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AN EXPLORATORY EVALUTION OF THE CHRISTA MCAULIFFE SPACE EDUCATION CENTER PROGRAMS

Shelley Ellington

An evaluation report submitted to the faculty of
Brigham Young University
in partial fulfillment of the requirements for the degree of

Master of Science

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ABSTRACT

An Exploratory Evaluation of the Christa McAuliffe Space Education Center Programs

by Shelley Ellington
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Master of Science

Recent calls for better education have many teachers trying out new ways to engage their students and teach them required content. In the current educational atmosphere of accountability, many people are beginning to question the effectiveness and utility of their educational programs. The Christa McAuliffe Space Education Center (CMSEC) is one such program. Key aspects addressed in this study included better understanding the essence of the CMSEC experience, whether it provides any beneficial impact to visitors, and how the CMSEC programs fit into the educational spectrum. An exploratory mixed-method design (utilizing focus groups, interviews, and surveys) was used to explore these issues. The director of the CMSEC hopes to use the information gained from investigating these questions to improve the program and to strengthen its foundation so it will survive beyond his retirement. We discovered that the CMSEC experience is based in simulation theory, very similar to other live simulation experiences that designers employ to meet similar learning outcomes. We found that much of the ambiguity that the CMSEC director identified results from ambiguous goals that are not as tightly aligned with program offerings and procedures as they could be. In order to strengthen the CMSEC programs we recommend they clarify their goals, train staff more explicitly on their goals and how to achieve them, and refine their evaluation methods to measure whether those goals are being met.

Keywords: Evaluation, Educational Simulation, Science Education

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Introduction

Recent calls for better education have many teachers trying out new ways to engage their students and teach them required content. When a small classroom initiative is particularly successful, it might expand into a full program. The Christa McAuliffe Space Education Center (CMSEC) is one such program. CMSEC director, Victor Williamson, began using a simple simulation activity in his classroom to engage students in science. This classroom initiative has grown into a small but popular education center which serves local schools and the community.

As the CMSEC program has grown, administration has been at times overwhelmed with the program's success. With increasing numbers of program participants and support staff, maintaining the functionality and integrity of the experience presents several challenges. Design and development of the education center programs, while successful, has been based on the director's intuition as an educator with the basic goal of engaging students' minds and getting them excited about science and social studies. In recent years the original intent was formalized in the statement—to practice the discipline of wonder. As the director nears retirement, he is looking at the program he created and wondering whether it can continue to function once he is no longer directing the center.

As the primary stakeholder for this evaluation, the CMSEC director believed that an evaluation could help bring some clarity to the program and contribute to its survival once he retires. A thorough evaluation would also help various stakeholders better understand the different aspects of the center and how these aspects work together.

Furthermore, an evaluation of the program and system could help identify weaknesses in the program and how the weaknesses might be overcome. The purpose of this evaluation was to describe and better understand the underlying theory of the CMSEC program and how the success of the initiative might be maintained and improved.

Evaluand

The Christa McAuliffe Space Education Center (CMSEC) is located in Pleasant Grove, Utah, housed in Central Elementary School. Unlike traditional education centers, the CMSEC does not have exhibits for visitors. The CMSEC operations are centered on a simulation experience. Visitors to the CMSEC participate as crew members on a space trip in one of the center's space ship simulators. School field trips provide about 80% of CMSEC business, but the center also provides after school and volunteer programs. Of those participating in after school and volunteer programs, 80% are return business from students who participated in a school field trip experience. The other 20% hear about the center through word-of-mouth as the CMSEC does no marketing.

School field trips. Ideally a school field trip begins before the students arrive with the teacher using pre-visit lesson plans and materials designed to prepare students for the visit. When students arrive at the CMSEC, they are greeted by a staff member, given an introduction to the CMSEC, and divided into two groups (one to go into the simulator, and one to go into a classroom experience). Students that receive the classroom lesson first are taken to the classroom and seated for their lesson. Students that enter the simulator first are taken into a hallway to review the rules of the simulator and

wait for the staff to *load* them onto the *spaceship*. Staff members call this process *loading*.

Simulator experience. The loading process begins with students standing in the school gym in front of a revolving darkroom door (called a *transporter*). They are transported onto the ship by their position (or job) on the simulated space ship which was previously assigned to them by their teacher (e.g., security guards first, regular crew members next, and commanding crew/officers—captain, first officer, and ambassador—at the end). Two at a time, students are sent through the darkroom door by their teacher or a staff member and emerge on the other side in a darkened hallway that is decorated to look like the hallway in a space ship. Sending the students through the darkroom door is called *beaming* or *transporting* them onto the ship. As the students emerge in the space ship, they are given a shirt-like costume (called their *uniform*) that designates whether they are a regular member of the crew, a commanding officer, or a security guard. Security guards also get toy space guns called *phasers*.

Once students have their uniforms on, they are led down another hallway to another transporter and are transported onto deck two of the space ship where there is a set made up of bunks, a galley, a sick bay, and a bathroom. They are led through the set to a spiral staircase that takes them up to the main set of the simulator, the star ship's bridge (see figure 1). When they go up onto the bridge students are seated at different stations according to their position. Each station (except the captain's station) has a computer, keyboard, and mouse. In addition, one station also has a phone, one has a printer, and several have extra documents to help each student in performing their job.

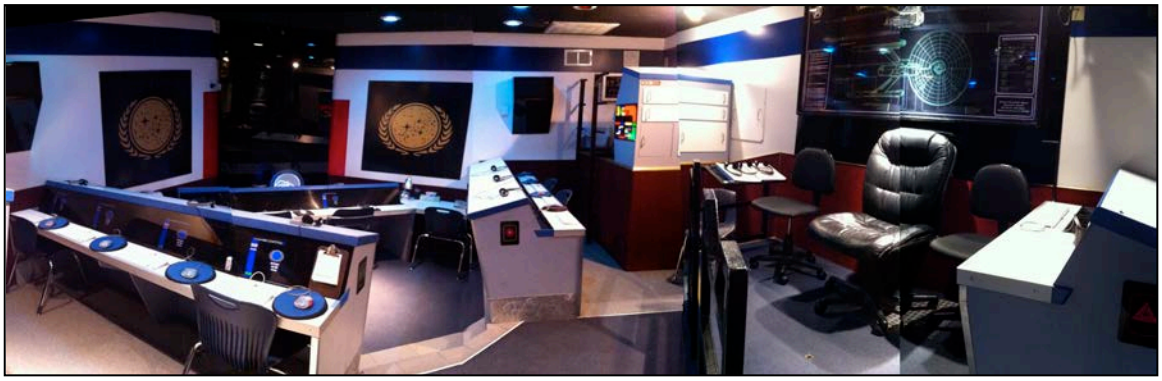

Figure 1. Half of the bridge of the simulator called Voyager

Once each of the students are seated in their positions, the director of the simulation, or flight director, reminds them of the rules and the fact that they are in a simulator acting the parts of people in the future going into space to solve problems similar to the problems we solve today. The problems they face are linked together into a complete storyline with a specific mission objective. The director reminds them of their mission and leaves the simulator (going to the flight control room, see figure 2). Music begins and over a loud speaker the director starts the simulation (and the story) by taking the part of one of two main characters. The two main characters are the chief engineer and the main computer. The chief engineer usually comes on first and tells the students that he's been working on the space ship for ten years, has seen a lot of things, and will be able to help them with some issues they might run into. Throughout the simulation, the chief engineer acts as the helper giving students feedback when they are having technical difficulties, when they aren't responding well to the simulation, when they've missed an important piece of information, or when they are making bad decisions. The chief engineer also introduces them to the main computer—a character played by the

director of the simulation with his voice altered through a voice synthesizer. The main computer acts as a helper and a reference tool. The main computer helps emphasize certain pieces of information, and answers scientific and technical questions students may have about the simulator or the universe. Using the chief engineer, the main computer, and the computers at each of the students' stations, the flight director gives students pieces of information they need to understand the problems they are facing and support them in figuring out how to solve those problems.

Figure 2. One part of the flight control room

The whole simulation usually lasts about two hours. Figure 3 shows a storyboard example of how a mission might go. The CMSEC has several storylines, each involving several problems the crew must solve. The flight director monitors the simulation from the control room and adapts the story to respond to how the crew reacts to the situation. After students complete their mission, the flight director reviews what they accomplished and congratulates them on completing their task. Students are then escorted out of the simulator and to a lunch break before going to the classroom.

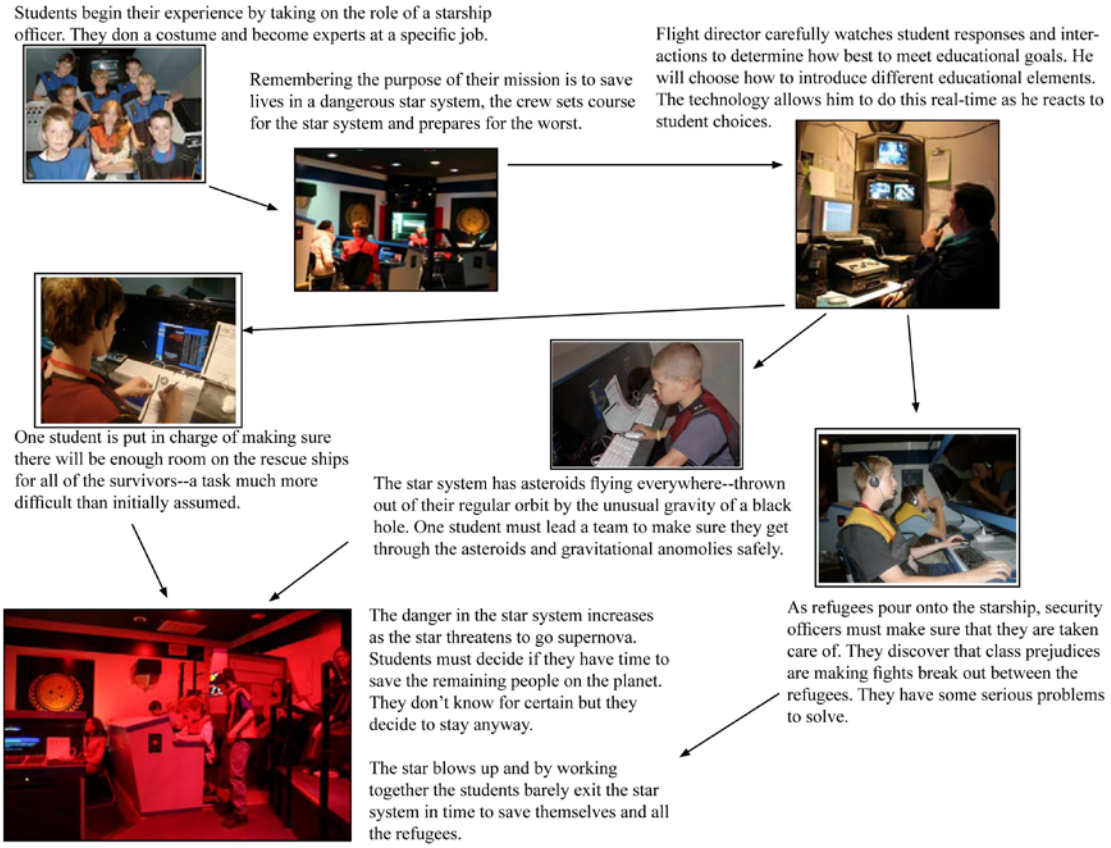

Figure 3. Storyboard Example for CMSEC Storyline 'Cry in the Dark'

Classroom experience. When students attend the classroom session, they receive a briefing on how the simulation relates to science, social studies, and what the students are currently learning in school. This briefing will be slightly different depending on whether the students attend the class before they experience the simulation or after. In addition to having a briefing they also receive a science lesson that is based on one of the critical science topics in the state's core standards that relates to the simulation. For example, one of the lessons that goes with 'Cry in the Dark' is a lesson on energy and the electromagnetic spectrum (see appendix D). The classroom lesson uses multimedia (video and pictures) and activities (interactive demonstrations) encouraging inquiry. The

inquiry involves the teacher asking questions throughout the briefing while encouraging students to ask questions about the topic. The teachers also encourage discussion between the students on the topic during the class. The class lasts approximately one hour and then the instructor takes them to a small planetarium (a vinyl inflatable bubble that holds 30 students) and gives them a brief lesson on the stars.

In the planetarium lesson, the instructor shows the students several of the notable stars in the sky (e.g., the North Star for navigating, Betelgeuse because it is the most visible red giant, and Sirius because it is the brightest star in the sky) several constellations, and some history about how humans have interacted with the heavens. The constellations used are the Greek constellations, and sometimes the instructor tells a few of the Greek myths about those specific constellations. Along with the stories of the constellations the instructor explains how the Greeks perceived the heavens and how the western perspective of the heavens has changed over time (i.e., how it was used for navigation and now is perceived as another part of the universe). The instructor talks about the different kinds of stars that are in the sky and a little bit about other galaxies. The planetarium lesson lasts about 40 minutes.

After School Simulations. The after school simulations are very similar to the school field trip simulations. The primary difference between the two is that the after school simulations are at least 30 minutes to 3 hours longer than the school visit simulations and the after-school program usually does not include the classroom and planetarium experience. The format and focus of the after-school programs varies. The focus is not aligned specifically with core curriculum objectives but geared more toward

problem-solving and higher-order cognitive processes. Some of these programs are provided as overnight experiences or birthday parties, so the format may also be adapted to the circumstance.

Volunteer Programs. Volunteer programs are experiences where previous participants volunteer to help the CMSEC. These programs come in varying degrees of formality include operating the simulators, software development, graphic development, and peer development or peer tutoring, and any other projects the volunteers want to pursue.

The volunteers who help run the center's main operations (operating and acting in the simulators) are the most formal volunteer group. The volunteers must fill out an application before they are accepted as volunteers and are usually between the ages of 10 and 14. When they are accepted, the volunteer start out by sitting and observing missions until they have attained a certain amount of hours. They keep track of their hours on a card with a magnetic strip by checking in with the director of the center when they arrive and have the director slide their volunteer card. They keep track of hours as they go through their observations for each simulator and then they are promoted to being able to participate as a *2nd chair* helper. The 2nd chair helper aids the flight director by putting things into the computer, or turning on the lights. There are several more levels that a volunteer can pass through depending on where their interests are. If a volunteer is more interested in management, then they'll study under the supervisors and eventually become a supervisor themselves. If the volunteer is interested in acting then they'll study under the actors. If they're interested in becoming a flight director, then they can study

under the flight directors. The different jobs and levels of opportunity are outlined with the outcomes each volunteer is expected to meet before they are allowed to move on to the next level (even if they do gain enough volunteer hours before becoming proficient). Older volunteers will mentor younger volunteers to help them prepare and meet the necessary proficiencies. Besides gaining proficiency on the specific jobs at the CMSEC, the volunteers gain valuable experience working with others, managing others, and meeting expectations in a work environment. To reach the higher levels (supervisor and flight director), volunteers must show high proficiency in multi-tasking, improvisation, problem solving, and many others. In this environment volunteers and staff members take part in peer development.

The software development program is a semi-formal volunteer program. The program participants all meet together on Saturdays for several hours (between 3 and 5 hours) to design and develop software for the simulators. The participants are CMSEC volunteers and staff members (ages 12-25) that have an interest in software development. Some of the older participants have gone to college and taken classes in software development but all of the participants have a self-taught foundation and several years' experience before ever receiving formal training. During their Saturday meetings, the most senior developer (usually the one that has been in the program the longest) spends 2 hours instructing them in programming in Coco (the language used to program in Mac OS) and directing them on current projects. Then they will break into groups working together and tutoring one another for the next few hours. Sometimes the flight directors

will come into the meetings as clients and meet with the developers to guide them in project specifications.

All of the software used by each of the 5 ships has always been developed by student volunteers. The main software used is the software that visitors interact with directly—the controls of the starship. Other software includes the background servers and media content and delivery systems to keep track of and deliver visual effects.

Graphic development is similar to the software development in that there are senior developers who spend time with the junior developers but the time isn't regular and the group isn't as large. Like the software developers, the graphic developers are primarily self-taught and haven't taken any classes. Their ages usually range between 12 and 17 years old. They develop both 2D and 3D graphics and videos for the simulators.

When volunteers or staff members have other projects they want to pursue then they are mentored by either senior staff members or the director of the center. For example, one staff member decided that in her spare time she wanted to design, develop, and deploy a leadership camp for older teenagers (15-17 year olds) with classes and workshops. Although she was mentored by senior staff members, they did not intervene or control her in any way. In a larger example, there have been many times a staff member or volunteer has wanted to expand the simulator by gathering money, sponsors, and constructing the simulator themselves. In each case the director of the center and senior staff members make it clear that they have limited time and can only serve as a counselor instead of an active team member on the project. And while many projects

flounder and eventually die, there are many projects (like leadership camp and additional simulators) that are successful.

In general, efforts to create new materials, software, graphics, or simulators are all done as volunteers or staff members see a need and volunteer their time to do it. They don't keep formal records or documentation of design decisions made or changes implemented, and usually the only person involved, besides the one doing the work, is the person's direct supervisor. If a project is successful than the director of the center will provide funding and encourage the volunteer to continue pursuing their projects.

Stakeholders

The primary stakeholder for this evaluation was the director of the CMSEC, Victor Williamson. He created the center, has been operating it for 19 years, and would one day like to see it replicated. Williamson is preparing to retire in a few years, and he wants to make sure the program is solid and prepared for him to leave. His opinion is that this evaluation of the center and the program will strengthen it and give it a more solid foundation.

Secondary stakeholders include the students who attend the CMSEC programs, the teachers and administrators who support the programs, and the staff members who operate the programs. The students are primarily fifth and sixth graders who come and participate with their class—once in fifth grade and once in sixth grade. Teachers and administrators are primarily teachers who bring their students to participate in the program and administrators who give permission for students to attend. Staff members range in age from children age ten and up through adults of all ages and span a spectrum

of experience. All of these stakeholders may be benefited by the evaluation as far as it improves the experience at the CMSEC.

Other stakeholders might include students, teachers, and administers in other schools outside the CMSEC area that would benefit from the program if it were replicated and transferred to their area. If the evaluation contributes to the replication and transfer of the CMSEC experience to other schools, these stakeholders would benefit by having the possibility of creating a simulation in their area. Furthermore, the results of this evaluation might help these stakeholders make decisions regarding the implementation of a program similar to the CMSEC in their area.

Previous Work

In 1993, Rogers conducted a preliminary study on the visitors' response to the center. He administered questionnaires to participants who attended the school field trip and the overnight programs. Rogers provided a foundational idea about what participants think about their experience and how they feel after the experience—the basics of how participants are affected by the experience. He found that, in general, students reported feeling better about themselves and their abilities after the experience and identified students' self-perception after the CMSEC experience as an area that needed further research.

Evaluator

I, Shelley Ellington, am the primary investigator for this evaluation. I am currently a graduate student at Brigham Young University in the Instructional

Psychology and Technology department. I had my first encounter with the CMSEC when I was in elementary school and attended their school field trip program. Through friends I attended more of their programs and volunteered at the center on occasion over the next several years until I began working there part-time in 2003. I stopped working part time in 2004 and continued to do volunteer work periodically and remained up to date on the things that the CMSEC was doing.

While I worked there, the instructional aspects of the program intrigued me. It influenced my decision to pursue secondary science education and later instructional design. Although I stopped working there regularly in 2004, I have remained intrigued by the experience students have when they participate in the field trip and I have wanted to understand it better.

Considering my relationship to the center, I am in a unique position to conduct this evaluation. I have an insider's understanding of how the CMSEC runs, and I have an external responsibility to conduct the evaluation. My previous involvement with staff members would seem to position me as an insider. My volunteer work however has been limited and usually amounted to no more than five hours per month, I am not involved in the day-to-day workings of the center. This aspect of my interaction with the center would position me as an external evaluator. The truth is somewhere in the middle. Because I did enough work to develop a relationship with the center, my knowledge allows me a better understanding of how the center is run but not enough involvement to be part of the administration. This will help as I analyze the different pieces of the center and conduct interviews.

Background in Simulation Theory

As the purpose of this evaluation is to describe and better understand the underlying theory of the Christa McAuliffe Space Education Center (CMSEC), comparing the program to literature on similar programs can provide a solid foundation. Finding relevant literature was an exploratory experience since the CMSEC program doesn't identify with any specific type of educational offering, method, or theory. But after an examination of several different areas of literature, I discovered that the only literature truly relevant to the operation, and improvement of the CMSEC program was simulation literature. The simulation literature looks at what simulations are and what they should do—providing insight into how the CMSEC can strengthen its programs.

Attributes of Simulators and Simulations

Strictly speaking a *simulator* is a set of models that represent a real-world system. The term simulator refers to the models themselves—both physically and mechanically. Using a simulator, a scenario is put together, and that is a simulation. To make a simulation educational, a designer adds scenarios that take instructional objectives into consideration. The government and many other groups have been researching best design for educational (and training) simulators for several years. Since the CMSEC programs are driven by the simulator activities, evaluating the CMSEC simulator is a good foundation for evaluating the CMSEC's programs and activities.

When designing an educational simulator, it is ideal for designers and engineers to consider the instructional objectives and determine the type of simulator that will best

meet those objectives (Quinn 2005). The U.S. Department of Defense (1997) identified three types of simulations for a designer to consider: *live simulations* (i.e., real people interacting within simulated systems), *virtual simulations* (i.e., real people controlling simulated people—avatars—interacting within the simulated systems), and *constructive simulations* (i.e., simulated characters interacting with simulated systems in which humans do not determine the scenario outcomes). The designers of an educational simulation determine the kind of fidelity that will be required to best support learners as they interact or observe the simulation. They decide whether the simulator must have *high fidelity* (i.e, objects or tasks in the simulator closely represent the objects or tasks in real life), *low fidelity* (i.e., the objects or tasks in the simulator don't closely represent the objects or tasks in real life), or some mixture of high and low fidelity. Fidelity can be applied to different aspects of the simulation. For example, *physical fidelity* applies to the physical surroundings in the environment that is being modeled and how realistic they need to be. *Cognitive fidelity* refers to the cognitive tasks the learner must perform and how realistic they need to be (Jacob & Dempsey 1993; Hays & Singer 1989; Alessi 1988; Alessi 2000).

Simulator types can be further categorized by the types of learning outcomes they are intended to address. The main kinds of learning outcomes simulators are used to teach include *physical learning outcomes* in which the student must learn to perform or become proficient at some kind of physical task. There are also *cognitive outcomes* in which the student must learn to perform or become proficient at a cognitive task. To meet physical learning outcomes it is important that a simulator has high physical

fidelity. That is to say the physical tasks students perform in the simulator should be very similar to the physical tasks that students must perform once they have completed the simulation training. For example, in a simulation where military personnel are learning or practicing aircraft operation, it is important that the physical surroundings (buttons, switches, etc.) accurately model the physical surroundings in the actual aircraft. It might be less essential that the decisions they'll have to make while in the aircraft are modeled as accurately. To meet cognitive learning outcomes, it is important that the simulator has high cognitive fidelity. For example, a group of upper-level management may need training or practice in decision-making (a cognitive learning outcome) and so it would be essential that the cognitive tasks they engage in accurately model the cognitive tasks they are expected to learn but this could be represented in a 2-D board game because it is not necessarily essential that the simulation accurately depict the physical surroundings in which they'll make those decisions.

Within the learning outcome types, simulators can further be broken down by the way they will be used (i.e., to educate, train, practice, assess, motivate students toward learning the outcome, or reward students' performance of the outcome). What activities the learner will engage in during the simulation will be directed by the purpose of the simulation and the success of the simulation will be determined by whether it helps students accomplish the intended learning outcomes (Quinn, 2005; Gatto 1993).

Nature of the CMSEC Simulation

The CMSEC's simulator attempts to establish physical fidelity for a fictional system (i.e., a fictional starship in a fictional universe). This is done to provide a realistic

model in which specific cognitive outcomes can be taught (i.e., information processing, problem-solving, and teamwork). The story in each scenario provides the context for the simulation. In order to get participants to engage in the cognitive systems being simulated, it is necessary to make sure the physical systems are not too distracting but realistic enough for the participants to suspend reality and engage in the exercise. The CMSEC simulators (i.e., spaceships) utilize lighting, images, and props (e.g., simple computer technology) to unobtrusively provide participants with information they need to work through the scenario. The simulations that the CMSEC develops (i.e., problem-laden stories) are the vehicle through which the participants learn the intended cognitive outcomes and get practice using the cognitive skills they are supposed to develop in the simulation.

Evaluation Design

This evaluation focused on describing the Christa McAuliffe Space Education Center (CMSEC) in terms of the design decisions they have made in developing and maintaining their programs with a brief objectives-based look at the results of their design decisions (whether they ended up doing what they thought they were doing). As principle investigator I began with observations to get a more thorough understanding of the CMSEC (processes, procedures, culture, etc.). I analyzed the processes, procedures, and culture and then spent time with the stakeholders to refine the evaluation questions—we wanted to pinpoint exactly what they wanted to know and how it would be best to get that information. After some discussion, we decided it would be most beneficial to better understand and document the *essence* of the center (what makes it what it is) and to

discover what visitors are getting out of the experience (whether there is a beneficial impact for visitors). An additional outcome of the evaluation that Mr. Williamson wanted is to know how the center he has built relates to other centers of learning in specific and what his center contributes in the broader educational spectrum. The evaluation questions are as follows:

1. What is the *essence* of the CMSEC?
2. What beneficial impact, if any, does participation at the CMSEC have for visitors?
3. How does the CMSEC fit into the broader educational spectrum?

The word *essence* is not very descriptive but it is the word that the director of the CMSEC used continually. Throughout the study I interpreted this word to mean the foundations or core purpose of the center—what makes the CMSEC what it is. The director of the CMSEC acknowledged this although he continued to use the word essence in communications. Additional terminology that I wrestled with appears in the third question involving the 'broader educational spectrum.' This phrase reflects the ambiguity with which the director of the CMSEC and other staff members view their programs in the context of education in general. They realize that their programs are very different from a regular classroom experience but they were not sure whether their programs are more similar to a field trip experience (i.e., a museum or science center), whether their programs are more like an after-school club (e.g., the YMCA), or whether their programs would be better placed along-side roller-coaster rides, video games, or table-top role-playing games. To reflect their desire to know more about their program in the context of

other experiences, I chose to ask the question of how does the CMSEC fit in the broader educational spectrum.

Methodology and Approach

To answer these questions, a number of techniques were used to gather, examine, and cross-examine the data. These techniques were specific to the evaluation question being addressed and whether we were working through an exploratory lens or the objectives-based lens. Initially, I set out on the evaluation anticipating it to be an objectives-based case study. Although I wasn't influence by any single theorist, my approach was influenced by several people throughout the literature (e.g., Schwandt 2002; Stufflebeam & Shinkfield 2007). As I got further into the study, I realized that the CMSEC had such an unclear idea of what the center was and that it would be better to conduct the evaluation as a descriptive exploration of what the center is from the perspective of those running the center. To determine proper methodologies for this sort of approach I consulted literature on evaluating informal learning environments and was most influenced by Rahm 2004; Brody, Bangert, & Dillon 2008; and Davidsson & Jakobsson 2009. These authors had experience evaluating similar programs and by reading their experiences, I was able to determine some of the best methods for approaching this sort of situation (e.g., conducting interviews and focus groups, and committing a significant amount of time to observation).

The question of essence and the question of the broader educational spectrum were primarily considered using an exploratory lens using a descriptive approach in an attempt to better understand and articulate the workings of the CMSEC. The question on

beneficial impact was primarily considered under the objectives-based lens, looking for evidence that program objectives were being met.

Data Collection and Analysis

The Question of Essence: What is the Essence of the CMESC. Answering question one began with observations to create a foundational schema for the organization, processes, discourse, culture, and workings of the CMSEC. I sat in on staff meetings, simulation experiences, and in the office commons area listening and recording staff and visitors comments and behavior as they interacted and went about their activities. Analyzing the results of those observations led to preliminary conclusions. Member-checks were conducted to determine whether these observations were accurate and what the next course of action should be. I decided to conduct focus groups with higher-level staff members to further develop the information I was gathering and so I obtained informed consent documentation to conduct a 90 minute focus-group with senior simulator staff and another 30 minute focus-group with senior educational staff (teachers in charge of the classroom and planetarium). As I analyzed the information from focus groups, I decided that follow-up interviews were needed to explore specific topics, issues, and concerns that were raised in the focus groups. These follow-up interviews were four 5-minute discussions with individuals from the staff member focus group. After more analysis, I put together a general staff survey, posted it online and advertised it through the CMSEC director on the staff-member yahoo group forum.

Final analysis on the question of essence included thematic analysis of notes, combining results obtained from researching the other two questions (i.e., the questions

on beneficial impact and broader educational spectrum), and categorizing the information as seemed appropriate. This process established general categories of the operational essence of the simulator (the intended theoretical foundation) and the experienced essence of the simulator from the perspective of members and patrons. These specific categories describe the different features of the CMSEC (what characteristics make up its essence).

The Question of Beneficial Impact: What beneficial impact, if any, does participation at the CMSEC have for visitors? Answering the question on beneficial impact began with a review Rogers (1993) did and an attempt to help stakeholders be more specific in describing their learning outcomes. Although stakeholders consistently cited only general learning outcomes, a survey was put together to administer to visitors. I compiled the survey and it was reviewed by a consulting evaluator (Dr. Randy Davies) before being given to a student to test for readability and validity. Then the survey was administered online (a link to the survey was emailed directly to teachers who participated in field trips). And the survey was administered in a paper and pencil format to after-school groups. All groups who attended a CMSEC program during the specific time-frame of the evaluation were invited to provide their feedback by completing the survey.

Several survey questions measured affective characteristics, whether there was any change in visitor perceptions of their confidence levels in social situations, affinity towards science, affinity toward science activities, and whether they thought that they learned anything from the experience (see survey in appendix A). Several of the

questions on the survey were demographic, asking what age group students were in, how many times they had attended the CMSEC previously, and whether they were male or female. The data was gathered over a one month period of time. Affective questions were rated on likert scales and then treated as interval data and analyzed with an independent t-test to see if there is any significant difference between visitor responses before and after their experience in the simulator. Perception and experience questions were analyzed looking both at frequencies and any differences in the response distribution as measured by a chi-squared goodness of fit analysis.

The Question of Broader Educational Spectrum: How Does the CMSEC Fit into the Broader Educational Spectrum? To answer the question of the broader educational spectrum I conducted a literature review to explore how different aspects of the CMSEC are similar to and different from other experiences. As I found answers, I checked conclusions with staff members at the CMSEC as well as contacts within the different disciplines being researched. Aspects of the CMSEC were compared to aspects of other learning experiences which provided a clear picture of how the CMSEC fits within the larger learning community.

Results and Discussion

Since this evaluation was exploratory, it turned out many more results than would be appropriately addressed in a traditional “results” section. Thus, I and my advisor have decided that only the most relevant findings will be presented here.

Question 1: What is the Essence of the CMESC

In describing the essence of the Christa McAuliffe Space Education Center (CMSEC), I decided to consider it primarily in terms of the program goals and the way the staff and volunteers run the programs. In other words, comparing the intended with the actual implementation. The CMSEC has a set of programs that are all centered around the operation of a simulator. Figure 4 shows a simple representation of the programs that visitors attend and the various aspects of the simulator that make it what it is. In conceptualizing the Evaluand, it is important to remember that a strong staff and volunteer culture affect the whole center.

As mentioned previously, the school field trips make up about 80% of the business that the CMSEC does. These field trips usually are the first encounter a visitor has with the CMSEC. Both the volunteer programs and the after-school field trips are comprised of 72% return business from students who attended the school field trip; the other 28% of CMSEC business come from word-of-mouth. The CMSEC draws volunteers into their volunteer programs from their return visitors. When someone has been part of the volunteer programs for some time they may be invited to join the paid staff. The staff and volunteers develop and maintain all of the components that go into the simulation experience (the control system, the physical setting, and the scenarios).

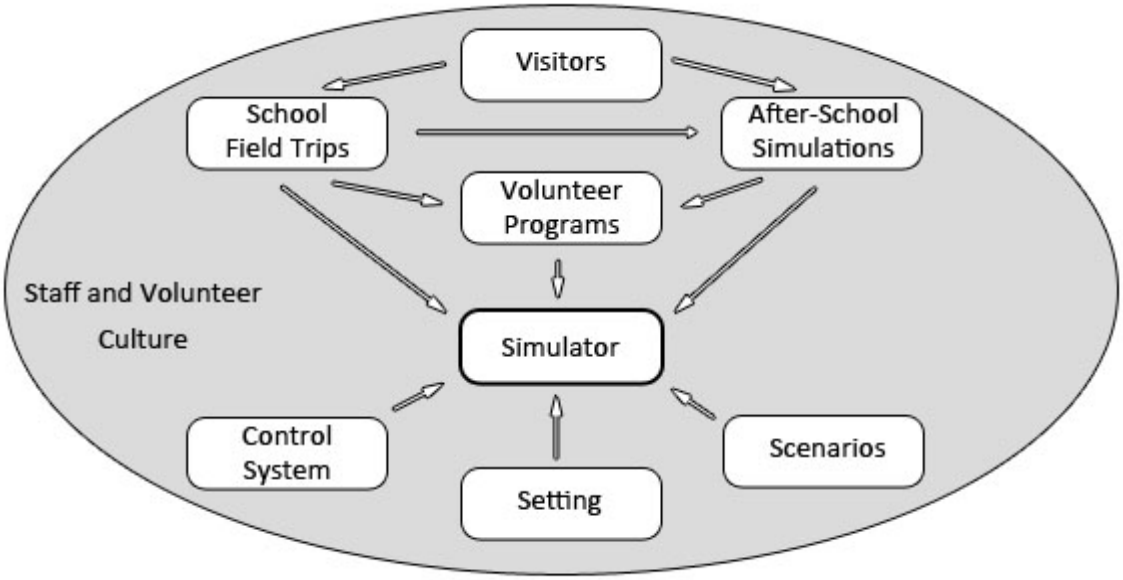

Figure 4. *A simplified representation of the CMSEC program interactions*

The choices that staff members make in operating and innovating the center are guided by a culture and oral tradition that has been established by the center director and is propagated by a rich discourse and informal interchange between the director, the paid staff, and the volunteers. That culture, the goals of the center, and the way staff members run the center constitute the theoretical foundation or essence of the CMSEC. In an attempt to communicate the purpose and function of the CMSEC, the director recently crafted the following mission statement for the center—practice the discipline of wonder. As an objective for the center, this phrase is vague in terms of what the center tries to accomplish. Unfortunately, like this mission statement, the learning outcomes and other goals of the center are somewhat ambiguous and encompass a diverse set of possible outcomes depending on where you look and who you ask. The director has an idea of what he wants and has passed down his ideals, goals, and outcomes for the CMSEC using

an oral tradition. In addition, the director has transmitted some of his ideas in a few formal documents (e.g., flyers and an entertaining and informative newsletter-like blog).

While this is a culture of excellence, hard work, and passion many aspects of the experience remain ambiguous. Finding the essence of the CMSEC has largely been a task of distilling distinct information obtained from various sources. For example comparing the formal documentation with perceived and stated goals of staff and volunteers, along with the actual implementation of the program. A significant part of the evaluation involved articulating and reconciling divergent viewpoints of the center's goals and objectives and aligning center activities and potential outcomes with intended and actual implementation actions.

As I observed and interviewed various staff and volunteers I found that there were four distinct sets of goals:

1. Connect the experience to classroom curriculum and core standards through pre- and post- visit lesson plans and assignments.
2. Teach problem solving and teamwork skills in the simulation by introducing the basic principles and then scaffolding students through practice.
3. Improve participant's academic and social self-efficacy by giving them success (to complement any failures) as they become more proficient in problem solving and teamwork.
4. Engage the participants and make sure they have a fun experience.

When staff members and I discussed each set of goals individually, each set seemed to encompass what the CMSEC programs were about on their own and when

discussed together, staff and volunteers insisted that these goals were all part of the experience offered at the CMSEC. With such a diverse and ambiguous set of expected outcomes, the CMSEC cannot reliably say that they are providing deep or consistent results. If each program at the CMSEC had its own specific goals that were clearly understood then the staff and volunteers at the CMSEC would have a clearer understanding of the essence of the center, what benefit their visitors receive, and where the CMSEC fits in the educational spectrum. Furthermore, having a clearer idea of the goals they are working toward will strengthen the programs they offer by providing more consistently obtained outcomes.

The four sets of goals came from three different sources: what little formal documentation exists, observations I made of staff members' actions, and day-to-day discourse among staff and volunteers.

Formal Documentation. As mentioned previously, the CMSEC has documented very few things formally. Of their documentation 60% is scripts. The scripts give very basic directions on running certain scenarios in certain simulators in the form of story points and accompanying actions the simulation director is expected to take. About 20% of their documentation is in the form of newsletter-like communications through their website; a staff, volunteer, and supporter message group (yahoo groups); and a public blog (http://voyagerslog.blogspot.com/). About 10% of their documentation is in the form of lesson plans and instructions to teachers on how they should prepare their students for a field trip to the CMSEC. And the remaining 10% is administrative documentation.

Although the story scripts may be heavily modified from one simulation to the next, the core of the script is taken from a story written by one of the teachers who assists (or has assisted) the director in running the center. In interviews, the story writers explained that they took their ideas from historic events and wrote an exciting drama that would engage the participants, get the participants to think about certain concepts, and pose a problem that students would have to go home and solve in preparation for another simulation experience. Although it has been several years since the CMSEC has offered visitors the option of participating in a series of simulations that are connected to one another, the original intent behind the stories is still evident in recent stories they've written and old stories they've continued to use. Since the CMSEC does not offer simulations in a series format like they used to, the objective of having participants leave considering a problem to research and solve has diminished significantly and has been replaced by a set of lesson plans that are intended to be used in conjunction with student curriculum for field trips. The objective of the stories (and thus the scripts) is to guide participants through a set of problems that will require them to think about issues relevant to content they have been (or will be) studying in their regular classrooms.

The newsletter-like communications are stories and thoughts from the director of the center about things they have been doing and whatever is on his mind. Without a thorough inventory of the director's posts, I read through several on random days and estimate that the bulk of the posts are related to academics (what schools are teaching, how schools are functioning) and how that is relevant to their endeavors at the CMSEC.

The rest of the posts are simple entries describing which schools attended the CMSEC for their field trips.

Most of the lesson plans used are available on the CMSEC website and are sent to teachers when teachers sign up for a field trip are written with clear lesson objectives that tie directly to state core standards for science and social studies. The CMSEC expects students coming on field trips to have these lessons in conjunction with the CMSEC experience (as either a pre-visit or post-visit experience). The other lesson plans are used in the CMSEC field trip program to add academic value to the experience. The director of the center is concerned that the simulation doesn't have enough academic content on its own so he makes certain that there is also a classroom and planetarium lesson that are heavy with curriculum-centered content that directly relates to the state core standards.

Considering the nature of 90% of their documentation (curriculum founded stories, academic-focused newsletters, and standards-based lesson plans) the goals of the CMSEC appear to be primarily academic and curriculum-centered.

Implementation Practices. The actions of staff members and volunteers who interact with participants resemble the actions of a highly involved teacher. They carefully guide and scaffold participants through activities in the simulation much like a teacher guides students through a new task or process. Furthermore the staff members spend the bulk of their energy in the simulation watching participant responses to see whether or not the participants are picking up on the information necessary to solve the next problem. Then the staff member will figure out ways they can most strategically get participants the needed information so that participants can solve the problems with as

little scaffolding as possible. Staff members are most energized about a group of participants when the participants are using given information and tools to correctly solve problems with minimal scaffolding. Thus, the nature of staff and volunteer actions in the CMSEC programs would make the goals appear to be teaching cognitive tasks in a group setting—how to take and use information appropriately to solve problems in a group setting.

Considering the CMSEC simulation in context of the literature, the CMSEC is a live simulation (live people interacting with simulated systems) that is covering a wide array of higher order learning outcomes broadly (instead of few learning outcomes in depth). The simulation is primarily used to practice several higher order cognitive learning outcomes, motivate students toward seeking out lower order cognitive learning outcomes on their own, and reward students for having done their work previously. The learning outcomes are primarily cognitive learning outcomes and ought to have high fidelity in its representation of the cognitive skills students are expected to practice. A few minor learning outcomes that have been mentioned at times by the director include psycho-motor tasks in which learners must correctly use computers and correctly interact with other people.

The learning outcomes the CMSEC hopes to accomplish are accomplished in the simulation through the use of a control system, different settings, and scenarios. The way the simulator is put together and the way it delivers the instructional material will be considered in the context of the control system, the different settings used, and the scenarios used.

Control System. The CMSEC control system is a system of inputs and outputs through which the simulation visitors interact with the simulation director and staff members. The control system includes verbal cues between the visitors and staff members in the form of role play to communicate decisions about the situations; software that staff and visitors use to convey decisions about the operation of the star ship; and lighting effects, sound effects, and music that staff members use to convey the state of the star ship and the severity of the situation. The control system is designed to perform like a space ship from science fiction movies like Star Trek. It does not have the fidelity of a real space shuttle as they are currently developed by NASA but it provides a sufficient physical environment to allow students to perform the physical tasks relevant to the instruction (interact face-to-face with others and perform basic tasks on computers).

The control system isn't built as a model of a physical system (to teach learners how to interact with a physical system), it is a model of a cognitive system—how problems are solved and decisions are made. Thus, the control system is used to provide pieces of information (just as information would come into the mind in a decision-making process) and staff members walk the learners through the process of what to do with the information and how to use it properly. Unfortunately, although teaching cognitive processes is an underlying purpose that I could sense in observations and discussions, staff members at the CMSEC don't explicitly realize that this is their goal or that this is the purpose of the simulator. The result is that the simulator control system can have a variety of effects on learners instead of a single purposeful one.

At the beginning of the mission students' actions are heavily scaffolded through the decision-making process as the director tells them exactly where to look for which pieces of information, what to do with those pieces of information, and what questions to ask themselves. As students grow accustomed to looking to their computers (and each other) for information and looking to each other to solve the problems they start asking better questions and start responding with better answers. The pieces of information given them usually include scientific facts (like the position and state of planets, stars, and other celestial objects nearby), and story facts (like the position and state of their ship or other characters nearby). The problems students face in the simulator are crafted to require them to critically think through both scientific and social problems (usually requiring them to make ethical decisions) using the facts they receive. Students are allowed to use the chief engineer and the main computer to help clarify facts they've received or as a method to get more information. The director can also use these two characters to help students learn how to put facts together to solve problems and as the simulation progresses, the flight director gives the learners more less scaffolding so they solve problems on their own.

With proper scaffolding and guidance through the different problems, the students as a group usually make it through an entire mission successfully (reach their goal) without having any large failures, but sometimes when their choices are exceptionally bad or they are not responding to the help provided to them, then the result is that their ship will be destroyed and they will all 'die.' At that point the sound and lights are all turned off and the director of the simulator talks to them more explicitly about what they

think they've done wrong, what he noticed they've done wrong and what ideas they have about approaching the situation differently. He discusses which pieces of information they missed or used incorrectly and how they could more correctly use the information if they were re-do the situation. Then he allows them the chance to re-do the situation.

Unfortunately, since the flight directors are not explicitly aware of what they are doing (their goals are ambiguous and driven by oral tradition) each of the learners may not be experiencing the simulation as a cognitive learning experience even if the whole group may seem to be. When asked how they make the decisions of what to do next while directing the simulation, flight directors didn't make reference to using the control system to accomplish their goals but their comments only implied a use of the control system. Some representative responses are shown below:

> B: but I don't think that it's a conscious decision, it's more of a subconscious "wait, what can I do to make that kid feel important?"
>
> M: I don't know that, you just said that that was subconscious. I think it might be now but it's just because you're so used to it, y'know, we just, we don't really think about it, we look up and think "okay, this person isn't doing anything, what can I do to give them something to do.
>
> B: it's habitual.
>
> M: or y'know, my captain, the captain's not the one giving orders, how do I fix that. And so at one point it was probably a conscious effort and I had to say, y'know, looking at like I'm training Kevin to be a flight director and I look at him and he can't tell "oh this person's not doing anything, how can I fix that." He can't, he is not to that level yet.

These responses reflect the ambiguity in the flight directors' goals in the general statements 'what can I give [this person] to do' or what can I do to make that kid feel important' and also in the lack of a strategy to accomplish their goals. This reflects the conclusions that flight directors are unaware of what they are doing when they are using

the control system and that they are not strategically working toward specific goals. Furthermore observations of the learners in the simulation confirm the conclusion that some of the students became actively engaged in obtaining and utilizing information to solve problems, some watched the action going on around them without engaging, and other learners engaged in activities that did not require higher level cognitive reasoning but where meant to keep the learner busy.

Also, the control system is underutilized as a tool when flight directors place greater focus on another aspect of the simulator—establishing the setting or relaying the scenario. When this happens, the experience can become more entertainment than education. Furthermore because the flight director is working with whole groups of students, some of them will get more attention than others and thus may get an educational experience while others get merely an entertaining experience. All of these factors come together in varying degrees during a simulation and change from simulation to simulation and from flight director to flight director. If the flight directors had a clearer idea of the learning outcomes they were trying to accomplish in each simulation and how the flight directors were supposed to accomplish those goals, the outcomes of the simulations would be more reliable and more educationally sound.

Setting. The setting is comprised of the set and the costumes that visitors wear to help them suspend reality and disbelief. It increases buy-in to the game-like characteristics of the simulation. While the setting could be used to help flight directors give participants a closer connection to the curriculum, or to provide a higher fidelity in the cognitive skills participants learn, it is often underutilized. Often the flight director

gives only a bare setting of where the students are, what people or objects are around them, and how the people or objects can be interacted with.

Scenario. The scenarios are a combination of specific problems, the story, and specific control system visuals that are used to convey a specific set of ideas. Each scenario will have a specific focus on different problems and learning outcomes. Scenarios will usually be written down to help the flight director and staff run the simulation in a similar way each time the scenario is used. They are written with a technical script giving the flight director basic directions on using the control system to tell the story and deliver the problems. Some scenarios are documented with more information like a summary of the story, a description of the visuals used in the scenario, or a description of the characters visitors should encounter in the scenario. Flight directors loosely follow the storylines provided and change it however they see fit to accomplish the goals in their oral tradition. But it is in the storylines that flight directors most frequently place the strongest emphasis. They use the stories to entertain, to bolster participant's confidence, and to put the participants in problem-solving situations. Unfortunately, since the flight directors don't have training in structuring problem-solving situations, they often sacrifice that aspect for the others (entertaining and improving confidence).

Discourse and Oral Tradition. There were two main themes in listening to the discourse between staff members. One theme was a continuation of the goal that staff members are teaching a cognitive skill and the other theme was a goal of improving academic and social self-efficacy.

About 90% of the observed interactions were discussions between staff members and were either anecdotes about mistakes that were made (by staff members or visitors), anecdotes about successes, or discussion of how to improve the experience (for visitors and other staff members). When staff members told stories about mistakes that were made, the anecdote was told the same whether the mistake was made by the individual telling the story, another staff member, or a visitor. I noticed the stories could be classified in two groups—stories that were closed (nothing could be done to prevent the same circumstance in the future) and stories that were open (something could be done and the topic was an invitation for discussion among other staff members). When staff members engaged in conversation about improving the experience, it was primarily staff members who were close in age and had a similar amount of CMSEC experience that participated in the conversation. Discussions on improving the experience varied from discussing mechanical changes that could be made to the physical aspects of the simulator, content changes to the scenario or setting or to the program offerings themselves. From the conversations, I drew the conclusion that staff members felt like they were teachers in a sense and that they are guiding visitors through a cognitive learning experience. The other 10% of interactions were directions to one another about things that needed to be done. The content of these interactions varied from repairs and maintenance to specifics regarding how to interact with visitors.

When confronted directly in a focus group about the goals of the CMSEC they responded by talking about it as if it was a confidence course whose aim is to improve academic and social self-efficacy. Representative responses are below:

> B: I think the goal, or at least to me, the goal of the space center is to help the kids become something that they didn't think they could be and that we put them in situations where they are bigger than they really are.
> M: Kind of with that, we are trying to instill more confidence in them. Y'know, if you put them in whatever position it is, we always try to make them important and feel like 'I made a difference' and then they can y'know, take that and put it somewhere else.
> J: I think that also it kind of lets kids come out of their shells that they have. They have either like maybe, either a social barrier or something and it really helps them come out of it.
> C: it really gives them a chance to be themselves, instead of y'know the person they see in school or the shy little quiet kid in the corner, they get to come out and do whatever.
> E: My turn. Um, well, a lot of the things that I've already thought of have already been said. so I guess I have to think of something unique and original. I think that the situation we're putting them in, in the futuristic simulator not only accomplishes those things but also gives them a broader vision of what the future could be like and inspires them to want that future for themselves.

Discourse between staff members and volunteers supports the objective of teaching cognitive skills and adds an objective of improving participants' academic and social self-efficacy.

Another aspect of the CMSEC discourse that is apparent is the difference they see between the school field trip experiences and the after-school experiences. When asked what the difference is, their responses indicate that the field trip experience is more rushed (i.e., staff do not have as much time to run students through the simulation) and it is more important that certain content areas are addressed. With the after-school experiences staff members indicate having more time to develop problems in the storyline and allow the participants to work through difficult issues they encounter.

When talking about the difference, staff members felt pressured to mold the after-school experience to the expectation of the participant because they are paying for it. They say that this usually means a more problem-solving experience but also means that they must consider how much fun the participants are having. They want to make sure that participants get their money's worth.

Regarding the goals of the CMSEC, there isn't a clear delineation of all of the goals and outcomes that staff members and volunteers hope to achieve. There are four distinct and different sets of goals that are evident in the CMSEC's formal documentation, their actions, and their discourse. The fourth goal (i.e., having fun) is found throughout each of the three areas (i.e., documentation, implementation, and discourse). Although it was not as prominent or evident as the other goals described in each section in terms of what was said or observed, it was very apparent that having fun was an essential aspect of the simulation. After numerous observations and interviews, I think that these four goal sets are what constitute the essence of the CMSEC experience. If the CMSEC staff and volunteers were more aware of the goals that make the CMSEC experience what it is then they could get a deeper, more consistent, and more measurable outcome of what the CMSEC is doing for its visitors.

Question 2: What beneficial impact, if any, does participation at the CMSEC have for visitors?

The method decided upon to measure beneficial impact was a survey to the visitors with general constructs addressing the items mentioned in the staff focus group. Unfortunately, the informal environment at the CMSEC didn't respond well to having a

formal survey administered. The senior staff members wanted to administer the survey themselves when it seemed most unobtrusive for the visitors and although the survey was designed as a pre- and post- test, the staff members did not keep track of who took which test so in final analysis there was no way the tests could be paired. It is possible that the same groups were not given the surveys both before and after their experience—the pre-surveys and post- surveys may actually be independent samples of a group that had not had the intervention and a group that did have the intervention. Another problem was found in that it was assumed that those completing the pre-visit surveys had never attended a program at the CMSEC but when the surveys came back (there was a question asking how many times they had attended) I found that 72% of those taking the pre-visit survey were return customers. (See Table 1).

Table 1

How many times have you been to the CMSEC?

	Never attended before	Attended 1-3 times	Attended 4+ times	Total count
Number of students	103	187	82	372

Although there were data gathering errors, a few items on the post experience survey provide some indication of the center's impact. The post-survey asked about what participants learned in the simulator, in the classroom, and in the planetarium. The summary of that data can be found in Tables 2-4.

Table 2

Summary of What Students Learned From the CMSEC Simulation

	School Field Trips		After-school Simulations	
Students Indicated Learning	count	%	count	%
Working with teams or people	44	39%	23	31.5%
No learning	20	17.7%	14	19.2%
Working the CMSEC simulator	20	17.7%	11	15%
Science/technology content	16	14.2%	5	6.8%
Problem solving skills	7	6.2%	6	8.2%
Social or Academic Self-efficacy	5	4.4%	4	5.5%
Other, non-specific (e.g., ‘stuff’)	3	2.7%	3	4.1%
Fun	2	1.8%	6	8.2%
Total responses	113		73	

Table 3

Summary of What Students Learned From the Classroom Experience

Students’ indicated learning	Count	%
Science Content	71	62.8%
Working with teams or people	5	4.4%
Other, non-specific	2	1.8%
No learning	35	31%
Total responses	113	

Table 4

Summary of What Students Learned From the Planetarium Experience

Students' indicated learning	Count	%
Science Content	77	69.4%
Working with teams or people	1	0.9%
Other, non-specific	3	2.7%
No learning	30	27%
Total responses	111	

From the analysis of these data, it is apparent that most participants feel like they had learned something from all three experiences (82% in the simulation, 69% in the classroom, and 73% in the planetarium). Simulator participants most often noted learning teamwork and problem solving skills although their responses showed varying degrees of specificity. For example, some students reported that they learned "teamwork" whereas other students explained that they learned that "if you work together good things happen," "it's important to do your part," or "if a person was not doing their job it would ruin the mission." None of the students cited having learned 'problem-solving skills' verbatim but instead they reported things like "you have to listen and pay attention to get the job done right even if you make the wrong decisions sometimes" or "you have to be calm under pressure and sometimes negotiate instead of just acting."

A similar pattern was found in the data from what students learned in the classroom and planetarium experience. Sometimes the students were specific about the

science content they learned and sometimes they were vague. For example one student said, “I learned about the electro-magnetic spectrum and how little we can actually see,” and another student said, “heat-light-sound.” Likewise from the planetarium one student reported having learned “about orange stars and Betelgeuse and how they are going to blow up” whereas another student reported learning “more things about space.” Students in the classroom and the planetarium also reported having learned ‘teamwork’ skills even though they did not participate in any teamwork activities. One possible explanation for this may be that the instructors include a debriefing of the simulation during the classroom lesson in addition to the science content. During that debriefing the instructor often discusses with the students how they can use what they learned from the simulator in their daily lives—emphasizing the teamwork and problem-solving skills. Another possible reason could be that students did not all distinguish between the different experiences when answering the survey questions. For example one student responded to the question about learning in the simulator but simply responded with “I already told you” when asked what he or she had learned in the classroom and planetarium.

Also of note is that participants who went on the simulation with their school field trip reported learning more science content in the simulator than those who came to the after-school simulations. This may be an indication that the field trip simulations have more science content teaching in them, or it could show that the participants have a propensity to feel like they are learning more because they are on a school field trip rather than when they are doing something on their own time. In contrast, participants who came for the after-school experience responded to the learning question by indicating that

they had more ‘fun’ than those who came with their school field trips. Again, this could be a reflection of the way the simulation is conducted by staff members, or it could be a reflection of how students perceive their leisure time versus their in-school time.

The staff members at the CMSEC regularly evaluate their own and one another’s performance based on criteria implied from their oral tradition and a survey given to weekly overnight camps. The survey is in appendix B and primarily addresses whether or not participants had a good experience—focusing on how much ‘fun’ they had, whether staff members were friendly, and if the participant felt like they made a difference in their simulator. After the survey is administered to visitors, the results are reviewed with all of the staff members and volunteers that worked that mission (usually about 25-30 staff members and volunteers). Rewards are given out for outstanding performance but there is rarely any discussion at this meeting about how to improve performance. Discussion on improving performance is administered one-on-one between staff members (usually senior staff members pulling junior staff members aside). The data which senior staff members use to determine whose performance needs to improve and how it needs to improve is their own observational data gathered and administered in anecdotal forms. The criteria used to determine who and what needs to be improved is ambiguous and communicated through stories and examples. From this, the staff members get a vague idea of the impact they are having on visitors but nothing specific enough to help them make a significant change.

While there are anecdotal evidences of a beneficial impact and some self-reported learning on the participant’s part, the CMSEC could learn much more about the

beneficial impact they are having by examining the intended learning objectives in more depth.

Question 3: How Does the CMSEC Fit into the Broader Educational Spectrum?

I began the exploration of where the CMSEC fits into the broader educational spectrum by asking staff members where they thought they fit. Like their responses to questions about goals, staff members gave a variety of responses. Most of the staff members felt like they were too young and unfamiliar with educational experiences to have any idea of what the CMSEC might be like. But since they had been told by older staff members that there is nothing like the CMSEC anywhere, many of them believed that it is unlike any other educational program. When asked, older staff members (staff members over the age of 50—there are 4 of them) responded by saying that it isn't like anything out there and that the CMSEC programs would not be accepted into any legitimate educational communities. One staff member laughed as she said that the experience was role-playing and that role-playing is not accepted as a legitimate teaching method. From their responses, I concluded that none of the staff members are involved in any professional communities in education and don't see themselves as belonging to one. After speaking with staff members, I began looking at aspects of the CMSEC experience to try and determine if the literature and communities surrounding that specific aspect would be an appropriate way to view the CMSEC programs. I found that while simulation education is the best fit for the CMSEC simulator in the broader educational spectrum, the goals of the CMSEC require their program to incorporate

aspects of other educational experiences: field trips (with a classroom and a planetarium experience) and after-school youth programs.

Simulator

Simulations have been used in classrooms for many years as a role-play in social studies—simulating things like the economy or the judicial system (Cruickshank, D.R. 1980). Recently simulations have gained technology that allows instructors to implement role-play simulations for STEM topics in the classroom (Colella V 2000; Dunleavy, M., Dede, C., & Mitchell, R. 2009; Klopfer, E., Yoon, S., & Rivas, L. 2004). Technology also creates a variety of other options when having students engage in simulations on the computer (Gibbons, A. S., Fairweather, P. G., Anderson, T. A., & Merrill, M. D. 1997; Guyot, P., & Drogoul, A. 2005). One other aspect of simulations that the CMSEC is using (that is also being used in other educational situations are game-based simulations (DiPietro, M., Ferdig, R. E., Boyer, J., & Black, E. W. 2009; Dondlinger, M. J. 2007). The CMSEC simulations (both during school and after school) incorporate many aspects of each type of the simulations used in other environments (role-play, technology, and games).

Field Trips and Planetarium

Just like other field trip experiences, students come to the center and take the day off to participate in enriching activities—besides the simulator they attend a classroom and a planetarium. The methods and philosophies used by the CMSEC in the classroom and planetarium are similar to those employed in classrooms (and similar learning

environments everywhere). The experience is based around a lecture experience where the instructor explains a concept and then poses a question to guide students into thinking about the topic in more depth. Then the CMSEC instructor guides students through the way to answer a question like the one she just asked and involves the students in demonstrations to further illustrate the concepts.

After School Youth Programs

Many visitors enjoy the simulation experience so much that they want to be part of delivering that experience to other visitors; for this the CMSEC allows volunteers to participate in a number of ways that have turned into an after school youth program comparable to other STEM youth programs around the U.S.. The most formal volunteer program is one where youth (ages 10-17) come and help run the missions by acting as characters in the story or by helping monitor and work the simulator's control system.

The director of the center maintains count of how many volunteers are helping in which simulators and when and these volunteers have a card on which their hours are tracked and they receive rewards for volunteering a certain number of hours. Each youth volunteer is put in a group to watch over them and oversee their development and encourage their learning. If the volunteers show dedication and skills in running simulations, then they may be invited to be staff members.

If the volunteers get really involved, then they usually engage in courses offered through the CMSEC. The director of the CMSEC allows enthusiastic older staff members to put together and teach courses to younger staff members and volunteers. The courses cover a number of topics from aviation to programming. The older staff

members decide what they will teach and they decide how it will be taught even though most of them have no teacher experience or training. Observations of the courses show surprising quality in the skills being taught and the methods of teaching.

Like informal learning in games, youth groups, and science centers, the culture of the CMSEC is largely what guides the way staff members, volunteers, and visitors interactions with one another. It guides the choices that staff members make and the way they treat the visitors. The main driving force behind the culture of the center is the center director's insistence that everything they do work to practice the discipline of wonder. The director (and the staff members) want to inspire a sense of wonder for the world—for science and social studies—in one another and in the visitors. The result of this is a culture of frequent evaluation and constant innovation—staff members constantly look to make the experience better for younger staff members, volunteers, and their visitors. Staff members make changes and innovate toward the goal of making the experience more fun and educational. In short, the CMSEC has a lot in common with a variety of other educational experiences.

Conclusions and Recommendations

Overall the CSEC has a set of programs that are well loved with certain aspects that could use some work. Participants, volunteers, and staff members all like it and see value in participating even if they cannot articulate or measure that value as clearly as would be preferred. The general purpose of this evaluation of Christa McAuliffe Space Education Center (CMSEC) program was to describe the theoretical foundation and document any beneficial impact it might have for participants.

Essence of the CMSEC

The essence of the CMSEC is best described by the goals of the center. This is where there is some confusion. The goals of the center vary depending on whether you look at the written documentation, the discourse of individual participants, or the actual implementation practices. There isn't a clear delineation between the goals and outcomes that staff members and volunteers hope to achieve but an analysis of the evaluation results suggest the primary goals, and thus the essence of the CMSEC, include (1) making connection to classroom curriculum, (2) teaching problem solving and teamwork skills, (3) improve participant's academic and social self-efficacy, and (4) engaging students in a fun learning activity.

Beneficial Impact

While there are anecdotal evidences of a beneficial impact (e.g., letters from previous participants), there is also statistical indication that participants feel like they are learning something from the experience. From all of the students that participated in the survey, 82% said that they learned something from the simulation, 69% said they learned something from the classroom experience, and 73% said they learned something from the planetarium. Of those that reported having learned something in the simulator, 43% indicated that what they learned was related to teamwork. Of those that reported having learned something in the classroom and planetarium, 93% said they learned something related to science content. The question on the survey was an open-ended question that asked what they learned. The participants' responses ranged from specific examples of

what they learned to very generic responses. This would not be unusual for a group of sixth grade students as many of them would not think deeply about what they were learning, only that they had a good time and had learned something.

Part of the reason that staff are unaware of the beneficial impact they have been having on participants is because they have been unaware of specifically what kind of impact they are trying to have on students. They have a general, ambiguous idea and from that they have been able to see a general, ambiguous beneficial impact (i.e., stories from pleased participants and a general sense that participants have improved from the experience). If the CMSEC staff and volunteers were more aware of the goals that make the CMSEC experience what it is then they could get a deeper, more consistent, and more measurable outcome of what the CMSEC is doing for its visitors.

CMSEC and the Broader Educational Spectrum

The CMSEC experience is primarily a simulation experience but because of their diverse and ambiguous goal sets, their program can also be considered to apply to several different educational contexts including field trips, school youth activities or serious games. The main function for using simulations is to create a somewhat authentic environment in which participants can practice building problem solving, teamwork and information processing skills. The simulators (i.e., ships) provide physical fidelity in which a high-fidelity cognitive simulation (i.e., stories) are established. The degree to which this is accomplished depends on a number of factors. Ultimately, it is the flight directors' ability to make explicit links to the learning objectives that determines whether the simulation is educational or simply entertaining. The pre-visit lesson plans and

materials certainly can facilitate the degree to which this is educational but only if the content is directly linked to the simulation story.

Recommendations

Based on evaluation findings, I recommend that the CMSEC first clarify and communicate their goals and then use those goals as a foundation in their efforts to improve the center. I also believe that if the CMSEC were to make their goals clearer, it would provide them with a stronger idea of how to maintain the center when the director has retired. In addition to clarifying their goals, I recommend several other actions to help the CMSEC strengthen their programs.

Since their three sets of goals are so diverse, I recommend the CMSEC either clearly state what each goal set is and how they work to meet that goal or focusing in on only one of the goals. Since the culture and goals of the CMSEC are the foundation of what it is at its essence, changing those goals (by dropping one set or another) would fundamentally change what the CMSEC experience is. But clearly stating the goals and how they can be accomplished will strengthen the offerings of the experience while being true to the core of what it is. Since the goals that I found in this evaluation reflect current practices and beliefs of staff members at the CMSEC, I recommend that they use these as their goals instead of trying to formalize a new set.

I recommend that the director of the center post the CMSEC's goals in a prominent place and remind staff members of those goals periodically. I recommend that the CMESC staff refine their current evaluation activities to more directly assess whether or not their goals are being met.

Also, in considering the aforementioned goals and the data gathered in the evaluation, I would recommend the CMSEC change the simulation scripts so they are written with more direction to the flight directors regarding the each simulation is meant to meet and how they can meet those goals.

In summary, I recommend the following:

- Clarify and communicate CMSEC goals through prominent placement of the goals and regular meetings reviewing them.
- Be more clear and direct about how those goals are expected to be met
- Refine current evaluation methods to more closely align with clarified goals
- Rewrite simulation scripts to help flight directors and staff members know exactly what they should do to accomplish the goals of the CMSEC.
- Train flight directors on the goals and their impact on the individual simulations

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Appendix A: Survey Given to Participants

Visitor Pre-visit Survey

We're very excited to see you when you come on your field trip to the space center. Right now we're working on understanding our visitors (that's you) and so we appreciate you taking a moment to complete this survey. Thanks and see you soon!

1. In general, how comfortable do you feel sharing what you think, feel, and believe?
( ) Very uncomfortable
( ) A little uncomfortable
( ) A little comfortable
( ) Very comfortable

2. How shy would you consider yourself?
( ) Very shy
( ) A little shy
( ) A little outgoing
( ) Very outgoing

3. On a scale of 1-10, how confident are you in school?
( ) Completely Confident
( ) -
( ) Very Confident
( ) -
( ) Confident
( ) Insecure
( ) -
( ) Very Insecure
( ) -
( ) Completely Insecure

4. On a scale of 1-10 how confident are you around people you don't know well.
( ) Completely Confident
( ) -
( ) Very Confident
( ) -
( ) Confident
( ) Insecure
( ) -
( ) Very Insecure
( ) -

( ) Completely Insecure

5. Describe your vision of the future in one sentence.
_____
_____
_____
_____
_____

6. How much do you agree that you make a difference in the world?
( ) Strongly disagree
( ) Moderately disagree
( ) Slightly disagree
( ) Disagree
( ) Agree
( ) Slightly agree
( ) Moderately agree
( ) Strongly agree

7. Do you believe that something can be both fun and educational?
( ) Yes
( ) Sometimes
( ) No

8. What is your age?
( ) 8
( ) 9
( ) 10
( ) 11
( ) 12
( ) 13
( ) 14
( ) 15

9. Are you the kind of person that likes to learn science?
( ) No, not really
( ) Sometimes
( ) Yes, I love science

10. How cool would you say it is to know a lot of science?
( ) It is not cool at all
( ) It can be cool sometimes
( ) It's totally cool to know a lot of science

11. Do you enjoy going to science museums?
( ) No, they're boring
( ) Not really but they're not that bad
( ) Sometimes
( ) Yes, they're kind of interesting
( ) Yes, I love science museums

12. Are you male or female?
( ) Male
( ) Female

13. How many times have you been to the space center (The Christa McAuliffe Space Education Center or CMSEC)?
_____

14. What do you expect you will do at the space center?
_____
_____
_____
_____
_____

Thank you for taking our survey. Your response is very important to us.

You and the Space Center (Visitor Post-visit Survey)

We're very excited to see you when you come on your field trip to the space center. Right now we're working on understanding our visitors(that's you) and so we appreciate you taking a moment to complete this survey. Thanks and see you soon!

1. In general, how comfortable do you feel sharing what you think, feel, and believe?
( ) Very uncomfortable
( ) A little uncomfortable
( ) A little comfortable
( ) Very comfortable

2. How shy would you consider yourself?
( ) Very shy
( ) A little shy
( ) A little outgoing
( ) Very outgoing

3. On a scale of 1-10, how confident are you in school?
( ) Completely Confident
( ) -
( ) Very Confident
( ) -
( ) Confident
( ) Insecure
( ) -
( ) Very Insecure
( ) -
( ) Completely Insecure

4. On a scale of 1-10 how confident are you around people you don't know well.
( ) Completely Confident
( ) -
( ) Very Confident
( ) -
( ) Confident
( ) Insecure
( ) -
( ) Very Insecure
( ) -
( ) Completely Insecure

5. Describe your vision of the future in one sentence.

_____
_____
_____
_____
_____

6. How much do you agree that you make a difference in the world?
( ) Strongly disagree
( ) Moderately disagree
( ) Slightly disagree
( ) Disagree
( ) Agree
( ) Slightly agree
( ) Moderately agree
( ) Strongly agree

7. Do you believe that something can be both fun and educational?
( ) Yes
( ) Sometimes
( ) No

8. What is your age?
( ) 8
( ) 9
( ) 10
( ) 11
( ) 12
( ) 13
( ) 14
( ) 15

9. Are you the kind of person that likes to learn science?
( ) No, not really
( ) Sometimes
( ) Yes, I love science

10. How cool would you say it is to know a lot of science?
( ) It is not cool at all
( ) It can be cool sometimes
( ) It's totally cool to know a lot of science

11. Do you enjoy going to science museums?
( ) No, they're boring
( ) Not really but they're not that bad

( ) Sometimes
( ) Yes, they're kind of interesting
( ) Yes, I love science museums

12. Are you male or female?
( ) Male
( ) Female

13. How many times have you been to the space center (The Christa McAuliffe Space Education Center or CMSEC)?
_____

14. Was your experience at the space center what you expected? Tell us how it was similar and different to what you expected.
_____
_____
_____
_____
_____

==========
Considering the Simulation Experience . . .
==========

15. Did you learn anything new from your experience in the simulation?
( ) Yes
( ) No

16. if so, what did you learn?
_____
_____
_____
_____
_____

17. Did you understand anything better because of your experience in the simulation?
( ) Yes
( ) No

18. if so, what did it help you understand?
_____
_____
_____
_____

_____

19. What was most memorable about the simulation?
_____
_____
_____
_____
_____

20. Do you feel like it helped you feel comfortable being yourself?
( ) Yes
( ) No

==========
Considering the Classroom Experience . . .
==========

21. Did you learn anything new from your experience in the classroom?
( ) Yes
( ) No

22. if so, what did you learn?
_____
_____
_____
_____
_____

23. Did you understand anything better because of your experience in the classroom?
( ) Yes
( ) No

24. if so, what did it help you understand?
_____
_____
_____
_____
_____

25. How often do you ask questions about science?
( ) never
( ) rarely
( ) sometimes
( ) often

( ) all the time

==========
Considering the Planetarium Experience . . .
==========

26. Did you learn anything new from your experience in the planetarium?
( ) Yes
( ) No

27. if so, what did you learn?
_____
_____
_____
_____
_____

28. Did you understand anything better from your experience in the planetarium?
( ) Yes
( ) No

29. if so, what did you understand better?
_____
_____
_____
_____
_____

30. How interested are you in astronomy?
( ) Not at all
( ) a little
( ) a lot
( ) a whole lot

Appendix B: Survey the CMSEC Administers

Overnight Survey:
Space Center

1. Age? _____
2. Circle: Boy or Girl

What Ship were you on?
Circle your Ship.
Voyager, Magellan,
Odyssey, Phoenix,
Galileo
What was your job? _____

3. How Would you Grade Your Mission?:
A = Outstanding; B = Good; C = Average;
D = Not That good; F = Bad

• Story: (Think about the whole story. Was it fun? Did it have good Characters? Did it challenge your brain or way too easy to solve?

A B C D F

• The Staff (think about the following: friendliness, helpfulness, and acting)

A B C D F

• How much did you enjoy your job? Great! Good. OK. Not So Good. Bad

4. Did you feel doing your job made a difference in the mission?

Yes Maybe No

5. Would you like to come back again for another mission some day?

Yes Maybe No

6. **Any suggestions for the Space Center to make it better?**

What was the funnest thing about your overnight camp?

What one thing or things didn' t you like about your overnight camp you would like us to improve for next time?

How would you grade your overall experience at the camp today: Circle One

10 = The Funnest Thing I've Ever Done!

9

8

7

6

5 = It was OK. Like going to a good movie.

4

3

2

1 = The Worst most Boring Thing I've done.

PAT ON THE BACK FOR THE VOLUNTEERS.

1ST PLACE: _____
WHY?
_____

_____

_____

2ND PLACE: _____

3RD PLACE: _____