A Case Study of the Space Telescope Science Institute’s Learning Community

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Abstract

Professional development opportunities are critical in any scientific or engineering discipline. Engineers need professional development in order to apply state of the art concepts and techniques to solving company problems.

Basically, there are three broad categories of professional development opportunities: individual, group, and organizational opportunities. Individual opportunities include technical sabbaticals and planned professional development. Group opportunities include engineering colloquia with guest lecturers from industry and seminar courses on specific topics. Organizational opportunities include tuition refund program and other human resources initiated opportunities. All of these techniques intertwine to foster a strong organizational learning culture.

The Space Telescope Science Institute (STScI) has implemented a successful program of sustained learning opportunities for its employees. This paper will provide a case study of the STScI’s learning community. This paper will explore the professional development opportunities available to employees and examine the costs and benefits associated with them based on the STScI model.

Keywords: Learning Community, Professional development, Technical Training

1. Introduction

Professional development opportunities are critical in any scientific or engineering discipline. This is especially significant for technology fields such as computer science and software engineering. Employees must continually update their knowledge so that they can effectively perform their job responsibilities.

STScI, and in particular the Engineering and Software Services (ESS) division, has created a vibrant learning community. Employees are encouraged to learn and apply new and innovative techniques to improve the operations.

1.1. Purpose and Scope

The purpose of this paper is to present a critical, empirical analysis of STScI’s and particularly ESS’s learning community. The specific focus is on the analysis of the opportunities available to engineers and how the various opportunities compliment one another.

This paper is not a research paper on learning community theory. This paper is meant to be an analytical case study of a specific organization based on the experiences of the author.

1.2. Background

In order to understand the learning community at STScI, a brief description of the organization is necessary. STScI is organized into several divisions. Only three divisions, ESS, Operations and Data Management (ODM), and the Instruments Division (INS) are referenced in this paper.

ESS is responsible for research, development, and engineering software and systems to support both the astronomical community at large as well as the ODM division. ESS primarily acts as a service organization for the Hubble Space Telescope (HST). ESS is organized into branches or teams of domain experts who have in-depth knowledge of specific disciplines. For example, there is a Planning Systems Development Branch (PSDB) that engineer planning systems, a Scheduling Systems Development Branch (SSDB) that engineer scheduling systems, and an Astronomical Proposal Systems Branch (APSB) that engineer proposal preparation tools for astronomers (both internal and external to STScI).

ODM is responsible for the day-to-day support and operations of the HST. ODM performs long-range planning, short-term scheduling, and mission critical operation utilizing software developed by ESS.

INS is responsible for the instruments on board HST. The division is organized into smaller groups that are domain experts in each instrument. For example, there is a group dedicated to the operation and calibration of the Advanced Camera for Surveys and another group dedicated to the operation and calibration of the on board spectrograph.
The STScI is physically located on the Homewood campus of the Johns Hopkins University (JHU) in Baltimore, Maryland. STScI is a not for profit, zero asset institution primarily dedicated to the operation of HST and the upcoming James Webb Space Telescope (JWST). STScI has over 400 employees. ESS is the largest division with approximately 130 total staff members.

2. Learning Opportunities

This section describes the learning opportunities that are available to STScI employees. When data is available, an example cost benefit analysis is provided. The cost analysis is meant to be as accurate as possible; however, the numbers are provided as more of an example than for their factual content. The section begins with opportunities available to individual employees upon request. Then, group educational activities follow ordered by the number of participants.

2.1. Technical Sabbaticals

Starting in 2000, ESS staff members were eligible to take 80 hours per year of technical sabbatical time. The technical sabbaticals allow engineers to research topics and technologies that they may not normally utilize in the course of their job activities. The only stipulation on the time usage is that the sabbatical must, in some way, relate to the mission of ESS or of STScI in general.

The process for completing a technical sabbatical is deliberately simple. Engineers complete a brief proposal of around 200 words stating what they intend to do with their time. They also submit a plan of how they will utilize their hours (e.g. 8 hour increments over 10 weeks). The proposal is submitted to management for approval. To date, no proposal has been rejected.

Finally, after completing the 80 hour sabbatical, the engineer is expected to produce a final output product of the lessons learned from the sabbatical. The output product does not have to be a lengthy tomb devoted to the topic. In fact, some final reports take the form of a prototype or an instructional PowerPoint slide show. Ultimately, the final output is stated in the proposal and negotiated with management.

2.1.1. Costs. Technical sabbaticals take up to 80 hours of employee time. There is additional overhead associated with writing the proposal. The final report is usually written within the 80 hours of sabbatical time; however, this is negotiated with the employee’s manager.

2.1.2. Benefits. The benefits are numerous but not necessarily obvious. Technical sabbaticals allow employees to research creative and innovative solutions to technical problems. Some employees have utilized sabbatical time to study a programming language and then provide training to the rest of ESS staff members. Other employees have examined incorporating new technologies such as speech recognition into STScI software products.

At its heart, engineering work “is essentially creative problem solving” [4]. Technical sabbaticals provide ESS staff members the freedom to explore innovative techniques and concepts that might not otherwise be available.

2.2. Planned Professional Development

Each fiscal year, employees have the opportunity to attend some planned professional development activity. The activity can be anything related to the specific job function of the employee. For example, conferences, trade shows, and off-site professional development classes fall under this category. Generally, any activity that requires off-site travel falls into this category as well.

2.2.1. Costs. The costs for professional development vary greatly depending upon the scope. In general, planned professional development is very costly in terms of out-of-pocket expenses. For example, Sun Microsystems’s JavaOne conference can cost STScI in excess of $6000 per employee plus the cost of over 40 hours of lost productivity.

2.2.2. Benefits. The obvious benefit of planned professional development is the knowledge gained from the experience. This will be true for every opportunity described in this paper. However, there are other, less obvious benefits to many learning opportunities. Attending a conference provides employees with an opportunity to travel. Hence, if an individual likes traveling, one can see professional development as a perk in this instance. Off the record talks with employees who have returned from conferences have shown an obvious increase in employee satisfaction. While this may be short-lived, it can be quite noticeable.

Of course, there is always the possibility of abuse for a policy such as this. Therefore, managers have latitude in approving training in exotic locations. However, managers are fully aware that some “questionable” training opportunities have value beyond the training itself. Hence, requests are not heavily scrutinized if funding is available.

2.3. Reading Groups
Reading groups are a staff initiated focus group used for concentrated, in-depth analysis of a specific topic. The group meets on a semi-regular basis to discuss research papers, book chapters, and specific topics related to a domain.

Since ESS is organized in branches of technical experts, the reading groups are roughly composed of branch members. Some employees from ODM also attend if the topic is of interest to operations staff. The group is chaired by a technical expert who has breadth of knowledge in the topics being covered but not necessarily depth in a particular paper’s topic. Hence, even the group chair learns from the meetings.

Experience has shown that reading groups should be kept small. When the group grows to more than 10 people, critical discussion of the paper content suffers. Since much of the learning is achieved from group interactions, larger groups can stifle critical discussion and get tied down discussing insignificant points.

2.3.1. Costs. There is no strict monetary cost associated with reading groups. The only cost to the company is the labor cost. Table 1 shows a rough breakdown of the labor costs in terms of hours of work. Please note, the chairperson of the group is also a member so the chairperson does expend significant effort in preparing the reading group.

<table>
<thead>
<tr>
<th>Member</th>
<th>Hours</th>
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<tbody>
<tr>
<td>Chair</td>
<td>10</td>
</tr>
<tr>
<td>Group member</td>
<td>(2-3) * NumberOfMembers</td>
</tr>
<tr>
<td>Group meeting</td>
<td>(1-2) * NumberOfMembers</td>
</tr>
<tr>
<td>Total Average Cost</td>
<td>10+(4*NumberOfMembers)</td>
</tr>
</tbody>
</table>

The group size ranges from 8-12 people including the group chair. From a management point of view, this represents an average cost of 42-58 hours per paper. On an individual basis, this corresponds to 4.8-5.25 hours per learner.

2.3.2. Benefits. The obvious benefit of the group is the knowledge gained from reading the research. Group members have used research paper knowledge in an effort to improve operations at STScI.

A less obvious benefit is gained from the interaction of group members. In discussing the specific topic presented in the paper, the group often times relates the topic to previous topics or other ancillary research. Although not easily quantifiable, group interactions specifically related to job functions have proven to be very valuable.

2.4. Technical Reviews

Most technical disciplines require technical reviews of some form or another. For software engineering, design reviews and code reviews are typical. In ESS, reviews are usually open to the entire division. However, most of the time, attendance is under 10 people. Presenters usually e-mail review material a few days prior to the meeting. This allows attendees to review the material and come prepared to discuss critical points.

Since reviewers are ultimately criticizing the design or code being presented, technical reviews can inspire anxiety in the person being reviewed. Instead of holding reviews after a design or code is completed, engineers are encouraged to share prototype products early in the process. In this way, engineers may not feel as attached to a particular implementation as they would have been after a product is finalized. Moreover, by holding a review as a learning experience at an early stage of a project, engineers go into a review knowing that things will change.

This approach is highly dependent upon the individual presenting the material. Individuals who are overly attached to their work may not be able to present material as a learning experience.

2.4.1. Costs. There is no out of pocket costs associated with technical reviews. Once again, the only cost associated with this task is the labor cost. Table 2 shows a rough estimate of the labor costs in terms of hours of work.

<table>
<thead>
<tr>
<th>Member</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>Presenter</td>
<td>8</td>
</tr>
<tr>
<td>Member Preparation</td>
<td>1.5 * NumberOfMembers</td>
</tr>
<tr>
<td>Group Meeting</td>
<td>1 * NumberOfMembers</td>
</tr>
<tr>
<td>Total Average Cost</td>
<td>8 + (1 * NumberOfMembers)</td>
</tr>
</tbody>
</table>

Technical reviews are not widely attended. They usually have about 10 people (including the presenter). Therefore, the average cost is 33 hours or 3.3 hours per employee.

2.4.2. Benefits. The obvious benefit is for the presenter. The presenter finds critical flaws in design or could potentially discover bugs in code. Code reviews can also show where code is unreadable or otherwise not maintainable. Hence, this allows developers to add comments or refactor code as appropriate.

A less obvious benefit is for more junior employees. Some recent work by authors such as Paul Graham
suggests that programming can be learned by examining other programs [3]. Junior engineers can learn from examining both good programs as well as bad programs. Finally, “most software is intended for a human audience” [3]. As such, authors can benefit from seeing their software from another person’s perspective. If the software is not supportable by other people, the author may be condemned to maintaining the software throughout his or her entire career.

2.5. ESS/INS Training Lecture Series

The ESS/INS Training Lecture series is open to all STScI staff. Topics vary but they are usually structured like a college level seminar. For example, the last series was an Introduction to Python Programming. Typically, topics alternate between ESS and instrument specific topics. In this way, the series helps facilitate the needs of both ESS and INS staff members. For illustration purposes, the python series is further described here.

The python series provided STScI staff the opportunity to learn elementary programming techniques and data structures of the python programming language. Python is a scripting language that is used for numerous applications both at STScI and in the astronomical community in general. Hence, having a lecture series available to both ESS as well as other institute staff was deemed very beneficial.

2.5.1. Costs. The cost depends upon two factors: 1) the cost of producing the seminar and 2) the cost of lost productivity time for staff members to attend. Obviously, these costs depend upon the author and the level of interest among STScI staff. In general, each lecture usually lasts about 1.5 hours.

The cost of producing the series is probably the easier to track since it is not dependent upon additional participation. The author of the python series estimated that he used 80 hours to produce the series. Incidentally, he used his technical sabbatical time to produce the lecture material. Table 3 shows an estimated level of effort for the lecture series:

<table>
<thead>
<tr>
<th>Member</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>Instructor</td>
<td>80</td>
</tr>
<tr>
<td>Participant</td>
<td>$1.5 \times \text{NumberOfSessions} \times \text{NumberOfParticipants}$</td>
</tr>
</tbody>
</table>

Using the python course as an example where there were 6 lectures and approximately 35 attendees, this amounts to 395 hours. On an individual basis, this corresponds to roughly 11 hours per learner.

2.5.2. Benefits. The educational benefits are obvious and will not be discussed here. In researching this paper, the author discovered a related benefit that is worth mentioning here. In general, engineers do not necessarily make the best public speakers. In fact, teaching technical material is a very difficult task. In describing his motivation for creating the introductory python course, the lecturer stated that “I enjoy a good challenge and teaching has become one of them”. Individuals who thrive on challenges can see developing a lecture series as very rewarding. Hence, the individual motivational benefit of the seminar designer is worth noting.

2.6. ESS Engineering Colloquia

The ESS Engineering Colloquia are larger, one time lecture on a specific topic. The lectures usually last 1 hour but additional time is available depending on the lecture. The lecturers can be either STScI staff or invited experts from industry and academia. Invited lecturers have included Steve Smith from Carnegie Mellon University and Marty Hall from JHU’s Applied Physics Laboratory.

Specific cost and benefit information for the colloquia is not available. However, the out of pocket costs are considerably more when a guest speaker is obtained for the lecture.

2.7. STScI Software Workshop

In 1999, STScI had its first annual software workshop. The workshop is an opportunity for technical staff to present their latest work for the entire institute to review. In 2002, the workshop was opened to allow other sister organizations to attend and participate (e.g. The National Optical Astronomy Observatory).

The workshop acts much like a conference. However, participants only present a 20-minute slide show outlining their current work. There are no articles; only presentations and posters are allowable submissions. As with all STScI educational opportunities, participation is optional.

2.7.1. Costs. The costs for the workshop vary depending on participation. Accurate numbers are difficult to obtain because the level of effort required for staff members to create presentations depends upon the staff member as well as the level of detail. Therefore, no definite costs are presented here.

2.7.2. Benefits. There are numerous benefits to the workshop. First, from the development team’s point of view, the workshop provides the opportunity to display and even boast about their software. STScI staff
members have a great deal of pride in their work; the workshop provides teams with the opportunity to show their software to their fellow peers. Second, the workshop enables peer groups of developers to interact. In modern object oriented software systems, there can be many overlapping capabilities across subsystems. The workshop describes the detailed implementation of software system and hence facilitates the reuse of design and code.

3. Employee Benefits

Most, if not all companies have some form of Human Resources initiated, organizational learning opportunities. STScI is no different and has numerous organizational initiated programs open to employees at various levels. Since HR learning opportunities are relatively common, only a cursory description of STScI’s programs are provided here. The description includes a brief summary of how the opportunity fits into the overall STScI learning community.

3.1. Tuition Refund

STScI’s tuition refund is similar to what many other organizations have available with some small changes. First, the Institute provides 6 credits of reimbursement per semester. This allows employees to take up to 18 credits per year (Fall, Spring, Summer) with complete, tax-free reimbursement. Second, the institute provides 65% of the course fees prior to enrollment. For example, if the courses cost $3000, the institute would provide $1950 prior to enrollment. The additional $1050 is reimbursed after the course is completed. Finally, STScI provides up to 3 hours per week of paid leave to attend classes.

Why is this approach more advantageous? With the rising cost of tuition, simply providing a fixed annual reimbursement can be limiting. Also, by providing a large portion of the tuition cost prior to registration, this also lowers the barriers to enrollment altogether. Finally, the work-life pressures that today’s professionals face can be staggering. By providing paid time off to attend classes, the barrier to actually attending classes is lowered.

3.1.1. Costs. The average cost for a part-time, graduate engineering course in the Baltimore area is around $2000 per 3 credits for a total of up to $12,000 per year. Obviously, this will vary depending on the university. The cost of the hours of lost productivity vary depends on the seniority of the individual. Hence, no specific data will be mentioned here.

One of the major arguments against this extensive tuition benefit has been that employees with increased job skills are more attractive to other companies and hence may be more likely to leave. However, research has shown the contrary. In fact, Nelson writes that “the more you help employees develop marketable skills, the more likely they are to stay with your organization”[1]. See Nelson’s article for additional details.

3.1.2. Benefits. The obvious benefit includes increased knowledge that can be applied on the job. A less acknowledged benefit is on employee morale and motivation. Although no quantifiable evidence is presented here, research such as Nelson’s seems to indicate that motivation is directly related to opportunities.

3.2. Other Policies

STScI has numerous policies in place to help staff develop themselves. This section highlights some of those policies. Since administrative time is not specifically tracked on a per policy basis, costs are not presented here.

STScI has a group dedicated to the administration of grants from external entities. Engineering staff members are eligible to apply for grants and have them administered and accounted for by the grants organization. In order to diversity funding sources, both technical and scientific staff members are encouraged to apply for external funding when appropriate.

STScI also has specific policies in place that allow staff members to act as outside consultants and adjunct professors. Employees merely need to submit information about the outside opportunity to HR for approval along with appropriate documents. Having a procedure in place streamlines the process and allows employees to quickly respond to adjunct positions.

4. Community Benefits

This section describes the community in which STScI is located and the opportunities afforded by its close relationship with other institutions. Each institution and its relationship to STScI is described here.

4.1. Johns Hopkins University

STScI leases space in two buildings on the Homewood campus of JHU. Members of the senior scientific staff of STScI also act as adjunct professors in the physics and astronomy department. Additionally, senior members of the technical staff act as adjuncts for the computer science department. Basically, STScI has a strong relationship with JHU. Employees benefit from
the numerous learning opportunities that are afforded by the close relationship with JHU.

4.2. University of Maryland State System

Numerous STScI staff members are graduates of the University of Maryland state system of higher education. This includes University of Maryland at College Park, University of Maryland Baltimore County, Towson University, as well as other state schools. Several of these institutions are located within an hour driving distance to STScI. Given the small proximity, STScI staff members benefit from lectures and colloquia at these institutions as well. The universities also benefit from this relationship since STScI recruits entry level engineers from U. Maryland campuses.

4.3. Goddard Space Flight Center

STScI receives a majority of its funding from NASA’s Goddard Space Flight Center (GSFC) located in Greenbelt, Maryland. GSFC is located approximately 40 minutes south of STScI. GSFC is a large NASA facility employing over 3000 civil servants and over 6000 contractors [2]. Numerous lectures, seminars, and colloquia are available to GSFC and STScI personnel. Information on learning opportunities are posted on GSFC’s website for easy access and reference.

5. Closing Remarks

The STScI provides a wide variety of learning opportunities to its employees. There are opportunities for individual as well as group learning experiences. This paper has explored the organizational costs and benefits of the learning opportunities available to STScI staff with a particular emphasis on engineering professionals.

Measuring the cost of a learning opportunity is a relatively simple task. By adding the labor costs along with the out of pocket costs, an estimated total cost can be easily calculated. Measuring the value of learning for an organization is quite a different exercise that goes beyond the scope of this paper. Additional research could examine the retention, motivation, and general employee satisfaction derived from learning opportunities.

Professional development opportunities are critical for technical, scientific, and engineering disciplines as well as numerous other careers. Organizations can examine the STScI learning model for information on one successful learning community.

6. References