Analysis of Organizational Learning at NASA

Erica Inge

Virginia Commonwealth University

Analysis of Organizational Learning at NASA

The organizational learning cycle as outlined by Dixon (1999) consists of the following four steps: widespread generation of information, integration of the new information into the organizational context, collective interpretation of the information, and having the ability to act based on the interpreted meaning of the information. Based on this understanding of the learning cycle, I will analyze organizational learning at NASA from the interpretation of mistakes made during the development of the mirror for the Hubble space telescope and by reviewing more recent NASA documentation of learning.

Background on the Hubble project

Work began on the mirror for the Hubble space telescope in 1978; its manufacturer was Perkin-Elmer. The construction of this mirror was the first time Perkin-Elmer used computers to measure and control all aspects of the mirror polishing process. Previous to the Hubble mirror, polishing was done by skilled craftsmen who used techniques described as "somewhere between science and art" (Capers & Lipton, 1993, p. 41).

A cascading set of errors doomed the mirror polishing process to failure. Due to the precision needed for the mirror to work correctly once installed into the telescope, a new null corrector was designed especially for the Hubble mirror by Perkin-Elmer scientists. During the construction of the null corrector, a small piece of paint wore off one of the parts which caused the calibrating laser to bounce off that worn spot. Therefore the laser didn't accurately indicate the dimensions for building the null connector. When the null corrector was put together the lens wouldn't fit into the space allocated. Technicians putting the null corrector together compensated for this flaw by adding common household washers to the bracket holding the lens. This compensation caused the null corrector to give faulty readings to the polishing computer and to

the men responsible for building the mirror. This was the fatal flaw in the Hubble telescope that was, unfortunately, not discovered until the Hubble began sending out-of-focus images back to Earth from its orbit.

Other issues existed at Perkin-Elmer and at NASA at the time of the construction of the Hubble mirror. The project was awarded to the lowest bidder and NASA planned for an unrealistic production schedule. An outgrowth of these two issues meant that the budget was of primary importance and there was a project timeline that could not be changed. These two pressures led to errors in judgment about the data received from the calibrating equipment. The Hubble mirror project management and technicians had an overreliance on equipment data--they trusted the output from the computer and the flawed null corrector more than what they saw and what they experienced. Even when a secondary testing device showed flawed results that information was pushed aside by the chief engineer.

The organizational learning cycle and the Hubble project

By taking Dixon's organizational learning model and applying it to the Hubble construction process, it is difficult to map how each of the steps were applicable to the process. However, it is possible to look at what barriers existed to each of the steps in the organizational learning cycle. The barriers are as follows:

Barriers to widespread generation of information	Barriers to collective interpretation of information
External: • Unable to publish reports about the polishing process • Closed work environment due to national security concerns Internal: • Marshall Space Flight Center director didn't like bad news • Managers overlooked quality concerns	• Problems with the null corrector and other anomalies were raised but no one interpreted the meaning of those issues • Workers added washers to the null corrector but didn't tell anyone of this field change to the measurement instrument
Barriers to integration of new information	**Barriers to the authority to take action**
• Data from the flawed null corrector was ignored • The quality assurance officer refused to sign off on the project but this was ignored	• No one seemed to have the authority to stop or back up the process • Issues and data were ignored

Examining the barriers to the widespread generation of information begins with Dixon's (1999) idea that "the generation of information needs to be the responsibility of all members of the organization" (p. 95). By prohibiting employees from publishing reports or even talking to individuals outside the mirror building process, NASA and Perkin-Elmer blocked the widespread

generation of information from the start of the project. A closed system can rarely sustain itself; homogeneity of information does not create dialogue and without the dialogue ideas become stagnant.

In the case of the construction of the Hubble mirror, this stagnation, or blockage, of generating information crossed into the internal structure as well. The director of the Marshall Space Flight Center was known for not liking bad news. As the director had ultimate authority over the Hubble mirror, his behavior blocked managers from raising concerns about the process. Dixon (1999) suggests that by not confronting others who possess different meaning structures a diversity of meaning can not be constructed. The unfortunate outcome of this behavior not only led to difficulties with the Hubble mirror but later investigations also pointed to this behavior as being part of the problems associated with the Challenger space shuttle failure (Capers & Lipton, 1993).

In addition to blocking the generation of information, the collective meaning structure was not allowed to flourish which led to the stifling of the process to integrate new information. When data from the null corrector indicated problems those issues were ignored. In addition to not trusting a secondary, but less accurate, null corrector's data as a red flag for the flawed data coming from the specially designed mirror null corrector, management brushed off a quality assurance officer's concerns. In large part, the quality assurance officer was told to not worry about the quality of the mirror but only about its safety (Capers & Lipton, 1993). NASA ignored its own requirements as the quality assurance officer refused to sign off on the mirror. NASA pushed the project through without this critical approval.

Not only were the problems with the integration of new information, but there was also an issue with collectively interpreting the information throughout the life of the Hubble mirror

construction process. When technicians added common household washers to the null corrector, this decision led to the generation of false data. This change in the construction of the null corrector can be considered private meaning held only by the technicians. This failure to share private meaning, whether because the project's climate was so focused on budget and deadlines or because there was a hierarchy that prohibited technicians from raising issues is unclear. However, the outcome of this failure to collectively interpret information led to the inability of technicians and managers alike from clearly understanding the parameters of the problem. They ignored the obvious flaws in the data and as Dixon (1999) states by ignoring the ability of each individual in the process to reason and contribute to the meaning-making process there is a "considerable loss to learning" (p. 105).

Finally, there did not seem to be any authority to take action based on the information gathered during the construction process. Even when one of the optical engineers noticed the data coming from the null corrector was flawed and then took that information to the lead engineer on the project, the lead engineer refused to act on the data and blocked the junior engineer from doing any more with the flawed data.

At all levels of the Hubble project, the ability to act on data that was considered flawed or puzzling was denied. This inability to use all the capacities of employees' expertise and knowledge led to a failure to create organizational learning on the Hubble project.

Lessons learned and NASA's move to a learning organization

Since the fiasco of the Hubble mirror construction project, NASA has undergone improvement processes that continue today. Even with improvements in place, there have been other problems at NASA including the loss of two space shuttle crews and equipment failure on the Mars explorer project. Because the nature of the work of NASA is risky and expensive, the

space agency remains committed to improving their organization's learning and management of projects.

NASA utilizes learning-based project reviews. The key component to the learning-based project review process is the use of a set of procedures that supports learning throughout a project's life cycle rather than at the end of a project. The learning-based process is similar to Dixon's learning cycle as it consists of four steps: plan (the project team determines the nature of the problem and creates a plan), do (implementation of the plan), study (reflection on the plan and results), and act (closing the loop by continuing or abandoning process improvement) (Kotnour & Vergopia, 2005).

In addition to learning-based project reviews, NASA has implemented a knowledge management system that is more than a passive repository of project data and lessons learned. It has "a 'push' capability to send appropriate lessons-learned to individuals based on completed user profiles" (Liebowitz, 2002, p. 41). This lessons-learned knowledge management system has led to cultural changes at NASA and continues to help NASA embrace aspects of Dixon's learning cycle (Maya, Rahimi, Meshkati, & Madabushi, et al, 2005).

Telescopes using lessons learned at NASA

As detailed in Capers' article "NASA post Hubble: Too little, too late?" the AXAF project was revamped based on lessons learned from Hubble. The Chandra X-Ray Observatory is the result of the work of the AXAF project and is currently in operation and sending images to scientists.

During the construction process of the Chandra X-Ray Observatory, testing was very important to the success of the project. Unlike the Hubble project where additional testing was not implemented because of cost and time, "…the telescope system and the scientific

instruments were put through thousands of individual tests in an X-ray calibration facility especially constructed for this purpose by the Chandra support team at Marshall Space Flight Center" (Harvard-Smithsonian Center for Astrophysics [HSCA], 2008).

Sometimes called the successor to the Hubble Space Telescope, the James Webb Space Telescope, due to deploy in 2013, will actually observe the universe using infrared technology instead of optical and ultra-violet wavelengths used by Hubble (both use large-scale mirrors). Some lessons learned from Hubble are being implemented by the team working on the Webb telescope such as continuous reviews of the process (tying into the lessons-based project review process), the technology used to build this telescope is tested (unlike Hubble's trailblazing use of computers and other equipment), and one site (Goddard Space Flight Center) owns the operation and data delivery rather than splitting the responsibility amongst multiple NASA sites (National Aeronautics and Space Administration [NASA], 2008).

Summary

While it is hard to find organizational learning that took place during the construction of the Hubble mirror, I think NASA has learned lessons from the experience. In addition to the examples listed above, I contacted my sister who completed post-doctorate work at NASA beginning in 2005. She described NASA as an open community where "NASA data is public data" (C.R. Thomas personal communication, September 19, 2008). By this she meant that widespread generation of information was accepted and encouraged both internally, and externally through the publication of scholarly papers. Although she did not work in one of the space departments, she did indicate that NASA fostered an environment where all levels of employees were able to raise issues.

In addition to the widespread generation of information, also evidenced by the presence of so much data available on the Internet, NASA's use of project reviews at all points during a project's life-cycle, the implementation of a knowledge management system, and the ability to act on the collective meaning of the organization as evidenced by adjustments to the way new space telescopes are constructed and deployed demonstrate NASA's progress towards becoming an example of organizational learning.

References

Capers, R. S. (1994, May). NASA post Hubble: Too little, too late?. *The Academy of Management Executive, 8*, 68-72. Retrieved August 25, 2008, from ABI/INFORM Global database.

Capers, R. S., & Lipton, E. (1993, November). Hubble error: Time, money, and millionths of an inch. *The Academy of Management Executive, 7*, 41-57. Retrieved August 25, 2008, from ABI/INFORM Global database.

Dixon, N. M. (1999). *The organizational learning cycle: How we can learn collectively* (2nd ed.). Hampshire, England: Gower Publishing Limited.

Harvard-Smithsonian Center for Astrophysics (2008, September 24). *Chandra X-Ray Observatory [web site].* Retrieved October 4, 2008, from http://chandra.harvard.edu/index.html

Kotnour, T., & Vergopia, C. (2005, December). Learning-based project reviews: Observations and lessons learned from the Kennedy Space Center. *Engineering Management Journal, 17*, 30-38. Retrieved September 29, 2008, from EBSCO host

Liebowitz, J. (2002, May/June). A look at NASA Goddard Space Flight Center's knowledge management initiatives. *IEEE Software, 19*, 40-42. Retrieved September 29, 2008, from http://www2.computer.org/portal/web/csdl/doi/10.1109/MS.2002.1003451

Maya, I., Rahimi, M., Meshkati, N., & Madabushi, D., et al. (2005, December). Cultural influence on the implementation of lessons learned in project management. *Engineering Management Journal, 17*, 17-24. Retrieved September 24, 2008, from ABI/INFORM Global

National Aeronautics and Space Administration (2008). *The James Webb space telescope [web site]*. Retrieved October 5, 2008, from http://www.jwst.nasa.gov/