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HOW DO MARINE AND COASTAL CITIZEN SCIENCE EXPERIENCES FOSTER ENVIRONMENTAL ENGAGEMENT?

Angela J. Dean [a,b,c]
Emma K. Church [d,e]
Jenn Loder [d,f]
Kelly S. Fielding [c]
Kerrie A. Wilson [a,b]

[a] ARC Centre of Excellence for Environmental Decisions (CEED), The University of Queensland, St Lucia, QLD 4072, Australia
[b] School of Biological Sciences, The University of Queensland, St Lucia, QLD 4072, Australia
[c] School of Communication & Arts, The University of Queensland, St Lucia, QLD 4072, Australia
[d] Reef Citizen Science Alliance, Conservation Volunteers Australia, PO Box 423, Ballarat VIC 3353, Australia
[e] School of Social Science, Monash University, Victoria 3800, Australia
[f] Great Barrier Reef Foundation, 13/300 Ann St Brisbane, QLD 4000, Australia

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Corresponding author: Dr Angela J Dean, ARC Centre of Excellence for Environmental Decisions, School of Biological Sciences, The University of Queensland, St Lucia, QLD 4072, Australia
E: a.dean@uq.edu.au P: +61 7 336 52527

ABSTRACT

Citizen science programs enable community involvement in scientific research. In addition to fostering greater science literacy, some citizen science programs aim to foster engagement in environmental issues. However, few data are available to indicate whether and how citizen science programs can achieve greater environmental engagement. We survey individuals choosing to attend one of seventeen reef citizen science events and examine the extent to which attendees reported three indicators of greater environmental engagement: (i) willingness to share information, (ii) increased support for marine conservation and citizen science, and (iii) intentions to adopt a new behavior. Most participants reported being willing to share information about reef conservation (91%) and described increased support for marine science and conservation (87%). Half of participants (51%) reported intentions to adopt a new conservation behavior. We found that key elements of the citizen science experience associated with these outcomes were learning about actions to protect reefs and coasts (procedural learning), experiencing surprise, and experiencing negative emotions about environmental problems. Excitement was also associated with positive outcomes, but only in participants who were less likely to see themselves as environmental, or were less frequent visitors to reefs and coasts. Importantly, the association between factual learning and environmental engagement outcomes was limited or negative. These findings suggest that the way citizen science experiences make people feel, may be more important for fostering future environmental engagement than factual-based learning. When designing citizen science programs for community members, these findings provide a reminder to not focus on provision of factual information alone, but to highlight environmental impacts while providing meaningful experiences and building environmental skills.

1. INTRODUCTION

1.1 Citizen science and environmental management

Citizen science is a participatory model of science, where non-professionals are involved in diverse aspects of scientific research (Dickinson et al., 2012; Theobald et al., 2015). Within the environmental context, most citizen science projects involve environmental monitoring, also referred to as "community based environmental monitoring" (Conrad and Hilchey, 2011; Dickinson et al., 2012). Citizen science programs are diverse, and may comprise: biological monitoring initiatives, such as biodiversity monitoring or monitoring species range shifts; monitoring environmental processes such as water quality; or monitoring impacts of global change, such as coral bleaching (Cigliano et al., 2015; Dickinson et al., 2012; Schläppy et al., 2017; Scyphers et al., 2015). Citizen science has the potential to contribute to a range of management outcomes: existing programs have assessed effectiveness of marine reserves (Cigliano et al., 2015), provided a basis for restoration funding (Jordan et al., 2016), and identified sources of marine debris and enabling pollution source reduction initiatives (Hastings et al., 2015).

1.2. Can citizen science foster environmental citizenship?

Many citizen science programs emphasise education (Hobbs 2012), with research suggesting that citizen science may increase content (factual) knowledge (Jordan 2011, Haywood 2016), build literacy in scientific processes related to the project (Cronje 2011), and build skills (procedural learning) (Johnson et al., 2014). In addition, many programs also aim to foster engagement in environmental issues (Hobbs and White, 2012; Johnson et al., 2014; Marshall et al., 2012), where engaged individuals are conceptualized as those that understand, value and act to promote environmental outcomes (Dean et al., 2016c). Behavioral outcomes indicating greater engagement could include private-sphere behaviors such as reduced plastic consumption, and public-sphere behaviors, such as stewardship activities or petitioning for improved policy approaches (Jordan et al., 2011; Stern, 2000). In addition, the Diffusion of Innovations theory (McMichael and Shipworth, 2013) highlights the important of sharing information with others as an important conduit for changing community norms and practices. This is becoming recognized as an important pathway for environmental change (Dalrymple et al., 2013; Dean et al., 2016a; Johnson et al., 2014).

A number of studies highlight the potential for citizen science to promote environmental engagement. For example, one case study in the area of natural resource management, reported that 39% of citizen science participants described a change in their management decisions as a result of participation. However, many of these participants were also professionally involved in natural resource management (Chase and Levine, in press). Participants in wildlife monitoring programs report that their involvement influenced their intentions to adopt a range of other conservation behaviors (Toomey and Domroese, 2013). Other programs indicate that citizen science experiences may elicit information sharing about environmental issues (Johnson et al., 2014; Jordan et al., 2011). Despite these encouraging findings, there remains an evidence gap regarding whether citizen science can provide an entry point to environmental engagement (Groulx et al., 2017;

Schläppy et al., 2017), and if so, *how* participation may elicit this change. Specifically, what elements of the citizen science experience are associated with change, and can these elements influence all participants, or only certain types of individuals?

1.2 What types of citizen science experience are necessary to foster environmental citizenship?

It has been argued that citizen science can lead to personal transformation and subsequent behavior change (Groulx et al., 2017). Transformative Learning Theory describes how certain experiences challenge existing perspectives or frames of reference—which then lead to new perspectives, and new actions (Chao, 2017; Groulx et al., 2017; Mezirow, 1997). Within this framework, there are many elements of citizen science experiences which may provide an impetus for change. For individuals with limited nature experience, being in nature or close to wildlife may trigger reflection and transformation (Chao, 2017; D'Amato and Krasny, 2011). Hands-on procedural learning experiences in a social setting may provide opportunities for learners to incorporate and reflect on new perspectives (Diduck et al., 2012; Nohl, 2015). There is also increasing recognition that emotions are a central element of transformative experiences (Maiese, 2017). For example, evoking surprise may challenge perspectives (Nohl, 2015). Positive emotions, such as feeling awe (D'Amato and Krasny, 2011), and negative emotions related to seeing environmental degradation (Diduck et al., 2012), may both trigger transformative learning.

Research demonstrates that citizen science can generate experiences that are central to transformative learning—skills development and empowerment, emotional experiences, connecting with natural environments, reflecting on experiences, and socially-focused activities (Cigliano et al., 2015; Groulx et al., 2017; Haywood et al., 2016). However, it remains unclear which of these elements are most associated with transformation, as conceptualized by increased environmental engagement.

1.3 How do experiences influence different types of people?

Experiences that challenge existing perspectives have the greatest potential to be transformative (Mezirow, 1997). This raises the possibility that individuals with different perspectives or experience may exhibit differential responses to distinct elements of citizen science experiences. Two issues of relevance to this study are frequency of visiting marine ecosystems, and the psychological construct of environmental identity—the extent to which someone sees themselves as an 'environmental person' (Dresner et al., 2015; Fielding et al., 2008). It is possible individuals with limited experience of marine ecosystems or who do not see themselves as an environmental person may experience emotions such as surprise or excitement during marine citizen science experiences, which may be transformative. However, many citizen science participants have an established interest in nature recreation, and conservation (Chase and Levine, in press; Hobbs and White, 2012; Martin et al., 2016; McKay and Johnson, 2017). This raises the question of whether there is scope for citizen science programs to elicit transformation for these 'more engaged' participants. And if so, what elements are transformative for this group compared to less engaged participants?

1.4 The current study

We examine how attending marine citizen science events influences engagement in environmental issues. First, we quantify the degree to which attending a citizen science event is associated with three self-report measures of environmental engagement: willingness to share information with others, increased support for marine conservation and citizen science, and intentions to adopt a new behavior. We then examine the relationships between different elements of the citizen science experience and these measures, and whether these relationships are moderated by environmental identity and frequency of marine visits. We anticipate that this study will enable citizen science programs to foster behavior change and environmental citizenship, and assist these programs in targeting activities to social groups or types of experiences that generate the greatest impact.

2. METHODS

2.1 Citizen science events

The Reef Citizen Science Alliance is a collaborative network of 13 coastal and marine citizen science organisations, which collaborate on citizen science initiatives to improve the health of reef and coastal ecosystems. ReefBlitz is based on the BioBlitz model: events which integrate rapid biological assessments with public outreach (Lundmark, 2003). The promotion of BioBlitz events as social events is thought to be an important approach for raising awareness, and creating entry points for participation in environmental monitoring or stewardship. ReefBlitz events operated over larger spatial and temporal scales to align with existing community monitoring programs in Queensland and regional management priorities, while also allowing for the dependence of coastal monitoring activities on tide and weather conditions. While the majority of field-based events were held on a single weekend, ReefBlitz encompassed a 6-week period of broader activities (e.g. school visits, art exhibitions) which were conducted across a regional scale (coastal areas of Queensland, Australia).

Field-based events comprised community monitoring of reef, mangrove, saltmarsh and seagrass ecosystems, water quality, and beach-based marine debris. The majority of participating programs coordinate long-term monitoring, within a contributory model of citizen science, where citizens contribute to an existing monitoring project that is managed by a professional team (Conrad and Hilchey, 2011; Shirk et al., 2012). ReefBlitz 2016, was held in October 2016. Seventeen field events were targeted for surveys. Attendees at each of these events were invited to complete a brief (five minute) survey. Participants did not receive any reimbursement. Ethical clearance was provided by The University of Queensland Human Research Ethics Committee.

2.2 Survey

In addition to participant characteristics (age, sex, and participant experience of citizen science), the survey assessed the following dimensions:

2.2.1 Dependent variables – environmental engagement

- *Willingness to share information*: three items rated willingness to: talk about what others can do to protect reefs, persuade others to get involved, share information about protecting reefs and coasts on social media. Items were rated on a 5-point scale (1=strongly disagree, 5=strongly agree); the mean formed a 'Willingness to share' score (Cronbach's α=0.83).
- *Increased support for marine science and conservation*: participants were asked to consider their experience at the event, and rate its influence on: their support for initiatives to protect reefs/coasts; their ability to help protect reefs/coasts; their support for coastal/marine science; their interest in coastal/marine science, and their ability to contribute to coastal/marine science. Each item was rated on a 5-point scale (1=lower, 2=no change; 3=a little higher; 4=higher; 5=much higher). The mean formed an 'Increased Support' score (Cronbach's α=0.94).
- *New behavioral intentions*: a single item asked participants to identify a new action they could do to protect reefs and coasts. They were then asked to rate the likelihood of them taking this action in the next four weeks (5-point scale, 1=very unlikely, 5=very likely). For those unable to identify a new action, responses were coded as 'very unlikely'.

2.2.2 Independent variables – elements of the experience

Ten items adapted from previous research (Ballantyne et al., 2011), quantified elements of the citizen science experience:

- *Factual learning:* I learnt new things about marine life
- *Procedural learning:* I learnt about things I can do to protect reefs and coasts
- *Empowerment*: It felt good to learn what I can do to make a difference
- *Reflection*: I found myself reflecting on new ideas about marine life and environments
- *Connection*: I felt an emotional connection with what I saw
- *Surprise*: I experienced something surprising or unexpected
- *Wonder*: I felt a sense of wonder or awe
- *Excitement*: It was exciting to see marine life
- *Negative emotions*: Something I saw or heard made me feel sad or angry about environmental problems
- *Social context*: I observed others who care about reefs or coasts

Items were rated on a 4-point scale (1=strongly disagree, 4=strongly agree). Because each item was intended to capture a discrete element, these items were not combined into scales.

2.2.3 Moderators

- *Frequency of reef visits*: a single question asked 'how often do you visit reefs or coastal areas?' (5-point scale: 1=very rarely, 5=very often).

- *Environmental identity*: participants rated their agreement with the following statement, adapted from Fielding et al (2008): “I am the type of person who acts in an environmentally-friendly way” (7-point scale: 1=totally disagree, 7=totally agree).

2.3 Statistical analysis

Initial data descriptives and correlations (Table S1) provided a basis for data-reduction procedures, prioritizing variables for inclusion in multivariate analysis. Independent variables which were highly skewed (i.e. those generating strong agreement, with less than 5% of respondents scoring below midpoint) were excluded from subsequent analysis. Variables excluded were: Empowerment, Wonder, Reflection, Connection, and Social Context. A mixed-effects model was developed for each dependent variable. Event was included as a random effect to enhance generalizeability of findings across events (Zuur, 2009). Analysis began with a full model (all independent variables, moderators, age, sex, and two-way interactions between independent variables and moderators). To identify the optimal fixed structure, each model iteratively removed the least significant factor at each step, using the Akaike Information Criterion (Akaike, 1974) and maximum likelihood (ML) estimation to identify the final model, which was refitted using restricted ML estimation (REML) (Zuur, 2009). Normality of residuals were inspected to ensure models adhered to normality assumptions. The variable ‘Willingness to share’ was highly skewed; to address this, the variable was inverse transformed and standardized, ensuring the final model adhered to assumptions.

3. RESULTS

3.1 Sample characteristics

Surveys were completed by 138 participants (response rate of 42%). Complete data for dependent variables was available for N=127. All age groups were represented (42% <30 years; 34.0% 30-49 years; 23.9% ≥50 years) and 58.3% were female. Half of participants reported having heard of citizen science before this event (51.6%), and 37.0% reported previous attendance at a citizen science event. The most commonly cited reason for attending was to ‘learn about reefs and coasts’, cited by 54% of attendees. Most participants scored above the mid-point of environmental identity (M=5.79±1.14, Table S1). Over half of all participants reported visiting reefs and coasts ‘often’ or ‘very often’ (59.4%); 24.2% indicating sometimes, and 16.4% reporting ‘rare’ or ‘very rare’ visits to reefs and coasts (M=3.55±1.14, Table S1).

3.2 Willingness to share

Most participants were willing to share information, with 91.3% scoring above the scale mid-point (Table S1). Greater willingness to share was positively related to negative emotions (F=4.32, $p<0.05$), and surprise (F=7.40, $p<0.01$) (Table 1). The relationship between excitement and willingness to share was moderated by environmental identity (F=5.26, $p<0.05$, Table 1): excitement was associated with greater willingness to share only in those with low environmental identity; for those with high environmental identity, excitement was associated with *lower* willingness to share (Figure 1a). A significant interaction between factual learning

and reef visits (F=10.12, *p*<0.01, Table 1) showed that factual learning was associated with greater willingness to share only in those who were infrequent reef visitors; in frequent visitors, factual learning was associated with *lower* willingness to share (Figure 1b).

3.3 Increased support for marine science and conservation

The majority of participants reported an increase in their active support for marine science and conservation, with 86.7% of participants revealing a mean score of at least 3 (equivalent to a small increase) (M=3.83±0.82, Table S1). Analysis indicates that increased support was associated with both procedural learning (F=16.60, *p*<0.001), and novelty (F=14.80, *p*<0.001) (Table 1). The impact of negative emotions on increased support for citizen science was moderated by environmental identity (F=4.87, *p*<0.05) (Table 1), where experiencing more negative emotions in relation to environmental problems was related to increased support for citizen science, but only for those with lower environmental identity (Figure 1c).

3.4 New behavioral intentions

Half of all participants (51.3%) indicated that they were likely or very likely to adopt a new behavior; 17.9% reported being somewhat likely, and 30.7% were unlikely or very unlikely to adopt a new behavior (Table S1). Sixty six individuals identified what behaviors they intended to adopt. These included: participation in citizen science (42%); reducing plastic consumption (13.6%), removing marine debris (7.6%), and persuading others to act (10.6%). Stronger intentions to adopt a new behavior were associated with negative emotions (F=4.35, *p*<0.05), and procedural learning (F=7.69, *p*<0.01). A significant interaction between procedural learning and environmental identity (F=4.01, *p*<0.05) revealed that while procedural learning was associated with new behavioral intentions across high and low environmental identity, this relationship was strongest in those with low environmental identity (Figure 1d). A significant interaction between excitement and frequency of reef visits (F=6.64, *p*<0.05, Table 1) showed that excitement was associated with greater behavioral intentions only in those who were infrequent reef visitors; in frequent reef visitors, excitement was associated with *lower* behavioral intentions (Figure 1e). Contrary to expectations, factual learning was associated with reduced intentions to adopt a new behavior (F=4.61, *p*<0.05).

4. DISCUSSION

This study identifies which elements of citizen science experiences are most associated with greater environmental engagement. The majority of participants reported willingness to share information and increased support for marine science and conservation, while half expressed intentions to adopt a new behavior (Figure 2). Participants were heterogeneous—while many saw themselves as ‘environmental’, many were not regular visitors to reefs and coastal areas, and were unfamiliar with citizen science. Although the potential increase in engagement was not restricted to a certain type of participant, participant characteristics exerted some influence on which elements of the experience were associated with self-reported change. We observed that procedural learning, negative emotions, and surprise were most

associated with engagement outcomes across all participant groups (Figure 2). Positive emotions, such as excitement, were only associated with change in individuals with low environmental identity, or less frequent marine visitors. Interestingly, factual learning had limited positive effects on outcomes, highlighting the importance of moving beyond simple factual information when engaging community members about environmental issues.

Our findings indicate that procedural learning was strongly associated with increased support and new behavioral intentions. Developing practical skills is a key element of many environmental citizen science programs (Johnson et al., 2014). Research indicates that knowledge about *how* to act is likely to have a greater influence on behavior than general awareness (Kaiser and Fuhrer, 2003; van der Linden, 2015). Building procedural knowledge is a commonly utilized element of effective behavior change interventions (Osbaldiston and Schott, 2012), and hands-on learning is an important way to increase salience of the learning experience. The finding that factual learning was associated with *reduced* behavioral intentions, and limited positive influence on other outcomes, is unexpected. This finding aligns with studies that suggest perceptions about climate change are more influenced by psychological issues than scientific literacy (Drummond and Fischhoff, 2017; Kahan et al., 2012), and serves as a reminder that factual knowledge is only one of many factors that influence environmental behaviors (Dean et al., 2016b; Kollmuss and Agyeman, 2002).

Negative emotions were associated with stronger behavioral intentions and willingness to share across all participants, and were associated with increased support for marine science and conservation in those with low environmental identity. Qualitative evaluations of citizen science participants suggest that viewing environmental impacts is a strong motivation for action (Haywood, 2016). Individuals starting citizen science training were more likely to report being upset in response to impacts than those who had completed training (Haywood et al., 2016). Interviews with environmental activists also indicate that negative experiences, such as viewing habitat loss, were a strong motivation for becoming activists (Chawla, 1999). Collectively, these findings suggest that negative emotional responses to environmental impacts may be an important impetus for action. From a psychological perspective, emotions are specific internal states that emerge in response to situation appraisal and 'action readiness' (Frijda et al., 1989; Kuhne and Schemer, 2015). Humans are inherently loss averse (Tversky and Kahneman, 1981), and contextually-appropriate negative emotions (as opposed to persistent negative emotions that occur in depressive states) have been associated with uptake of adaptive behaviors (Coifman et al., 2016). We measured negative emotions as 'feeling sad or angry'. Both sorrow and anger are associated with action readiness (Frijda et al., 1989); however, sadness is associated with focusing on the object of sadness (e.g. environmental degradation), whereas anger is associated with focusing on the causes of a problem (Bodenhausen et al., 1994; Coifman et al., 2016; Kuhne and Schemer, 2015). Given this, it would be useful for future research to explore the differential impacts of sadness and anger that arise during citizen science experiences on motivating environmental action. Importantly, our findings were generated in field-based, social settings, which elicited

high ratings of empowerment and reflection. It is possible that negative emotions in the absence of these contextual influences may risk generating disengagement (Kollmuss and Agyeman, 2002). In contrast to the role of negative emotions, positive emotions may generate openness to new ideas (Fredrickson, 2004). One experimental study reports that positive emotions were associated with deeper processing of information only when the experimental task focused on enjoyment, but not when the task focused on performance (Côtè, 2005). This differential role of positive emotions is suggested in our findings, where excitement was only associated with outcomes in individuals with low environmental identity, or infrequent marine visitors.

We observed that surprise was associated with greater willingness to share information and increased support. Surprise has been associated with information seeking (Wang and Ahern, 2015) and deeper situation appraisal (Frijda et al., 1989; Stiensmeier-Pelster et al., 1995), where differences between what is expected and what is experienced may stimulate deeper thinking about the causes of such differences (Stiensmeier-Pelster et al., 1995). From a practical perspective, zoo visitors prefer conservation information that emphasizes novelty (Smith et al., 2010) and novel messages about environmental issues may reduce the risk of 'issue fatigue' (Maibach et al., 2010). Interestingly, the effects of surprise were observed in all participants, not just in 'less engaged' participant groups. While it is possible that the aspect of the experience that led to surprise differed between groups, this finding suggests that citizen science events may provide a pathway for exposure to novel perspectives, even in individuals with experience of the ecosystem or environmental issues.

4.1 Implications for practice

Our findings suggest that that citizen science events may foster new environmental behaviors. Citizen science events bring locally-focused monitoring programs together to showcase programs, and provide entry points for citizen science participation that build on social, or place-based, connections. The profile of participants, in particular the large age range and number of individuals with limited citizen science experience, suggest that citizen science *events* may attract more diverse participants than long-term monitoring programs, where most participants tend to be older with established interest in environmental issues (Haywood, 2016; Hobbs and White, 2012). With regard to program design, these findings provide a timely reminder to not rely on simple factual messages to motivate change; rather that the necessary ingredients for transformative, field-based experiences include procedural learning, surprise, and negative emotions. While procedural learning and novelty may be readily incorporated into monitoring events, the role of negative emotions poses a challenge for practitioners, who are motivated to ensure participants have an enjoyable experience. Our findings suggest that designing experiences that expose participants to environmental impacts—which may give rise to negative emotions—need not be avoided. Because of its hands-on focus, citizen science may provide an important means to highlight environmental threats, while ensuring that individuals do not feel disempowered. Our findings were generated in a field-based setting, with strong ratings of elements such as wonder and awe, connection and social context. As such, these findings may not apply to settings where individuals participate in citizen science on their own or in non-

nature based settings, e.g. collecting opportunistic data or contributing to analysis of online data. Our findings also highlight a role for tailoring experiences to the target audience. For those familiar with the ecosystem, or who have a strong environmental identity, practitioners should focus on building novelty and skill development. For less ‘experienced’ participants, excitement may provide an entry point for engaging this group in ongoing experiences that promote skills.

We note that these findings have emerged from a sample who chose to attend a citizen science event. It is likely that this group is more receptive to experiences that promote environmental engagement. Although our findings indicate that existing environmental identity does not constrain or magnify the impact of experience, it would be useful for future research using controlled designs to explore how these experiences may influence ‘less engaged’ subgroups and to examine the differential impact of different citizen science experiences on behavior over time using longitudinal methods. Similar to existing research (Johnson et al., 2014), most participants reporting being willing to share information with others. It would be interesting for future research to explore both the types of information likely to be shared and the types of social networks targeted. While many studies assess environmental identity as a stable construct, there is increasing recognition that certain experiences can foster environmental identity (Lauren et al., in press). It would be interesting for research to examine how certain actions may foster environmental identity, which might then influence other environmental behaviors.

4.2 Conclusions

Citizen science provides an important approach to engage communities in environmental monitoring. Our findings show that citizen science events can attract attendees who may have limited experience of marine science and monitoring. While participants tend to identify as being pro-environmental, this doesn’t limit scope for change, but may influence which element of the experience are ingredients for change. When designing citizen science monitoring activities for community members, these findings provide a reminder to not focus on facts alone, but to highlight environmental impacts while providing meaningful experiences and building skills.

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Table 1. Mixed effects models examining associations between aspects of citizen science experience and (i) willingness to share information with others, (ii) increased support for marine science and conservation, and (iii) new behavioral intentions (Significant findings are highlighted in bold).

	WILLINGNESS TO SHARE			**INCREASED SUPPORT**			**NEW BEHAVIOURAL INTENTIONS**		
	F	**Coefficient±SE**	**95% CI**	**F**	**Coefficient±SE**	**95% CI**	**F**	**Coefficient±SE**	**95% CI**
Factual learning	3.10	-0.05±0.03	-0.10, 0.01				**4.61***	**-0.38±0.18**	**-0.73, -0.03**
Procedural learning				**16.60*****	**0.29±0.07**	**0.15, 0.44**	**7.69****	**0.42±0.15**	**0.12, 0.71**
Excitement	0.81	-0.02±0.02	-0.07, 0.02				0.30	0.09±0.16	-0.23, 0.40
Surprise	**7.40****	**0.07±0.02**	**0.02, 0.12**	**14.89*****	**0.27±0.07**	**0.13, 0.40**			
Negative emotions	**4.32***	**0.04±0.02**	**0.005, 0.08**	1.25	0.07±0.06	-0.06, 0.20	**4.35***	**0.30±0.14**	**0.01, 0.59**
Environmental identity	**34.91*****	**0.12±0.02**	**0.08, 0.16**	1.68	0.08±0.06	-0.04, 0.20	0.50	-0.11±0.15	-0.41, 0.19
Procedural learning × identity							**4.01***	**-0.26±0.13**	**-0.52, 0.00**
Excitement × identity	**5.26***	**-0.05±0.02**	**-0.10, -0.01**						
Surprise × identity	3.06	0.04±0.02	-0.01, 0.08						
Negative emotions × identity				**4.87***	**-0.12±0.05**	**-0.23, -0.01**			
Reef visits	0.32	0.01±0.02	-0.03, 0.05				0.16	-0.06±0.14	-0.34, 0.23
Excitement × reef visits	3.81	0.05±0.02	-0.001, 0.10				**6.64***	**-0.41±0.16**	**-0.73, -0.09**
Factual learning × reef visits	**10.12****	**-0.07±0.02**	**-0.11,-0.03**				2.93	0.26±0.15	-0.04, 0.57
Age	**4.05***	**-0.04±0.02**	**-0.08, -0.001**						

*p<0.05; **p<0.01; ***p<0.001.

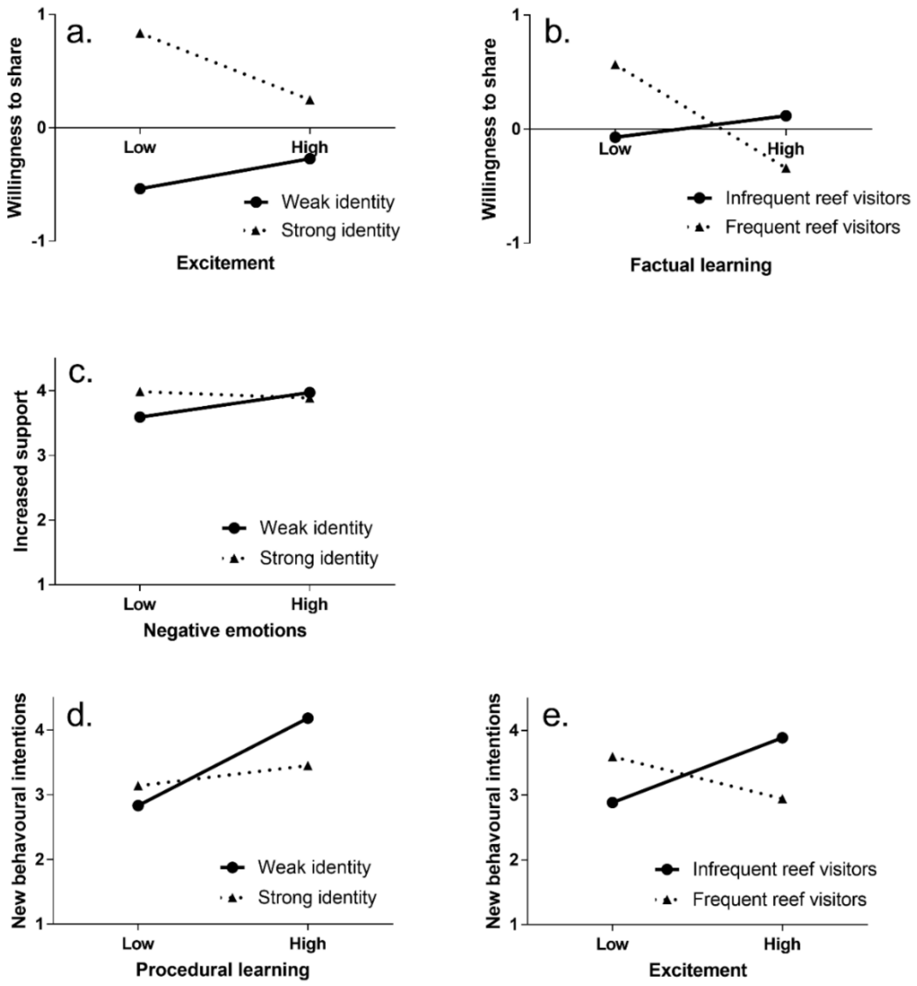

Figure 1. Significant interactions identified in Table 1: (a) the relationship between excitement and willingness to share is moderated by environmental identity; (b) the relationship between factual learning and willingness to share is moderated by frequency of reef visits; (c) the impact of negative emotions on increased support for marine science and conservation was moderated by environmental identity; (d) The impact of procedural learning on new behavioral intentions is moderated by environmental identity; and (e) the impact of excitement on new behavioral intentions is moderated by frequency of reef visits.

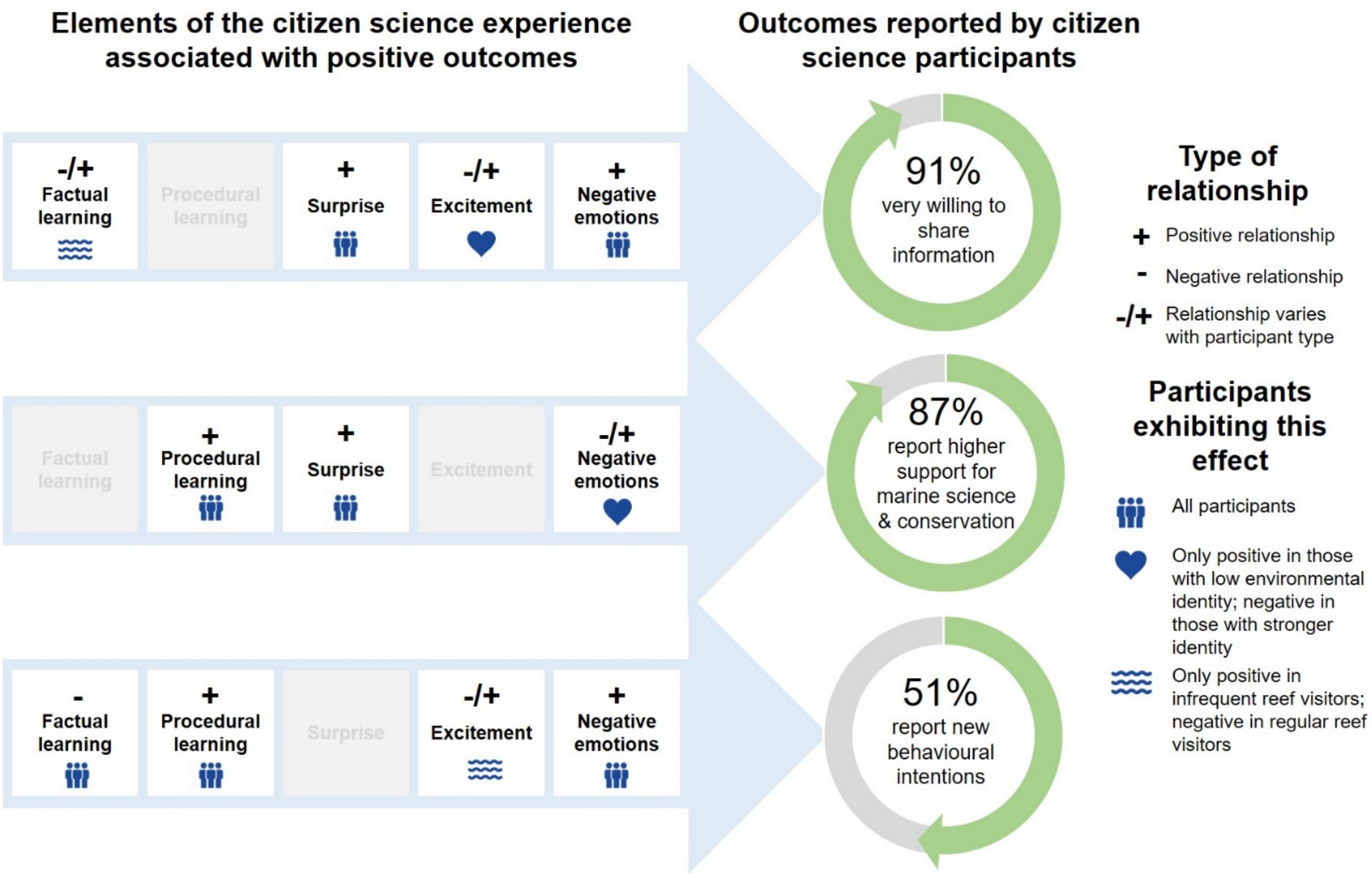

Figure 2. Summary of key research findings: what elements of the citizen science experience are associated with self-reported outcomes (willingness to share, increased support for marine science and conservation, and new behavioral intentions).