Project Plan Report
IPRO Team 341 Fall 2004

Intoduction:

IPRO 341: Developing a Prototype Display for the Prenatal-to-Newborn Blood Flow System

Final Project Report Fall 2004

***Project Sponsor**: Museum of Science and Industry*

***Faculty Advisors**: Dr. Paul Fagette and Dr. Eric Brey*

Students Involved: *Alex Budiman, Eric Dunaway, Grace Lin, Calvin Moy, Sean Pitroda, Narayan Justin Ram, Shalini Ravella, Archita Shrivastava, Suruchi Thakore, Christopher Tuthill, Anand Vankawala, Kedari Vasu, Michael Wright.*

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Introduction

In today's society, we acknowledge the birthing process as a 'miracle' of sorts. Bringing a new life into the world has long been thought of as one of the most amazing capabilities of the human body. At the same time, the actual physiological processes that the mother's body and fetus undergo remain a mystery to the majority of the world's population. Most people consider the birth of their child as one of the most important events in their lives, yet most do not understand what is actually happening at the physiological level.

Project Background:

Background

The Museum of Science and Industry (MSI) is currently developing a number of new displays to help better educate the general public on the relationships between physiology, pathology, and medical technology. Our IPRO team will be working with the MSI to help promote public awareness of medical knowledge by developing a bench-top working model as well as an educational computer animation that demonstrates the change in blood flow from fetus to newborn.

The idea to work with MSI originated through Sean Pitroda during October of 2003. Sean developed the initial relationships with MSI through Dr. Barry Aprison, the director of science and technology at MSI. Originally, Sean hoped IIT would be able to help update one of their exhibits. Sean, as well as faculty members from the Biomedical Engineering department met

with Dr. Barry Aprison and Dr. Patricia Ward, the museum curator, about the department becoming involved with the museum. Initially the museum was interested in working with IIT in the area of biomaterials. After considering the needs of the museum and, more importantly, the public, it was decided that the neonatal section of the museum needed updating. More specifically, MSI wanted to work with IIT to help the general public understand how pressure and blood flow are related; MSI wanted the importance of pressure and blood flow during birth to be illustrated as an engineer would envision it. Thus, through displaying the importance of the changes in the circulatory system, the public could be educated about how pressure and blood flow are interrelated and change at birth, which could, also indirectly educate them on the complications involved with abnormal blood pressures during adult life. Because of this opportunity MSI agreed to use our help in inventing a novel exhibit. Consequently, Dr. Paul Fagette compiled an IPRO request at the end of the 2003-2004 school year to have an IPRO with the project of developing the neonatal exhibit concerning the changes in the circulatory system that occur at birth. The IPRO team is currently maintaining the relationship with MSI by working with museum curator, Patricia Ward.

In the past, MSI formed relationships with students from colleges in the area, such as Northwestern and University of Chicago. Most of the students the museum works with are at the graduate level. Previously a graduate student from Northwestern worked on a similar project IPRO 341 has attacked this semester of showing how blood flow changes from fetus to newborn. The model this student developed was simple, but informative. By analyzing her work, IPRO 341 expanded her ideas to create a more involved and detailed model and presentation.

The students in IPRO 341 were recruited from a variety of majors, mostly having a strong background in biology. Students with ECE, and CS backgrounds were also recruited for their ability to help produce the visual presentation and model.

Project Purpose:

Purpose

The purpose of the IPRO this semester was to develop a prototype of a cardiovascular display for the prenatal to newborn blood flow system for the Museum of Science and Industry. The museum's main goal was to have a display that would emphasize the changes in pressure within the body before, during, and after birth. To accomplish this, the group decided the goal of the semester was to create a visual presentation, which could ultimately be on a touch screen monitor, and bench-top model as the display.

To begin developing the bench-top working model as well as the educational presentation, a significant amount of research about the fetus in pre-natal conditions and the newborn during the post-natal period had to be done. In order to use our time in the most efficient manner, we divided the group into four teams, with each focusing on a different aspect: prenatal circulation, postnatal circulation, development of the interactive computer prototype, and development of the interactive mechanical model prototype. Due to the multiple skill and knowledge levels required

to carry out this project, our group consisted of people with a variety of different educational backgrounds.

The computer group determined the program "Flash" to be the best tool for building the presentation. The goal of the Flash presentation was a walk through presentation, with extra buttons for secondary information, covering the material of prenatal, at birth, and postnatal circulation. The goal of this presentation evolved over the semester to include audio, by having the general information of the presentation all being read to the observer, as well as animation for many of the pictures in the presentation. This group also formed the website for the IPRO.

After the research groups refined their findings so the material could be inserted into the Flash program, these groups combined, and split into two smaller groups. One group became the IPRO Day group. Their goal was to accomplish the tasks set forth from the IPRO office of the final project report, the team presentation, the project abstract, and the IPRO Day exhibit. The other group became the model group whose goal was to design a 3-D model of a functioning heart that would emphasize the changes at birth. This goal progressed as the group decided to use a roller pump, plastic tubing (to represent the blood vessels), acrylic containers (to represent significant circulatory organs), and colored fluid (to represent blood) to simulate blood flow and its changes during birth.

Project Research Methodology:

Research Methodology

Each IPRO sub-group (pre-natal group, post-natal group, computer group, model group) had specific research goals.

The pre-natal group used a variety of online resources but the primary source of information was *Gray's Anatomy*. Online resources were also used to find pictures to help illustrate corresponding information in the computer presentation.

The post-natal group also used *Gray's* for basic information on circulation in neonates as well as for problems that could arise during this time. *Textbook of Fetal Physiology*, *Fetal and Neonatal Physiology*, and Guyton's *Medical Physiology* were additional resources used in order to further investigate problems. Like in the pre-natal group, online resources were used to help illustrate the computer presentation.

Both pre-natal and post-natal groups were able to further research the fetal circulatory system through discussion with Sylvia Botros-Brey, MD, an Obstetrician/Gynecologist, who provided useful and essential information.

The computer group initially investigated what platform to use to create the presentation portion of the prototype. Research was performed on the internet and by soliciting advice from people experienced with working the types of platforms available. When it was decided the Flash platform would be used, the original group members realized they were not experienced enough

to create the presentation on their own. Next, they asked another student who had the background needed to help create the presentation. This new student's experience concluded a drawing pad was also needed to incorporate pictures into the presentation. Through research on the internet, an instrument with the regards to price and ability to meet the requirements of the presentation was chosen. The group also researched into what audio equipment was available on campus to allow audio to be added into the presentation.

The model group primarily focused on what type material could be used to best represent the actual shape and functioning of a real circulatory system. After concluding that modeling the heart in its actual dimensions was not feasible, the group decided to make a model representing essential organs and blood vessels to display the changes in pre-natal to post-natal circulation. After this decision, the materials used to make the model were further researched with the new model parameters in mind. Input was solicited from Professors with expertise in blood rheology and fluid dynamics. After constructing the model, the group continued research into various light emitting diodes (LED) and control boards. Through comparing price and the characteristics of possible control boards, the Kit 742V2 PC Parallel Port Relay Board from DIY Electronics was tentatively chosen to allow the desktop model to be controlled by the Flash presentation. The LED product is being researched in the same manner, but a product has not yet been chosen. These two components will be introduced to the model, hopefully in the next semester of IPRO.

Assignments:

Assignments

Sub-Groups (Part One):

Pre-Natal Group

Calvin Moy
Sean Pitroda
Shalini Ravella
Archita Shrivastava

At-Birth Group
This group was originally formed to perform an in-depth investigation of the changes occurring exactly at birth. When it was determined that much of their research overlapped with the post-natal group, the two groups converged.

*Suruchi Thakore
*Christopher Tuthill

Post-Natal Group

Alex Budiman
Grace Lin

*Suruchi Thakore

*Christopher Tuthill
Anand Vankawala
Kedari Vasu

The pre-natal, post-natal, and at-birth research groups were formed to learn and become experts about the physiology in relation to blood flow and pressure, but also to educate the rest of the IPRO team on this topic. The teams started by brainstorming how to create a presentation that they would show the rest of the IPRO team and decided that the group members should first perform their own research individually and read all the materials, mainly excerpts from textbooks purchased that were provided to the team by Dr. Fagette. After meeting a number of times, they were able to put together presentations showing the information that they felt was important to include in the final presentation. They received critique from the other group members, the group advisors, and also Dr. Ward from the Museum of Science and Industry concerning level of detail, time limits, and public responsiveness. From the input they received, they were able to revise and conclude what should be included in the final presentation. Each group then met with the computer group to work on the specific content, which would be portrayed in story form.

Computer Group

***Eric Dunaway
Narayan Ram
Michael Wright

***Eric Dunaway was a student who was added to the IPRO team after the first meeting.

The technology committee was formed during the first general meeting and its first task was investigating how the team's final project should be presented as a multimedia experience. The lack of knowledge in this area was corrected by adding an additional member to the IPRO team. The goal to find a platform that would grab the audience's attention, compete with scrolling text, sound, and animated pictures was reached by using Flash and Dreamweaver software packages, and "Pen-Writer" which could "draw" the photos the team wanted to include in the software program. The group went onto fine-tune the text given to them by the research groups and implement animated pictures and audio dialogue with scrolling text to create the final computer presentation.

Sub-Groups (Part 2):

*After research was completed, new groups were formed from the pre-natal and post-natal group members.

Model Group

Calvin Moy
Sean Pitroda
Suruchi Thakore
Christopher Tuthill

The model group worked on the desk-top model of a prototype pre-natal to post-natal heart. After extensive research and advice, the model group decided to use a roller pump, plastic tubing, acrylic containers, and colored fluid to stimulate blood flow and its changes during birth. The plastic containers serve as basic representations of each of the important organs: placenta, heart,
brain, lungs, liver, and the lower half of the body. The tubing represents the blood vessels and the colored fluid represents the blood. The change that occurs with the onset of birth is shown on the model with a stopcock in the heart.

IPRO Presentation Group
Alex Budiman
Grace Lin

Shalini Ravella
Archita Shrivastava
Anand Vankawala
Kedari Vasu

The IPRO presentation group was formed to put together the final production of the team's efforts on IPRO day. The group worked on the final poster exhibit, the final paper, and the final power point presentation. These assignments served as tools to help portray the hard work that went into the IPRO to the public.

*Computer Group continued with its original members.

Barriers and Obstacles:

Obstacles

Each sub-group was faced with obstacles on the path to its goal.

One of the main problems the research groups dealt with was how much information to include in the presentation. Either too much detail or not enough description of major processes was often debated over. This obstacle was overcome through correspondence with Patricia Ward from MSI. By meeting with Ms. Ward, the groups were given more definite guidelines to follow, which simplified the sorting of research material. Also, finding appropriate pictures and diagrams to include in the final presentation was difficult. Using online websites instead of textbooks and journals significantly decreased the time spent on this task.

For the computer group, the first obstacle they encountered was the lack of knowledge of software programs. Eric Dunaway, was not an original member of the IPRO team; he was

recruited specifically to fill this void based upon his computer skills. The next problem the group had to deal with was difficulty obtaining the research material from the other groups. Communication with the other group members between scheduled class times proved to be difficult because of varying schedules. Also, final decision making was often clouded because of opposing viewpoints. Through compromise and patience, the problems were tackled providing the final product to be satisfactory for the entire IPRO team.

The model group's first obstacle was in deciding how to portray the circulatory system. After deciding the IPRO was not to the stage where they could make a circulatory system in the actual dimensions of the heart and other essential organs, it was decided that the model would represent the system's components. When first creating the model the problems that arose were the type of fluid to be used, how to visualize the flow, path of the flow and the size of tubing to use for the whole model. Research was completed in order to determine the solutions to these problems. The media to be used was provided by one of the members of our IPRO group, Michael Wright. This media was aerated with permanent bubbles therefore solving the problem of flow visualization. When the model was tested however, these bubbles could not be seen and therefore the media was required to be aerated further to produce more bubbles. The option of Styrofoam balls were too expensive to be used and the glitter was thought to sediment out of solution and accumulate in the bends of the model. The LED lights were investigated in more detail, however the time needed to place them in the model was extensive and therefore could not be completed this semester. Due to the lack of same size valves, it was determined that both sizes of tubes would be used in the model, allowing intentional change of resistance and pressure to create the flow system that was required. Once these problems were fixed, the model was built and then was wet tested. The pump being used model was a complex device that needed calibration and instruction before it was put into use. With the help of Dr. Hall, these challenges were overcome. A few new problems that arose during wet testing were problems with backflow, unbalanced resistances, and viscosity of the colored aerated gel "blood" that Michael provided as our main fluid. This new media caused leakage around certain valves which were experiencing more pressure than other valves used throughout the model. In order to compensate for the backflow, clamps and other devices were used to increase resistance in particular areas to push flow in the proper direction. By changing the lengths of the tubing used and the heights at which the compartments "organs" were located, a semi-balanced resistance system to help move the flow of the media in the proper direction was developed.

The main obstacle the presentation group encountered was the lack of knowledge in the details of what each group's research methods and obstacles comprised of. By forming specific questions to ask each of the teammates, the presentation group was able to obtain the information needed to complete their tasks.

Results and Conclusions:

Results

The group was able to complete an interactive Flash presentation. The presentation has a base run time of around 6.5 minutes. The presentation also includes many sub-layers which the user could explore based on individual interest, in addition to animated illustrations, (flowing blood,

moving lungs, toolbars, timelines) and audio throughout the base layer. An example interface of the presentation can be seen below. The computer group also created the website including the meetings minutes, pictures and biographies of the group members, the Flash presentation, and the Final Power Point Presentation.

The Model Group assembled a prototype of the circulatory system. Clear acrylic containers represented the significant circulatory organs. Rubber Tygon tubing represented circulatory vessels, and stop-cocks represented various valves of the pre-natal circulatory system which could be closed to represent the post-natal circulatory system. These components were all positioned to represent the changes occurring at birth in the circulatory system of the fetus. A diagram representing the model can be seen below.

Recommendations:

Conclusions and Recommendations

The IPRO team was able to accomplish:

1) An interactive computer presentation including animation, text, and audio-visual narration.
2) A working bench-top model representing the changes occurring in the fetal circulatory system at birth.
3) A positive working relationship with MSI.

Recommendations:

1) Build on presentation after conducting marketing research of current prototype.
2) Improve bench-top model to be more aesthetically pleasing and to include a solenoid valve to regulate flow.
3) Incorporate LED in the model to better represent flow.
4) To use a control board with the presentation and model so they are able to run in sync with each other.
5) Maintain relations with MSI and work towards final exhibition at the museum.

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Acknowlegements:

Acknowledgements

To:

Our advisors: Dr. Paul Fagette and Dr. Eric Brey, for giving us tremendous support and guidance throughout the project as well as funding to accomplish our goals.

Dr. Sylvia Botros-Brey: For providing us with additional material and proving to be an essential resource in our research.

MSI - Dr. Patricia Ward, and Dr. Barry Aprison: For their encouragement. We hope to continue to work with you to provide a final exhibit prototype.

WIIT: For allowing the use of studio equipment to aid audio recordings.

Dr. Connie Hall: For the allowing the use of the BME Fluids Lab and the pump used in the model as well as her guidance and advice.

Dr. Vincent Turitto, Chair, Dept. of Biomedical Engineering: For his support, space, and encouragement.

Unilever: For providing aerated viscous material initially substituting for the blood in the model.

Computer Networking Systems: For the availability of the software needed for the IPRO team to purchase.