

An Interpretive Study Of Meanings Citizen Scientists Make When Participating In Galaxy Zoo

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ABSTRACT

A particularly successful effort to engage the public in science has been to move the nearly countless galaxies imaged by the Sloan Digital Sky Survey to citizen scientists in a project known widely as Galaxy Zoo (URL; <http://www.galaxyzoo.org>). By examining the motivations, methods and appeal of Galaxy Zoo to the participating public, other models of citizen science might be purposefully formulated to take advantage of the success exhibited in Galaxy Zoo. In addition, we want to understand the reasons people engage in science in informal settings in order to better enhance teaching methods in formal settings. We pursued an investigation of the underlying reasons for the success of Galaxy Zoo revealed by inductively analyzing contributor's posts and discussions through the accompanying Galaxy Zoo online bulletin board. Using a grounded theory approach, we learned that many of these motivations originate in the aesthetic power of astronomical images or the opportunity to become an empowered and contributing scientist, which Galaxy Zoo successfully harnesses, while not compromising the scientific value of the project.

Keywords: Science education; computer-based learning; informal education; citizen science

INTRODUCTION

 Over the past decade, scientists have allocated considerable time and resources to bring their scientific imagery to the public through the Internet. A particularly successful effort in recent years has been to move the nearly countless galaxies imaged by the Sloan Digital Sky Survey to students and the general public in a project known widely as Galaxy Zoo (URL; <http://www.galaxyzoo.org>). Although Galaxy Zoo has undergone several rapid evolutions since its inception, the original Galaxy Zoo was launched on July 8, 2007, with a data set made up of a million galaxies from the Sloan Digital Sky Survey. The scientific challenge faced by the team was that the morphology of galaxies is largely too subtle to be done automatically by computers. So, astronomers decided to match their scientific needs to their educational needs and build an interactive website where visitors could be trained to contribute to the scientific enterprise by classifying galaxies themselves according to a few simple rules, the result being that each visitor was able to meaningfully add to the data collection effort at large.

To everyone's surprise, the unexpectedly large participation in the website has caused the data set, numbering over a million images, to be classified multiple times, quicker than the project leader anticipated, and continues to boast a high hit count on the website (15 classifications per second). Within 24 hours of launch, the site was receiving 70,000 classifications an hour and more than 50 million classifications were received by the project during its first year, from almost 150,000 people. In March 2010, the website achieved the milestone goal of 60 million classifications, but galaxies continue to be classified to improve the reliability of the data.

The overwhelming participation in this successful venue of "citizen science", and the following investigation of motivations, has great potential to improving teaching in science, technology, engineering, and

mathematics, known widely by the acronym, STEM. As a model of "citizen science," harnessing human capital as volunteers who participate as field assistants in scientific studies, Galaxy Zoo serves as a new, innovative, and easy to access model.

The Galaxy Zoo forum was created to handle the flood of emails that occurred alongside the flood of classifications, the team hoping that it would encourage the participants to handle each other's questions. As of April 11, 2009, the forum had more than 11,000 members, which required separate registration from the main website (Raddick et al. 2009).

By examining the motivations, methods and appeal of Galaxy Zoo to the participating public, other models of citizen science might be purposefully formulated to take advantage of the success exhibited in Galaxy Zoo. In addition, we want to understand the reasons people engage in science in informal settings in order to better enhance teaching methods in formal settings. Although in the past, citizen science has primarily been used as a data collection method, there are many new opportunities contained in citizen science motivations and methods that we can use in future applications (MacGregor 2009).

RESEARCH QUESTION

This new and innovative method of online citizen science creates data for researchers of galaxies, but there is a parallel set of underlying data that has not yet been deeply analyzed: the motivations and underlying themes within the population of citizen scientists that could lead us to improve STEM curriculum, teaching methods, and future citizen science projects. To address this, we have designed the following research question to make first steps toward investigating the underlying reasons for the success of Galaxy Zoo revealed by inductively analyzing contributor's posts and discussions through the accompanying Galaxy Zoo online bulletin board forum. To guide our efforts, we have adopted the following research question: When investigating the data interpretively collected from the Galaxy Zoo forum, what sort of trends emerge as motivations which contribute to the overall success of this citizen science model?

CONTEXT OF THE RESEARCH

Previously, Raddick and colleagues (2009) conducted an exploratory investigation into the Galaxy Zoo forum using conventional qualitative educational research approaches. In Raddick's study, he and his colleagues determined frequency counts of motivation keywords and ideas evident in the online forum postings. This was done through review of the forum and classifying posts into categories based on the motivation presented and through a following telephone interview process with 22 members of the forum. Though the frequency data is necessary to establish a quantitative foundation, much underlying data within the forum responses can be missed, due to the limiting 12 classification categories. In addition, classifying the forum posts into motivational categories do not necessarily provide insight into where these motivations developed, or any circumstantial information that could be contained in the posts. Understanding the types of interest which develop in this case is ideal for understanding how to apply the data from the forum to situational interest of students, in an effort to produce greater engagement in learning in the classroom. In other words, their method and conclusions are unable to provide sufficient insight into improving curriculum and further citizen science project efforts. Investigations based on a quantitative approach conducted on the forum thread suggest a richness of response that is not illuminated through frequency counts.

One wonders if more insight could be gained using an interpretive research lens (Bailey, Slater, and Slater 2010). As such, this study proceeded in an interpretive manner in the spirit of Erickson (1986) working in a grounded theory model (Creswell 1998). In this approach, data analysis focused on discerning the meaning Galaxy Zoo users make of their experience, with the intention of developing a theory, or "a plausible relationship among the concepts" related to the research questions (Strauss & Corbin 1994).

The intentional use of the term "interpretive," in contrast to "qualitative," indicates that the study is placing "central research interest in human meaning in social life and in its elucidation and exposition by the researcher" (Erickson 1986) Interpretive research considers the local meanings of actions, as perceived from the point of view of

the actors involved in the social setting. The difference between such work and the work of researchers operating from a behaviorist or positivist position is one of content and intent, rather than procedure (Erickson 1986).

The interactions between the volunteers' Galaxy Zoo experiences to other life events or circumstances is critical to the understanding of the behavior of the participants; people's behavior becomes meaningful and understandable when placed in the context of their lives and the lives of those around them. Without that context, there is little possibility of exploring meaning of the experience (Patton 1989). Thanks to the length of response and conversations of many forum participants, this data is readily available to consider when reflecting on the quantitative data previously collected.

Interpretive work is also a means by which to examine the social setting beyond superficial features by providing local meaning (Slater 2010). This may be exceptionally important in the case of this internet forum data, because of the extremely diverse backgrounds of individuals contributing to the forum posts.

DATA AND RESULTS

The online forum data interpreted for this study all originated from forum posts contributed in response to science team member Kate Land's stimulus which reads:

We have been overwhelmed by the awesome response we have had to this project. We feel like we've really captured people's imaginations with Galaxy Zoo, and we'd like to know why. Please feedback here about why you are taking part. We hope that what we learn from you can be helpful to future projects like ours.

As of January 27, 2010, 1386 posts were analyzed interpretively for contribution to our research question. These posts are checked using results tabulated from *Leximancer* and compared to previous results published by Raddick et al., in order to reveal any further or conflicting trends. After sorting through unrelated posts and topics (such as welcomes to new members) slightly over 200 posts were analyzed for having direct and significant contribution to the research question.

During the interpretive classification of forum posts, it was immediately clear that the majority of members had more than one motivation in their posts. Within this inductive approach to analysis, it was also necessary to continually re-evaluate the relative importance of emerging categories of motivation and then re-categorize the data. This yielded category results similar to Raddick and colleagues released in *Galaxy Zoo: Exploring Motivations of Citizen Science Volunteers*. Through the interpretive data collected by hand, several trends became apparent which lead to excellent findings for the science and math teaching areas, in addition to results that can be used for future citizen science projects.

SUMMARY OF DISCUSSION

While many different trends appeared in the collection of data, both by hand and by coding software this paper chooses to discuss some of the most prominent motivations and topics found. This prominence is based on both numerical count of posts and descriptiveness of post, correlating passion and interest in the topic to magnitude of motivation. The five motivations discussed here are: professional-amateur collaboration, sense of community, returning to a passion, use of variable interval reinforcement, and aesthetics of astronomy. While the initial investigation into this field is for motivations, retention also appeared as a key factor in the success of the project, and can be used for future citizen science projects and classroom applications.

Astronomy as a Professional-Amateur Collaboration/Community

A trend prevalent in the forum users' posts is the idea that the professional scientists that head the project are very interactive and friendly to the participants. This has helped develop a sense of community that is a defining reason for many users to continue working on the project. In other words, many participants are hopeful that they can interact online with "real scientists" and are excited when they do. It is worth noting that the intellectual and scientific lead on the project has great notoriety as a television personality in the UK..

Thank you, to be honest the spirit of the site was obvious from the very first time I came across it! That is what drew me in. If there had been the sense of "I'm cleverer than you" I would have run a mile! This for me is the true meaning of scientific endeavor, to spread knowledge as far as possible and to discover together whatever there is to discover! - anonymous

In earlier work, evidence is reported suggesting that many users wish to contribute to a larger cause or to science, labeled under the motivation “contribute”. This motivational category was also clearly evident in the present analysis, but an additional motivation emerged from the data, which we label as “attracted to working with scientists or professionals”. This shows up in several different contexts.

It makes me swell with pride, to get to work alongside some of the smartest people in the world, and not a single one of you, have come across as, hey I'm smarter than you, shine my shoes, ...or something like that, you welcome each newbie with open arms. -scientifically_inclined

Within the above quoted post there is not only a sense of pride and desire to spend time working with the professional scientists, but there is also degree of happiness inferred at the idea that they are not looked down upon for being an amateur. This seems to be an important characteristic in determining what might make for a fruitful or populate citizen science project, as this attitude impacts the retention and durability of members.

A contributing factor to these motivations is the sense of community and the lack of grandiose separation between amateur and professional within the forum. Participants not only comment on the community being essential to their continuation of citizen science with Galaxy Zoo, but also highlight the lack of elitism or cast system that they have purport to exist in other fields or projects.

The most wonderful thing about the ZOO community as I see it is that it naturally exudes a sense of belonging. You feel right at home starting with your first post with all the sincere and spontaneous welcomes from the FORUM ... But ultimately it is the Zoo spirit of friendship, equality, mutual respect for one another (between members as well as between professionals & amateurs which is a high ideal put into practice here - no "holier than thou attitude "), generosity in sharing their knowledge & experience, contribution to science that has won over the day and has made this utopia on the NET a reality. –Joseph K. H. Cheng

That's exactly what I love about Astronomy - that beginners, amateurs and professionals are all friends and helpers to each other. I wish the other sciences were like that! It really, really works! And I think it's the happiest subject in the Universe. -Alice

According to Mitton (2001) astronomy alone has 3,200 words and abbreviations that are distinct to communications in the field. Moreover, in this community, unnecessarily obfuscatious language or acronyms are routinely used as a gatekeeper, where outsiders do not share the same linguistic norms are intentionally excluded from the community, such as “nerd culture” (Bucholtz 1999). As described by Urry, social discourse within the astronomy world in particular is frequently influenced by a culture of elitism and exclusiveness (2007). Operating under the notion that language is intimately related to participation in other social practices within a community, being able to speak the language of the culture of academic astronomy, to comprehend the cultural meanings associated with places, events, and persons, requires enculturation into that community as a participant (Bourdieu 1978, 1991).

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Galaxy Zoo has managed to safely and yet efficiently immerse the forum participants within this culture, not only making them feel free of risk, but eliminating barriers between the professional scientists and the amateur citizen scientist participants. The forum is actively moderated by the project researchers, and has recently recruited adopted amateur astronomers to help out, due to the high volume of questions and comments. In the forum, amateur

astronomers with questions seem to feel free to ask what they may consider a “stupid” or “embarrassing” question, and receive an answer that does not involve jargon or condescending tones:

If there had been the sense of "I'm cleverer than you" I would have run a mile! -Louise D.

This breakthrough has made Galaxy Zoo a success, continuing to keep the body of citizens engaged and actively included in the project. In this situation, the connection between the scientist and the citizen has not stopped at the transaction of data. This interaction between project leaders and amateur astronomers on a daily basis in the forum has not only heightened the level of professional-amateur collaboration, but allowed the creation of a community. Again, this idea is necessary in order for retention of members to occur, and for many to look forward to a future iteration of Galaxy Zoo.

Transition between “Returning to Their Passion Field” and “Pro-Am Collaborations”

Another facet of Professional-Amateur collaborations and the idea of returning to a passionate field is the component of “making a difference.” With potential astronomers and physicists returning to their field of interest via Galaxy Zoo, they have an opportunity to not only enjoy their hobby, but to really put their name on something. It isn’t like looking through your backyard telescope anymore for your own reasons; these individuals are now contributing to papers and projects that will advance the scientific body of knowledge. Alongside this empowering idea is another small trend that appeared, linked to the spiritual aspect of Galaxy Zoo. This idea was “being part of a bigger picture” and it meant slightly different things to different participants. To some, it was being a “real” contributor to “real” science, while to others it was a chance for them to reflect on their role in our society, our planet and the universe itself.

My passion for astronomy is lifelong. Ever since I can recall I've gazed skywards. Storm clouds in daylight and stars at nightfall, equally fill me with awe and wonder and make me want to know 'Why' about my place in the world. Simply knowing that we can know something about the objects we're looking at in this amazing project humbles me. Nothing religious here, mind. Simply one Human looking out into the deep history of us all. - BunnyBB

Returning to Astronomy after being Deterred

Many of those who participate in Galaxy Zoo are in fact returning to astronomy as a passion, after being deterred during their childhood education from pursuing a career in astronomy. A common theme present in these sorts of posts was that in a certain historical time frame, women were deterred from their goal of joining the scientific enterprise by being told that women did not have the cognitive capacity to do well in math and science. These are not the only factors claimed in the leaky pipeline of female astronauts, physicists and astronomers, but are the ones commonly listed in the forum responses. As with any complex social situation, in the process of young people choosing a career it is almost impossible to isolate variables completely (Blickenstaff 2005). The pipeline has several leaks, beginning in elementary school and continuing until retirement (Pell 1996). A report by the Office of Technology Assessment (1985) cited by Widnall (1988) studied a cohort of 2,000 male and 2,000 female ninth grade students. By ninth grade, only half of each group had studied enough mathematics to remain eligible for scientific careers. In addition, academic decisions made in elementary and junior high school often exclude women from technical careers because have inadequate preparation for science and engineering programs. Failure to take sufficient mathematics in high school can disqualify students from three-quarters of all college majors (Matyas, 1985).

Anyway, I'm one of those girls who had bad teachers, and was convinced that she wasn't good at math. So I took as little as I had to, then dove into the humanities. I didn't take calculus or physics in high school, and thus in college, did little in math or science beyond the basic requirements, even though I was interested. The math aspect of science confound me, but the observational aspects of the sciences entrance me. Now, as an adult, I'm struggling to learn what I missed, so that I can understand and appreciate things just like this. -speedymarie

This difficulty in math is not only limited to specific genders of forum members, as many men were dissuaded from astronomy after being told they were poor in math or reaching the realization themselves.

I heard of this site from the BBC website and signed up straight away because ... It was something that I, with the mathematical genius of a woodworm, could do. –froggy

Several participants bring mention to the idea that during the space race, there was a distinct gap between the careers possible to each gender. These exhibit the segregation present during the time which may not exist now, but products we still feel today in the low retention among women in the science, technology, engineering and math (STEM) fields.

I took Astronomy in high school, plotted stars, memorized constellations and might have gone on into Astronomy except I was weak in Math. Back in the 70's, girls weren't encouraged to go into the sciences much. Had I been stronger in Math, I think I might have pursued a career as an Astronomer or Meteorologist. But now, thanks to Galaxy Zoo, I can look at stars and galaxies to my heart's content! -RobinA56

Long, long ago, in this galaxy, when I was a very young girl, I told my family that I wanted to be an astronaut. They all laughed. At the time, girls weren't allowed to take autoshop or even wear pants to school. –mgp

I'm surprised at how many share my story: I've loved astronomy since I can remember, but I never understood the math part of it (calculus makes my brain hurt...) and so chose to pursue my other great love, literature. Bit still, I remember when I was just learning to read, I would steal my dad's star book (H. A. Ray's "The Stars" IIRC, but it's been ages) and just marvel at it. Stargazing was the best pastime ever, and I would sneak outside in August to watch the Perseid meteor shower and get in trouble for not going to bed on time. I still love to stargaze, but I don't make it out of town and away from the lights often enough to do that much anymore, either. When I found out about Galaxy Zoo, I didn't even hesitate. Even if I can't be a professional astronomer like I once wanted to, I can pretend. I can live that dream I had, and maybe be a little bit less of a disappointment to the 12-year-old aspiring astronomer I used to be. And I get to see some of the most breathtakingly beautiful images in the entire universe. What more could I ask for? –Jaina

This paradigm of segregation in the STEM fields repressed the potential astronaut or astronomer in these participants, which Galaxy Zoo has unlocked, decades later. This access to the potential well of interest has allowed Galaxy Zoo to access the floodgates of participation, providing an excellent model for citizen science. Regardless of mathematical ability or science aptitude, anyone with interest in astronomy is able to participate without scrutiny, and without the 'chilly climate' sometimes associated with women and minorities in the STEM fields (Blickenstaff 2005).

When they return, they have the option of armchair astronomy or observing, and armchair is easier.

For those that were deterred from a career in astronomy, and elected to continue their passion as a hobby, they could choose either the path of astronomical observer, or armchair astronomer. In the past, being an amateur astronomer has involved owning or having access to a telescope and having a good location free of light pollution. For those interested in similarly interested hobbyists, community can also be found, in amateur astronomy societies. There are a large number of amateur astronomical societies around the world that serve as a meeting point for those interested in amateur astronomy, whether they be people who are actively interested in observing or "armchair astronomers" who may simply be interested in the topic. Due to light pollution,

Unfortunately, most of us are experiencing more and more light pollution, blinding us to these marvels of nature. -genel

and gender-related factors, astronomical societies may find their numbers decreasing, as members continue their hobby through galaxy zoo. Amateur women astronomers may feel discouraged from star parties and astronomy clubs, which result in lower membership and representation of women. These themes paraphrased are: boorish or predatory behavior in rare situations by men, necessity of child care, and providing a more relaxed environment for

females by making it female-only (Naeye 2010). Galaxy Zoo provides an environment where gender is a minimal fact of membership, and sometimes indistinguishable in the forum community. Online astronomical observing is also becoming more common with the spread of the resources on the Internet. Members are finding it harder and harder to justify club meetings, as they require travel, and sometimes conflict with work. Many are finding their space news and information online, in addition to their sense of community. Online forums, like Galaxy Zoo, are becoming the new meeting places for amateur astronomers. Even the act of “stargazing” no longer requires a telescope, access to dark skies, or the ability to go outdoors. Internet access to telescopes and digitized surveys give people the ability to see stars online, rather than through the eyepiece (Kinoshita 2009).

For years, observing and astronomy clubs have been the primary method of amateur astronomy, but with the contributing factors of spreading light pollution, gender separation in clubs, cost of telescopes, and difficulty of telescopes, Galaxy Zoo has become a more prominent tool for amateur astronomers. Gender becomes a non-issue on a internet forum, light pollution is non-existent, and the ease of it convinces those who may turn away from amateur astronomy to try out the Zoo.

Astronomy Developing as A Child in the Space Race Generation

One of the first trends that appeared resulted from the revealed age or age group of many users. Though this trend cannot be applied to a large body of participants, there are significant reference to being born or raised during the space race, which informally began in 1957 with the Soviet launch of Sputnik 1. References to viewing the first moonwalk also in 1969 also appear frequently, allowing us to determine that a significant portion of forum contributors grew up prior to the 1970s.

I was Born in 1966 so I have had Space and Rockets in my Face from Day1. I was 2 and a bit when Neil Armstrong Walked on the Moon and I watched the other Apollo Missions Growing up... – Blackprojects

While the forum lacks the demographical data necessary to quantify the ages, the volume of forum post referencing historical events serves to bring attention to this specific population that is participating in Galaxy Zoo.

It was in 1968 the APOLLO programme got my attention. By this time i graduated from University.” – daitha

One summer night I was outside talking to a friend. I looked up and spotted a Sputnik. A few years later I read Einstein's description of the universe, "infinitely great and bounded". For many years I went to sleep trying to imagine what was on the other side of the boundary. –bostoncharlie

I grew up in the 60's with the space race things in the news all the time. It made me wonder just what's out there and want to learn about it. Maybe I can learn at least some of the basics of "real" astronomy here and find out just what is really out there. -buffy3kins

It is evident in the posts that Galaxy Zoo harnesses a lot of potential interest that was created decades earlier during the global space race. This time period not only began an era of technology, but an era of academia focused on physics, mathematics, and astronomy (Roark, 1991). Many of the participants who were children during that era set their sights on a career such as a physicist, astronomer, or astronaut, but were sidetracked from that for several reasons. Perhaps surprisingly, the Galaxy Zoo forum became a venue to air shared experiences in this regard. Some of these reasons will be addressed later in this paper. Also during this time, the concept of our final frontier was blown open to the public, putting the idea into the public's head that they too could be a pioneer (Gray 1999).

Ever since I was a child and I was standing near the television to see the first moonwalk I have had an interest in space exploration. And now almost 50 years old I have not lost that awe and wonder of what is out there. -Pat

Since we cannot know all the exact ages of these contributors, we cannot assume that this interest originated during the space race, but one can infer the trend that astronomy develops as an interest at a young age and does not dwindle throughout a lifespan. The many participants who have returned after retirement to partake in their passionate hobby exhibit this.

Through the course of initial data collection, a distinction was necessary in the motivation of “interested in astronomy.” As the data was evaluated the first time, it became apparent that some participants had developed an interest in astronomy later in life, while many of them claimed to gain the interest at a young age. This was also connected to an idea of “returning home to astronomy” as they had been sidetracked from it by their career. The latter category of interest was exhibited in several mentions of the space race or their desire to grow up to be an astronaut.

...when i was a child i remember watching [N]iel [A]rmst[r]ong step on the moon. [I] was sure that by the time i was old enough i would fly there myself... -njapntr2

I've always had an interest in space ever since my dad took me to see John Glenn's ticker tape parade in New York City when I was child. I still have clippings of the original 7 astronauts! I graduated from high school on Virginia's Eastern Shore about 5 miles from NASA's Wallops Island facility and they had a small rocket museum which kept me interested along with the occasional rocket launches. -drcreten

Aesthetics in Astronomy

For many amateur astronomers, the passion developed the first time their parents took them outside to look at the stars, or the first time they had access to a telescope. This interest and gateway to a lifelong hobby is typically associated with the idea of beauty, or attachment to the aesthetic value of astronomy. This has been cited not only by previous authors in astronomy, but also by the Galaxy Zoo team (Raddick et al. 2009, Kessler 2007). Galaxy Zoo has been no exception to this key topic in astronomy, with the primary motivation listed by forum posts as associated with beauty, awe, or mystery.

Aesthetics have proven to be the primary method of citizen involvement and interest, since the Hubble telescope images captivated the public and prevented the early retirement of it. It is not through the scientific data or conclusions from this data that has made the Hubble telescope the poster child of NASA, but the awe-inspiring images it produces. Regardless of whether the telescope does benefit from another mission and years of additional usefulness or ends its life prematurely, the images will continue to influence our view of the universe at both a scientific and popular level (Kessler, 2007). Although there is a distinct separation between images cleaned and processed for the public and reduced images that astronomers use, Galaxy Zoo is able to bridge this gap as well. While some of the images are blurry and warrant the given nickname of “fried eggs,” some are high quality ellipticals or spirals. Such images are used to determine the nature of galaxies, but are also providing aesthetic satisfaction to citizen scientists and remaining behind on computers as screensavers and backgrounds. Some of these references to beauty have even gone so far as to cite or compose poetry about galaxies or space.

As one forum member posted to explain their motivations:

Why should I leave this green-floored cell, Roofed with blue air, in which we dwell, Unless, outside its guarded gates, Long, long desired the Unearthly waits, Strangeness that moves us more than fear, Beauty that stabs with tingling spear, Or Wonder, laying on ones heart That finger-tip at which we start As if some thought too swift and shy For reason's grasp had just gone by? -C.S. Lewis

Within the forum posts, one of the most prominent reasons for participation was under the classification of “beauty” for both Raddick and colleagues and the author. This abstract idea alone can be attributed to a third of the forum members’ participation, and is also linked to two further motivations for retention in the project.

This aesthetic value of astronomy serves to not only create a beginning for many amateur astronomers, but also serves as a unifying theme in the other motivations and trends investigated by Raddick and colleagues and by the author as well. Without the aesthetic beauty and mystery contained within the night sky, the initial interest astronomy would not have grown into this lifelong passion or hobby.

I love the aesthetic beauty of galaxies and the universe in general. The universe continually surprises me with its unexpected beauty. -rbpeake

Astronomy as A Spiritual Venue

Although few, Galaxy Zoo has reached participants on a spiritual level, investigated and presented by Raddick and colleagues under the category of “other”, and by the author as “being part of a bigger picture”. Whether causing participants to consider their humanity or just providing perspective, the series of images and scope of the project provide a spiritual venue to some. This sense of reflection that these images provide are closely related to the awe-inspiring beauty that the aesthetic value of the images.

I'm also joining in with a religious interest. Me: Christian, Protestant, Non-conformist. I'm keen to look at God's universe of Galaxies, and wonder at it and praise him for it... –random_fruit

I've always been attracted to astronomy and especially by the really BIG picture - the universe of galaxies beyond our own. To be able to participate in however small a way in studying that big picture is a rare treat. – tom kaye

Many citizen scientists are struck by the idea that there are so many galaxies to classify, and within each image are billions of stars with planets orbiting them. This sense of scale is difficult for many individuals' spatial abilities to grasp, which in turn may lead to this sense of impossibility, which leads to a spiritual trigger.

My reason for being here is actually, a lot of reasons. One sentence that would sum it up is, "The wonder of the Universe!" I am in awe of its vastness, beauty, strength, and amazement. The answers are out there, but we, as Star-Children, will never know everything that is out there! In this case, my ignorance is bliss! -Goniners

Use of Variable Ratio Reinforcement

An idea that surfaced during the initial data analysis but isn't necessarily a trend of motivation is addiction. Many of the responses mention not being able to stop classifying, and some even go so far as to claim addiction to the project.

The addiction comes from the fact that the next picture - possibly incredibly beautiful, and perhaps a scientific milestone as well - is just one click away. –Hexmaster

While this may not be a motivation for being attracted to the project, it is definitely a contributor to the retention of members. The mechanics at work in this situation are classified as *variable ratio reinforcement*, and more commonly manifests in gambling. In behavioral psychology, there are 4 main types of scheduled reinforcement. Variable ratio reinforcement can be described as reinforcement for an unpredictable number of responses that varies around a mean value. A similar form, known as variable interval reinforcement is already a term used to describe astronomy, as stargazing uses the reinforcement of seeing a new comet, for example, which appears at irregular, unpredictable intervals. As a result, both professional and amateur astronomers watch the sky regularly in hopes of this reinforcement. Galaxy Zoo uses a similar method to retain classifiers, and variable ratio reinforcement proves to receive the highest response rates, there is no pause after reinforcement, and is the most resistant to extinction. The positive reinforcement used in this activity of citizen science is the aesthetic value of rare images.

...But I believe there is one very strong and basic reason why I (and maybe others, too) keep going for hundreds and thousands more, even though it should get boring...Well it never gets boring because every time I think "ok, that's it, one more and then I go to bed", I betray myself. I wonder what would the next one be like. Would it finally be a real stunner? When is the real stunner going to show? The last 50 have been "oh so boring". So where's the next great galaxy? "I bet it's the next one, let's see". and so I click one more, and one more, and one more....It's a terribly basic instinct of curiosity!...and then when I get a real cool one, do I go to bed?? NOOO! It's my burning eyes that drag me away. -Ingmar

Exhibited here is the resistance to extinction that variable ratio reinforcement creates, created by the lack of knowing when the aesthetically pleasing galaxies will be exhausted. Variable ratio reinforcement also serves as the most productive method of scheduled reinforcement in this setting. Fixed ratio reinforcement receives a high rate of

response, but a brief dropoff just after reinforcement. In addition, fixed ratio reinforcement does not reward breaks, which will lead to decline in accuracy and efficiency. As a result, we see an ideal method of scheduled reinforcement using the aesthetic value of images in Galaxy Zoo to yield high classification count and high retention, whether intentional or not. Such a model can be applied to other citizen science projects and even the classroom, particularly when classifying data. Any large body of data potentially could use this so long as there is an aesthetic, or reinforcing artifact intermingled within the data.

But; eventually you hit that "log out" button, the screen changes and shows you the next one you WOULD have had and WHOOOOOOOOOOOOOOOOOOOOAH! It's a stunner! So, you log back in and boom, it changes the page on you again and :-[the stunner is all gone. –TrexterZiam

LEXIMANCER TABULATION OF RESULTS AND DISCUSSION

While this interpretive investigation of Galaxy Zoo's data provides new information not previously published, it is also necessary to check the data from another perspective, as the author alone was responsible for the collection of themes. To do this, Leximancer 2.25 Software was used to find correlations between specific terms within each post. Leximancer provides a strength percentile for discovered concepts, whether inputted manually or automatically discovered by the software between two words, related to their co-occurrence value. Using these values, and the visual representation of the terms, we can confirm or deny the lack of evidence involved in the manually established themes reviewed by the author and previous authors. Leximancer has proven its reliability as a phenomenographic tool (Edwards 2010), and creates a visual representation of "concept clusters" which provide an alternate insight into qualitative data. The automatic nature of the process is such that "any researcher bias is removed..., thereby removing issues such as coder reliability and subjectivity" (Isakhan 2005). A glaring limitation to this method is the lack of ability to capture tone of voice or personal style contained within forum posts, which is observed quite often in the manual analysis of data, only somewhat rectified by the claim by the Leximancer creator that it is capable of identifying signatures of genre (Edwards 2010). Another issue that remains unresolved in this phenomenographical method is correcting for spelling mistakes, which is prevalent in the data due to the relaxed atmosphere of the forum.

RESULTS

The following concepts were identified by Leximancer after the first iteration, but are classified into two columns in order to discriminate better between misleading concepts. The terms *Galaxy* and *Zoo* were discarded as they were not considered concepts with regard to the forum prompt and were not included in any further analysis. The following concepts were initially determined from the first iteration of the software, without the "Learning" function enabled, yet as the most common or prevalent concepts (Table 1): *time, galaxies, astronomy, project, zoo, sky, years, universe, science, think, space, love, night, feel, Galaxy Zoo, people, learn site great, stars, amazing, long, knowledge, heard, contribute, ago, telescope, found, few, pretty, real, find, research, hope, cool, world, questions, thought, fun, back, beautiful, work, pictures, reasons, should, idea, home.*

From this initial collection of data, terms *Galaxy Zoo* and *board* were immediately removed due to their lack of relevance and reference to the prompt itself. Then, the concepts listed were transferred into categories for further reduction of data. Table 2 shows the following groups identified through this process.

The concepts *zoo, think, site, heard, few, hope, thought, world, back, work, should, idea* and *home* are categorized as questionable in being related to a motivational concept and were removed as concepts in the next iteration. These concepts are labeled as questionable because they appear to be more of subjects or nouns appearing within the concurrent discussions within the forum thread, as opposed to directly addressing the prompt. While they are not initially related to the prompt, they do contain information about related topics or ideas that may reveal motivations within the data. Certain concepts were merged due to their similarities, the main one being any reference to time. In addition, terms like *understand, understanding, and understands* are also merged into one concept. Figure 1 shows the resulting visual representation of the concepts.

Table 1: Initial Leximancer Concepts List

Concept	Absolute Count	Relative Count
time	136	100%
galaxies	97	71.3%
astronomy	68	50%
project	65	47.7%
zoo	56	41.1%
sky	48	35.2%
years	48	35.2%
universe	47	34.5%
science	46	33.8%
think	45	33%
space	45	33%
love	44	32.3%
night	41	30.1%
feel	37	27.2%
Galaxy Zoo	36	26.4%
people	35	25.7%
learn	34	25%
site	29	21.3%
great	28	20.5%
stars	28	20.5%
amazing	27	19.8%
long	27	19.8%
knowledge	27	19.8%
heard	26	19.1%
contribute	26	19.1%
ago	25	18.3%
telescope	25	18.3%
found	25	18.3%
few	25	18.3%
pretty	24	17.6%
real	24	17.6%
find	24	17.6%
research	24	17.6%
hope	23	16.9%
cool	23	16.9%
world	22	16.1%
questions	22	16.1%
thought	22	16.1%
fun	22	16.1%
back	22	16.1%
beautiful	21	15.4%
work	21	15.4%
pictures	19	13.9%

Table 2: Categories of Potential Concepts for Reduction of Data

Questionable Concepts	Pro-Am Collaboration	Community	Contribute	Addiction	Deterred from Science	Aesthetics
zoo	science	love	project	addictive	time	sky
think	people	people	science		years	space
site	great	friend	contribution		learn	love
heard	real	community	great		long	amazing
few	research		contribute		ago	pretty
hope			real		kids	beautiful
thought			research			pictures
world						
back						
work						
should						
idea						
home						

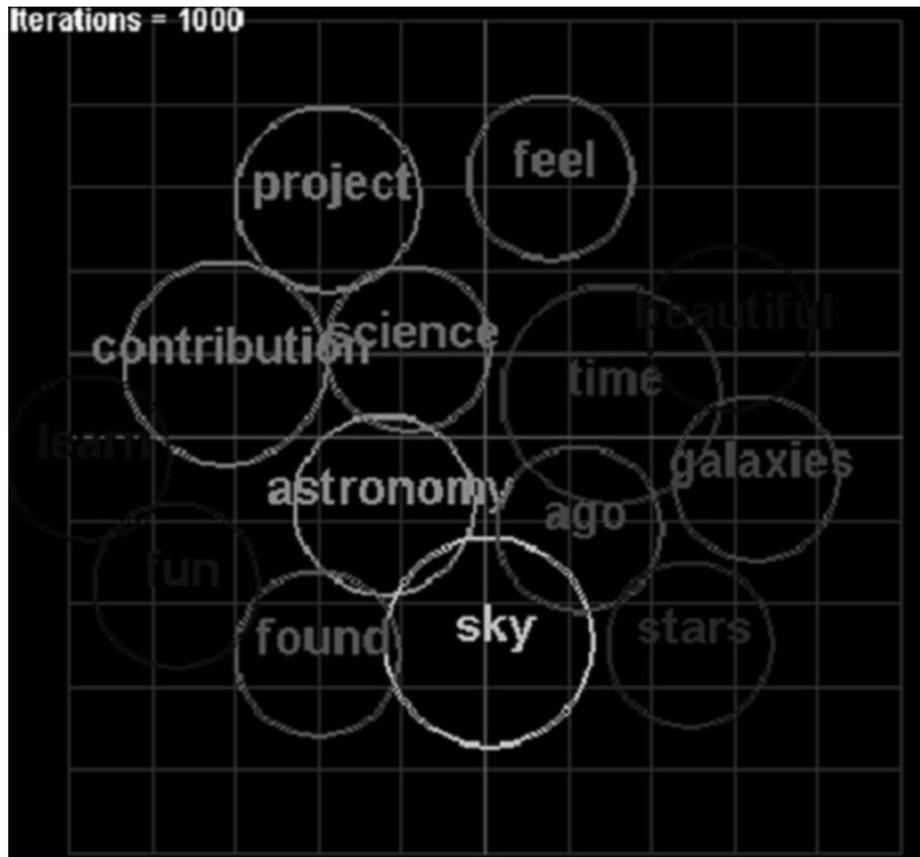


Figure 1: Leximancer Visual Representation of Forum Data after Refinement

This representation shows the numerical strength of the terms within the forum posts in addition to their proximity or magnitude of connection between it and related concepts. Table 3 shows the specific concepts reinforcing the motivations discovered interpretively.

Table 3: Core Concepts and Values

Pro-Am Collaboration	#	%	Community	#	%	Contribute	#	%
science	47	34.3	love	44	32.1	project	65	47.4
people	35	25.5	people	35	25.5	science	47	34.3
great	28	20.4	friend	20	14.5	contribution	37	27
real	24	17.5	community	11	8	great	28	20.4
research	24	17.5				contribute	26	18.9
						real	24	17.5
						research	24	17.5
Addiction	#	%	Deterred	#	%	Aesthetics	#	%
addictive	19	13.8	time	##	100	sky	48	35
			years	48	35	space	45	32.8
			learn	34	24.8	love	44	32.1
			long	27	19.7	amazing	27	19.7
			ago	26	18.9	pretty	24	17.5
			kids	12	8.7	beautiful	22	16
						pictures	20	14.5

After clumping similar concepts, the terms *sky*, *space*, *love*, *amazing*, *pretty*, *beautiful*, and *pictures* were assigned to the original theme of “Aesthetic” for motivation. While terms like *amazing* do not necessarily completely refer to aesthetics, it is still a component to this category. The first reference besides time is the project itself, but there are also correlations among *amazing* and *sky*, *galaxies*, *night*, *universe*, *space*, and *beautiful* (Table 4). These concepts show high quantity for providing motivation within Galaxy Zoo and are exploited not only for spirituality, but also for perspective and reflection by members. The range of related terms to the idea of aesthetics contributing to the motivation of members runs from counts of 20 (*pictures*) to 48 (*sky/night sky*).

Table 4: Selected Concept – Amazing

Concept	Absolute Count	Relative Count
<u>time</u>	11	40.7%
<u>project</u>	8	29.6%
<u>love</u>	7	25.9%
<u>sky</u>	5	18.5%
<u>find</u>	5	18.5%
<u>ago</u>	5	18.5%
<u>galaxies</u>	5	18.5%
<u>long</u>	4	14.8%
<u>people</u>	4	14.8%
<u>night</u>	4	14.8%
<u>site</u>	4	14.8%
<u>community</u>	3	11.1%
<u>universe</u>	3	11.1%
<u>space</u>	3	11.1%
<u>beautiful</u>	3	11.1%
<u>feel</u>	3	11.1%
<u>stars</u>	3	11.1%
<u>science</u>	2	7.4%
<u>contribution</u>	2	7.4%
<u>real</u>	2	7.4%
<u>pictures</u>	2	7.4%
<u>questions</u>	2	7.4%
<u>cool</u>	2	7.4%
<u>fun</u>	2	7.4%
<u>knowledge</u>	2	7.4%
<u>addictive</u>	2	7.4%
<u>years</u>	2	7.4%
<u>contribute</u>	2	7.4%
<u>friends</u>	1	3.7%
<u>pretty</u>	1	3.7%
<u>learn</u>	1	3.7%
<u>kids</u>	1	3.7%
<u>learning</u>	1	3.7%
<u>astronomy</u>	1	3.7%
<u>research</u>	1	3.7%

The terms *science*, *people*, *great*, *amazing*, *real*, and *research* have been determined to correspond to the motivation of professional-amateur collaboration. The terms *people* and *project* are also assigned to the Community motivation, so it is necessary to investigate it more thoroughly. It is necessary to note that the term *science* in the visual representation covers the term *sciences* and *scientist* as well. The term *people* has been assigned to multiple motivations as the concept map of the term relates the term to not only “professionals”, but the project as a whole. This is linked to the concept of community, which is also shown through the automated analysis to be a prevalent motivation. The references to *kindness*, *nice*, and *people* illustrate this and are summarized in Table 5. *Community*,

project and *friends* are all corresponding terms in the visual analysis as well and correspond to high strength values. This also relates to the community motivation within Galaxy Zoo discovered by previous authors.

Table 5: Selected Concept – People

Concept	Absolute Count	Relative Count
<u>time</u>	8	22.8%
<u>project</u>	7	20%
<u>feel</u>	7	20%
<u>science</u>	5	14.2%
<u>amazing</u>	4	11.4%
<u>great</u>	4	11.4%
<u>universe</u>	4	11.4%
<u>space</u>	4	11.4%
<u>knowledge</u>	4	11.4%
<u>real</u>	3	8.5%
<u>galaxies</u>	3	8.5%
<u>contribution</u>	2	5.7%
<u>find</u>	2	5.7%
<u>questions</u>	2	5.7%
<u>beautiful</u>	2	5.7%
<u>found</u>	2	5.7%
<u>addictive</u>	2	5.7%
<u>years</u>	2	5.7%
<u>stars</u>	2	5.7%
<u>love</u>	1	2.8%
<u>community</u>	1	2.8%
<u>pretty</u>	1	2.8%
<u>reasons</u>	1	2.8%
<u>sky</u>	1	2.8%
<u>ago</u>	1	2.8%
<u>pictures</u>	1	2.8%
<u>learning</u>	1	2.8%
<u>cool</u>	1	2.8%
<u>idea</u>	1	2.8%
<u>fun</u>	1	2.8%
<u>astronomy</u>	1	2.8%
<u>night</u>	1	2.8%
<u>contribute</u>	1	2.8%

The deterrence of individuals from astronomy as a child or their interest can include the following concepts: *love*, *astronomy*, *back*, *stars*, *night*, *found* and the multitude of references to *time*. These references to *time*, which include *year*, *month*, and *day* are the most common terms overall, ranking 100% within the posts coded. This means that every post that was labeled by Leximancer as important and containing a concept or concepts contains a term related to *day*, *month*, *year*, *era*, *time*, *ago*, *ages*, *age* or similarly related terms. While they are not all referencing a specific era, age, or event, this analysis provides us an unbiased confirmation that members are actively engaging in a motivation related to their childhood, current age, or past events. *Age*, *galaxies*, *young* and *astronomy* are similarly connected, reiterating this avenue of discovery, and youth created interest in astronomy. *Back* and *time* references are also interconnected, again referencing the older age demographic of the forum members, in addition to re-stating that motivations for participation existed long before Galaxy Zoo was created.

The use of variable reinforcement, coded by the author under the terms: *addiction*, *addict*, and *addicting* appeared in 19 separate posts, providing evidence that forum members are recognizing it and attributing their retention to it.

A theme that appeared through the visual interpretation of the data was the use of *amazing* and *project* simultaneously. Though common, this can be dismissed as many forum members begin their post by congratulating the Galaxy Zoo team for their work and allowing them to participate. This should still be considered in terms of the retention aspect of Galaxy Zoo, just like the use of variable ratio reinforcement.

A topic discussed by the author, and by previous authors is the learning experience that Galaxy Zoo has provided to the members. This concept numerically appears to be a very strong theme from Leximancer’s analysis, with the terms *understanding*, *learn* (and similar words), *found*, *knowledge*, *science*, *answer*, and *questions* receiving high strength values. A summary of these connections are shown in Table 6.

Table 6: Data Table of Concepts and Values after Final Combination and Elimination of Terms

Concept	Absolute Count	Relative Count
<u>time</u>	137	100%
<u>galaxies</u>	99	72.2%
<u>astronomy</u>	68	49.6%
<u>project</u>	65	47.4%
<u>zoo</u>	56	40.8%
<u>sky</u>	48	35%
<u>years</u>	48	35%
<u>universe</u>	47	34.3%
<u>science</u>	47	34.3%
<u>think</u>	45	32.8%
<u>space</u>	45	32.8%
<u>love</u>	44	32.1%
<u>night</u>	41	29.9%
<u>contribution</u>	37	27%
<u>feel</u>	37	27%
<u>people</u>	35	25.5%
<u>learn</u>	34	24.8%
<u>site</u>	30	21.8%
<u>great</u>	28	20.4%
<u>stars</u>	28	20.4%
<u>amazing</u>	27	19.7%
<u>long</u>	27	19.7%
<u>knowledge</u>	27	19.7%
<u>ago</u>	26	18.9%
<u>heard</u>	26	18.9%
<u>contribute</u>	26	18.9%
<u>find</u>	25	18.2%
<u>telescope</u>	25	18.2%
<u>found</u>	25	18.2%
<u>few</u>	25	18.2%
<u>pretty</u>	24	17.5%
<u>real</u>	24	17.5%
<u>research</u>	24	17.5%
<u>hope</u>	23	16.7%
<u>cool</u>	23	16.7%
<u>thought</u>	23	16.7%
<u>world</u>	22	16%
<u>questions</u>	22	16%
<u>beautiful</u>	22	16%
<u>fun</u>	22	16%
<u>back</u>	22	16%
<u>work</u>	21	15.3%
<u>pictures</u>	20	14.5%

Overall, Leximancer provided new perspective to the findings of previous authors referenced earlier, using an automated quantitative coding system. While this method appeared to confirm some of our findings, it did not address all interpretive findings. This is understandable as the interpretive analysis focuses more on the weight and strength of the quotes and comments, as opposed to the frequency of words used to describe motivations. These concepts, such as reference to the ages and time provides an alternate body of evidence that establishes the concept of a potential well of interest that Galaxy Zoo has been able to access. The aesthetic value of astronomy is prevalent throughout the posts, and the quantity of concepts showing that reflect the motivational aspect it can induce. The concepts illuminated by the software also reconfirms that many members are interested in the learning aspect of Galaxy Zoo. While this alone has been reported by previous authors, the concept mapping shows that this can be linked to the concept of love for astronomy or interest in the topic. Lastly, the concepts reveal the interest of members in the entire project or process of science, linked to the idea of contributing to science. While these findings have been similarly reported in this paper through interpretive investigation and in previous papers, Leximancer provides an unbiased and automated analysis of the data, and has been able to find weight of concept in areas different than those stressed previously. While this provides a great confirmation to previous authors work and some of our discoveries as well, it fails to really explain why over 60 million classifications have occurred at an astounding rate. Leximancer shows general ideas and trends within a project, but fails to pick up on culturally relevant material, nor does it take into the account the weight of words. As a result, it cannot truly discern any important motivations, similar to those reported by previous authors, such as “fun” and “likes to contribute”. The idea of transcendence, spirituality, a second chance at a dream, and the great interactions between the Galaxy Zoo team and the members cannot be discovered through simple numerical counts of words and types of words within the forums. Only through analyzing the stories, quotes, poetry and discussions between members using grounded theory is it possible to truly make meaning of Galaxy Zoo’s success and hidden motivations.

LIMITATIONS OF STUDY

Though significant data comes from the forum posts, the pool of contributors must be considered, as not all members who participate in Galaxy Zoo are registered in the forum, or use it. This brings no surprise to the large amount of those who desire community, for these responses would not exist without this component.

Within the forum contributions existed several posts claiming “ditto” or reiterating previous comments, which reduce reliability and make it difficult to track exact values of each motivation. Due to this, the author feels that an interpretive investigation serves better to determine the trends present as conducted.

CONCLUSION

Through the evolution of Galaxy Zoo, we have seen a great phenomenon emerge, bringing together amateur astronomers and scientists on a massive scale to sort through an enormous data set. While other citizen science projects work through large data sets, Galaxy Zoo is unique in the motivations and retention abilities. While the interpretive data collected for this research is of a subset of the larger body of citizen scientists, this subset can still yield powerful results for use in future citizen projects and the science classroom. This method of grounded theory proves to be ideal in determining trends of motivation within the present context and have revealed trends not seen before in previous studies of Galaxy Zoo.

Many of these motivations originate in the aesthetic power of astronomical images, which Galaxy Zoo successfully harnesses, while not compromising the scientific value of the project. From within the data emerged several trends of motivation, the primary being the sense of community created within the project that promotes professional-amateur collaboration; fulfilling a dream of being an astronomer, physicist, or astronaut; tapping into a potential well of interest created during the space race era; the spiritual aspect generated when the imagination interacts with Galaxy Zoo; and uniting them all, the aesthetic appeal of the galaxy images. In addition, a very powerful tool also emerged as a method of retention unique to Galaxy Zoo. This tool, known as variable ratio reinforcement in behavioral psychology, uses the most appealing images as positive reinforcement to maintain classification rates over time.

The use of Leximancer, while proven in the hands of phenomenography experts, revealed confirming data for the themes gleaned by the author, but did not necessarily reveal data confirming all categories in previous papers, nor all the categories collected by the author. The categories brought to light specifically in this paper do find supporting data through Leximancer, though, and show an alternate method of forum or interview analysis that can be used in the future. Unfortunately, Leximancer failed to reveal anything other than to confirm previous and less telling motivations contained within the Galaxy Zoo culture.

While it may not be possible to again harness the exact interest and feelings created during the space race in the classroom, being able to recreate some of that excitement in the classroom could prove to improve the epistemological beliefs of students. Breaking the barriers between gender differences in the STEM fields should also serve to reduce the leaky pipeline, preventing the educational gaps that occurred in the 60's and 70's.

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