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# Narratives as a mode of research evaluation in citizen science: understanding broader science communication impacts

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**Abstract**    Science communicators develop qualitative and quantitative tools to evaluate the 'impact' of their work however narrative is rarely adopted as a form of evaluation. We posit narrative as an evaluative approach for research projects with a core science communication element and offer several narrative methods to be trialled. We use citizen science projects as an example of science communication research seeking to gain knowledge of participant-emergent themes via evaluations. Storied experience of participant involvement enhances understanding of context-based and often intangible processes, such as changing place-relations, values, and self-efficacy, by enabling a reflective space for critical-thinking and self-reflection.

## Introduction

Science communication is a goal of current research agendas and is being more thoroughly integrated into the core of research projects to exchange information across different disciplinary boundaries and in engagement with diverse stakeholders. We define science communication as a process which is increasingly integrated into research projects with 'engaged' methodologies rather than occurring only in separate one-off science communication initiatives or forms of 'dissemination'. Communicating the scientific component of research is critical in projects with a focus on multi-disciplinary, 'wicked problems' and public engagement. Science communicators are exploring how to measure the success of these efforts and on what criteria success should be measured. We posit narrative as a method to gain access to the types of meaningful engagement and critical reflection amongst participants that science communication activities strive towards (as 'impact'). Likewise, environmental organisations, museums and other public facing science educators often have similar goals to evaluate their engagement and communication strategies, and aspects of this paper will be transferable to these contexts. Narratives by their nature are complex and context-based and have potential to produce nuanced and in-depth understanding of the impact of initiatives which quantitative or universal/standardised indicators lack [Bornmann, 2013]. Whilst narrative has been explored as a tool for science communication it has not been considered to have an equal role as a form of

evaluation. In this proposition paper, we advocate the role of narratives in citizen science projects — a popular approach for engaging the public with science topics and communicating scientific information — to consider how narrative can illuminate often intangible, context-based factors informing and resulting from participant involvement, for example, about changes to behaviour, intention, and values or environmental- and place-relations.

We first outline current modes of evaluation in citizen science, then introduce how narrative has been engaged within the wider field of science communication and in citizen science more specifically. We offer five narrative methods that are well-developed as their own methodological fields and describe how these can be trialled, experimented with, and given practical application as evaluative approaches within citizen science research. We conclude the paper with a brief summary of complimentary analytic approaches and consideration of the limitations of narrative methods.

## Evaluation in Citizen Science

We forward the role of narrative for evaluating social outcomes of public-engaged science communication projects, using citizen science as an example. Citizen science involves 'public participation in scientific research' where members of the public work in partnership with professional scientists to collect, submit or analyse large quantities of data [Bonney et al., 2015]. More recently, citizen science is also associated with a 'movement to democratise science' by bringing the public and science close together by facilitating active dialogue and engagement in decision-making processes [Irwin, 1995]. Citizen science could therefore, be viewed as a unique form of science communication whereby dialogue and knowledge exchange can occur [Haywood and Besley, 2014]. Current evaluative research which focuses on the 'lived experiences' of participant citizen scientists in this field strives to answer questions related to the reasons for participants to become involved and benefits that projects may yield for example through providing learning and training opportunities, or benefits to society through influencing environmental behaviour.

Science communicators are engaged in evaluation impact studies to assess the outcomes of their work to identify improvements, barriers that need to be removed and lessons to be learnt to enhance their practice [Jensen, 2015; King and Svalastog, 2015]. Early evaluation studies of citizen science drew on existing measures from science communication studies to evaluate social outcomes due to a lack of established metrics and techniques in the field [Bonney et al., 2015]. Evaluators have explored the motivations for participating in citizen science, the ability of projects to enhance scientific knowledge and literacy, understanding of scientific principles and methods, and the ability to interpret scientific information [Jordan et al., 2011; Raddick et al., 2013]. A link between engagement in citizen science and changes in attitudes, norms, values and behaviour has been highlighted, according to people's views about their environment and perceptions of science institutions [Fernandez-Gimenez, Ballard and Sturtevant, 2008; Jordan et al., 2011]. Lawrence [2006] suggests that when "laypersons are engaged in structured observation and interpretation of nature, their values change and possibly even converge with those of ecologists, as scientific knowledge and practice meet local knowledge and practice. The act of data collection becomes not only a narrative of nature but an influence in turn on the actors — the narrators" [p. 295].

Science communicators and citizen science evaluators have adopted a number of approaches to evaluate "impact" namely front-end, formative and summative research which draw on a range of quantitative and qualitative methods from pre- and post-engagement questionnaires, interviews, focus groups and observation [Brake and Weitkamp, 2009; King et al., 2015]. Friedman [2008] proposed several indicators to assess educational outcomes which were applied by Bonney et al. [2009] to evaluate informal science education outcomes. They concluded that whilst participation can lead to improvements in awareness, knowledge, engagement and interest; changes in attitude and behaviours were difficult to detect. Other researchers who assessed knowledge, attitudinal and behaviour change conclude that generalisations of the data are problematic due to studies lacking similar methodologies [Jordan et al., 2011], [Crall et al., 2013]. Philips and Bonney [2016] are attempting to build evaluation capacity in the field through development of new assessment tools such as DEVISE (Developing, Validating, and Implementing Situated EvaluationInstruments) a project which develops an inventory of context dependant tools to measure science and environmental learning in citizen science.

Evaluation of education outcomes in citizen science largely focus on providing useful tools for research practitioners by developing replicable measures and conceptual frameworks that can be standardised and applied across different projects [Brossard, Lewenstein and Bonney, 2005; Friedman, 2008; Bonney et al., 2009]. While these studies provide valuable broad cross-scale trends and changes, the educational and attitude effects of citizen science have showed mixed positive results or no changes in knowledge or attitudes. Attitudes and behaviour toward science are likely to be high in people who already choose to volunteer for a citizen science project therefore, results derived from standardised scales designed for general populations are less likely to detect change [Bonney et al., 2009]. This may relate to the context in which the learning took place in which the learning took place as several studies have demonstrated a correlation between sense of place, enhanced learning and pro-environmental behaviour [Kyle, Mowen and Tarrant, 2004; Semken and Brandt, 2010], that adequate time is required for individuals to critically reflect on the scientific content or process and that learning may be temporal in nature and best understood when measured longitudinally [Rennie and Johnston, 2004]. This paper proposes that narrative approaches might provide greater access to these intangible and context-based factors associated with changes in values and behaviours over time. Narrative evaluation may also allow for the nuance needed to explore context-based factors relating to place-attachment and place-meaning, such as growing sense of stewardship developed through participation in environmental and science projects. These factors will be transferable to different degrees to other public-engaged science communication projects, but similar intangible and context-based factors may equally be sought through narrative evaluation methods outlined later in the paper.

Citizen science projects build on existing knowledge and relationships people have with their environment. 'Attachment to place' and 'place meaning' has been shown to foster pro-environmental behaviours, behavioural intentions and attitudes [Kudryavtsev, Krasny and Stedman, 2012]. Place-based research may provide greater insights into volunteer's experiences in particular places and the interlinkages that occur between conceptions of nature, environmental attitudes and behaviour [Haywood, 2014]. A range of methodological approaches have been adopted in this field for example, quantitative approaches to assess the dimensions

of place attachment and qualitative approaches using verbal and pictorial measures to understand place meaning [Lewicka, 2011; Kudryavtsev, Krasny and Stedman, 2012]. Haywood [2014] argues that place relationships "involve contingent and unique experiences and interpretations that resist broad and analytically generalisations" [p. 77] which highlight the importance of appropriate analyses to get closer to context-based factors for participants. More recently, research practitioners advocate the need to expand the scope of evaluative research to encompass the processes and outcomes of more meaningful deliberative modes of engagement. This might be illustrated via enhanced self-efficacy such as a sense of ownership or stewardship accrued over a local environmental issue or resource, and social advocacy, trust and social learning through being involved in a project [Fernandez-Gimenez, Ballard and Sturtevant, 2008; Johnson et al., 2014]. New frameworks are being devised to evaluate these different project outcomes, such as indicator frameworks to integrate outreach and participatory goals and to explore trade-offs and potential solutions for meeting different engagement goals [Haywood and Besley, 2014; Lakeman-Fraser et al., 2016]. This brief review of evaluation approaches identifies a shift towards more holistic and nuanced investigations into peoples 'lived experiences' and demonstrates the ways citizen science may encourage new ways of thinking and experiencing the natural environment.

Narrative research is only recently being explored as a method for evaluation although there are some notable exceptions. A User's Guide for Measuring Learning Outcomes in Citizen Science was developed to provide guidance on how to plan, implement, and disseminate evaluations advocating for a range of quantitative and qualitative methodologies including narrative methods [Phillips et al., 2014]. Greenhill et al. [2016] used narrative methods to assess incidents of play, socialisation, fun and amusement to consider how social interactions relate to the gaming elements of citizen science platforms.. The use of narrative has been explored in museum studies for science communication and education purposes [Murmann and Avraamidou, 2014] however it is rarely considered for evaluation. Methods encompassing narrative dimensions such as vox pops, personal meaning maps, journals, narrative interviews and conversation analysis have been suggested as evaluation approaches in wider evaluative reviews [Davies and Heath, 2014; Nelson and Cohn, 2015; Schorch et al., 2015]. We posit that collecting participant narratives might supplement or provide equally useful data to more traditional qualitative and quantitative methods. Narratives may give unique insight into procedural and impalpable aspects of participant experience, informing project design, and illuminate context-based impacts that give greater power to local people. Narrative approaches allow for unique, context-based evaluations through time-oriented structures (event-focused, causal, temporal) revealing how changes occur and evolve from a personal perspective.

## Narrative as science communication evaluation

Here we outline the unique characteristics of narrative to support our argument for narrative evaluations. Journalists have long understood the usefulness of narrative in communicating scientific information [Kormelink and Meijer, 2015; Shaffer et al., 2017]. Narratives have distinct communication features: a set of characters developing over the course of the narrative, a plot, a sequence of events, or a temporality with more or less degrees of cause and effect, and a narrator/point of view. Those arguing for greater use of narrative in science communication do so by

contrasting its characteristics with scientific discourse. Logical-scientific communication is abstract and context-free [Dahlstrom, 2014] and works using categorising and labelling language [Negrete and Lartigue, 2004]. As data, its purpose is to be generalisable and it works within a paradigm where it is possible to represent a universal truth in an objective fashion. In contrast, narratives are specific, context dependent and work as examples. In a narrativist paradigm, all knowledge is understood to be partial and truths are subjective. Narratives have a different type of legitimacy and function. Instead of labelling, narratives use interpretative language, to create linkages and patterns in people's mental maps, comprising existing knowledge and experiences [Negrete and Lartigue, 2004; see Sherren, Fischer and Price, 2010, on mentalmaps]. In this way, narratives can link scientific information to 'everyday' experiences and observations. Narratives are an effective form of science communication in several ways, argued to: improve knowledge acquisition and enhance learning; assist with the process of translating increased understanding into behaviour change [Lejano, Tavares-Reager and Berkes, 2013]; increase recall; ease of comprehension, motivation and interest; and transfer into long-term memory [Dahlstrom, 2014]. By storying complex and sometimes abstract science or issues like risk, they become meaningful. When something is meaningful, it relates to our identities, belief, and experiences, and is more likely to be incorporated into an existing worldview or cause us to challenge a pre-existing viewpoint.

Science communicators in the field of education argue that storytelling encourages more independent thinking within learning contexts. Storytelling in lessons allows students to imagine another time and place "to create their own meaning and find . . . the intersection between the familiar and the unknown" [Bedford, 2001, p. 33 in Zhai and Dillon, 2014, p. 423]. For students to engage in meaningful learning, "they need to be provided the opportunities to make sense of newly learned knowledge through their own talk. . . " [Zhai and Dillon, 2014, p. 423]. Storying creates meaning and also the practice of narrating new information consolidates learning; acquired information is integrated into narrative repertoires that become part of one's personal practical knowledge [Avraamidou and Osborne, 2009]. Quigley and Buck [2012] describe the importance of integrating scientific discourse into everyday discourse for student learning.. They propose the creation of a 'third space' when scientific discourses and everyday discourse are combined through authentic integration. Narratives can, then, trigger new understanding or new 'ways of seeing' as spaces of reflection where our existing knowledge and worldviews can be brought into question, deepened, or re-thought, with the possibility for behaviour change enhanced. People predominantly select (confirmation bias) and interpret (assimilation bias) information in ways that confirm existing beliefs [Mikulak, 2011]. In order for behaviour change to happen, existing behaviours or 'foundational narratives' [Goldstein et al., 2013] that were previously unquestioned have to be recognised and subjected to some form of critique based on acquired information. This then opens up a space for alternative behaviours to be consciously adopted, with the act of narrating lending itself to personal commitment, which Lejano, Tavares-Reager and Berkes [2013] call 'narrative resolve'.

Through this process, we propose that narratives create a critical, reflective space where self-evaluation can take place. Narratives often reveal personal values and social norms [Andrews, Squire and Tamboukou, 2008], the context through which

people's actions and perceptions are framed. This is valuable when evaluating how a science communication activity has influenced individuals. We argue that narrative is a suitable mode of communication to evaluate the degree and types of impact science communication projects like citizen science have had on a variety of 'publics', which will always be context-dependent. Conducting work in the area of conservation, Leslie et al. [2013] claim that "In the context of project evaluation, stories that people tell . . . may be mined to yield valuable data relevant to project outcomes, success and adaptive management" [p. 1127]. Stories, as knowledge carriers [Ogborn, Kress and Martins, 1996] can provide evidence of acquired knowledge and illuminate the ways in which it becomes contextualised within peoples values and existing knowledge(s). Through asking people to narrate their experience of a citizen science project we argue that self-evaluation is more likely than in instances where people are simply asked to report back what they have learnt. Personalising the experience brings it into a reflective space of knowledge integration and assimilation, where qualitative details of the wider impacts of engagement may be revealed.

Whilst proponents of narrative for science communication sometimes create an opposition between narrative and scientific knowledge/language, other writers stress the complexity of narrating. In everyday conversation, a combination of discursive resources is drawn upon. Narrative consists of indexical and non-indexical components: actions (the events that happened) and psychological commentaries, which ". . . make epistemic, attitudinal, cognitive, and affective attributions" to aspects of the narrative such as values, explanations, opinions and judgements [Kasper and Prior, 2015, p. 236]. Storytelling consists of non-neutral social actions such as "accounting, complaining, blaming, justifying" [Kasper and Prior, 2015, p. 230] and always attempts rhetorical work such as "fashioning interactively useful self-portrayals" and "management of confrontations or contradictions" [Morison and Macleod, 2013, p. 570]. Close attention to the interaction between how citizen science projects are indexically reported and the types of non-indexical claims people use reveals how scientific knowledge is integrated into existing worldviews via management of confrontations and contradictions in terms of people's previously held knowledge, values or beliefs. Narrative methods are able do this because narratives make explicit linkages between participant knowledge, learning and values through cause-and-effect sequencing and the use of "plot," which reveals the "relevance structure" [Jovchelovitch and Bauer, 2000] of the storyteller. Narrative also puts random events or abstract scientific terminology within a coherent, personal or autobiographical framework, making them meaningful, and through a cast of 'characters' reveals implicit 'moralities', for example, about 'good' and 'bad' environmental citizens, represented through the narrators' perspective.

## Suggested narrative approaches

We present a number of narrative approaches that may be drawn upon for evaluation purposes. As this is a novel approach, it is difficult to give concrete examples from the literature, but where possible we use citizen science projects to illustrate the method, and elsewhere draw from other science communication (e.g. health communication) and science education (e.g. curriculum-related) projects. We introduce five methods of narrative evaluation, outlining characteristics of the approach and then showing how it has been used in a science communication example. The five methods are: Narrative interview; Photo-elicitation/photo essay;

Research diaries; Storyboarding; and Digital storytelling. This section is designed to introduce science communicators and citizen science researchers to the range of narrative methods available for inclusion in evaluation. It is not intended to be comprehensive, but provides enough information for those new to narrative approaches to show their value and difference from other qualitative methods and to assess whether and which might be useful to them.

## 4.1 Narrative Interviews (NI)

In social science research, Narrative Interviews (NI) combine narrative and semi-structured questioning styles. When interviews have the purpose to answer specific research questions, such as citizen science evaluation, a repeated process of question and narration phases will occur. Interviews are conversational and use the language of the interviewee (i.e. 'everyday' rather than disciplinary) [Jovchelovitch and Bauer, 2000]. Interviewers ask open-ended questions designed to elicit responses that take a narrative form. They avoid 'how' and 'why' questions, which tend to result in abstract and generalised responses, favouring 'what' and 'when' questions that allow for 'accounting' practices that are specific and rich in detail [Jovchelovitch and Bauer, 2000]. The expectation in a normal interview is that the researcher is looking for facts and opinions "in so far as they are constructed as arenas where only logico-scientific knowledge can be legitimately produced" [Czarniawska, 2004, p. 51]. Currently, many citizen science projects designed to evaluate informal learning outcomes usually rely on prescribed numerical scales with pre-determined multiple choice responses which are designed for 'generalisable' data which do not allow for richer contextual details surrounding the nature of the learning experience to be revealed. In contrast, NI yield 'episodic knowledge' ['Episodic Interviewing'], specific to time and place, personal and embedded in people's everyday lives. NI can provide greater in-depth information on the way current experiences relate to the research topic and how these link to life stories of the respondent and the prevailing social context [Muylaert et al., 2014]. This is best achieved when the conditions of the NI allow the participant to take responsibility for 'making the relevance of the telling clear' by enabling the participant to speak about those parts of the citizen science activity that were meaningful for them [Polanyi, 1985 in Chase, 2003]. NI allows for interviewees to personalise, narrate and reflect on their own experiences. Asking interviewees to provide examples or to reflect on specific aspects of their learning experiences from their participation in citizen science, opens up new forms of systemic enquiry for the researcher by allowing interviewees to raise new topics of analysis which could go undetected from quantitative scale instruments. Haywood [2016] worked with citizen scientists on a large-scale environmental beach monitoring project in the US to discover personal outcomes for volunteers. This approach provided knowledge about participants increased awareness and appreciation of the coast, as well as their enhanced feelings of connectedness within the community and with wildlife and nature.. NI showed how wellbeing and fulfilment was achieved through participating. These types of emergent, context-based, intangible qualities related to personal values and place-relations would have been difficult to derive from pre-defined quantitative scales. Schorch et al. [2015] equally found NI effective for exploring intercultural, embodied encounters, feelings of connectedness and processes of meaning-making of students at a multi-sensory exhibition. NI can be conducted in situ as narrative walks, adding a further dimension by allowing

environmental cues to prompt discussion and enabling volunteers to share local knowledge ['Mapping histories: cultural landscapes and walkabout methods'; Forrester and Cinderby, 2011].

## 4.2 Photo-elicitation/photo-essay

Visual narratives can be a good way to explore people's unstated values and intangible aspects of one's experience. Sometimes these are deeply held and cannot be articulated through interview or survey but, via use of imagery, preferences and world-views can be highlighted through the process of framing and narrating [Sherren, Fischer and Price, 2010]. Photo-methods offer a more bounded view on the messiness of reality, offering a manageable entry point for people to begin to reflect on complex issues and intangible feelings [Sherren, Fischer and Price, 2010; Quigley and Buck, 2012]. By asking people to discuss photographs post-participation on a related/relevant topic (photographs may have been taken during participation of a citizen science project or collated by the participants in response to a particular question), the extent to which the activity has influenced them may be evident in the resultant images. An elicitation interview can be conducted to describe this process and could produce a space for critical self-reflection and to highlight a change in attitude, awareness or behaviour. It would also be possible to make comparisons between a pre and post photo-elicitation exercise to understand changes that may occur from participant experiences. Narrative work using photographs can build trust and rapport between researcher and participant where volunteers "frame their own lives, tell their own stories, represent their own situation, offer their own understandings" when evaluating citizen science projects [Pini, 2001 in Riessman, 2008, p. 173]. Narrative methods shift the responsibility away from the researcher and on to the participant who chooses what is important and creates linkages between themes, topics, events and experiences through their 'emplotment' or creation of narrative coherence. Photo-voice is a technique for sharing stories with a group via individual's photo-selection and elicited narratives. It is used in a range of science education contexts for eliciting tacit or experiential knowledge [Barton, 2015; Cook, 2015], aiding critical thinking by encouraging students to interpret their experiences, analyse relationships and self-reflection [Walter, Baller and Kuntz, 2012] and enquire about local science and change in the community [Cook and Quigley, 2013]. Cook and Quigley [2013] found Photo-voice an effective way to connect students meaningfully to science curriculum via their connections to community and to critically analyse the contribution science has directly and indirectly on their lives. These claims are transferable to informal and life-long learning settings like citizen science as a form of science communication and highlights opportunities for meaningful integration of scientific knowledge into 'everyday' forms of knowledge through personal and shared narrative repertoires. Wilkinson [2013] notes that it is through the richness and complexity of 'lived experience' that photo-elicitation enables, that tensions can arise between different types of knowledge. Her research revealed that motivations, practices and expectations of citizen scientist bird watchers differed from the discourses, rules and expectations of scientific enquiry, including 'correct ways of knowing'. This kind of insight is valuable in informing future projects. In turn, photo-elicitation techniques could also be used to explore sense of place relationships by asking participants to take photographs of the favourite aspects of

their study sites and to address questions relating to the place-specific contexts influencing engagement or learning experiences, or to explore how participation shapes place-based relationships over time.

## 4.3 Research diaries (researchers' and respondents')

Diary methods involve the collection of data written by participants over a period of time allowing for critical reflection during and after events which are logged and written. Solicited diaries have structured elements with a timeframe, guidelines and focus directed by the research practitioner, whilst unsolicited diaries are unstructured and written according to the participant's constructions of social reality or events [Cohen et al., 2006]. While everyday remembering can be eclectically structured, in its written form a diary imposes narrative coherence and episodic structure between memories, periods and locations of remembering [Keightley, Pickering and Allett, 2012]. In the field of citizen science, diaries have been used by birders to keep records of lists of birds they have observed over time and as a personal record of their cumulative experiences [Cottman-Fields, Brereton and Roe, 2013]. The diaries can be used to remind volunteers of their experiences and achievements and recently, citizen science projects such as eBird make use of diaries so volunteers can collate historical records of bird sightings that have been observed [Cottman-Fields, Brereton and Roe, 2013]. Researchers documented the processes of social interaction taking place in the citizen science platform Zooniverse by recording observed daily incidents of play, socialisation, fun and amusement from online users in a diary [Greenhill et al., 2016]. Online diaries create opportunities for interactions between evaluators and diary keepers to probe for further details, classify entries and obtain missing information [Cohen et al., 2006]. Video and audio diaries remove problems associated with the motivation required to maintain written diaries and overcome literacy-related inequalities. We propose that diaries could be used to ask volunteers to reflect on their experiences of engagement over time. This provides longitudinal and iterative self-reflection to document changes in values, attitudes, knowledge and behaviour. Diaries could be used in conjunction with a photo-elicitation approach or in place of a pre and post narrative interview. Evaluators can choose to allow volunteers to write about topics according to their own interest or to construct solicited diaries in order to ask the volunteer to reflect on a specific issue or question.

## 4.4 Storyboarding

Researchers have emphasised the complex nature of evaluating learning and behavioural outcomes of different interventions because participants are subject to a variety of mediating influences, including attitudes and beliefs, place-based attachments, motivations, and variations in expertise [Shirk et al., 2012]. Jensen suggests we can understand if and what change takes place through isolating the effect of an intervention by measuring an individual's thinking, values, attitudes and behaviour both before and after its implementation [Jensen, 2015]. Jensen applied pre and post-engagement qualitative methodology to understand changes in participants understanding of coral reefs, using a storyboard format to ask respondents to draw a coral reef identifying all the plants and animals that lived there [Jensen, 2015]. Evaluative research in the health sciences used storyboards constructed in written form with pictures [Lillyman, Gutteridge and Berridge,

2011]. Stories are powerful stimuli for reflective thinking because they transmit information related to cultural identity, norms and traditions [Lillyman, Gutteridge and Berridge, 2011]. Storyboarding has been used as a means of addressing end of life issues and engaging student nurses in critical thinking and deep reflection of their practices. Similarly, in a citizen science context, children and adults could be asked to create a story with either words and/or pictures in response to an open-ended question before and after their participation to assess not only what new information was gained and assimilated into their personal narratives but also the wider cultural narratives that shape these ideas. A focus on participant-led narratives shows how knowledge acquired through citizen science projects is assimilated in relation to existing norms, experience and behaviours. As with the photo-elicitation methods discussed above, this type of approach could provide valuable insight into underlying assumptions about science communications, such as what participants even view as 'scientific' [Scott, 2014]. Storyboarding sometimes forms a stage in other narrative methods.

### 4.5 Digital storytelling

Digital stories are usually created through participation in a workshop featuring story elicitation and sharing techniques such as Photovoice and storyboarding. They are short videos of 2 to 3 minutes duration, featuring an audio recording of a personal narrative, accompanied by a selection of images chosen by the speaker. Digital stories are a powerful form of communication due to their simplicity and the 'authentic voice' of the narrator [Wilson and Lewis, 2013]. They often connect a social or global issue to a personal experience or sequence of events, offering potential to explore integration of science communication into everyday lives and language [Yang and Wu, 2012; Tan, Lee and Hung, 2013]. Yang and Wu [2012] found that involvement in the process of making digital stories improved student's critical thinking and motivation for learning through self-efficacy. Tan, Lee and Hung [2013] asked students to embed a scientific concept within a narrative in their classroom digital stories. They found that place-based learning increased opportunities for 'trying out' abstract scientific ideas and improved student's storytelling, illustrating the connections between narrative, self-efficacy and place-relations. Digital stories are appropriate as a method to communicate science and as an evaluative tool, by asking research participants/members of the public to tell stories about their experience and use their own authentic 'voice' to articulate scientific knowledge and local environmental issues [Rambe and Mlambo, 2014]. Digital storytelling might give volunteers the opportunity to share their experiences and reflections of their involvement in a citizen science project. The focus of the digital story would be directed by the participants themselves and the outcomes they deem important, privileging emergent (research) themes and evaluation outcomes. Digital stories might also highlight empowering aspects of citizen science such as enhanced social advocacy and cohesion, interacting with scientists in ways that can alter power and knowledge hierarchies.

**A brief note on analysis**

In this section, we briefly mention the advantages and disadvantages of different modes of analysis. The focus of this paper is on giving an overview of methods and does not have space for in-depth outlining of analyses. Instead we give useful references to follow up with. Narrative analyses may be used in combination with

other approaches already familiar to qualitative researchers. Grounded theory, 'framework' approaches and other types of thematic analysis can be used in the same way as with any qualitative data [Emerson, Fretz and Shaw, 1995]. Thematic analyses make frequent comparisons across the data so the researcher can develop, modify, and expand theoretical dispositions, allowing for comparison across "cases" and enabling researchers to look for recurring patterns, themes of interest and wider contextual information. Thematic approaches have been critiqued for privileging researcher-imposed fragmentation of accounts, and removing the context of lived experience [Montgomery, Pope and Rogers, 2015]. Narrative analysis has a focus on the structural elements of a story, such as characters who function in certain ways to move the story forward or how a story moves through sequential stages which serve different purposes focusing on the entire account or event-based episodes given by the participant [see Czarniawska, 2004; Silverman, 2015]. Narrative analysis can focus on identity work, such as how narrators aim to tell a consistent story of their lives, a believable or reliable story within their cultural context and how a lack of narrative, contradiction or moment of "trouble" can reveal something about the micro-politics of particular localised discursive contexts [see Morison and Macleod, 2013]. Evaluation of science communication will have varying goals and therefore analysis may need to combine methods that focus on identity-work/life-history, discourse and emerging themes [Czarniawska, 2004; and Jovchelovitch and Bauer, 2000, are a good place to start]. They may require the researcher to pay attention to both indexical (what happened) and non-indexical (psychological commentaries) aspects.

## Limitations

The approaches outlined in section 4 are designed for depth of understanding of the impacts of citizen science activities and detailed feedback to feed into research and science communication design rather than for their 'reach'. These are time-intensive methods, which will limit the amount of people that form part of the evaluation process. We are not concerned with "statistically significant" impacts; we propose narrative evaluation for looking to broader and sometimes intangible impacts, to enhance the experience itself, for example through the arguments we have laid out that narratives aid learning, and through its role in empowering and democratising types of knowledge and dialogue. When working with narrative (as originating from arts/humanities disciplines) and scientists together there will always be the question of 'reliability' or 'validity' of data. Can personal narratives be treated as a type of data to rate the success of a citizen science project? Humans have built-in bias, are motivated unconsciously, they have imperfect memories, and through storytelling they may transform scientific knowledge from its universally accepted and abstract terminology into something more personal and specific, thereby removing its transferability and replicability. In response to this, narrative researchers like. Muylaert et al [2014] state: "...narratives are considered representations of the world and therefore, are not open to evidence and cannot be judged as true or false, they express the truth of a point of view in a particular time, space and socio-historic context" [p. 186]. Narrative evaluation is about accepting and reflectively acknowledging these characteristics, using them to gain greater understanding about science communication processes. Equally, the social and interactional composition of narrative has been increasingly highlighted; narratives are designed for their audience and so methods that involve a narrator and a listener or anticipated audience may result in bias. This is no different from more

traditional methods and narrative approaches may actually limit bias by giving responsibility over content and 'relevance structures' to the narrator.

## Conclusion

Narrative approaches offer a way for researchers to enhance understanding of participant involvement in engaged science communication projects like citizen science, through context-based and often intangible processes revealed through storying experience. Participant's changing place-relations, values, and self-efficacy may come to the fore, by enabling a reflective space for critical thinking and self-evaluation. Science students and student nurses, in our examples, gained deeper understanding and increased critical reflection through narrative evaluations. Students gained self-efficacy at a local level through combining scientific and local knowledge in their stories and narrative evaluations captured changing place-relations through a beach monitoring project. Through our examples of narrative methods and their application in citizen science and science education settings, we have illustrated not only that narrative evaluations might be more appropriate to yielding context-based, tacit and intangible factors involved in personal outcomes of participation — such as wellbeing, fulfilment and connectedness for the beach monitors and science project students — but also that the evaluation process may act as a space of critical reflection and learning, as a 'third space' where new scientific information is integrated with everyday experience, local knowledge and values. These types of approaches might even bring into question what is viewed as scientific, such as the bird watchers and their observational knowledge and differing ways of doing research, and the interactions between participants and evaluators in the Zooniverse, that can usefully feed back in to project design and help to democratise the creation of knowledge. We invite science communicators to take up, trial and improve the narrative methodologies we outline in their own evaluations.

Narratives garnered around science communication and engagement activities can be used to support the 'coherent narratives' and case studies favoured in the UK Research Excellence Framework assessment (see HEFCE website). Environmental organisations and museums might also use positive narratives from the evaluation process as a way to raise awareness of their campaigns — as a potentially engaging form of multi-media — and a way to improve information and engagement activities for the public in the future. Whilst narrative evaluation may prove challenging in one-off engagement activities such as science festivals, its role can be explored in longer-term, public-engaged, science communication projects, especially where participants are engaged more than once. Narrative is useful as a method for self-evaluation, for deeper understanding, and as part of iterative engagement strategies where science communication design is developed through feedback and knowledge from stories which can, themselves, be viewed as a form of exchange or coproduction.

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