Emotion in Informal Learning as Mediated Action: Cultural, Interpersonal and Personal Lenses

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Article Info	Abstract
	Emotion and affect are important but undertheorized and under researched elements of learning in informal contexts such as science centers, museums, zoos, and aquariums. An interactional and discursive approach to emotions as mediated action was used to develop a three-part framework for documenting and exploring the place of emotional expression among family groups (n = 10 groups; 33 individuals) visiting an ocean exhibit in an interactive science museum in Rio de Janeiro, Brazil. Among our results, we observed that the most commonly expressed emotion was surprise, excitement, amusement and curiosity; the most frequently occurring categories of emotional expression among the families in interaction were those associated with being actively engaged in positive emotional interaction. Transcripts of interaction are presented to illustrate the framework and examined in light of emotional expression as a mediator of 1) active, collaborative, meaning making; 2) learner agency and protagonism; and 3) empathy. Results from the entire data set are interpreted using the Core Affect Model of Engagement. We present examples of and discuss how and why a mediated action approach to emotion as a social, distributed, interactional and discursive phenomena may be helpful both for advancing the study of emotion as an aspect of informal learning and exhibit design.

Introduction

Emotions are a powerful component of learning in all contexts of life, yet the affective component of learning is often sidelined or simply ignored in research, programming, curriculum development and assessment (Alsop & Watts, 2003). When emotions or affect are considered, it is often as a component of motivation (Bandura, 1977; Deci, 1992; Hidi & Reninger, 2006). In the case of informal science learning, for example, it is assumed that because experiences in museums and similar environments are socially and personally engaging and infused with affective coloring, they are motivating in ways that formal education often is not (Schänzel, 2004; Dierking, 2005; Falk et al., 2008).

Often in everyday life, emotions are treated as highly idiosyncratic traits of individuals that are largely pre-cognitive, primordial responses to stimuli that we experience in an immediate and natural way and then categorize and interpret cognitively as we struggle to talk about and understand them. Many people can certainly relate to

this Western, folk-psychology view of and experience of emotion and affect. However, such a view is not particularly helpful in articulating and understanding how emotions mediate learning and especially the kinds of self-directed, non-mandatory, free-choice, science learning in informal educational contexts that we present here which are largely collaborative and interactive in nature. To understand how emotion and affect contribute to this kind of learning in science museums, out-of-school programs, and to related areas of research in science museums, zoos and aquariums such as the development of empathy toward animals or the environment, the field of informal science learning needs nuanced models for exploring emotion as part of human experience and activity that attends to its mediating role in learning interactions.

Physiological and Constructivist Accounts of Emotion in Informal Learning

The place of emotional experience and expression in supporting or hindering learning has long been recognized (Alsop & Watts, 2003; and for review see, Staus, 2012). In informal science teaching and learning, researchers have explored the links between emotion and long-term memory (Anderson et al., 2007; Falk & Gillespie, 2009), emotion and empathy (Alsop & Dillon, 2018; Rowe, 2018), and emotion and engagement (Staus & Falk, 2017; Evans et al., 2018). Many studies in informal science focus on arousal, the physiological component of emotion (Russel, 2003), documented through biological measures such as cortisol levels (Falk & Gillespie, 2009; Staus, 2012) or skin conductance (Evans et al., 2018), correlating increased arousal with measures of learning such as recall or memory on the one hand or behavioral measures of engagement on the other.

Based in the tradition of work that since the late 19th century (e.g., James-Lange Theory) has focused on the physiological aspect of emotions, much of this work is based in a scientific desire to universalize descriptions of emotion and the experience of emotions. Because they reduce emotion to biology, such approaches purposefully circumvent cross-cultural variability in emotional expression, bypassing expression of emotion in favor of biological indexes of arousal, but in that move they fail to account for either what that arousal means for learners as individuals or what the expressions of that arousal mean to and for other participants in the moment or over time. For example, are emotions supportive of interactional engagement that leads to learning because they are construed as the "right" kinds of emotion to be expressing? Alternatively, are they seen as disruptive of learning because they are interpreted as the "wrong" kinds of emotions to be expressing at the moment? Thus, while such studies have helped to establish that arousal is an important part of learning in informal environments and may be connected specifically to both short-term engagement and long-term learning, they do not shed light on how emotion mediates interpersonal engagement and interaction.

As an alternative to accounts of emotion that focus primarily on the driving role of biological response, a second group of theories posit cultural constructionist (e.g., Harre, 1986) or constructivist (e.g., Averill, 1980; 1991) accounts of emotion. Studies undertaken from this perspective emphasize both the cognitive and cultural/linguistic shaping of emotional experience and expression and often rely on self-report to document or measure emotional states, correlating these with other measures of engagement or learning (Moneta et al., 2001; Jacobs et al., 2012). Rappolt-Schlichtmann et al. (2017) and Evans et al. (2018), for example, adapted Russel's (2003) model of Core Affect in examining the self-reported emotional reactions of 10-14-year-old children during a visit to a

mathematics exhibit. The Core Affect model ranges emotional responses on two axes, level of arousal (passive to active, measured through skin-conductance) and valence (negative to positive measured by self-report). These data were correlated with measures of cognitive engagement (measured by eye-tracking) and behavioral engagement (measured by observational rubric). Results show that children were most engaged during periods of high arousal associated with feelings of frustration or confusion. The authors interpret this as a state of "productive struggle":

> In this state, children experience some frustration or confusion while on a physiological level they are stimulated and activated. Behaviorally, they display characteristic traits of deep concentration and engagement, suggesting that feelings of struggle in informal science learning environments may coincide with deep, meaningful learning (Evans et al., 2018, p.5).

Studies taking a cognitive and cultural approach combined with basic physiological measures clearly allow researchers to document the behavioral outcomes of feelings for individuals and may also acknowledge the cultural, historical and social differences in the expression of emotions, but the data collection itself relies on a relatively standard level of emotional literacy and metacognition among participants and tends to focus on the emotional experiences of individuals who are seen as clearly fluent in expressing and interpreting their own emotions, something that may not always be the case, especially with younger learners. To date, such approaches also require interrupting the actual flow of experience and engagement for data collection. Thus, while they help to establish how emotions may correlate with individual engagement and learning, they may not be as useful for understanding the place of emotional experience and especially emotional expression in ongoing engagement and interaction as part of a group, a common context for learning in informal experiences (NRC, 2009). Thus, despite many years of fruitful research on emotion in learning, work based on the traditional theories of emotion has given us a clear understanding that arousal and valence are important predictors of individual learning and engagement, but has not advanced a substantive understanding of the multitude of ways that emotional experiences and expressions -- especially the interactional and interpersonal aspect of emotion and its expression -- shape and are shaped by informal learning experiences.

Emotions as Distributed, Mediated Activity in Informal Learning

As an alternative to physiological or constructivist approaches to the study of emotion, cultural historical activity theory (CHAT) approaches emotion and its development in the same ways it approaches other kinds of learning, as transformation of communicative tools for intrapersonal regulation (Holodynski, 2013). Specifically, we argue for examining the role of emotions in collaborative learning activity as a variety of mediated action (Wertsch, 1998; Rowe & Bachman, 2012; Lewis & Tierney, 2013); that is, as an emergent property (or outcome) of an agent (or agents) employing mediational means toward some objective or goal within the context of social, cultural, institutional, and historical roles, rules, and communities (Engeström, 1987; 2010; Roth, 2007; Rowe & Bachman, 2012).

Emotion and affect, from this perspective, are culturally, socially, and historically developed and situated performances (Stearns, 1995). Moreover, emotion is seen as a joint production of interacting agents that is always

distributed among agents and objects, agents and symbol systems, and among multiple agents all of which contribute to what the emotional expression can and does mean in its immediate context, including how it is regulated and either supportive or hindering of ongoing interaction and learning (Järvelä et al., 2013). Largely improvisatory in nature, these performances are culturally, historically, socially and linguistically mediated activity. They are intimately tied to and make activity and interactivity possible. As Sorjonen and Peräkylä (2012) put it:

> Expression of emotion is part of an action at a particular place in the on-going interaction, and it makes relevant specifiable responses from the co-participants that go along with or change the jointly constructed emotional ground (p. 1).

That is, expression of emotion is always a social action and is shaped by and contributes to ongoing interaction. From this perspective, emotions and affect can be thought of both as outcomes of interactions and as motivators of action.

To explore the value of a mediated action approach to understanding the role of emotion in learning in situ this paper presents a mediated discourse analysis (Norris & Jones, 2006; Scollon, 2001) of transcript examples taken from a larger video-based study of multigenerational groups visiting a temporary science exhibit in Rio de Janeiro, Brazil. The study reported here was guided by the following research questions:

1. What are the most commonly occurring emotional expressions among families interacting with the focal science exhibit?
2. Are there particular groupings of emotional expression associated with particular types of affective interaction in the focal dataset?
3. In what ways is expression of emotion shaped by and in what ways does it contribute to interaction with science exhibits for participating families?

Methods

The Oceans Exhibit

This study was carried out with Brazilian families, here operationalized as multigenerational groups of two or more individuals, visiting a temporary exhibition entitled Oceanos (Oceans) housed at the Museu da Vida (Museum of Life) located at the Oswaldo Cruz Foundation (Fiocruz), Rio de Janeiro, Brazil, between June 2017 and April 2018. The 200 square-meter exhibition's primary theme was ocean biodiversity, and it employed scenery, lighting, and models to create a highly immersive space with a strong marine aesthetic.

Visitors were invited to 'dive' in different ocean environments, organized by different benthic zones as they moved through the exhibition. Exhibit content focused on the extent of ocean biodiversity, including in relatively unexplored areas such as the deep ocean as well as the evolutionary adaptations of marine creatures and the factors that threaten their survival. Specific content included, for example, the debate over the interdependence of humans and marine biodiversity, environmental regulation, the importance of the oceans for food, and the environmental impact of human-caused pollution (including plastics). Exhibition components included diorama and animal model elements evocative of aquariums along with interactive touch screens focusing on information about

particular marine fauna including habitats, range, food, and size. Other interactive elements included a large touch screen table with visuals of a wide range of oceanographic phenomena and information about marine animals as well as a marine debris field visitor could walk through.

As visitors moved through the exhibit physically, they moved conceptually from the surface of the ocean to its depths. Near the beginning, a particular exhibit focused on the theme of trash in the ocean, for example, and consisted of an immersive installation through which visitors had to pass mimicking the difficulty faced by marine animals when traveling in areas with large accumulations of trash. Photos of animals impacted by marine debris appeared at the exit to illustrate the issue of waste and its consequences for marine ecosystems. As visitors moved "deeper," interactive "aquarium" screens – with digital representations of animals – presented species adapted to greater depths, showing their evolutionary characteristics and adaptations.

Ocean depths were displayed as visitors walked through a digital representation of a submarine, which showed videos from Brazilian and international research that captured images of deep ocean habitats and animals such as the "dumbo octopus" (*Grimpoteuthis*). The exhibition also included a diorama representation of an aquarium of abyssal species, such as the devilfish (*Melanocetus johnsonii*) and the long-nosed chimaera (*Rhinochimaeridae*), aiming to present the peculiar characteristics of the species that inhabit the depths of the ocean.

Data Collection and Participants

This qualitative, exploratory, video-based study was carried out as part of a larger study in science museums and centers throughout Latin America (Massarani et al., 2019a; 2019b; 2019c; 2019d). Data collection was carried out on three Saturdays in November and December and focused on multigenerational family groups who visited the Museum of Life. Data were only collected on Saturdays since this is the day of the week that there are free family visits while from Monday to Friday the visits are guided by explainers usually leading peer or school groups. The focus of the present study is families with young children, defined as visiting groups including at least one adult (independent of gender and legal kinship) and at least one child aged 6-10.

The families were approached by the researchers when entering the exhibition and invited to participate in the research. No family who was approached refused to participate. Sampling ceased once the target of 10 participating families had been reached for the study. To implement the data collection, an adult and a child in each visiting group used a GoPro® camera attached to a special holder and placed on their bodies. This point-of-view camera approach (Burris, 2017; Glaveânu & Lahlou, 2012) was used with the aim of recording visitors' experiences in the exhibition from their own points of view, reducing the researchers' interference during the data collection and following procedures outlined in Massarani et al. (2019a; 2019b; 2019c; 2019d) and Guimarães et al. (2019). The visits of the ten families ranged from a minimum of six minutes to a maximum time spent of 25 minutes. Additionally, before starting the video-recording of the visit, families completed a short questionnaire containing sociodemographic information and some questions related to their cultural and leisure habits, especially those related to similar places and activities (e.g., visits to zoos, museums and libraries, among other spaces). They were also asked if they had visited the Museum of Life previously and how often they usually

participate in similar kinds of activities (Guimarães et al., 2019).

In total, 33 people participated, including 17 adults and 16 children. The majority of participants were female (12 adults and 12 children); five adults and four children were male. Five out of the 10 groups were from the North of the city of Rio de Janeiro, two of them from Manguinhos, a low-income neighborhood of the museum; one group was from the West Zone, one from the South Zone, one from the city center, one from the municipality of Magé, and one from the municipality of Niterói. Regarding the professions of the adults who participated in the research, the women identified as housewives (four women), nursing technician, circus professional, beautician, biomedical, mathematics teacher from the municipality of Rio de Janeiro, party planner, biologist and one who did not provide an answer. The men self-identified as a circus professional, municipal civil servant, chauffeur, truck driver, radiology technician, and advertiser/party planner. Only two of the 10 family groups replied that they were first time visitors of science centers/museums; five groups had visited such sites more than once in the past year while three groups had visited only once. As for the Museum of Life, four families claimed to have visited more than once; none of them had visited the Oceans exhibition before. This means that, independently of the region of the city where they live and their socioeconomic status as indicated by profession of parents, the majority of the groups had previous experiences in visiting places dedicated to informal science communication.

Data Analysis

Videos from the GoPro® cameras were uploaded to Dedoose, an online qualitative data analysis software application, for initial review and coding by two of the authors. This round of coding was carried out directly on the video without the use of transcripts allowing research to account for gestures, tone, movements, body position, eye-gaze, touching behavior, and other paralinguistic markers of emotion and interaction during coding. Subsequent review of the initial coding was carried out by the four-author team together and followed by creating transcripts in Portuguese of selected video segments following the procedure outlined in the next subsection. The final round of additional coding and review of codes was carried out on the transcripts by one of the authors. Finally, the team worked together to identify selected transcripts to be translated for use in English publication, and a final round of review was carried out on those by one of the authors.

Significant Events as Units of Analysis

Following procedures similar to those used in Rowe & Kisiel (2012) and Massarani et al. (2022), videos were parsed into large scale segments of activity (such as interacting with a particular exhibit component) and then reviewed to identify "significant events" (Ash et al., 2008). A significant event is an analytical category of activity that in this case contains four components:

1. A clear beginning, middle, and end (such as an approach to, interaction with, and exit from a particular exhibit component);
2. discursive content relative to the exhibit or discipline displayed (e.g., STEM content, biology/conservation talk, or talk about exhibit meaning or use);
3. an externalized dialogue/conversation either between participants or by one participant with an imagined

other (e.g., self-regulative speech; externalized inner speech); and

4. identifiable linguistic (e.g., spoken) or para-linguistic (e.g., gestural) discursive markers of emotion.

Using significant events as the primary unit of analysis allows the researcher to both reduce the very large amounts of data video collection of human interaction creates, and also to focus transcription and analytical effort on episodes of interaction directly related to the research focus. Once significant events were identified, they were marked with time codes, and these clips were collected into a separate data set for further analysis. Of the nearly four-and-a-half hours (4:27:46) of video collected, 7.41% percent (0:19:51) was identified as significant events using these four criteria. That data makes up the data set for this study.

Identifying Emotions

As we are interested in the interactional and performative aspects of emotion and affect, we focused our coding on observable, discursive markers of emotion such as intonation, facial expression, gestures, words with emotional connotation, exclamations, laughter and body positioning. In order to establish a reliable structure for coding emotion, for the present study, we began with the Emotion Representation and Annotation Language (EARL), a list of 48 emotions compiled by the Human-Machine Interaction Network on Emotion (HUMAINE) described in Schröder et al. (2006) and listed in the Appendix. In some cases, other affective or emotional expressions than those included in EARL emerged from the data review and were added to the code list. Like the Core Affect model described above, the EARL emotions are grouped into larger categories based on level of arousal (passive to active) and valence (negative to positive). Figure 1 overlays the EARL categories on the Core Affect model.
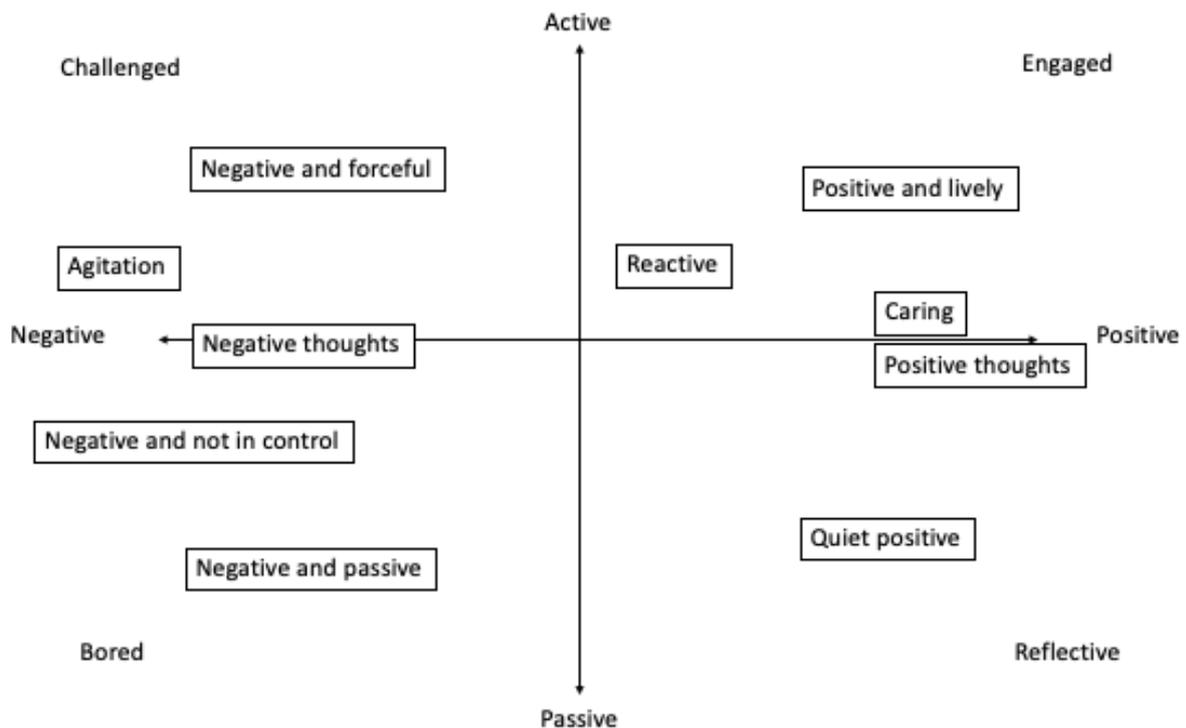
Figure 1. EARL Emotion Categories (see the Appendix) mapped to Core Affect Model of Engagement

Framework of Valence and Activation (Adapted from Russel, 2003; Rappolt-Schlichtmann et al., 2017)

Transcript Conventions

Codes were applied directly to stretches of video rather than to transcripts. This procedure allowed us to account for both linguistic (easily captured in a text transcript) and paralinguistic (difficult to transcribe in text) expressions of emotion in interaction. To facilitate presentation of transcripts relative to video coding, we have adapted a standard set of transcription conventions from the discipline of conversation analysis.

These note temporal and sequential relationships such as overlapping talk, latching of phrases together by speakers without pause, silence, gaps and pauses, as well as intonation, volume, variations in pitch or speed and laughter or aspiration. These features of everyday speech are common markers of emotional expression (see studies in Sorjonen & Peräkylä, 2012). To that end, the following transcription conventions adapted from Kasper and Wagner (2014) are followed throughout the remainder of the paper:

Speaker ID	DESIGNATION (e.g., A1 for Adult 1, C1 for Child 1)
Pause/in seconds	(.), (0.4)
Overlapping speech	[ ]
Rising intonation	?
Continuing intonation	,
Falling intonation	.
Lengthening of word elements	:
Latched turns	= =
Loud Voice	AAfrican
Stressed syllable	word
Spoken with smile	□word□
Breathing	h
Spoken in softer voice	°word°
In breath	hhhhhhh
Laughter	[laughter]
Laughter in word	(h)
Text read out loud	"word"

These transcription conventions do not easily allow us to present the paralinguistic components of discourse for discussion, so these are included in parentheses in the transcripts or described in the accompanying text where needed.

Note on Translation

All participants spoke in Brazilian Portuguese. Brazilian Portuguese speakers prepared and coded the transcripts. For the purposes of the presentation here, they have been translated into English with attention to maintaining speech style, tone, and register as much as possible.

Results

Emotional Expression across the Data

Research Question 1: What are the most commonly occurring emotional expressions among families interacting with the Oceans exhibit?

Figure 2 illustrates the emotion codes appearing across the data set by name, frequency of occurrence within the final data set of significant events and total number of videos containing (i.e., families exhibiting) that code.
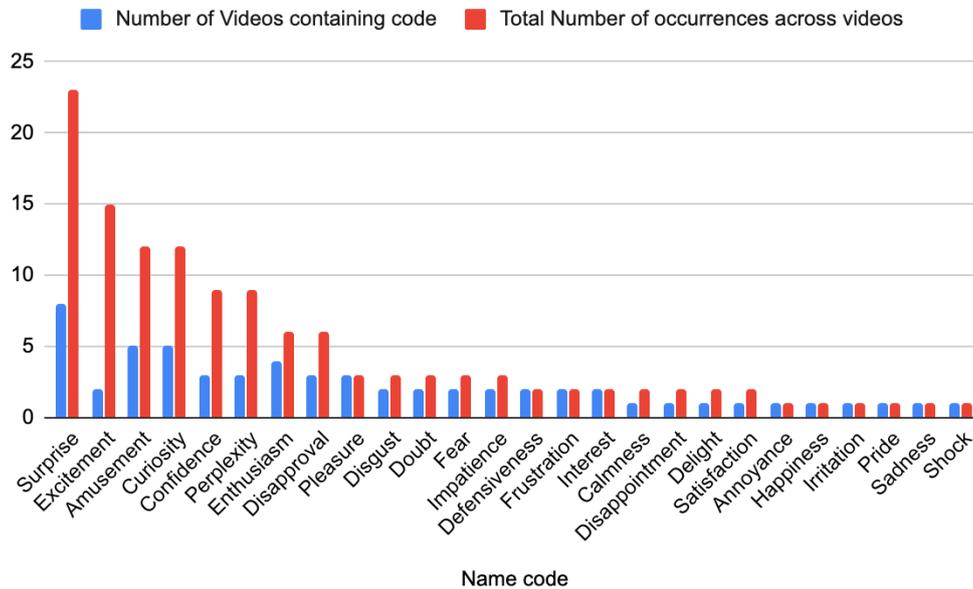
Figure 2. Frequency of Emotion Name Code Applications by Number of Families (videos containing that code) and Total Number of Occurrences across Videos

Across the data, the most commonly expressed emotion was SURPRISE, occurring in 7 out of the 10 family groups and 23 times. It most commonly co-occurred in activity with the second most common code, EXCITEMENT, though most of that is due to only 2 out of the 10 families. AMUSEMENT and CURIOSITY occupy a second tier of frequency, each expressed by half (5 of 10) the families and occurring 12 times each in the data. Among the remaining codes, CONFIDENCE, PERPLEXITY, ENTHUSIASM, and DISAPPROVAL all occur more than five times and in at least a third of the family groups.

Research Question 2: Are there particular groupings of emotional expression associated with particular categories of affective interaction among the focal families?

The Core Affect Model and the EARL coding frameworks described above both recognize that individual emotional expressions may be categorized into larger groupings based on similarity of valence (see Figure 1). The Appendix groups the emotion codes used in the study into the 10 categories identified in the EARL framework. Figure 3 groups the codes we identified in the data by the larger-scale EARL categories listed in the Appendix, sums their frequencies, and places them by categories on the Core Affect Model axes of valence and activation.
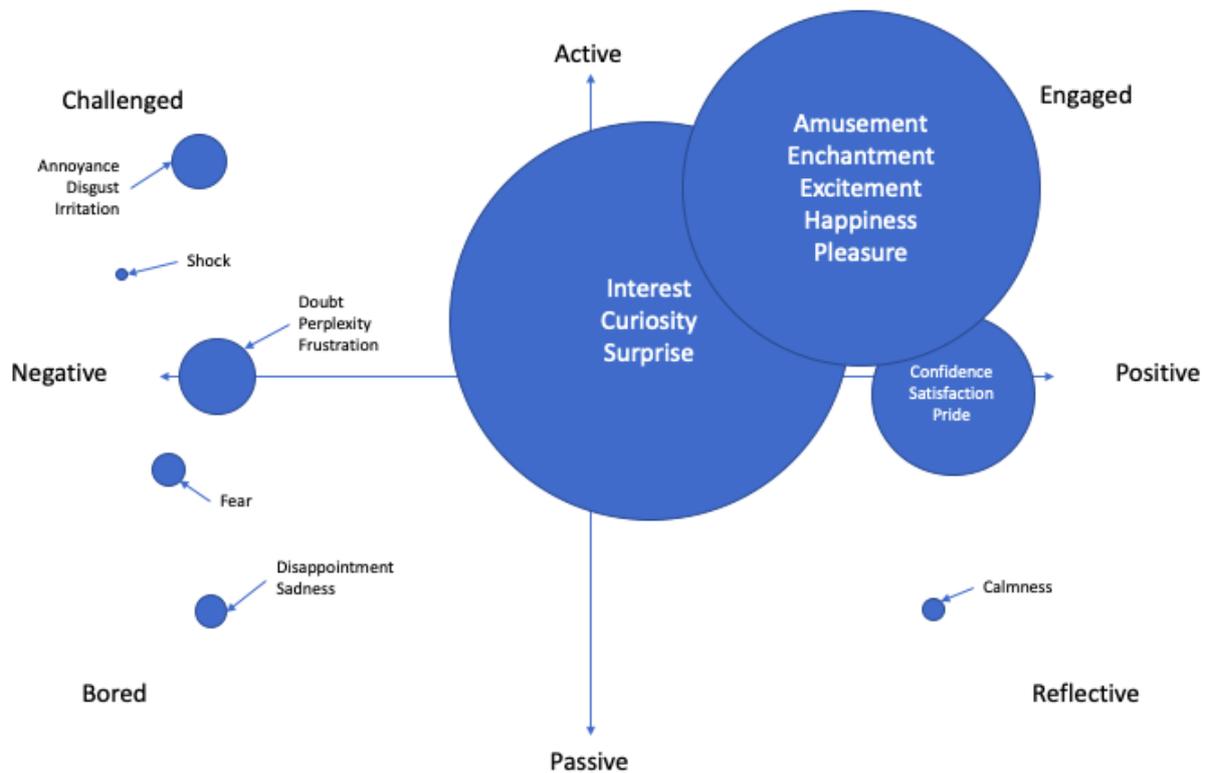
Figure 3. Codes grouped by EARL Emotion Categories (see the Appendix) and mapped to Core Affect Model of Engagement Framework of Valence and Activation (Adapted from Russel, 2003; Rappolt-Schlichtmann et al., 2017)

Note: Size of circle corresponds to sum of appearances for those codes in the data set.

The most frequently occurring categories of emotional expression among the families in interaction were those associated with being actively engaged in positive emotional interaction, a finding similar to that reported by Rappolt-Schlictman et al. (2017) and potentially typical of informal STEM experiences mediated by exhibits. Thus, the Reactive (INTEREST, CURIOSITY, SURPRISE, ENTHUSIASM), Positive and Lively (AMUSEMENT, DELIGHT, EXCITEMENT, HAPPINESS, PLEASURE), and Positive Thoughts (CONFIDENCE, SATISFACTION, PRIDE) categories were the most prominent. The categories of Negative and Forceful (ANNOYANCE, DISGUST, IRRITATION, DISAPPOINTMENT, IMPATIENCE) and Negative Thoughts (DOUBT, PERPLEXITY, FRUSTRATION, DEFENSIVENESS) represent a second tier of frequency and fall into the negative/active quadrant. Far from being simply negative aspects of experience, these emotions provide evidence of what Evans et al. (2018) and Rappolt-Schlictman et al. (2017) refer to as Productive Struggle, a zone where challenging experiences reflected by negative emotional expressions may help pave the way for extended collaborative engagement and sense-making.

Research Question 3: In what ways is expression of emotion shaped by and in what ways does it contribute to interaction with science exhibits?

Once we have developed a coding scheme and framework for identifying emotions in talk and action during visits to interactive museum exhibits, we are in a position as researchers to begin more clearly articulating the

interactions among expressions of emotions and learning that shape interaction among visitors and with staff and exhibits in the museum and exploring ways in which emotional expression may promote or hinder engagement and learning. In this section, we highlight examples in three areas: 1) emotion as a mediator of active, collaborative, meaning making, 2) emotion and learner protagonism, and 3) emotion and empathy.

Reactivity and Positive Thoughts as Mediators of Active, Collaborative, Meaning-Making

In Transcript 1, we see the Reactive emotions CURIOUSITY and SURPRISE co-occurring sequentially and supporting collaborative activity, joint attention, and, thus, meaning making.

Transcript 1: Turtle Displacement

A group made up of a child and his two adult cousins have approached an exhibit component made up of a touch screen table containing a series of filters visualizing diverse oceanographic data including ocean currents, salinity, and sea-surface temperature as well as biological data such as whale migration tracks and biodiversity in the ocean. The child (C) approaches the touch screen table exhibit and watches until A1 arrives and makes comments about what is being shown.

1.	A1:	Are you seeing this here?
2.	C:	These balls?
3.	A1:	It's turtle displacement.
4.	C:	What is displacement?
5.	A1:	That's when you move to another place.
6.	C:	Ahhhh, I got it. What about blue whales? Jeez!
7.	A1:	"Humpback whale" (reading information on screen)
8.	C:	It's much faster, they move in groups. It is different.
9.	A1:	Those here are the ocean currents.
10.	A2:	Red is hot current, blue is cold current.
11.	C:	It's better the hot current. Because it warms up.
12.	A1:	I think so too.
13.	C:	What is this? (child selects another filter on touchscreen)
14.	A2:	"Global ocean circulation" (reading information on screen)
15.	C:	What is this? Ah (.) g:::l::::o::::…?=
16.	A1:	=I'll read it to you here. Here, look.
17.	A1	"It is a type of marine current formed by differences in temperature and
18.		salinity. It brings heat from the tropics to polar regions on a slow path that
19.		takes about a thousand years to complete." [...]
20.	C:	Jeez!
21.	A1:	Blue cold current, red hot current.
22.	C:	What is this? (changes the filter in the touch screen table)

23.	A1:	"Biomass."
24.	C:	What?
25.	A1:	Biomass.
26.	C:	What is it for? What is it for?
27.	A1:	Here, look. It's talking about weight. Look, "How many tons of living beings
28.		are there in one place?" (Text reading). Look, the color, what is more
29.		purple, is less.
30.	C:	hum ...
31.	A1:	And more orange, more red, is more (.) In this case at the bottom of the
32.		ocean. Wow! There is more in the cold regions than in the hottest regions
33.		(…) That's not what it is saying? (Addressed to A2)
34.	C:	Ah, got it. (Child goes to another exhibit)

Note: A1: Child's cousin. A2: Child's Cousin 2 . C: Child (6-year old boy)

As is typical of many exhibit interactions, although the child is the first to arrive at the exhibit, the adult is the first to open conversation about it, drawing attention verbally and physically to a particular aspect of the display in line 1. The child evinces CURIOSITY in lines 2, 3, and 6 about both what the shapes represent and what they mean as well as SURPRISE by the speed of the whale (lines 6 and 8). This pattern of CURIOSITY embedded in questioning followed by an exclamation of SURPRISE at what is shown is repeated in lines 13-20 and lines 22-24 and finally in the child's next set of questions, lines 26-33 which end with the Adult this time expressing SURPRISE at the (correct) fact that cold water is more productive of life than warm water. This pattern of question and answer accompanied by CURIOSITY and SURPRISE encourages a good deal of content being shared and made sense of between both the exhibit and participants and among the participants themselves. In fact, most of the content shared is accompanied by some sort of emotional coloring or expression.

Across the data, the three codes, INTEREST, SURPRISE, and CURIOSITY, which, following the EARL categorizations belong to the larger category of positive reactions to stimuli or experience, were very common (see Figure 2 above) and were generally associated with significant collaborative, meaning making activity indicated by the large number of speaking turns including objects of shared attention, signaled in the transcript by joint attention to and engagement with the touch screen itself, touch and pointing, both individual and joint reading aloud, and the large number of deictic terms such as "this", "that", "here" that make sense only in context of speaking and are signs of shared attention and distributed cognitive activity (Tomasello, 1995). In Transcript 2, Reactivity (again expressed through SURPRISE and CURIOSITY) as well as Positive Thoughts (expressed through AMUSEMENT and EXCITEMENT) mediate child and parent interaction as they jointly construct meaning based on what they are observing in the exhibit as well as how that connects to their shared prior experiences.

Transcript 2: Puffer Fish

In Transcript 2, an adult who is a biologist by education and profession and a 6-year-old child have approached

an exhibit featuring the La Plata dolphin (*Pontoporia blainvillei*) as well as a variety of other animals. As with the other exhibits, a touch screen monitor provides additional information about some of the species displayed.

1.	A:	Okay, then click on which one you want (.) Let's search for pufferfish
2.		(baiacu) (.) Lives in Braz;il, in South America, Africa and e::ven Europe
3.		(indicates on the map).
4.	C:	(.) May I?
5.	A:	Y::es (.) It eats "some animals and (.) shells" (reading the monitor)
6.		Oh=
7.	C:	=ahahaha (laughs)
8.	A:	So small. The size of a school ruler (0.4) "You see a fish swimming and
9.		suddenly shihhhhhi (.) the animal is swollen in the shape of a
10.		balloon" = (reading the monitor)
11.	C:	=[A:::::h]
12.	A:	[Is that true or is] it a lie? =
13.	C:	=True?=
14.	A:	=Have you seen it?
15.	C:	(.) I already saw it.=
16.	A:	=And where is this?
17.	C:	In the sea? it's a thorn fish, but when it got some air (.) it became a ball full
18.		of spines.
19.	A:	That's it? this fish we saw, it's called a pufferfish.

Note: A: Mother of C. C: Child (6-year-old boy)

The interaction begins with A establishing joint attention and joint activity by directing the child to touch the screen while she reads from it. The child expresses AMUSEUMENT in line 7 at the appearance of the pufferfish (*Tetraodontidae*) on the screen, and they both react with some SURPRISE to both the initial size of the fish (line 8) and its size after inflating (the pufferfish's primary defense mechanism) (line 11).

This is followed by the adult asking a question about whether it is true or not that the pufferfish swells so dramatically and the child's CONFIDENT expression that it is true and a brief exchange where the mother and child jointly construct with obvious EXCITEMENT a memory of seeing a live pufferfish in the ocean. In both transcripts, expressions of INTEREST, SURPRISE and EXCITEMENT serve to create intersubjectivity – a state of shared attention, shared meanings, and shared situation definitions (Rommetviet, 1974) that is supportive of collective meaning making in informal learning activity (Rowe, 2011).

Positive Thoughts as Mediator of Learner Protagonism

Individual and collective agency as outlined in CHAT (Engeström, 2000; Stetsenko and Arievitch, 2004) and the related notion of autonomy as articulated by self-determination theory (Ryan and Deci 2017) are important

components of lifelong learning. Prior research has identified the concept of learner protagonism as a particular active type of agency or self-authorship, which shapes in important ways cognitive and behavioral engagement with exhibit-based experiences (Massarani et al., 2019a). Across this data, learner protagonism is signaled in interaction in a variety of ways including making and supporting claims, asserting positionality as an expert or knower, directing the activity of others, or initiating activity verbally or physically, each of which is associated with emotional expressions often related to CONFIDENCE or EXCITEMENT. In the following example, two mothers and their two children interact with a museum explainer (docent) in front of the ray exhibit. They engage in an extended dialogue about the lionfish (*Pterois*), during which one of the children exercises her protagonism by claiming agency as a knower based on her previous experience.

Transcript 3: Lionfish

1.	A2:	What is written here? "Small fishes, shrimps and crabs" (read information).
2.		It is the food, is it the food?
3.	A1:	It is little, this little fish is small.
4.	C1:	This fish pricks (.) the little foot= (?)
5.	Exp:	=[laughter]
6.	C1:	Isn't it beautiful ?
7.	A1:	Look, how beautiful!
8.	C1:	This fish (.) this fish is beautiful
9.	C:	It's a lionfish! (.) It's a lionfish!
10.	C1:	This is n::::ot a lionfish!
11.	C:	Yes it is!= ,
12.	A1:	=But does this fish stick if [something touches it?]
13.	A2:	[João, it is written here] (points on
14.		screen), "lionfish."
15.	Exp:	[No, not this one]
16.	C:	I know because I've been there with my dad (.) at AquaRio (.) so (.) I saw
17.		it, (.) M::om, did you know the AquaRio has this type?
18.	A1:	Really?
19.	C:	It's a lion (.) lionfish!=
20.	Exp:	=Beautiful, isn´t it?
21.	C:	It's lionfish
22.	A1:	(.) But I don't think that it is the name that [is there, love],
23.	C:	[ye:::ah].=
24.	A1:	=oh, yes. (.) G::irl, but
25.		you're smart, huh?
26.	C:	It's because (.) it's because I saw it in [AquaRio],
27.	C1:	[Look, here] the lionfish!
28.	C:	The lionfi:::::sh! (?)

29.	C1:	lo:::ok! (?)
30.	C:	Lo::;ok (.) hu.hhhh!
31.	A1:	☺ Very cool, right? ☺,

Note: A1: Mother of C. A2: Mother of C1. C: Child (5-year old girl). C1: Child (4-year old boy). Exp: Explainer

In this extended interchange, C claims agency as a knower in the interaction as she attempts to convince the rest of the group that she knows what the specimen is. The transcript demonstrates multiple ways in which emotion and affect are distributed interpersonally and as a direct component of collaborative meaning making interaction. All participants express themselves with emotion, ranging from shared aesthetic PLEASURE (lines 6-8, line 20) to expressions of CONFIDENCE and PRIDE (lines 21-25) in recognizing that the child is, in fact, correct. C also invokes previous experience and the everyday warrant that comes from that experience (lines 16-26) in establishing her authority to identify the lionfish despite C1's and A1's contrary claims. Her EXCITEMENT and CONFIDENCE are indicated interactionally by the increasing repetition of the word lionfish as well as increasing modes of expression of the word including increasing volume and lengthening of word vowels (e.g. line 28).

Emotional Expression as Mediator of Empathy

A key function of both live animal exhibits in zoos and aquariums and realistic, immersive models of animals like those displayed in Oceanos is to create the kinds of emotional attachments to animals and nature that research suggests underlies empathy (see Young et al., 2018 for a review) and thus a willingness to act on behalf of animals or the environment (Clayton et al., 2009) Across the data, both reactive and positive emotional expressions co-occur with signs of anthropomorphism (talking about animals in terms of human characteristics) and feelings of worry, concern, or value related to empathy for the models themselves or the animals they represented. For example, in Transcript 4, an adult and two are standing at the ray exhibit (see Figure 4).

Transcript 4: The Dead Fish

1.	A:	It's the Bahia brain coral (reads screen) (.) This is a coral(?) it is a little
2.		plant.
3.	C:	Yeah, it's a plant.
4.	A:	It's a little plant. Let's close here, see something else (.)
5.	C:	Here!
6.	A:	Look, this one is the spotted ray (reads screen) (.) Look, how many
7.		pictures!
8.	C:	Wow!
9.	A:	Look, here you can click and it gets bigger.
10.	C1:	Look here the dead fish! (?) (pointing out to a representation of fish that
11.		has fallen to the floor of the exhibit)
12.	A:	Look!
13.	C1:	The dead fish.

14.	C:	N::o, he dropped down,
15.	A:	[Laughter]
16.	C:	☺He dropped down☺
17.	A:	☺There is a fish there that must have fallen and João is saying that he
18.		died☺ [laughter] (.) ☺Very good☺ [laughter]

Note: A1: Mother. C: Child (5-year old girl). C1: Child (4-year old boy, friend of C)

The interchange begins with the adult using the exhibit label to identify a brain coral and the incorrect joint categorization of it as a plant. The child shows INTEREST in pointing out models and they both express SURPRISE (lines 5 and 6) and EXCITEMENT over what they see on the screen and how it works (line 7). The second child then directs everyone's attention with an exclamation of SURPRISE (line 8) that one of the fish models has fallen from its mount to the floor, which is echoed by the adult (line 9). C1 interprets the broken exhibit as an indication that the fish has in fact died and signals SADNESS with a drop of the head, extended lower lip, and dropping intonation (line 10). The other child rushes to reassure the young boy that the model has simply fallen, and the adult and child together express AMUSEMENT over the boy's mistake (lines 12-14), revoicing and explaining his explanation in their own words. The boy's expression of SADNESS demonstrates clear empathy for the model, which he perhaps assumes is a real, living fish.

Discussion

Seeing Emotion from Multiple Levels of Analysis

A key component of a mediated action approach is the acknowledgement that all human activity operates on multiple planes simultaneously and gains meaning differently from each of these planes. Thus, any given interaction may be studied or understood from the level of personal meaning and sense making; the meaning that it has for interaction in the immediate context; or the meaning that it has as part of its institutional (e.g., school or family), social and cultural, or even historical contexts (Wertsch, 1998). Following the example of Rogoff (1995), we identify particular lenses for analysis that allow us to identify the ways in which expression of emotion operates not simply at the level of the individual learner, but also as a distributed, interpersonal phenomena, and a way of connecting individual episodes of experience to larger social and cultural frameworks for making meaning of that experience. This allows us to explore the individual, interpersonal, and cultural components of and patterns within the component elements of mediated activity without reducing emotional experience and expression to either a physiological state or cognitive appraisal. These lenses may also help us as researchers bracket our own cultural emotional fluency which can lead us to culturally situated assumptions about others' emotional experiences and expressions that may not be adequate as interpretations.

Cultural Historical Lens: Emotional expressions as resources for connecting episodes of experience to larger social and cultural ways of making meaning of the experience.

The term axiology refers to the philosophical study of values and evaluation - that is to the study of a society's "should" and "ought" statements. This is the realm of statements and beliefs about what one should and should

not do or say or believe or feel. An axiological lens on experience encourages the researcher to focus on those times and places in discourse and activity where rules and values are invoked and the emotional experiences and expressions that go along with those invocations.

Because it has to do with social and cultural norms, rules and mores, an axiological lens encourages us to recognize the ways in which culture shapes what and how we feel in interpersonal interaction as well as how those rules, norms and mores are invoked, reinforced, or challenged as part of interaction and activity. In transcript 5, for example, an adult and child are moving through and around an exhibit representing trash in the ocean.

Transcript 5: Dirt in the Sea

An adult and child have approached the marine debris exhibit where visitors walk through a physical ocean "garbage patch" made up of plastic bottles and bags, aluminum cans, and other materials hung from the ceiling making it difficult to pass through. At one point (line 2) the young boy and adult pass through the garbage and move toward another exhibit before turning back to return through the garbage patch.

1. C: Let's see?! Can we pass through here? (.) All this stuff? (0.10)
2. A: What is this? (passes through and comes across the dolphin exhibit)
3. C: °A dolphin°(.) Oh boy! (turns back to trash exhibit - bottle hits child's face)
4. A: Do you see why you can't [throw dirt in the sea?]
5. C: [But I never throw]
6. A: So, but then you tell your friends how the sea is full of trash
7. C: Okay.

Note: A: Child's Aunt. C: Child (6-year old boy)

The child initiates movement into the garbage patch, exhibiting SURPRISE at the amount of "stuff" (line 1). A ten-second pause in conversation occurs as they move through the exhibit and emerge in front of a dolphin on display in the next exhibit. The dolphin elicits an EXCITED whisper of SURPRISE and INTEREST from the boy, who exclaims (line 3) in SURPRISE again as one of the bottles hits him in the face. SURPRISE and EXCITEMENT, in this case, create a positive emotional environment as part of which the adult initiates an axiological move -- a moral lesson -- with a question to the boy about whether he understands the human role in marine trash and debris. The boy perhaps interprets this as a lesson about his own personal behavior, responding in a DEFENSIVE manner (line 5) that preempts the adult's finishing her statement in line 4. The adult responds by delivering a more general moral lesson and imperative to "tell your friends" (line 6), a clear axiological moral to the story of the interaction.

Interpersonal Lens: Emotional expression as distributed, interpersonal resources for assessment in activity.

An assessment lens helps us focus on the evaluative aspect of emotional experience or expression. Closely related in many ways to axiology, an assessment lens encourages the researcher to identify how and when emotional

evaluations of statements or actions are made explicitly and implicitly as well as the responses to those evaluations. These may be assessments of appropriateness or rightness of behavior (and thus closely related to the axiological lens); assessments of accuracy, skill, or correctness (and thus closely related to exhibit content); or simply comments about how one feels about an object, person, or experience. In this later sense assessments are closely related to the Personal lens of valence described next as they may involve naming or identifying emotions and feelings. The assessment lens encourages us to recognize the ways in which particular social institutions (such as science or schooling or families) shape what and how we feel by identifying when we are accurate, correct and right or inaccurate, clumsy or wrong as in the following example.

Figure 4. Adult identifies the Lobster on the Panel [Image obtained from point of view camera worn by child]

Transcript 6: Ray

An adult and two children approach a panel containing a lobster (see Figure 4) and an exhibit containing a variety of specimens including a ray, and an octopus. A monitor positioned next to the exhibit contains information on the animals represented. The adult and child arrive at the ray exhibit, and the mother encourages her daughter to recall the species names.

1.	A:	°Alice, look at this one, look at this one!° I think this is a lobster
2.	C:	M::other, it is a lobster.
3.	A:	What is this here? [This one you know]=
4.	C:	=[I forgot the name]=
5.	C1:	[Look at the fish! Look here the octopus!]
6.	A:	=[Try to remember,
7.		what has a big tail?]=
8.	C1:	=[Ray!]
9.	A:	Ra.hhhhy! João remembered the ray.

Note: A1: Mother of the child (C). C: Child (5-year old girl). C1: Friend of the child (4-year old boy)

Typical of much everyday speech, this transcript demonstrates a great deal of overlapping speech and latched fragments of speech. A opens the interaction in an EXCITED whisper by encouraging C to recall names by modeling her own remembering (line 1) before moving on to an Initiate-Response-Feedback (IRF) (Sinclair & Coulthard, 1975; cf. IRE in Mehan, 1979) sequence (lines 2-9) that ultimately involves both children. C1 demonstrates a great deal of EXCITEMENT in his identifications (lines 5 and 8) which is rewarded with an exclamation signaling PLEASURE from A (line 9).

C signals a playful ANNOYANCE in line 2 perhaps remonstrating her mother for the overt ENTHUSIASM of the whispered and insistent drawing of attention in line 1. In Transcript 7, on the other hand, two young adults approach the Sunfish (Mola mola) exhibit which consists of a simulation of an aquarium containing representations of various fish. Beside it, a touch screen contains information about the habitat, feeding behaviors, size and images of each animal displayed in the simulated aquarium. The participants express emotions and feelings of SURPRISE and EXCITEMENT in the first part of the transcript followed by a kind of metacognitive assessment of their own emotional response through the use of irony.

Transcript 7: Tiny

1. A3:   What animal is this? (points to touchscreen monitor)
2. A1:   "Sunfish" (reads information)
3. A3:   Sunfish?
4. A1:   "Habitat" (reading from the screen)(.) "Size" = (selecting option on screen)
5. A3:   =Jeez! Seriously?!=
6. A1:   =Look, the size it has!(?)=
7. A3:   =No,man, look at that! Look at this!
8. A1:   Damn right. Look at the size of this animal! Three meters in length!
9. A3: Tiny

Note: A1: Adult 1 from the same group described in Valence Negative 1. A3: Another adult from the same group

In this case, the act of reading to establish a name and some basic facts about an animal on display leads to a substantial, distributed expression of INTEREST, DOUBT, and EXCITEMENT, all of which is capped off with an ironic summation, "Tiny" (line 10). The use of irony may simply serve as a joke between friends, but it may also serve as an assessment of behavior and experience that reigns in or normalizes what may be seen by young adults as too much positive expression of emotion, a sort of interpersonal self-regulation based on what they may perceive to be appropriate age and gender norms for interaction.

Personal Lens: Emotional Expressions and Valence and Activation

As discussed above emotional experiences and expression always exist on a continuum from positive to negative. That is, the same feeling may be named differently depending on whether it is perceived as pleasant and good or

unpleasant and bad. This third lens is the most closely related to folk psychological or phenomenological accounts of emotions and emotional experience as well as the accounts reviewed in the introduction as it focuses on our cognitive experience of and account of emotions — the names we and others give to what we are feeling or expressing at any given moment and the valence (neutral/moderate, pleasant, unpleasant, positive, or negative) and acuity (active or passive/strong or weak) of those feelings.

These feelings may be situation and context-specific and thus fleeting like immediate sensations or more general and long-lasting like individual or group dispositions (Averil, 1991). Transcript 8 illustrates how both positive and negative expressions of emotion may operate in parallel, almost non-interacting ways for individuals in a group interaction.

Transcript 8: I'm scared

An adult arrives at an exhibit containing among other specimens a sunfish (Mola mola) and begins to focus on reading the information on the screen beside the exhibit. Her daughter, C wants to explore the nearby exhibit, which is dark, representing the Abyssal Regions of the deep ocean, but she is afraid and moves back from the exhibit herself, saying her fear out loud, and calling her mother to go with her.

1.	C:	M:::om, I'm scared! (C stops and watches the exhibition space)
2.	A1:	[laughter] Ah, the fish! (looking to the screen)
3.	C:	Co:::me on, mo::m! (1.0) I wanna go there, mo:::m
4.	A1:	(0.6) Ugly fish haha [laughter]. I'm seeing the pictures.
5.	C:	Co::::me on, mo::::m!
6.	A1:	Here it is, I put it there now. (points to the model of the sunfish then goes to
7.		meet C and follows with C to another exhibit)

Note: A1: Mother of C. C: Child (6-year old girl)

In this case, the adult expresses both SURPRISE (line 2) and AMUSEMENT (line 4) as she interacts with the exhibit while the child expresses FEAR and IMPATIENCE as she tries to draw her mother into further interpersonal interaction with an exhibit component she wants to see, but is afraid to visit on her own. The child specifically names the feeling (line 1), thus making "relevant specifiable responses from the co-participants" (Sorjonen and Peräkylä, 2012, p 1) and therefore making an explicit bid to shape the possible directions and outcomes of the engagement. The bid is largely ignored by her mother, who laughs and attempts to draw the child's attention to other exhibit components verbally (lines 2 and 4) and gesturally (line 6).

While not common in this data set, the emotion of FEAR as expressed in Transcript 8 is not solely a negative aspect of experience. In their study of an exhibit about fear, Falk and Gillespie (2009) demonstrated that the arousal associated with fear created positive conditions for long-term memory and meaning making for visitors. In this sense, even a potentially intense negative emotion like FEAR may be associated like other negative emotions with the notion of productive struggle (Evans et al., 2018) described above and in Figure 3 especially to

the extent that it is associated with active individual or collective agency. By not addressing the FEAR or encouraging exploration sparked by it, the adult in Transcript 8 potentially bypasses an opportunity for collective productive struggle with the exhibit and its content.

CALMNESS, Reflection, and Metacognition

Like the negative emotions of FEAR and SHOCK, the positive emotion of CALMNESS was nearly absent in this dataset. Some researchers have argued that a sense of CALMNESS – especially as it promotes reflection on experience and metacognition (Dewey, 1966; Rogers, 2002) – is a key element of learning in informal science settings (Anderson & Nashon, 2007; Anderson, Lucas, Ginns & Dierking, 2000) but one that is not always realized or fully supported by exhibition design during the visit (citation). A handful of studies have demonstrated that simple interventions can be effective at increasing the amount of reflection (Ma, 2012) and metacognition (Gutwill & Dancstep, 2017) that family groups engage in during interaction with exhibits. Research has also demonstrated that visitors are more willing and able to engage in more metacognition at exhibits with a social science focus (Meluch, 2015) and in more reflection when given tasks that scaffold reflective conversations (Rowe, 2018). This suggests that blending both natural science and social science in exhibition design and creating interventions that promote reflective conversations might be fruitful ways to promote deeper engagement with science and its larger meanings among families.

Conclusions and Implications

Among our results, we observed that the most commonly expressed emotion was surprise, excitement, amusement and curiosity; the most frequently occurring categories of emotional expression among the families in interaction were those associated with being actively engaged in positive emotional interaction. Once we have developed a framework for identifying emotions in talk and action during visits to interactive museum exhibits, we proposed a model for articulating the interactions among expressions of emotions and learning that shape interaction among visitors and with staff and exhibits in the museum and exploring ways in which emotional expression may promote or hinder engagement and learning, in particular, we highlighted examples in three areas: 1) emotion as a mediator of active, collaborative, meaning making, 2) emotion and learner protagonism, and 3) emotion and empathy.

Because of our own cultural, social, personal and institutional contexts and practices, we have assumptions as designers, educators, evaluators, visitors and researchers about what counts as a "normal" or "correct" or desirable emotional response to an exhibit. The exercise of applying the sociocultural (axiology), interpersonal (assessment), and personal (valence) lenses to thinking about the place of emotional expression in interaction with exhibits may help us museums to identify when and where those assumptions may be impeding or supporting visitors' and learners' experiences. In turn, this recognition may help us recognize and support emotional experiences that are different from what we otherwise think of as normal and expected in interaction.

Universalist, physiological perspectives on the study of emotions have been critiqued for decades for privileging and normalizing Western European cultural manifestations of emotion (Stearns, 1995; Edwards & Potter, 1992).

Cross-cultural research that acknowledges both the universal and contextual aspects of all mediated activity is an important step in decolonizing research on the role of emotions in learning. Future research should not only incorporate triangulation of multiple forms of data including interview and self-report (Sinatra et al., 2014), but it should also consciously embrace multiple social and cultural contexts of learning within not simply across studies.

Acknowledgements

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Appendix

Table A. List of Emotion Codes adapted from EARL

Negative and forceful (14)		Quiet positive (2)	
	Anger		**Calmness**
	Annoyance (1)		Contentment
	Contempt		Relaxation
	Disgust (3)		Relief
	Irritation (1)		Serenity
	Impatience (3)		
	Disapproval (6)		
Negative and not in control (3)		Positive and lively (33)	
	Anxiety		**Amusement (12)**
	Embarrassment		**Delight/Enchantment (2)**
	Fear (3)		Elation
	Helplessness		**Excitement (15)**
	Powerlessness		**Happiness (1)**
	Worry		Joy
			Pleasure (3)
Negative thoughts (9)		Caring (0)	
	Doubt (3)		Affection
	Perplexity (2)		Empathy
	Envy		Friendliness
	Frustration (2)		Love
	Guilt		
	Defensiveness (2)		
	Shame		
Negative and passive (3)		Positive thoughts (15)	
	Boredom		**Confidence (12)**
	Despair		Courage
	Disappointment (2)		Hope
	Hurt		Humility
	Sadness (1)		**Satisfaction (2)**
			Pride (1)
			Trust
Agitation (1)		Reactive (43)	
	Stress		**Interest (2)**
	Shock (1)		**Curiosity (12)**
	Tension		Politeness
			Surprise (23)
			Enthusiasm (6)