Citizen Science:

where the line between “public” and “researcher” blurs
Background:
How we have integrated science into society
(a view from HST)

Scientists work with communicators, educators, graphic artists, web developers and technical writers

Audience Needs

News
Outreach
Informal Education
Formal Education

25 Sept. 2013
Horsehead Nebula / Star Formation integrated into U.S. Middle School reading materials
Outreach

a system to provide services beyond conventional limits
OUTREACH

Online information, email alerts, social media (facebook, twitter, hangouts) interactions, Citizen Science

Watch, question, comment, interact, create your own images

Live talks each month
How science works.

Enthusiasts try their hand at processing HST data for visual appeal

….and Citizen Science

hubblesite.org
PUBLIC ENGAGEMENT PORTAL

active participation for image enthusiasts and science interested individuals

Art, science, games

HST observations treated to enhance the visual and artistic nature of the cosmos.

Challenges to artists to create their interpretations of HST imagery
Next: citizens collaborate in research

Volunteers perform tasks that contribute to research
Analysis requires large numbers of individuals applying cognitive skills
Studies cannot be performed through algorithms

Outcomes: impact / reach
(metrics and anecdotes)

Increase in refereed research papers
Improvement in machine learning
Creation/growth of interested community
Engage students in the classroom
Build science/technology skills
Case studies, best practices
40,000 separate exposures of M31

~3000 star clusters

the science:

8 members on science team

one month searching the first ~20% of the survey’s imaging

~600 likely star clusters

4x number previously known in same region
the result: launched on December 5\textsuperscript{th} 2012

~7,000 unique visitors examined ~12,000 image cutouts [reach]

> 100,000 image classifications in the first day.

overall classification rate > \textbf{one per second!}

after 16 days data collection concludes with > 1 million image classifications

80 individual classifications per image

First research paper January 2013
IMPACT: e.g., "TALK"

Tools
analyze, interact, and collaborate
discuss analysis and results directly with the science team

Example Outcome
Andromeda Project: 18% of volunteers accessed TALK
10% made comments

Snapshot Serengeti: volunteers progressed from assisted classification to recognizing species immediately

Other: volunteers begin to use scientific terminology expressed by science team
[~measurable impacts]

AP Example comments [case study]
...a fair number of the "highly-realistic synthetic clusters" look...synthetic

...This looks like a possible star cluster...The colors aren't particularly red...there isn't much dust in the cluster...so dust gives off the reddish look, got ya

...could this be a distant galaxy?
SPECIFIC OUTREACH AND EDUCATION OUTCOMES (we hope)

Interest/enthusiasm/engagement for and in science

Understanding of science and science process

Support of science/technology

Skills

- use of technology
- pattern recognition
- data collection
- data analysis
- data visualization
- interpretation
- independent research
- collaborative research
Education

knowledge, skill, understanding
EDUCATION: FORMAL & INFORMAL

“Students need opportunities to analyze large data sets and identify correlations. Increasingly, such data sets...are available on the Internet.“

What can we do?

- provide unique content
- leverage existing resources
- add CitSci tools
- engage educators
- create partnerships
- measure reach and impact
EXAMPLE: School of Physics, Astronomy and Computational Sciences

**Planet 4:** debris blown out of vents as polar ice melts on Mars

Examine, classify, collect images

Look for patterns

Form a model or hypothesis to explain observations

Test

[case study]

**Galaxy Analysis:** classify galaxies

Record classifications

Analyze statistics

Compare how groups of individuals classify

Make physical measurements

Explain why analysis by many individuals can create more robust results

[case study]
**EXAMPLE:** Classroom Supplements

**Galaxy Classification:**

- Use interface
- Write 2 pages about what they have learned
- Students really like the fact that they are helping 'real' astronomers identify galaxies
- Augments understanding the galaxies chapter covered in class

**Planethunters, GalaxyZoo, Stardust @ home, NASA's Be a Martian**

- Students select as a part of a laboratory component
- Specific activities from each accomplished
- Write documentation
- Typically students wait until last minute to use the site!
Hassman, et. al 2013, Computer Supported Collaborative Learning (conference).

-skill in collaboration,
-user annotation can indicate skill improvement, or at least deeper engagement
EXAMPLE: Bird Sleuth

Cornell infrastructure
THE CHALLENGES for the HST PROGRAM

- Addressing specific science education standards
- Fitting into specific curricula
- Specifying learning outcomes
- Creating an evaluation plan
- Providing and/or linking to existing relevant background and resources

Creating educator resources
- Providing data access and collection tools for student tasks
- Furnishing example authentic research questions

Measuring “reach” - how many teachers, students, individuals directly involved
Measuring indirect reach - leveraged (e.g., 1 teacher to X students; 1 exhibit to Y visitors)
Evaluating impact, learning achieved, understanding gained

From EDU researchers: “Based on pre- and post-[project] participant surveys, we determined that citizen scientists collected an impressive amount of data and enjoyed the experience but did not achieve the educational goals we hoped for”
THE HST FRONTIER FIELDS

What will we do?

Citizen Science....

scaffolding....news, educational materials, public engagement,
THE HST FRONTIER FIELDS

intrinsically deepest and widest survey of the high-redshift universe (sneak peak at JWST’s universe with Hubble now)

Jennifer Lotz, Matt Mountain, STScI Frontier Fields Implementation Team

6 strong-lensing clusters + 6 adjacent parallel fields

140 HST DD orbits per pointing
ACS/ WFC3-IR in parallel ~29th ABmag in 7 bands

2 clusters per year × 3 years → 840 total orbits

1000 hours Spitzer DD time for IRAC 3.6, 4.5 μm ~26th ABmag

Google: HST Frontier Fields
http://www.stsci.edu/hst/campaigns/frontier-fields/
Science Working Group and Community Input - Science Goals

- galaxies 10-100x intrinsically fainter than any seen before (z~5-10)
- characterize the stellar populations of high-redshift galaxies = the early progenitors of the Milky Way
- enable astrophysics on highly-magnified galaxies at z>=8 (spatially resolved sizes and structures)
- statistical studies of z>5 star-forming galaxy sizes and structures
- detailed maps of dark matter in clusters; test DM substructure predictions
- use 100s of multiple lensed images as independent probe of distance, DE
- deep and high-spatial resolution studies of z~1-4 galaxies study distant transients (SNe, AGN);
- use time delays of multiplied images transients as cosmology probe
- z~10 galaxy counts as a test of DM (rule out Warm Dark Matter?)
Understand light, optics, and gravity

How does science really work?

Who does science? (me)

How can I get involved?

FRONTIER FIELDS

News

Outreach

Public involvement

Informal Education

Formal Education

25 Sept. 2013

SPACE TELESCOPE SCIENCE INSTITUTE

C. Christian

Wednesday, September 25, 13
THE CITIZEN SCIENTIST TASKS

Find the lensed object fragments

Match pre-made models?

Adjust models to fit data?
TIMELINE – CORE EDUCATION & OUTREACH COMPONENTS

Fall 2013
Star Witness News (science process)
Professional Development – formal education

Spring 2014
Hubble Frontier Fields – intro video
Star Witness News (science content reading)
Hands-on Activity - Demonstrations
Professional Development – Hubble Science Briefing, formal education
Outreach – Local/clubs/afterschool

Fall 2014
AAS Poster (January 2015 AAS)
Professional Development - Hubble Science Briefing, formal education
Outreach – Public Lecture Series, local, clubs, afterschool
Lithograph

Spring 2015
Online Interactive – Hubble Deep Field Academy Module
Professional Development – formal education
ViewSpace – Galaxy Evolution
Outreach – local, clubs, afterschool
CitSci RESEARCH PROJECTS based on HST & MAST (archive)

- Galaxy Zoo Hubble: Distant galaxy morphology
- Galaxy Zoo 3: HST MCT CANDELS HST data - SN search
- Andromeda Project: part I, II of MCT PHAT HST data - identify clusters in M31
- Planet Investigators HST archive data - moving targets in solar system
- Space Warps: CFHT and perhaps future HST data - find lensed objects
- Pinwheel Parts: M83 HST data - classify clusters by age (development)
- PlanetHunters: Kepler MAST data - identify planet candidates and other variables
- Galex Transients: Galex MAST data - identify transients (in planning)
- Frontier Fields: HST data - identify parts of lensed objects (planning)