centers, clubs, and family trips. This relatively diffuse pattern of influence, having not been strongly influenced by any of the six experiences but generally influenced by many, may be due to the hobbyists' older age and longer length of involvement as they might have had more opportunities to pursue their hobby interest through various channels. Another significant finding from this work is that model builders spent the second highest amount of time per week on their hobby, after falconers. Though this result likely indicates these hobbyists have ample time to spend on leisure pursuits during their retirement years, this result is nonetheless surprising since model-building activities can be started and stopped at will; the nature of the activity does not dictate the length or frequency of interaction.

Home brewing and beekeeping: casual activities to pick up in adulthood

Participants in home brewing and beekeeping reported strikingly similar patterns of membership in their hobby. The majority of beekeepers and home brewers reported being involved with their hobby for 1–5 years. These were the only two hobbies in our sample where new members comprised the

majority of the membership. Additionally, fewer than one in ten members from either group reported being involved in beekeeping/home brewing for 20 years or more. The responses pertaining to length of involvement in beekeeping and home brewing were significantly different from the eight other hobby groups, but not from each other. This indicates that the beekeeping and home brewing hobbies both have a relatively small cohort of highly experienced practitioners. The large proportion of new members may reflect a high turnover rate of new hobbyists or may reveal that both home brewing and beekeeping have recently experienced a surge in popularity in the United States and are currently expanding. Indeed, if these new beekeepers and home brewers continue with their hobby, this study indicates that these two groups are the fastest growing STEM hobbies in our sample as measured by proportion of new members.

Beekeepers and home brewers reported a relatively low time commitment to their hobby, more than three-quarters of participants from each group reported spending five hours or less on their hobby per week, even though the hobbies often involve the maintenance of a biological system. Members of these two groups reported the highest ages at which they first participated in their hobby; the beekeepers' distribution of ages was significantly higher than all other hobby groups while the home brewers' ages were significantly different than seven other groups. Childrearing norms in the United States may be responsible for the relatively late start reported by the beekeepers and home brewers in this sample. Indeed, American parents might consider brewing alcohol to be an inappropriate activity in which to engage youth and some parents could perceive beekeeping to be a dangerous activity for children. Additionally, if both of these activities are currently experiencing a surge in popularity, it is also likely there were fewer opportunities for participation when the adults in our sample were younger.

A very high proportion of members of these two groups also reported that teachers, other educators, and significant events had no role in influencing the development of their initial interest in the hobby. One between group difference observed was that home brewers cited friends as having a high or very high influence in piquing their initial hobby interest, reporting at more than twice the rate as beekeepers. Home brewers' pattern of responses to this question was significantly different from eight other hobby groups in the sample. Certain experiences were reported by the majority of hobbyists from both groups (experiences in K-12 school, in museums/science centers, in clubs, on family trips, at camp), and by the majority of beekeepers (experiences in college) as having had no influence on their hobby development; the responses to most of these questions were significantly different from the distribution of responses from at least seven other hobby groups. Experiences in college were cited as generally supporting the development of home brewers as seven in ten brewers cited these experiences as influential. This result likely reflects the legal drinking age in the United States and the environment in which many of the home brewers were located when they began their interest in beer.

Other between group differences included the gender of the participants: home brewers were almost exclusively male while four out of ten beekeepers were women. The home brewers were also most likely to live in suburban (60%) or urban (23%) environments while the beekeepers were more likely to live in rural (48%) or suburban (37%) environments. Taken all together, beekeeping and home brewing hobbies were most likely to start in adulthood and were not influenced by many of the factors that are reported as influencing the development of the STEM hobbies that begin in childhood.

Falconers: focused and highly committed

Falconers were distinct from the other sampled hobbyists in several ways. The majority of falconers reported living in a rural environment, the only sampled group with a majority of rural members. Falconry was also the hobby group with the highest percentage of members (16%) who reported their highest education level was a high school degree or less. Falconers were also significantly different from all other hobby groups in the number of hours per week they devoted to their hobby. More

than half of the respondents reported spending 11 hours or more per week engaging in their hobby, while nearly all falconers (90%) reported spending at least six hours per week on their hobby. In addition to being highly active in falconry, as measured by hours per week of engagement, participants reported being involved with their hobby for relatively long periods of time. Half of the sampled falconers reported being involved with their hobby for over 20 years, and 86% reported being involved for six years or more. The large time commitment reported by falconers indicates that falconry may be more demanding of practitioners than some of the other hobbies investigated, likely owing to the care and maintenance of a living creature.

Shaped by community and place: environmental monitoring

The environmental monitors in our sample included similar numbers of male and female members, and reported living in suburban and rural environments in equal proportions. Group members were highly educated, with half of the sample reporting they had earned a graduate degree. Nearly half of the monitors reported other educators (i.e. educators other than teachers from formal education environments) to have had a high or very high influence on the development of their initial hobby interest; this result was significantly higher than the reported influence of other educators on all other hobby groups. Environmental monitors also reported their experiences in K-12 school (19%), in college (41%), and at childhood camps (15%) to have influenced their hobby development a lot; monitors rated these factors the highest of any hobby group and monitors' responses to these items were significantly different from seven or more of the other groups. Experiences in museums/science centers, experiences in clubs, and experiences on family trips also were also reported to be highly influential on hobby development. Monitors rated these influences at the highest or second highest rate of the 10 hobby groups. Overall, these hobbyists were highly influenced by the experiences they had with educators, learning resources, and institutions in their communities.

Leisure at a leisurely pace: continuing childhood interests as adult pursuits

The remaining five groups (astronomy, birding, electronics/robotics, gardening, and rock/fossil collecting) responded to the survey in similar ways across multiple dimensions. The majority of participants from these groups reported first participating in their hobbies in childhood, though slightly less than half of the sampled birders had first participated in their hobby by age 18. At the time of data collection, the median age of hobbyists in each of the five groups fell in the fifties decade, and 60–70% of the members of each group reported being actively involved with their hobby for 11 years or more.

Several influences were reported to have been significantly influential for each of the hobby groups. Many gardeners, birders, and rock/fossil collectors reported family to have had a high or very high level of influence on piquing their initial hobby interest. Four in ten birders also cited friends as highly influential in starting their hobby. Many astronomers and electronics/robotics enthusiasts found the influence of significant events to be highly or very highly influential to the development of their initial hobby interest, which likely reflects that many of these hobbyists came of age during the space race and during a time of rapid technological change. More than a third of electronics/robotics enthusiasts reported their experiences in college to have influenced their hobby development a lot, perhaps referencing the first opportunity they could take a formal class in the subject. Museums/science centers and clubs were reported by rock/fossil collectors and astronomers to also have influenced their hobby development a lot. This high level of influence might be due to the fact that both settings lend themselves to the display and discussion of hobby-related artifacts (i.e. rock/fossil specimens and telescopes, respectively).

Broadening participation in STEM: the potential of STEM hobbies

If the goal is to broaden participation in STEM, we must first examine the spaces where people organize to engage in STEM activities. STEM-interested youth and adults engage in structured and unstructured activities, alone and with others, to pursue their STEM interests – often through hobbies. The relatively small proportion of our sample that reported their race as American Indian or Alaskan Native; Asian or Pacific Islander; black, not of Hispanic origin; Hispanic; and other has prevented us from conducting a thorough analysis comparing the reported characteristics, influences, and experiences of the members of each of the ten hobby groups by race, and is an important point of discussion when considering the results and implications of this study. Ninety-three percent of the sample identified their race as white, not of Hispanic origin, which is considerably larger than the proportion found in the U.S. population (U.S. Census Bureau, 2011). Possible explanations for why the sample does not mirror the U.S. population were addressed in the limitations section of the methodology and includes the possibility that white individuals do participate in the specific STEM activities discussed in this work to a greater extent than individuals from other backgrounds. A direction for further research would be to investigate whether members of minority groups are more likely to participate in other STEM hobbies and activities not represented in this study. For example, some researchers have noted the high rates of African American participation in fishing (Washburne, 1978), an activity which likely involves STEM-learning. However, the important question remains: how should educators approach making free-choice STEM activities like hobbies more visible, more accessible, and more inclusive?

It has been illustrated in this work that STEM interests that begin in youth and young adulthood can become lifelong interests that are pursued as free-choice activities for many years. Indeed, our results show that, for several hobbies (model building, gardening, rock/fossil collecting, astronomy, electronics/robotics), more than half of the adults sampled reported getting started in their hobby during childhood. Other researchers have found that childhood STEM interests also lead to interest in STEM careers as adults (Dabney et al., 2011); nurturing youths' interest in free-choice STEM activities has many benefits. Support from other people is particularly important to sustain and develop interests (Hidi & Renninger, 2006), including interest in a STEM hobby (Corin et al., 2015), and our study illustrates which specific external supports (e.g. family, museums) are reported as important by the practitioners of those activities. This information should be attended to by hobbyists interested in outreach and member recruitment, educators, parents, and others who would like to support STEM participation in their communities. Adults are generally characterized as free-choice learners who approach their learning with a problem-centered or performance-centered frame of mind (Knowles, 1980), and it is reasonable to infer that adult STEM hobbyists seek out experiences that they perceive will support their hobby-related learning and help them reach their personal goals. Children, however, often don't enjoy the same autonomy as adults and need additional support to encourage their interests and to introduce them to new activities.

As Robinson (2008) pointed out, social networks are incredibly important to determining whether individuals, particularly African Americans, will develop a STEM hobby. His work stressed that if an individual doesn't personally know a hobbyist, then that person is less likely to become a practitioner of that activity. As many STEM hobbyists are introduced to their lifelong STEM interest during their youth, we would suppose that family members, friends, and teachers would be highly influential on their interest development. This work found family and friends to be quite influential when sparking an initial interest in a hobby. In the case of minority youth, if their family and other members of their immediate social network are less likely to participate in a STEM hobby themselves, then that child is also less likely to be presented with the opportunity to participate and develop a STEM hobby. Children who don't have these opportunities through their family and friend social network may be less likely to become STEM-interested adults, and may also be less likely to be interested in a future career in STEM. This presents a profound opportunity for K-12 teachers and

other non-family community members who spend time with youth to play a greater role in supporting youth interest development in free-choice STEM pursuits. Teachers should create opportunities for children to participate in these activities, perhaps connecting with hobbyists interested in outreach in their communities, to provide inclusive opportunities for their students. Only through intentional and targeted outreach will these free-choice spaces begin to be perceived as interesting and accessible to members of a broader community.

Conclusion

Many American adults spend their free time learning about STEM and engaging in related free-choice activities. The present study adds to the body of research on adults who use their leisure time to pursue STEM hobbies. This study allows for comparisons between physical science, biological science, and engineering-related groups to be made across dimensions such as the age the hobby began, length of time involved with the hobby, hours spent working on hobby, education level, in-school and out-of-school experiences related to the hobby, and other factors that influenced hobby development. This is important information for schools, museums, and other community organizations that are poised to provide opportunities that encourage community members from all backgrounds to participate in STEM across the lifespan.

Notes

1. Samples of hobby groups that have been reported as overwhelmingly Caucasian include amateur astronomers (87%) (Berendsen, 2005), home brewers (93%) (Murray, 2009), and birders (93%, 94%, 95%) (Carver, 2013; Eubanks et al., 2004; La Rouche, 2006). In a survey designed to investigate the prevalence of African Americans in birdwatching, Robinson (2005, 2008) found that 34% of survey respondents had never met an African American birder. The sampled birders had been involved in their hobby for an average of 21 years and, over that time span, on average, met only two African American birders. Robinson, himself an African American birder, reported he could only recall meeting three other African American birders over a 22-year period.
2. Eighty-nine percent of environmental monitors indicated their hobby development had been influenced by experiences in museums/science centers as well as experiences in college.

Disclosure statement

No potential conflict of interest was reported by the authors.

Funding

This work was supported by the National Science Foundation [grant number ISE 1114500].

ORCID

Elysa N. Corin http://orcid.org/0000-0003-4039-3331

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