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WWT Ambassadors: WorldWide Telescope for Interactive Learning

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Abstract. In our presentation, we demonstrated some key features of the WorldWide Telescope (WWT). Here we describe the results of a WWT Ambassadors (WWTA) Pilot Study where volunteer Ambassadors helped sixth-graders use WWT during a six-week astronomy unit. The results of the study compare learning outcomes for 80 students who participated in WWTA and 70 students at the same school and grade who only used traditional learning materials. After the six-week unit, twice as many "WWT" as "non-WWT" students understood complex three dimensional orbital relationships; tremendous gains were seen in student performance in science overall, astronomy in particular, and even in using "real" telescopes. We describe plans for expansion of the WWTA program.

1. WorldWide Telescope

The WorldWide Telescope (WWT) computer program is a "Universe Information System" that offers an unparalleled view of the world's store of online astronomical data. WWT weaves astronomical images from all wavelengths into an "interface" that resembles their natural context, the sky, while simultaneously offering deep opportunities to teach and learn the science behind the images. A 3-dimensional model of the Solar System and cosmos empowers students to visualize relationships between the Earth, Sun, Moon and beyond; to learn how their motions affect what we see in the night sky; and to understand the seasons we experience at different times of year. WWT tools are free for all non-commercial use. Figure 1 shows a screenshot of WWT, with some of the key features highlighted.

The full WWT application has been downloaded over 5 million times so far, and the "web client" and API forms of WWT have been accessed even more often.[1] WWT is evolving to become a key research tool within the online astronomy ecosystem known in the U.S. as the "Virtual Astronomy Observatory," but it also offers unprecedented opportunities for STEM outreach and education. WorldWide Telescope has been called out in the 2010 Astronomy Decadal Survey sponsored by the National Research Council (Committee for a Decadal Survey of Astronomy and Astrophysics & National Research Council 2010) as a significant contribution to the public understanding of astron-

[1]`www.worldwidetelescope.org/webclient/`

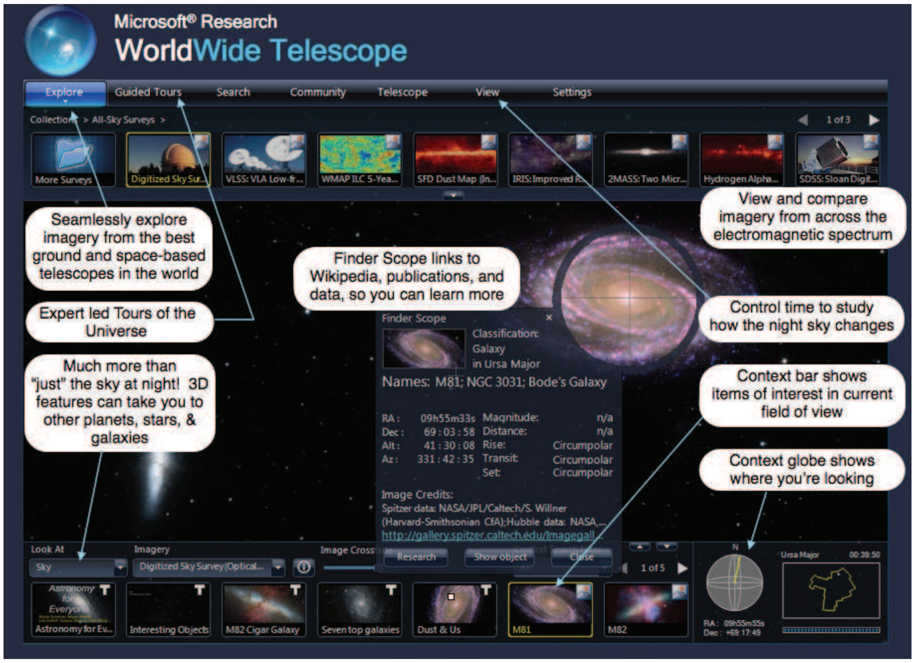

Figure 1. Annotated screenshot of WWT, showing the user interface and highlighting some key educational features of the program.

omy, calling it a *corporate version of previously under-funded efforts of astronomers to accomplish similar ends, [that] coordinates the world's public-domain cosmic imagery into one resource, allowing people on home PCs to explore the cosmos as if they were at the helm of the finest ground and space-based telescopes.* WWT was designed from its inception with personal inquiry, exploration, discovery, and explanation in mind, and those features have already been shown to excite STEM learners (Landsberg, Subbarao, & Dettloff 2010).

The WorldWide Telescope Ambassadors Program (WWTA) is an outreach initiative run by researchers at Harvard University and Microsoft Research. WWT Ambassadors are astrophysically-literate volunteers who are trained to be experts in using WWT as a teaching tool. Ambassadors and learners alike use WWT to create dynamic, interactive Tours of the Universe, which are shared in schools, public venues, and online. Ambassador-created Tours are being made freely available and will ultimately form a comprehensive learning resource for Astronomy and Astrophysics.

Our group has piloted the use of WWT in schools, and we present some preliminary results here. The pilot program took place in the spring of 2010 at Jonas Clarke Middle School (JCMS) in Lexington, Massachusetts. Michelle Bartley, our partner teacher, used WWT with 83 sixth grade students over the course of a 6-week long astronomy unit. Figure 2 shows some images from the classroom at JCMS during the pilot program. In the spring of 2011, we expanded the program to include all 240 sixth grade students at Clarke and another 100 students at Prospect Hill Academy, an urban charter school in Somerville, Massachusetts. All the results presented are from the completed first year pilot.

Figure 2. Students at work with WWT at Jonas Clarke Middle School in Lexington, Massachusetts, where we piloted some WWT materials in 2009–2011.

2. WWT and Moon Phases

Preliminary data from our Pilot at JCMS demonstrates the potential power of WWT's visualization environment. Our partner teacher Michelle Bartley named the Moon's phases as a topic that students typically struggle to visualize and understand, so we created an interactive WWT tour specifically to aid in the teaching of this topic. The 80 pilot students worked with the tour for only one class period, but our results show that the WWT approach holds great promise. After all the 6th grade students at JCMS completed their astronomy unit, we administered an anonymous quiz to Group A (79 students) who used the WWT Tour and to Group B (71 students) who used only traditional materials (see Fig. 3). One question was designed to test memorization skills (identify a Moon phase based on a picture), and the other question was designed to test understanding (sketch a diagram of the Earth, Sun, and Moon when the Moon is in the depicted phase). Students in both groups performed almost identically on the memorization question, suggesting that using WWT does not impact the type of learning that must be done by rote. However, there was a significant difference in student performance on the question that was designed to test their understanding. Although students in both groups struggled with Moon phases, confirming that it is a challenging concept for the sixth graders to understand, more than twice as many students in Group A than Group B were able to answer the "understanding" question correctly after working with the WWT Tour on Moon phases. Note that Group A only spent half an hour working with the tour, and perhaps even larger gains could have been made if they had had more time to devote to this topic.

Table 1 Sample size: N_A=79; N_B =71	**Q1: Memorization**		**Q2: Understanding**	
	Group A (WWT)	Group B (no WWT)	**Group A (WWT)**	Group B (no WWT)
Incorrect	7%	5%	**38%**	**65%**
Partially Correct	31%	33%	21%	16%
Correct	62%	61%	**41%**	**19%**

Figure 3. Results of a "Moon Phases Quiz" administered at the JCMS pilot after their astronomy unit. Twice as many students in the WWT group (Group A) were able to correctly sketch the relative positions of the Earth, Sun, and Moon for a given Moon phase than in the non-WWT group (Group B).

3. Student Feedback about WWT

Our preliminary pilot research shows that WWT has great potential to excite and interest students and help them learn science. After our sessions at JCMS, we administered anonymous free-response surveys. We received 72 complete surveys, and 71 (99%) were highly positive about using WWT. In questions about how WWT could help them learn science and what they would tell their best friend about WWT, the students expressed genuine excitement at being given the freedom to explore and learn in WWT's interactive environment. Figure 4 offers some representative student responses.

Student Quotes after working with WWT:

"Learning about our universe by actually seeing and exploring it makes it easier to contemplate and more fun."

"It gave me a better mental map of the universe."

"Awesome, amazing, cool, incredible (repeat 30 times)"

"You can explore the universe yourself and you don't always have to only learn from the teacher."

"This is way cooler than Call of Duty."

Figure 4. Sample feedback from students in the JCMS Pilot, answering the questions "How is WWT helping you to learn science?" and "What would you tell your best friend about WWT?"

4. Pre and Post-test Likert Scale Anonymous Surveys

As with the Moon Quiz, we surveyed two groups—one that used WWT (Group A) and one that did not (Group B)—about their interest level and self-perceived understanding of astronomy and science before and after the astronomy unit. We used a Likert scale (1=low; 5=high) on the survey, and we present the survey analysis results in Figure 5 in terms of the effect size. Effect size measures the gain (or loss) in units of the pre-test standard deviation:

$$\text{Effect Size} = \frac{(\text{posttest average} - \text{pretest average})}{(\text{pretest standard deviation})}$$

Effect size absolute values of 0.25 or less indicate essentially no effect, 0.25 to 0.5 a small effect, 0.5 to 0.75 medium, and 0.75 or greater large effect (Cohen 1988). In Figure 5, each point plotted shows mean effect size, and the bars show plus or minus one standard error on the mean. Group A (with WWT) showed statistically significant gains on all questions asked. Group B (no WWT) showed statistically significant gains in their self-reported factual knowledge and understanding of astronomy topics, but they did not show gains in interest in astronomy or science in general. Group A self-reported a significant gain in the ability to visualize Sun-Earth-Moon relationships while Group B did not, consistent with the results of the Moon Quiz described in Section 2. One concern expressed about WWT is that the beautiful immersive environment might lead users to lose interest in using real telescopes: our data indicates that the contrary is true (note the last question in the figure).

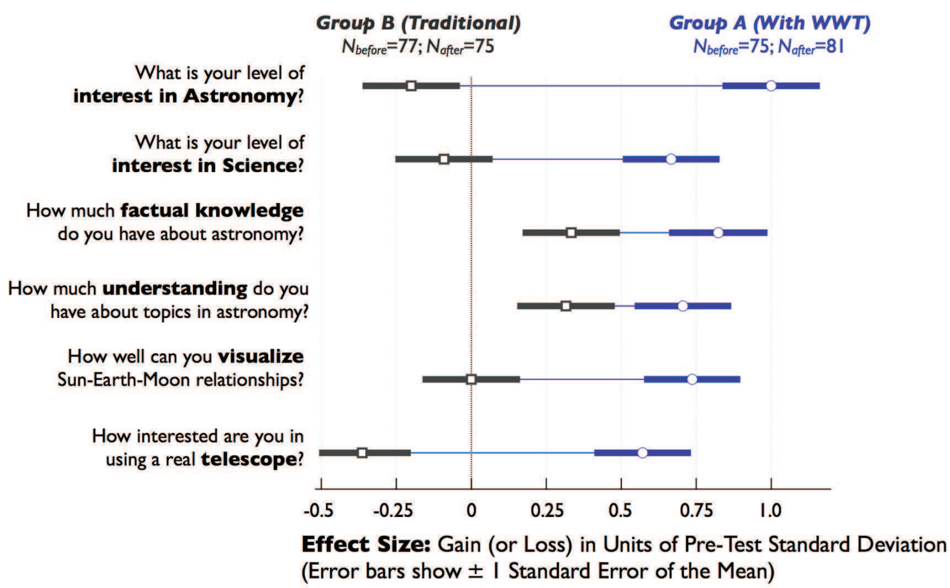

Figure 5. A plot comparing the Effect-Size seen in two different groups at JCMS in response to various survey questions. Effect size is the gain (post-test average minus pre-test average), normalized by the pre-test standard deviation. Group A was our pilot group that used WWT; Group B was a group of similar ability students that did not use WWT.

5. Beyond the WWTA Pilot

Pending funding, we plan to expand the WWTA program to three more carefully selected, socioeconomically diverse U.S. sites, and we are developing an online community that serves as a resource for Ambassadors, teachers, and students beyond those locations. Online materials will be available through several sites (at Harvard and Microsoft) and will be integrated with existing online curriculum programs such as WGBH's Teachers' Domain and Microsoft's Partners in Learning. More information is presently available at `wwtambassadors.org`.

We also plan to develop a series of "visualization labs" in WWT that promote a deep understanding of key space science concepts making up the National Science Education Standards for grades 5–8 (National Research Council 1996). The topics covered will include seasons, Moon phases, eclipses, and distance scales in the Universe. Beyond specific content knowledge, the labs will be designed to familiarize students with important science skills, such as connecting observations, evidence, and explanations. These labs will be free and will require no special equipment other than a computer and an Internet connection, helping to reduce the equity gap in access to lab experiences, and they will capitalize on astronomy's special appeal among students and the public, helping to turn around those who have lost interest in science.

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