

ICAT Day North Cross Exhibit Final Report

**Virginia Tech CS4624: Multimedia, Hypertext, and
Information Access**

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Sean Goodrich, Zack Stefan, Benjamin Kodres-O'Brien

Advisor: Dr. Liesl Baum

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Project Overview

1.1 Executive Summary

For eight days in mid-March, Virginia Tech's Institute for Creativity, Arts, and Technology (ICAT) held a camp for two hundred children from age 3 to the 5th grade at North Cross School in Roanoke, Virginia. The purpose of the camp was to engage children in a creative process with the use of informal learning. Our group documented the camp, providing an impression of what happened over those eight days. On May 2, 2016, at the annual ICAT Day we presented an exhibit of our documentation. We have contributed to a portion of a much larger exhibit, containing other student projects and demonstrations by the ICAT staff, of informal learning methods they have used and taught community teachers to use.

We documented certain parts of the informal learning process using two methods. First, we filmed 360 degree video of both indoor and outdoor workshops. We have displayed the video using an Oculus Rift so that during ICAT Day a visitor to the exhibit is able to interactively view the children in action. Our second method of documentation is a set of audio reflections from students who participated in the workshops. Towards the end of the camp we had children reflect and then speak about their experience, creating art based on the Rudyard Kipling poem "If." During ICAT Day, visitors connected with the children's camp experience by browsing these experiences digitally using their smartphone or similar device.

1.2 Client Information

Our client for this project is Liesl Baum; we also worked with others on the ICAT staff. We are responsible for delivering an immersive exhibit experience to the public, and we are being held responsible for that task by the ICAT staff members. Dr. Liesl Baum, the studio head for the IDEA Studio, is our main client as she is a research specialist in education techniques and is spearheading logistics for the North Cross School Camp. Zachary Duer, ICAT's Immersive Environment Specialist, and Todd Ogle, Sr. Associate Director of Applied Research and Planning, are our points of contact for more technical matters. While ICAT holds us responsible for completing this project, the success and reputation of the Institute and our project will ultimately be determined by its reception from the New River Valley public.

1.3 Relation to Larger Project

In the past few years, The Institute for Creativity, Arts, and Technology has championed a melding of different informal learning techniques to engage young students with the three different elements of their name.¹² The goal here was to break learning boundaries between the arts, science, technology, and design to get students involved in project-based learning where their ideas could roam free and be realized. In the summer of 2012, ICAT began running a "Maker Camp" to achieve this goal primarily with middle and high school students from North Cross School in Roanoke.

In 2013, the first formal documentation of the summer Maker Camp appears on the ICAT website where Benjamin Knapp, the director of the institute, discusses another key goal with the experience: to get students to learn STEM by doing something fun. The Maker Camp has typically been centered around a project to create musical instruments with technology, and has been held for a shorter period of time than this year's project.²

In March of 2016, the Institute held a slightly different kind of camp. The event spanned eight days and was much more focused on creativity than on technology. Further, the age range was also different as ICAT is trying to engage younger children this time, from ages three up to 5th grade. Important to the engagement with younger children is the concept that the young have not yet been conditioned to think that learning should be done in any specific way according to the subject matter. One might say that children are not yet "stuck in their ways." This concept signifies ICAT's use of the poem "If" by Rudyard Kipling to inspire idealistic dreams in children who have not been predisposed to align themselves with particular values. This dreamy idealism is complimented by practical realism in the coming to life of the children's ideas.³

But where do we come into the picture of ICAT's engagement of children with informal learning? Documentation of ICAT's projects has, so far, largely been a responsibility of ICAT itself with the making of videos and writing of articles. They also have displayed the work of children in their exhibits before. However, our role is to create an entirely new experience for the public to gain insight into the minds of these children as they go about their creative process. Simply, we are documenting the camp. More accurately, we are creating an experience whereby the public can become an integral part to the children's learning process.

User Manual

2.1 360 Degree Video

With the ultimate goal in mind of giving attendees at ICAT Day a complete experience of how ICAT engages children in informal learning, it is important to compile a broad, overall impression of the camp. The first portion of our project is a broad experience with the aid of three-dimensional, three-hundred and sixty degree video. This macro-level experience of workshops and discussions within the camp provides attendees with as real an experience as possible, meaning that attendees are supposed to feel as if they are standing in a room watching the scene unfold before them. (Note: We will now refer to 3D or 360 degree video as simply “360 degree video” for the sake of convenience, as 360 degree video has the effect of making one feel like they are in a 3D world.)

Over the past few months, ICAT has been experimenting with 360 degree video in Lane Stadium and Cassell Coliseum. They have managed to record both video and audio, and to sync the two to create an experience where someone can virtually step into a game at either venue. Our exhibit for ICAT Day will make use of this technology to create a somewhat similar kind of experience for the public.

360 degree video was shot in multiple locations during the eight day camp at North Cross School, and the resulting experience is one of an augmented reality whereby a user is able to put on an Oculus Rift headset to visually seem as if they are a part of the original camp. Additionally, the 360 degree video experience is viewable on YouTube without the addition of augmented reality effects with spatial audio.

The directional audio functions in two different ways for this experience in an Oculus Rift for the first third of our video. There is an audio source at the same location of the video rig, so that a user gets the broad, macro experience of standing in the place of the video rig. More interestingly, a user is able to turn and face specific groups of children to listen to their conversations. Let’s say, for example, that one is currently moving about the 360 degree environment, which is to say that they can change their orientation to face any direction from a central location where the 360 degree video rig is stationed. If one directly faces a group of students sitting at a table or working around a central location, the audio of the conversation the group is having about their work is louder than the surrounding audio. This melding of video and audio gives the user the option to augment their real experience of standing in the location of the video rig.

The user of this finished component will have the option of being interactively involved in our exhibit or standing idle, simply consuming information. If a user would like to participate more interactively, they are able to use the rotation of their bodies to interact with the technology we use to display our documentation of the school workshops. If a user is viewing the video on YouTube with a computer, they may click and drag on the video window to change the direction they are facing. In the case that the user is viewing the video on YouTube with an iPad, they can use the gyroscope to change their orientation. In the case that a user is viewing on the Oculus Rift headset, one does the same without holding anything.

2.2 Student Reflection

The second goal of the exhibit on ICAT Day is to expose informal learning methods used in March to attendees. Understanding what is valuable about the different approach to learning in these age groups can be accomplished from many perspectives. The perspective of the video documentation takes that of putting the user as close to “in the room” with the children as possible, so as to help them digest the curriculum and how the students engage with it. This view, compared to the individual student view of the curriculum, takes a higher level, “macro”, look at the discussions children have in order to actually see them learning. In contrast, individual student reflections take a “micro” view by showing the perspective of individual students in their own words. Taking a look at how the United States Holocaust Memorial Museum in Washington D.C. ferries attendees through its experience illustrates this approach and its advantages.

The format that the United States Holocaust Museum assumes allows the attendee to empathize with the history in multiple ways.⁴ The path through the museum is chronological, with each floor representing a different time period of the Holocaust. At the entrance of the museum, every attendee is given an Identification Card, which explains the experience, in each corresponding time period, that a particular victim or survivor had. As a biography of sorts, this allows attendees to empathize with a particular real, human experience while wading through the videos, letters, and other accounts of the time. It also starts a dialogue with other attendees about their unique victim or survivor’s experience, which engages the attendees themselves in the history. We have taken these advantageous aspects and applied them to our user experience.

This has been accomplished by having each child document their experience in a reflection appropriate to their age. Their teachers and ICAT staff has accompanied them in completing this reflection, which has been digitized to allow users to sift through them. Initially, the plan was for those in the younger age groups, ages 3-7, to draw themselves working on a project they completed during the camp. Following this, the older age groups, ages 8-11, were going to be asked to explain a drawing created by a younger student in words. Instead, camp coordinators worked with the students in groups and recorded them answering specific questions about the camp. This allows ICAT Day attendees to see the number of students affected by this camp, which is a little over two hundred students.

From the perspective of an ICAT Day visitor, one either uses their own phone to access www.icatday.com or walks up to a set of iPads with digitized versions of the children’s audio responses on the website. They can choose to hear a random audio reflection, to give a feeling to uniqueness. They also browse all of the audio reflections at their leisure in the ‘Browse All’ page. This gives the user a representation of the many students involved in the cam. It also allows each user to have a unique experience with the exhibit and to become familiar with a particular student’s camp experience, because it is not feasible to hear all of the reflections during the exhibit. An explanation for using the website during the exhibit was written by on a flier stuck to the exhibit wall, and it contained a project description and acknowledgements by. This is seen in Figure 2. The visitors of the exhibit used this to navigate to the website and use it throughout ICAT Day.

THE NORTH CROSS PROJECT

Lower School SEAD Experience, 2016

The Institute for Creativity, Arts, and Technology (ICAT) and the Moss Arts Center were approached in August of 2015 to design a new workshop program for students of the North Cross Lower School, pre-K through fifth grade, in Roanoke, Virginia. In previous years, ICAT has conducted projects and classes for the North Cross Middle and Upper school students with inspiring results.

The North Cross Lower School SEAD Experience focusing on science, engineering, arts, and design, was designed to strengthen community and collaboration among students and teachers in the North Cross Lower School. In addition, in support of exploring the multiple facets of STEM education, the experience provided an emphasis on the importance of incorporating the arts, creativity, and design into STEM curriculum.

The eight-day series of workshops also engaged students in activities that explore what are often referred to as “soft skills,” such as leadership, communication, empathy, and critical thinking, yet are crucial to participation and success in the STEM fields. Over the eight days, students were repeatedly divided and regrouped by grade, with the final working groups consisting of one to two students from each grade from Kindergarten through fifth grade. Centered upon *If* by Rudyard Kipling, a coming-of-age poem traditionally featured in North Cross’s fourth grade curriculum, students explored the verses together and chose how to interpret the poem to their parents, teachers, and peers. This innovative cross-grade, multidisciplinary exploration of literature, theatre, communication, and creativity culminated in a day of performances and exhibitions on the school campus. Artifacts and images from this day are on view here.

The program was co-designed and implemented by ICAT and Moss Arts Center faculty and staff, Virginia Tech faculty and students, and North Cross School administration and faculty.

Figure 1: ICAT Day Overview

Experience it!

Throughout our engagement with the North Cross Lower School, select workshops, interviews, and portions of the final exhibition were documented by computer science students Sean Goodrich, Benjamin Kodres-O'Brien, and Zachary Stefan with the assistance of Jackie Meese.

Using cutting-edge 360-degree video technology, you can view workshops and exhibits as if you were in the room!

To view 360-degree video of the North Cross SEAD Experience, please utilize one of the computer stations located here.

To hear audio interviews with North Cross students as they reflect on the North Cross SEAD Experience, navigate your device to:
www.icatday.com

Figure 2: ICAT Day Experience Poster

Developer Manual

3.1 Design

3.1.1 360 Degree Video

To design an experience is to think both practically and conceptually about its many interdependent parts, all of which contribute equally to the experience as a whole. This section discusses the two sections of pre-production and post-production independently, covering possible combinations of equipment and software use.

Recording (Pre-production)

The first of these parts for creating a 3D and 360 degree video experience is the actual recording, both video and audio. The design plan is to use one of the likely two available 360 degree camera rigs that ICAT shares with various different teams in collaboration with them. One of the two rigs is a 6 camera GoPro rig that shoots high quality video for relatively shorter periods of time. The other is an all in-one camera that has longer recording capacity at the expense of some quality.

To record sound, the plan is to use both a central microphone and multiple “boundary” microphones. Each of the microphones will record stereo sound. Below in Figure 3 is an ideal sketch of how a workshop at the camp might look from an overhead view without motion.

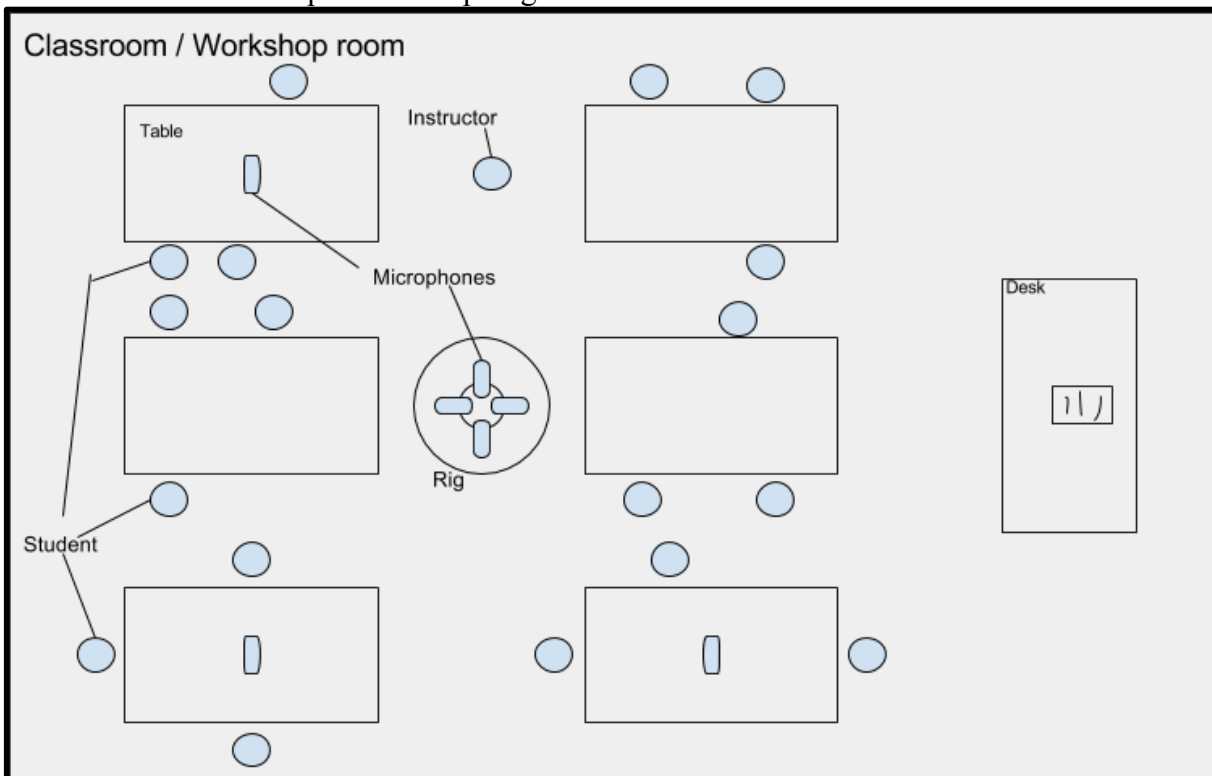


Figure 3: Overhead view of workshop room with camera and microphone setup

Video and Audio Stitching (Post-production)

After recording video and audio, the next step in the process of creating the experience is formatting the video. There are different options for achieving this end, and they are dependent on which video rig is available to us during the camp. In the first option, the use of the 6 GoPro camera rig, the stitching process is likely to be more difficult, as we will have to take six separate video feeds, and meld them to one. With the other camera rig, the job is made much easier by nature of already having an all-in-one recording.

To format the video, we must ask for help from some already written software. The two major software options in 360 video formatting are Unity3d, a gaming engine, and Adobe After Effects.⁴ There are others, but most do not have as widespread a support system as these. Unity3d is accompanied by many low cost plugins to stitch 360 video together. Adobe's software is most useful for taking 360 video and formatting it to play on flat screens with use of spherical mapping plugins such as Mettle's Skybox. This is the route we will take in order to use iPad's and headphones and/or a projector and speakers.⁴

Regardless of the video rig used, Unity3d must be used to format the sound in parallel with the video, as Adobe After Effects is a video editor and Unity3d is virtual environment editing software.⁵ To create the sound effects we want, we will format the stereo recording from the five microphones into binaural audio output for use within an Oculus headset and an iPad with headphones.⁶ A binaural audio format is preferable to a stereo format in that people will obtain a more three-dimensional space experience of the sound in a workshop room. Although everyone's pinna is different, as professor Bukvic discussed with us in his February 18th lecture, binaural audio is better than stereo audio. In the case of a projector and speakers, the audio will be stereo, unless there is time to format an ambisonic audio output and the ability to obtain a high quality speaker setup.⁷

To integrate the heightening of directional audio and dampening of field audio when one turns to face a boundary microphone, it will be up to us to implement an algorithm for doing so. First, we will create a three-dimensional model of the ambisonic sound-field recording. This is likely to be easy, as an ambisonic encoding is already a spatial encoding of audio. Subsequently, we will map the boundary microphones' positions within that three-dimensional model. With these positions, we will then write an algorithm within Unity3d that heightens audio from the field microphone that is closest to the center of the user's vision while lowering the sound from the field microphone.

It is again important to note that as we encounter problems with our current design of the 360 video experience, we will make changes. As we prototype, we will likely reach dilemmas that might force us to change our hardware and software decisions. As we approach deadlines, we may reach limitations that push us to simplify our end product, for the best ICAT Day experience. In these events, there may be small portions of audio or video omitted for the purpose of producing a well-packaged final experience. These design goals are considered by ICAT Media Engineer Tanner Uptegrove to be ambitious and attainable, and some potential routes of production may not be fully completed.

3.1.2 Student Reflection Overview

In order to create the website that can be displayed on an iPad for attendees to view individual reflections of students, we will first need to start by gathering the reflections. Teachers will work with students at the camp on days when ICAT personnel are not in attendance to complete the reflection: considering the good, bad, and fun about their camp activities. Finally, a web application will be created that allows visitors at ICAT Day to hear these audio reflections. Below in Figures 4 and 5 are wireframes of the web application and a storyboard in Figure 6 of the order of likely events on ICAT Day.

Wireframes and Storyboard

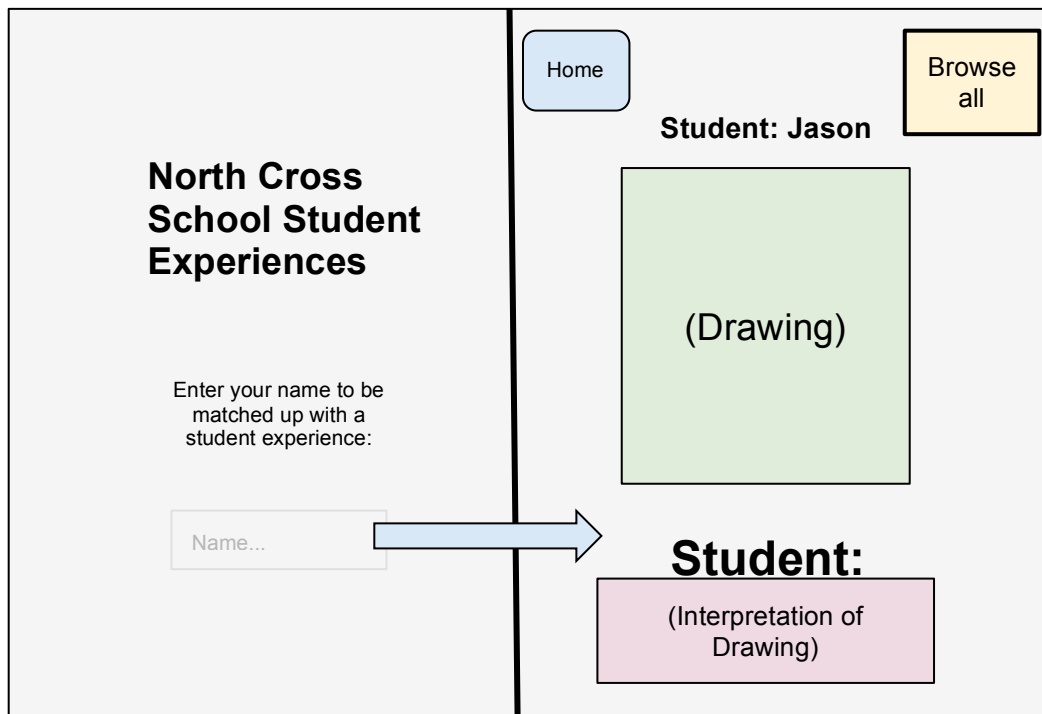


Figure 4: The wireframe illustrates the home screen, and the screen for a set of student reflections.

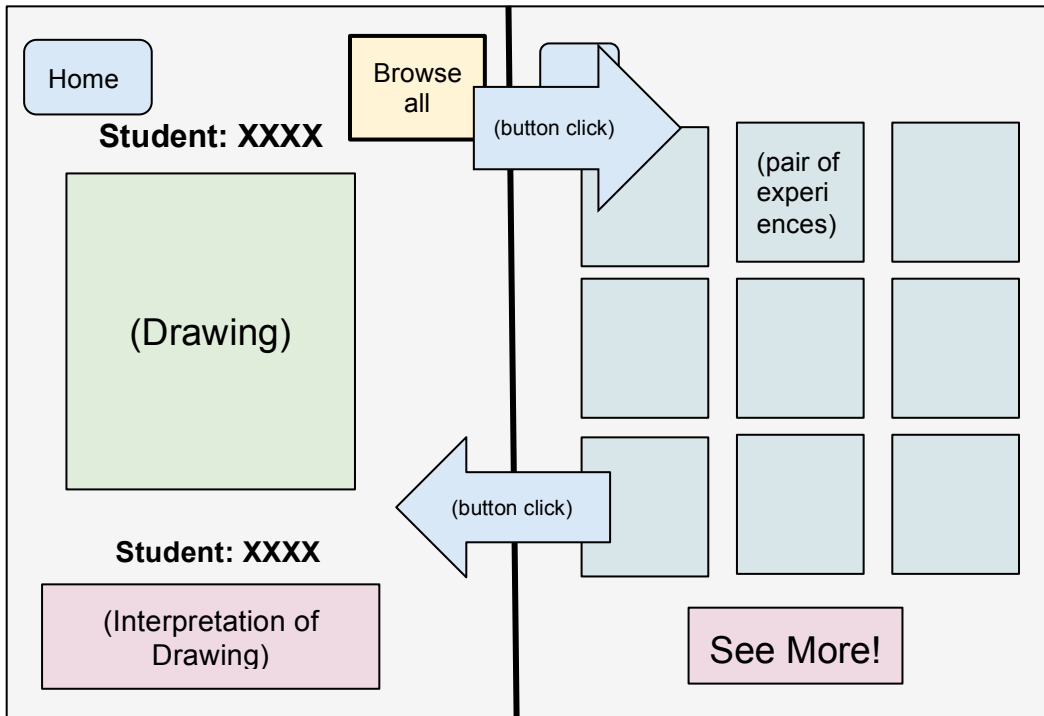


Figure 5: The wireframe illustrates browsing all experiences, and a single experience within those experiences

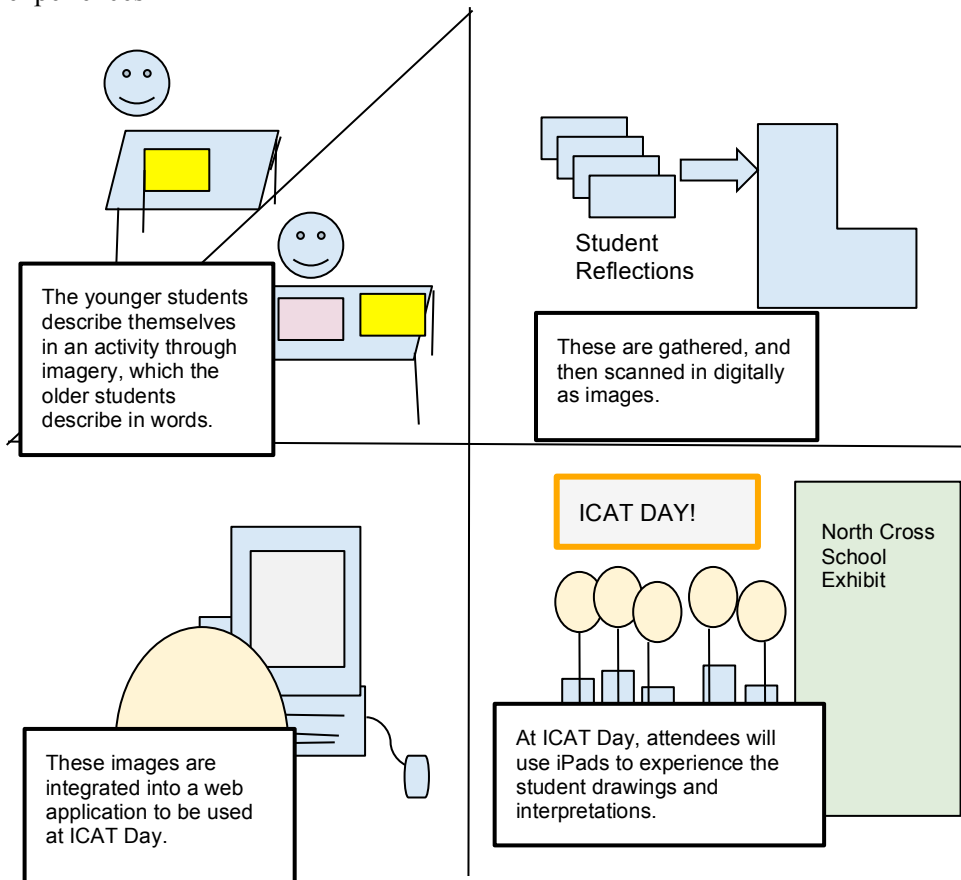


Figure 6: Storyboard of events for an ICAT Day attendee viewing student reflections

Web Application Architecture

We will be using Flask, a Python micro-framework, to build our web application for ICAT Day.¹³ Because of the relative simplicity of the web application relative to other more feature-filled web application, we decided to choose a simple framework. Flask will be used with HTML, CSS and jQuery on the front end. This application will only be used on ICAT Day, and will not need to be maintained or updated by ICAT staff or ourselves after the exhibit. This allows us to pick a technology that we are comfortable with. This application will be hosted on Amazon Web Services, to provide reliability and simplify the deployment process.

There were a few constraints we acknowledged when making the decision on architecture. First, we knew that the application would be run on an iPad and phones on ICAT Day. ICAT has a plethora of technical resources, but at the point in planning we were at, at the time, we were not able to with full confidence confirm that we will have a specific model iPad or device on ICAT Day for attendees. We may have had a hybrid of other tablets to use, or even touchscreen laptops. Acknowledging this, we decided to create a website, which is adaptive for the device, and would not limit us to a platform, unlike developing an app for Android or iOS. Secondly, the budget for the project presented a constraint. As we are borrowing camera rigs and audio equipment from generous lenders for our 360 degree experience, we also need to limit costs as much as possible on this side of the project. As such, choosing open-source and free software became preferable. Flask and the rest of the components in our architecture are all free, adhering best to the constraint presented. Hosting on AWS is also an extremely inexpensive option, considering this application will be running temporarily. This made deployment easy without the purchase of a dedicated server. Figure 7 illustrates the application architecture described above.

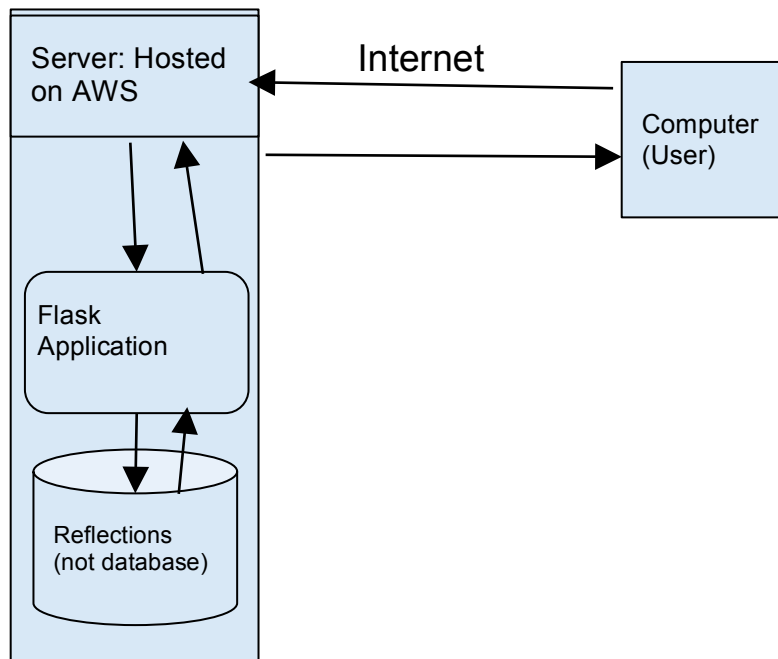


Figure 7: Student Reflection Application Architecture

3.2 Timeline

3.2.1 Progression

Gantt Timeline

Activity	February(weeks)				March(weeks)				April(weeks)				May
	8	15	22	29	7	14	21	28	4	11	18	25	2
Meet with Client about direction of the Camp	█	█	█	█									
Obtain Equipment and Training					█	█	█	█					
Filming of Camp					█	█	█	█					
Prototype individual parts							█	█					
Merge Video and Sound									█	█			
Put Student Reflection on Web App									█	█			
Test Finished Project											█	█	█
Final Report												█	█
Prepare ICAT Day Presentation												█	█

Table 1: Gantt Timeline

We began by ideating, defining our project, and working with ICAT throughout these processes. After our initial meeting with our client, Liesl Baum, we realized how broad and ambiguous our project would start out. This allowed us to spend time to ideate about how the camp could be documented, and what would best explain the children’s experience and the teaching methods used with ICAT Day attendees. We played with many ideas, and in the end presented two to Liesl. Liesl has approved both of the ideas, so we then started defining them more specifically and investigating their feasibility.

We met with Zachary Duer, Immersive Environment Specialist at ICAT, to discuss. He has pointed us to some of the projects that ICAT has done that involve similar technologies, and we then worked with him to secure two options for a camera rig that would enable us to take the video.

On the reflection side of our documentation, we started brainstorming ways to get each student involved in documenting their experience, so that we can display them at the exhibit. We’ve looked into things other museums do or have done in the past, such as the ID cards distributed at the United States Holocaust Memorial Museum, discussed in Section 2.2.

On February 17th, we attended a lengthy planning meeting for this camp, discussing the curriculum and logistics in anticipation for March. This gave us an overview of the workshops, the staff involved, and how the gallery at ICAT Day plays into these parts. It also gave us the opportunity to gauge the opinions of the other members of the planning committee for the camp.

In anticipation of the camp, the teachers at the school were trained on the workshops, and briefed on our student reflection portion to help students complete them, based on the material we worked with Liesl to prepare. In terms of videography, preliminary shooting with the camera rig and microphones was done prior to the camp, to train us on how the equipment functions, and how the stitching software adapts the footage. During the camp, we were present on multiple days, March 16 and March 31, to document through the videography and help the teachers administer the student reflection if necessary.

We met with Tanner Upthegrove, Media Engineer at ICAT, about possible methods of audio recording at the camp and presenting at ICAT Day. He spoke with us about the resources we may have access to in terms of audio at ICAT, and how these resources could fit into our goals with the project. We also met with Todd Ogle who has been experimenting with a 360 degree camera setup. He has lent us his GoPro camera rig and Jackie Meese, an IT specialist, has come with us to help with the cameras in Roanoke. We have been tinkering with software to edit and stitch clips of video Todd has already filmed with this camera rig. Additionally, we have been in contact with Innovation Space staff, and they have lent us audio equipment. We have rented two Zoom H4N and three H2N audio recorders and have recorded with them. We have filmed and recorded workshops on March 16 and March 31.

We made a loose prototype from the first set of footage, and it has been published to YouTube at https://www.youtube.com/watch?v=uq5clkk_d_Q. After the second day of filming we were able to select from the totality of our footage and create the final video progression with Adobe After Effects.

The integration of audio began shortly thereafter and was finished slightly behind schedule on April 25 after multiple evenings in the Moss Sandbox, of C# scripting and tinkering in Unity. Most of this time was spent in the cycle of importing files into Unity, testing their effectiveness, and changing scripts and files accordingly. When this life-cycle completed, testing began on Tuesday April 26 from the help of two students with no relation to ICAT. Mari Thomas and Tory Nagel, undergraduate students at Virginia Tech willingly agreed to provide feedback on the 360 video with the testing plan discussed in the testing section (3.4).

This web application ended up changing drastically through the prototyping phase. Talking with coordinators, our client and the gallery manager, it was decided that the most compelling reflections by the students were audio interviews taken in groups during the camp. Thus, the web application shifted to handling audio clips from groups of students. This is discussed in more depth in the “Lessons Learned” section of the report. As a result of this change, the audio had to be normalized (converted from .m4a or .mov to .mp3), because teachers and coordinators took the audio (and in some cases, video) on different devices. After this, the audio was uploaded to SoundCloud, where it will be referenced in the web application. The web application was then altered to handle displaying this information. Our testing of this is discussed in section 3.4.

In preparation for ICAT Day, we worked with Meggin Hicklin, Phyllis Newsbill and others on Sunday, May 1st to prepare our exhibit for Monday. We borrowed iPads from Innovation Space, retrieved headphones with the help of Tanner Upthegrove, and borrowed an Oculus with the help of Zachary Duer. A simple timeline of ICAT Day can be found below.

Location: Moss Arts Center

10:00 am Keynote

11:00 am - 4:00 pm: Exhibits

4:30 pm: Awards Ceremony

6:00 pm: New Music Blacksburg in the lobby

7:30 pm: DISIS Spring Concert in the Cube

We are part of the “Exhibits” section from 11:00AM-4:00PM mentioned above. Preparation for the exhibit began at 8:00AM on Monday, May 2.

3.3 Implementation

3.3.1 Roles

Sean Goodrich	Student Reflection (Web application)
Benjamin Kodres-O'Brien	360 Degree Video (Video)
Zack Stefan	360 Degree Video (Audio)

Table 2: Implementation Roles

All of us will be collaborating to obtain skills relevant to each part of the project, and to provide input of ideas. The roles above (Table 2) are guidelines to a loose ownership of the parts of the final project.

3.3.2 Video

Piecing together a 360 degree video is in many ways similar to what a studio film editor does. He takes shots from different angles and locations and splices them together in succession to create a montage. In this case, however, to construct a 360 degree video involves the stitching together of 6 to 7 video's being taken from the same central location for the entire duration of the video. In most video editing software, one can think of this as placing the various camera feeds on top of each other rather than next to each other.

First, though, is the filming process. We shot video on two separate days, and our amount of total footage was heavily dependent on various interactions the children being filmed had. We used Todd Ogle's Pro7 360Hero rig with 7 GoPro Hero 4's. Each camera has a memory card that stores roughly an hour's worth of video. Ideally, all cameras are turned on at the exact same time to minimize sync editing with Adobe Premier Pro.⁹ With the help of a remote, they can be started close to the same time, but to make up for sync problems, we loudly clapped once to provide an audible point for alignment.

Although various pieces of software exist for stitching and are used in different ways, we chose Kolor's Autopano Video Pro. Since the founding of a once small camera company in 2001, GoPro has risen to ubiquitous levels within the action sports community. In April of 2015 they purchased French virtual reality software company Kolor. Given this conglomeration, Kolor software is the most integrated environment to edit any kind of video with GoPro, and especially 360 video.¹⁰

Conveniently, the Sandbox in the Moss Arts Center of Virginia Tech has a machine with the professional versions of Kolor's software installed. The first of these useful software pieces is Autopano Video Pro, which will be used for stitching the 360 video. Stitching in this software works with the click of a button. However, each video file must be properly synced, something that Autopano Video does not always get precisely correct. In experimenting with some example footage from our camera rig in both Autopano Video Pro and Adobe Premiere Pro, Adobe's software tends to be more accurate with aligning the videos. Offset frame values can then be entered into Autopano Video Pro to sync them.¹¹

After stitching the video, it will have to be corrected as Autopano often leaves lines that make the stitch obvious. Kolor again has tools to correct for these issues. Simple issues like alignment of the horizon can be handled in Autopano Video Pro, but issues of blur and stitch lines must be dealt with in Autopano Giga. Kolor again provides help with video tutorials.

After editing, the video will be put on an iPad and an Oculus Rift. Unity3d provides an environment in which to format the video for the Oculus Rift, and publishing video to an iPad is as simple as it is to publish it to YouTube. Simple publishing can be done again with Kolor software. The timeline phases below have dates shown in the Gantt Timeline (Table 1).

Phases

1. Check Footage

The video will be checked for quality subsequent to filming. If video is not of high quality or is missing from any one camera, additional days of filming will be scheduled.

2. Stitch 360 Video

This phase will happen in parallel with the checking of footage. As footage is available, it will be stitched.

3. Integrate with Audio

Once audio and video have finished separately, they will be combined to form a three dimensional whole. This phase will likely take more time than most others, as Unity3d is a complicated piece of software.

4. Put on devices

The final 360 degree audiovisual experience will then be put on an Oculus Rift and an iPad for users.

5. Changes based on feedback

ICAT staff and artists will use the devices and provide feedback of the experience. We will then alter the 360 video if needed.

6. Gallery Integration

Once the 360 experience is finished, it will be integrated with the other portion of the project to be displayed in the gallery.

Video Prototyping

Before starting the explanation of the prototype, it is important to note that documentation from the Kolor website is constantly being updated to reflect software updates.¹¹ To make this prototype, Kolor's Autopano Video Pro 2.3 was used, and at the time of making this prototype Kolor's documentation had two sections labeled "WIP" for work in progress. Although the documentation only changes slightly from time to time, these changes may affect the process described below.

In beginning to develop a prototype, video files were collected together on a filesystem from the GoPro cameras and imported into Autopano Video Pro 2.3 by dragging all of the video files into the editor. Then, with seven video's from each of the GoPro cameras in the editor, one must sync the videos.

Kolor's software contains a feature to do this. It can sync videos using motion or sound. Because our footage was from an entirely stationary perspective, the obvious choice is to sync using each camera's audio recording. Autopano Video provides the option to select a range of the recording to use for synchronization. The larger the range, the more accurate the sync will likely be. However, more than about 10 seconds will suffice, and the law of diminishing returns applies in this scenario. With the click of a button to sync by audio, Autopano Video calculates the frame offset for each video, leaving one without any offset (i.e., frame number 0).

After syncing, the videos are ready to be stitched. Autopano's stitching feature allowed us to set the number of points in the recording to use for stitching. Their documentation claims that using 5 points is a good balance between time and effectiveness. Because we are using a powerful computer in the Moss Arts Center Sandbox, we raised that number to 7. Stitching takes a long time for the software to complete for even short videos so we have elected to use only 3 minutes of footage for the prototype.

After a stitch is computed, we edited the coloring using Autopano Video Pro's auto color detection feature and the horizon line of the stitched video by adjusting it at a start and an end time. Since the cameras are stationary, using only two points for correcting the horizon is adequate. Making the horizon flat is imperative for a good final viewing experience. With a flat horizon, the next step was to blend the stitching. There are always minute errors at the intersection of each camera frame's edges; no stitch is perfect. The blend feature in the software allows for smooth or sharp blending. Smooth blending caters to intense motion and sharp the opposite. Sharp was our obvious choice.

With all of the above done, the video was ready to be published, and it is on YouTube at the address https://www.youtube.com/watch?v=uq5clkk_d_Q. A still screenshot of the video without 360 degree effects applied is below in Figure 8.



Figure 8: Screenshot of 360 degree video in Quicktime

Our next major step was to gather more footage so that we have more to show and select from. We selected footage based on both the accuracy in depicting the events that transpired at the camp and the audiovisual artistic appeal of the footage. Two additional video clips from outdoors without spatial audio were selected. The videos were strung together and given transitions in Adobe After Effects to avoid disorientation of the user between shots. The final video was then moved into Unity to begin audio integration and virtual environment setup for use in an Oculus Rift. In consulting the Unity documentation and experimenting with creating simple 3D environments, we have put the video on the surface of a sphere, shown below.¹⁴

To impose a video onto a sphere required the help of Zach Duer, who was nice enough to give us readymade 3D object with inverted normals. This meant that the video could be viewed from inside of the sphere rather than on just the outer surface. As such, a camera object for view through an Oculus was placed inside the center of the sphere. Up to this point, it is important to note our consultation of the Unity documentation, which has served as an important reference for creating objects and writing simple C# scripts to add functionality to the scene.¹⁵ Those scripts can be viewed in this github repository: <https://github.com/bkodres93/oculus360video>.



Figure 9: Screenshot of 360 degree video scene in Unity

The video is played on a loop, with spatial audio present during the first portion, while the view is of North Cross School's multipurpose room. Following audio integration, the video in Unity was built for execution on an Oculus Rift. We were given access to an Oculus DK1 (Development Kit 1) in the Sandbox of the Moss Arts Center which we used during ICAT Day to display the video. The video is also available on YouTube at <https://youtu.be/ICNTcIoVztg>.

3.3.3 Audio

Even though the GoPro cameras have microphones for sound recording, they are generally of inadequate quality for immersion. To obtain quality sound we used external microphones. Sound adjusts as a user turns their orientation; for example, if the user looks at a group of kids then the sound from the microphone closest to the kids will output to the user and all other sound sources would be dampened.

After talking with Tanner Upthegrove, we determined that the only way to get the audio recorders we need was to borrow them from Innovation Space. We obtained five Samson Zoom portable audio recorders. We placed four of the microphones throughout the room and one beneath the camera. This allowed us to record audio for individual groups and for the whole room.

Once the sound was recorded we then synchronized the sound with a clap as a reference point. Following synchronization we began the process of mapping the audio in three dimensions to combine the audio and video together in Unity3d. The software allows for different gaming engine plugins that support three-dimensional audio and for the merging of a formatted video with that audio.

Phases

1. Record Sound

Each day we go to North Cross we will film and record sound. The five microphones will be placed in a circle around the 360 rig.

2. Sync Sound

After sound is recorded we will go back and cut the sound files so they start at the same time.

3. Integrate with Video

Once audio and video have finished separately, they will be combined to form a three-dimensional whole. This phase will likely take a long time in Unity3d.

4. Adjust Sound

After the sound is combined with the video we will adjust the sound so it more pleasant to hear what is going on. This will depend on what footage we use; if the kids are doing a theater activity then this is not an essential step. If the kids are doing workshops all at the same time, it may be useful to edit the sound so the user can hear one particular group instead of the chaos of 200 kids talking at once.

5. Put on devices

The final 360 degree audiovisual experience will then be put on an Oculus Rift and an iPad for users.

6. Gallery Integration

Once the 360 experience is finished, it will be integrated with the other portion of the project to be displayed in the gallery.

Audio Prototyping

Prototyping spatial audio begins with the syncing of both the audio from the video to the three other audio files from the microphones. Adobe After Effects contains a useful synchronization feature for this in which resulting subsets of larger audio files can be exported as smaller ones that are in sync with the video.

After syncing the audio files with each other, they were imported into Unity and attached to audio source objects in the scene, shown below.

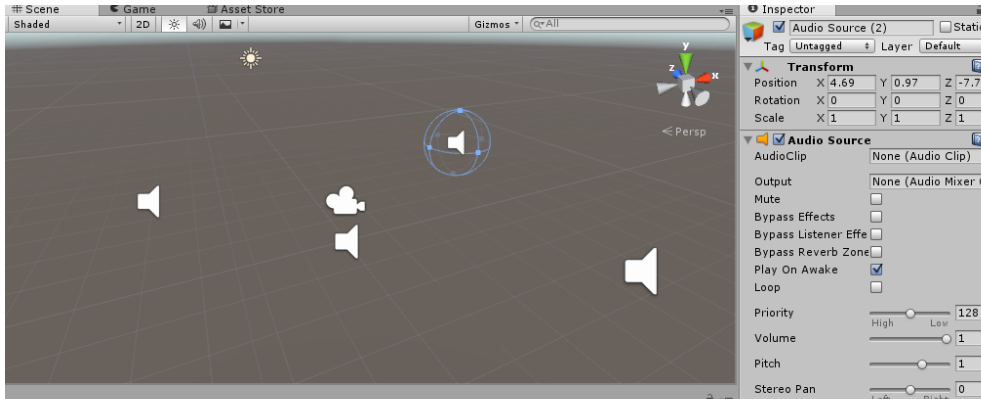


Figure 10: Unity engine with the placement of the 4 microphones

With audio in the Unity scene it was now necessary to control the volume in a spatialized way dependent on the camera's orientation. Unity contains a start event that kicks off entry into the virtual scene. Upon this start event, any C# script that implements the method "Start()" will also be compiled and executed. Inside of this method it is possible for the volume of each audio source to be adjusted. One can attach the same C# script to multiple audio sources in Unity, and one script will suffice for all audio sources if the code written is of a general solution. So, we developed an algorithm that compares the angles between the vector pointing directly away from the camera view and the vector that points from the camera to the microphone. Each microphone will call this script once every frame. The angle returned will be used to adjust the volume level of the microphone. So, if the user is facing directly at the microphone, they will hear it at 100% of its volume. If a user is facing 90° away, the microphone will be outputting 50% of its volume, and if the user is 180° away, that microphone will output no sound. A diagram of the situation is below.

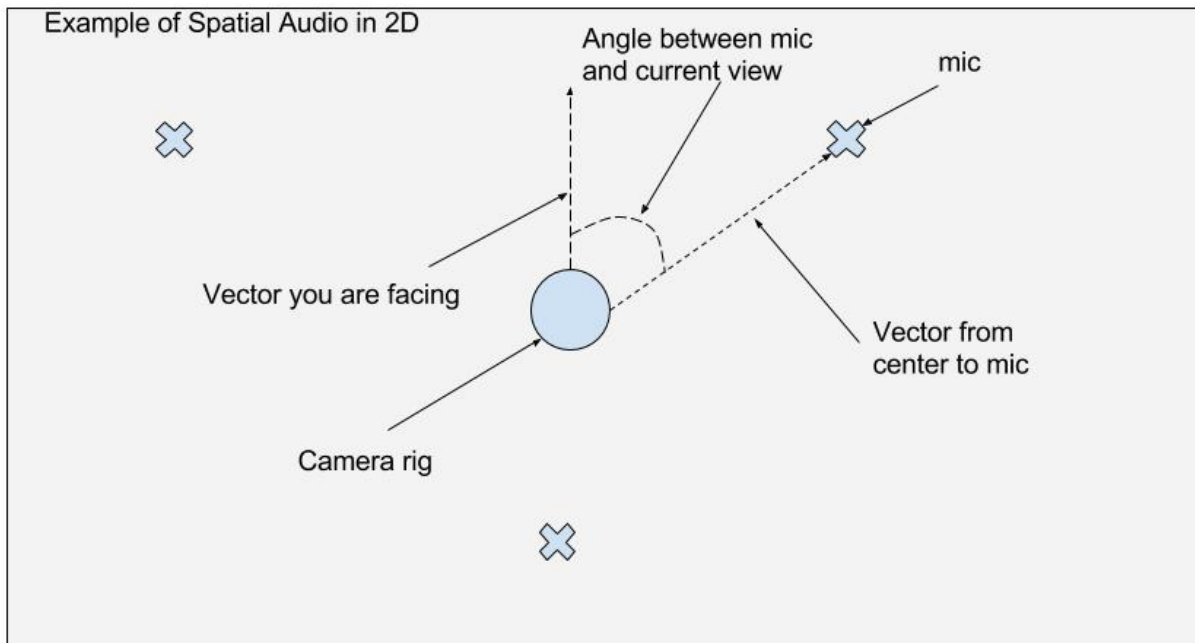


Figure 11: Calculation of angle for Spatial Audio

3.3.4 Student Reflection

Architecture and Tools

The Flask Python framework will be used to implement the student reflection web application for ICAT Day. Flask is a well-supported Python framework that will handle routing, database manipulation, view templating and more, for the application. It will serve views in the form of HTML/CSS/JavaScript to the user to interact with the student reflections. Bootstrap will be used as an HTML/CSS/JavaScript framework as well. These frameworks will be used to create the application in an efficient and aesthetically pleasing manner.

All of the application work will be managed using GitHub. This will give structure to the development process, and securely host our code and the version history. While Sean Goodrich will be the lead developer on this part of the project, other group members may need to contribute to the application as well. In this case, GitHub will allow all members to work on separate parts and safely develop throughout the lifecycle of the project.

This application will be deployed to an Amazon Web Services instance using Amazon Elastic Compute Cloud (EC2) to manage the Flask web application.

In summary, listed below are the components/libraries/services to be used to build this application and support usage.

- Flask: routing, business logic, view templating and more, for web application
- Bootstrap: HTML/CSS/JavaScript framework for quick and efficient front-end development
- Amazon Elastic Compute Cloud (EC2): hosting the Flask web application
- Amazon Route 53: domain hosting, routing to EC2 instance
- GitHub: code repository, version control, group development

Phases

1. File Digitization

This process needs to begin after the camp has concluded. All of the reflections completed by the students will be normalized into one file format (MP3) and stored in a central location.

2. Initial Local Development

After the reflections are available in a digital format, development of the web application can start. Using GitHub, application development can be done initially on a local server (laptop) for testing and experimenting.

3. Gathering and Addressing Client Feedback

An initial version of the application will be presented on a local computer to the client, Dr. Liesl Baum, who will provide feedback for changes to be made. Once these changes are made, deployment can begin. This step includes overall testing of the application as well, after changes are made. Testing will include simple use of the app by ICAT staff and artists.

4. Deployment

With a completed web application approved by the client and deployed to a local machine, migration to the Amazon Elastic Compute Cloud is next. Finalized versions of code will be approved by the whole team and moved to an EC2 instance.

5. Gallery Integration

Integrating the application into the ICAT Day gallery is the final step. Working with Meggin Hicklin, the group will prepare tablets and iPads with the web application for gallery attendees to view, and fix any final issues that come up in the process.

Student Reflection Prototyping

Prototyping for the Student Reflections web application started with the creation of static web pages that reflect the wireframes conceived in the design. These pages were created using the architecture discussed above, and demonstrated on the development laptop. Implementing the routing, serving of pages, and server initialization, were completed with the help of a tutorial from Miguel Grinsberg, an author and developer with regard to Flask.¹⁶ These pages can be viewed below in Figures 12, 13 and 14.

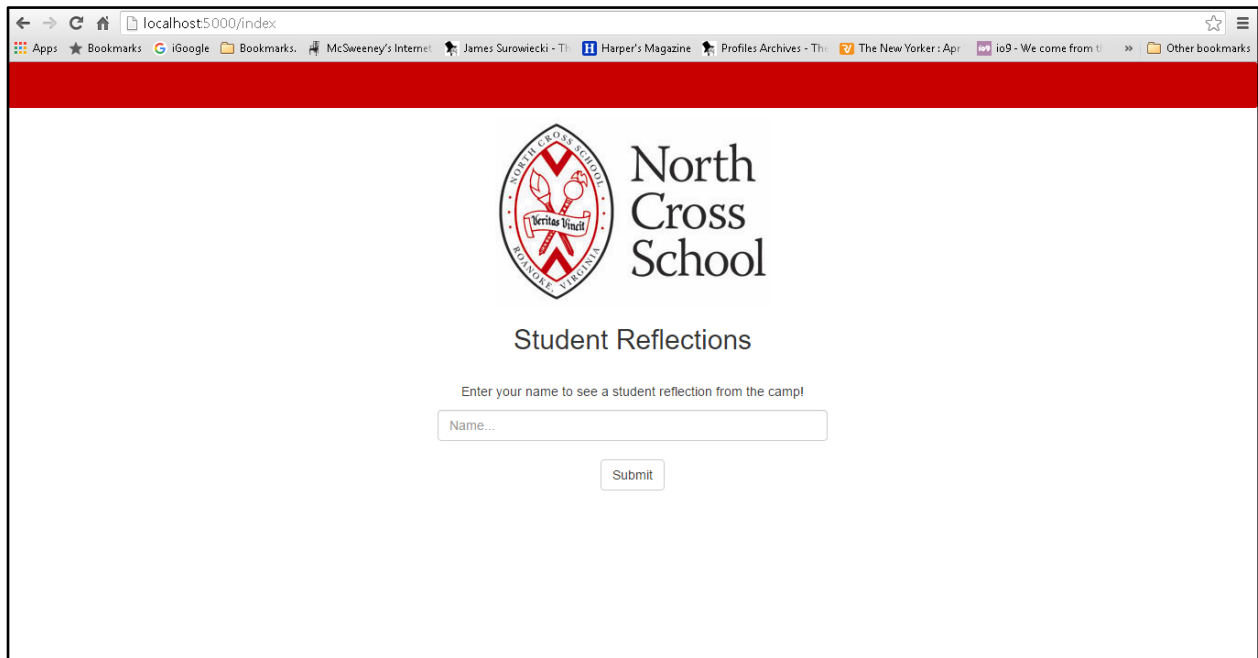


Figure 12: Homepage for the web application.

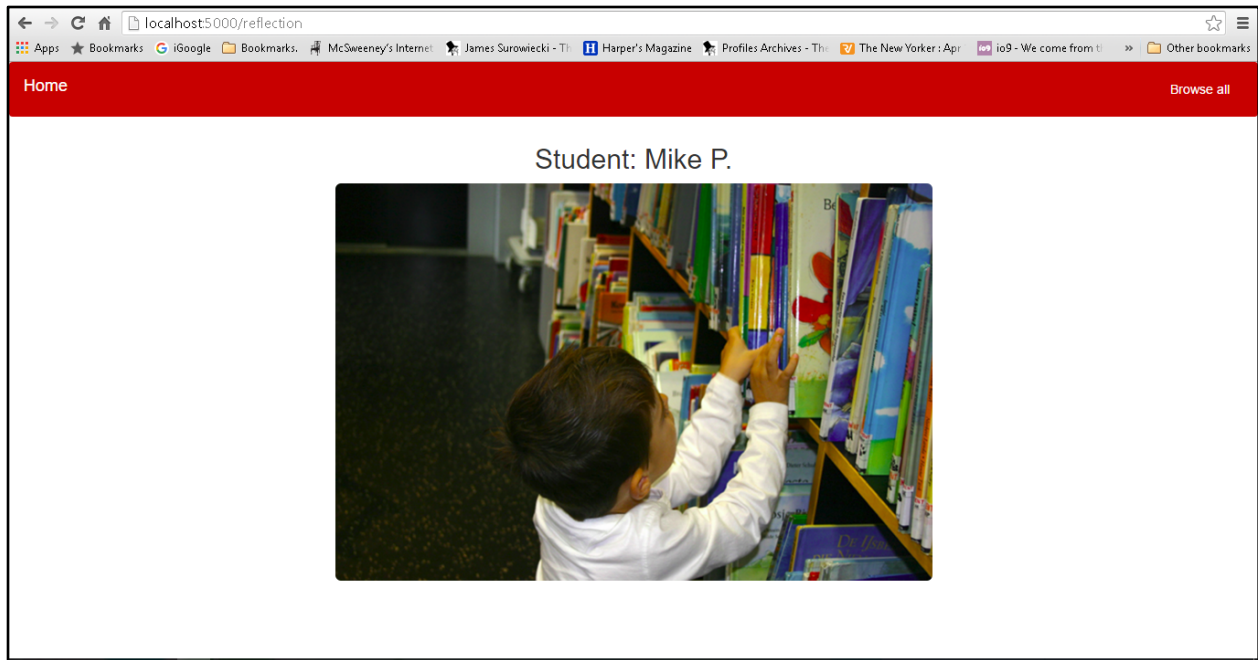


Figure 13: The reflection page, where a single student reflection is displayed.

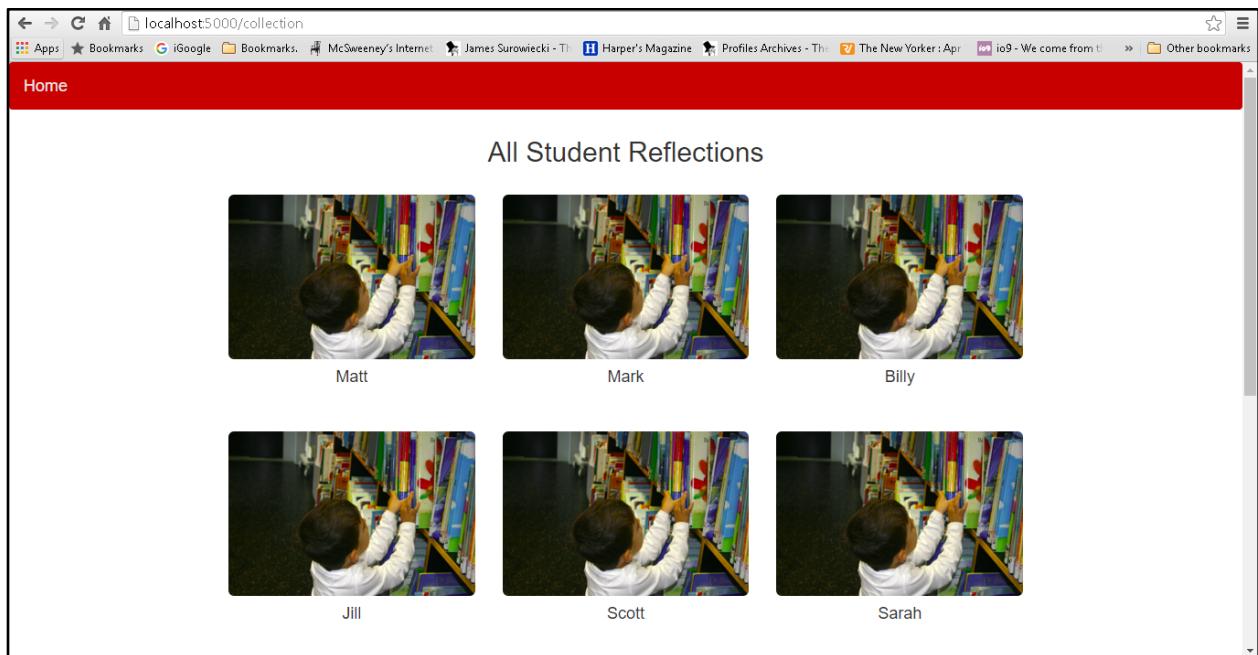


Figure 14: The collection page, where all student reflections are held to be viewed.

These pages use filler images and names because the ICAT camp had not concluded at the time of development. Also, this development was done prior to the changes made to reflection, which instead was taken using audio instead of a physical medium. The aim of this prototype is to inform the final design and functionality of the application before the camp is completed, and in time to iterate before the application's use in May.

As can be seen in Figure 9, the user would input their name in the input box and click submit to view a student reflection from the camp, as shown in Figure 10. Again, this feature was changed

due to the change in medium and quantity. This is discussed near the end of the report, under “Lessons Learned”. If interested, the user can then view all reflections by clicking in the top right corner, leading the user to the page shown in Figure 11.

Changes made to this prototype are tracked through GitHub, where all group members can contribute and look back at older versions of the application. All members needed to ensure that they had identical versions of Flask and Python for this to be successful, as only the source code for the application is being tracked in the repository. The GitHub repository where the web application prototype lives in is public and can be reached from this website address: <https://github.com/seantg/NCRreflections>.

Refinement

This prototype aimed to inform the final design and functionality of the application. As such, we planned to use this to gather feedback from our client. After receiving feedback from Dr. Baum, we continued to iterate on the prototype until the final material, the set of student reflections, was ready to be integrated. After this development and integration of media, we gathered final feedback from Dr. Baum and Meggin Hicklin, the gallery manager for ICAT Day. With all final changes made, the path to deploying this application onto Amazon Web Services began, and testing on iPads started afterwards.

Feedback from individuals involved in the project was the primary testing method for the application. As little business logic exists and a database was not used, there was not any Python code to unit test, as unit-testing a framework or the language itself is redundant. We had to personally check that every reflection stored on the server is accessible on the “Browse all Reflections” page (Figure 11), and that all references to audio are valid. After these steps, we were certain that the design and functionality are sufficient and all reflections are accessible on the application. By ultimately using Amazon Web Services to host this application, we are mitigating most risk of errors that would normally be tested for in deploying an application outside of basic walkthroughs of the application on deployment.

3.3.5 Media Statistics

360 Degree Video

Total video taken at North Cross School: 104GB (~14 hours)

Total audio taken at North Cross School: 1.37 GB (~4 hours)

Total video used in ICAT exhibit video: 324 MB (4 minutes)

Total audio used in ICAT exhibit video: 34 MB (4 minutes)

Student Reflections

Minutes of audio taken by interviewers: 24 minutes, 29 seconds.

Minutes of audio used in web application: 17 minutes, 48 seconds.

3.4 Testing and Refinement

3.4.1 360 Degree Video

Testing of the 360 Degree Video will proceed on two fronts: internal user testing and external user testing. In addition to our own opinions of the product, we decided to gather attitudinal feedback so we were focused on what people had to say about our project in order to then make changes based on user feedback.

Internal user testing

Our internal user testing consisted of each of our team members viewing our prototype using an Oculus. Based on our experience viewing it we decided to change our plans from making three separate videos to be shown on ICAT Day to making one long video that will run on a continuous loop. We reached this conclusion since our original plan was to use thirty-second clips and when we viewed the prototype we each used it for more than thirty seconds, since it takes a few seconds to get adjusted to using the Oculus. We also thought that rapidly switching from our first video, which is inside, and our second video, which is outside, would be disorienting so we have decided to add transitions between the videos. There is also plenty of movement by children and coordinators in the videos so we want our users to get enough time to enjoy viewing our project. We determined that if we were going to make the Oculus video longer we should combine our three videos into one long video. This way the user will have adequate time to use our project and we will be able to give the user a small taste of what happened over the duration of the camp.

External user testing

We will have other users wear an Oculus and view our 360 degree video from start to finish. Our goal is to obtain feedback that will affect decisions on two major fronts: the time spent in one location within the video, and the transitions between those locations. These testers will be picked at random from our set of friends, most of whom are unaffiliated with ICAT. An effort will be made to find at least one tester who is above the age of 40 and unaffiliated with Virginia Tech in any way.

In order to obtain user feedback after a tester has finished viewing the entire experience, a conversational interview will take place. Questions in the interview will be broad, and included some or all of the following:

1. What did you think and feel?
2. What about the experience caught your eyes or ears?
3. What are your thoughts on the transitions?
4. What would you change?
5. What about the length?

A user on ICAT Day likely does not have much time to stop and use the Oculus if they want to see the rest of the exhibit. Because of this, we want to be sure that people will enjoy the video without feeling too preoccupied with it. Therefore, although our questions are broad, they lead in the direction of obtaining feedback about the length. Most importantly though, the conversation will be casual and open so that all feedback is addressed.

Tester #1: Mari Thomas

What did you think and feel?

A: I felt a bit disoriented and like I was intruding on the experience. I also thought it was cool and a different experience than I've had before since I haven't spent long in a virtual reality scene before. It was cool, like yeah, cool is the word.

What about the transitions?

A: They seemed fine. They didn't affect me much. But at the end, things were distorted, and that was sort of confusing.

The length?

A: How long was it? I don't really know. Seemed not too short or too long.

What would you change?

A: The ending. Things got slow, kids were moving and stopping, and audio was glitching.

Tester #2: Tory Nagel

What are your thoughts?

A: I felt really old! Seeing kids run around brings me back to young days. But in the end we are all running around. This one kid is like rolling all over the ground, I love him. The natural sound is really good. There is someone right below me, which is a little weird.

Could you hear different audio happening?

A: Not really, I liked the audio outdoors with all of the sounds from a distance. The indoor setting was kind of confusing from a sound standpoint.

What about the transitions and the length of the video?

A: I felt the middle section was longer than the other two, I don't know if that was an intentional artistic choice or not. But I kept looking like 'I've been here before.' The transitions were nice, they felt cohesive in that the subject was the same.

What would you change?

A: The ending was confusing, I feel like there are some technical issues happening. I was confused.

Refinement

Because both testers negatively responded to frame rate problems in the latter third of the video, we have elected to display our video through Kolor Eyes for the ICAT Day demonstration. This means that spatial audio was not in effect for ICAT Day, but the project submission to

VTechWorks contains the implemented spatial audio. For more information on this decision, please refer to the Lessons Learned part of the report.

3.4.2 Student Reflection

The same division of internal and external testing applies to the Student Reflection portion of the project.

Internal user testing

Initially, we did internal formative user testing with our client, our group members, and the gallery manager. This communication was useful, because it is what started the conversation to change the material displayed in the student reflections to audio instead of images. That process is detailed in “Lessons Learned”. This formative testing did not involve critiquing things we plan to assess in external testing like navigation, critical incidents, and simulating the final environment. Our aim during this set of testing was to get rough feedback orally, to help refine the prototype and make any major changes that need to be made as soon as possible.

External user testing

This phase of testing aims to inform final design changes to the user interface, navigation, and to address any critical incidents that may occur. This summative testing will be done with external users, and aims to collect qualitative and quantitative data on their experience. Because our application is tied to the environment it will be displayed in, the second floor mezzanine of the Moss Arts Center alongside the rest of the exhibit, we will need to do our best job at simulating this environment when testing. This was done by guiding a set of representative users through the application, and asking them to use it in the space, walking around the potential exhibit path while interacting with the application. Permission by participants was given to publish survey results and use photos taken during the study.

We gained better insight by having the participants use the application in the place where the exhibit was held. Other group members took notes and documented the experiences of participants, and then a survey to gather feedback was given to the participant on conclusion. Data gathered from the exit survey and the observation of the tasks being completed was used to evaluate the application. This evaluation took place on April 22, 2016 with three participants. The evaluation form and plan is below.

ICAT Day Web Application Evaluation Design: **Time: April 22nd, 2016**

Location:

Moss Arts Center
190 Alumni Mall
Blacksburg, VA 24060

Number of Participants: 3

Plan:

1. Present the ICAT Day Exhibit concept and talk-through the exhibit experience with the subject.
 - a. Explain the web application in relation to the exhibit
 - b. Cover the general functionality of the interface
 - c. Define any terms or contextual information unknown to the subject
 - d. Answer subjects' questions
2. Give overview of evaluation to subject
3. Have them complete the following tasks through the use of the prototype. Take observations during each task.
 - a. Task 1: Access the website using a mobile device, following instructions drafted for ICAT Day.
 - b. Task 2: Navigate through the website while standing, and read all text on the website.
 - c. Task 3: Use the random audio selection mechanism to listen to a random audio reflection while walking around the space, and then browse all reflections to listen to a second reflection.
4. We will have users complete a post-evaluation survey to gather their thoughts on the tasks based on control, usability and more.
 - a. Name (Not published)
 - b. Age
 - c. Gender
 - d. Rank the usability of accessing the website in the space on a scale of 1-5
 - e. Rank the usability of website navigation and listening to reflections while moving through the space on a scale of 1-5
 - f. Rank the ease-of-use of the entire process (access to conclusion) as a whole on a scale of 1-5
 - g. Overall comments on the system.

In having participants perform these tasks, pieces of the application that need to be updated or changed were found. The survey results from the participants, as well as photos taken during the study, can be found below in Figures 15 through 21.

- a. Name
[REDACTED]
- b. Age
 - i. 22 years of age
- c. Gender
 - i. Male
- d. Rank the usability of accessing the website in the space on a scale of 1-5
 - i. 5: The website was easy to access and loaded quickly.
- e. Rank the usability of website navigation and listening to reflections while moving through the space on a scale of 1-5
 - i. 5: The audio reflections were easy to hear while moving through the space provided, and it worked well since i could close my phone and still listen to the audio reflections. The website navigatability is perfect for anyone as it is easy to use due to its simplistic design.
- f. Rank the ease-of-use of the entire process (access to conclusion) as a whole on a scale of 1-5
 - i. 5: The website makes the whole process easy and enjoyable. It allowed me to focus on the art while not worrying about the technology. Audio files were clear, and it gave the whole exhibit more meaning as I could listen to the children speak about their experience with art, while I looked at their art work in real time.
- g. Overall comments on the system.
 - i. I believe the system works great, and no changes need to be made. The exhibit along with the webiste should make the experience enjoyable for all who come. It gave a great insight into the hard work and dedication of these young art students.

Figure 15: Web Application Participant 1 Survey

- a. Name
[REDACTED]
- b. Age
 - i. 22
- c. Gender
 - i. Male
- d. Rank the usability of accessing the website in the space on a scale of 1-5
 - i. 5
- e. Rank the usability of website navigation and listening to reflections while moving through the space on a scale of 1-5
 - i. 5
- f. Rank the ease-of-use of the entire process (access to conclusion) as a whole on a scale of 1-5
 - i. 5
- g. Overall comments on the system.
 - i. The system was highly user-friendly overall. I think the simplicity of the website leads to a very understandable and easily navigatable experience. Above all else, I found the functionality that randommized the played audio recording to be very interesting and helpful, since choosing a particular recording from the "View All" list is a bit overwhelming. This is simply because the naming of the recordings in the "View All" listing are a little generic and un-descriptive.

Figure 16: Web Application Participant 2 Survey

- a. Name
[REDACTED]
- b. Age
 - i. 22
- c. Gender
 - i. Male
- d. Rank the usability of accessing the website in the space on a scale of 1-5
 - i. 5
- e. Rank the usability of website navigation and listening to reflections while moving through the space on a scale of 1-5
 - i. 4
- f. Rank the ease-of-use of the entire process (access to conclusion) as a whole on a scale of 1-5
 - i. 5
- g. Overall comments on the system.
 - i. I found that scrolling down on my phone to find the "randomize reflections" button was a little disorienting. Otherwise, I liked the application and thought it was understandable and navigable.

Figure 17: Web Application Participant 3 Survey



Figure 18: Web Application Participant completing Task 3 of study

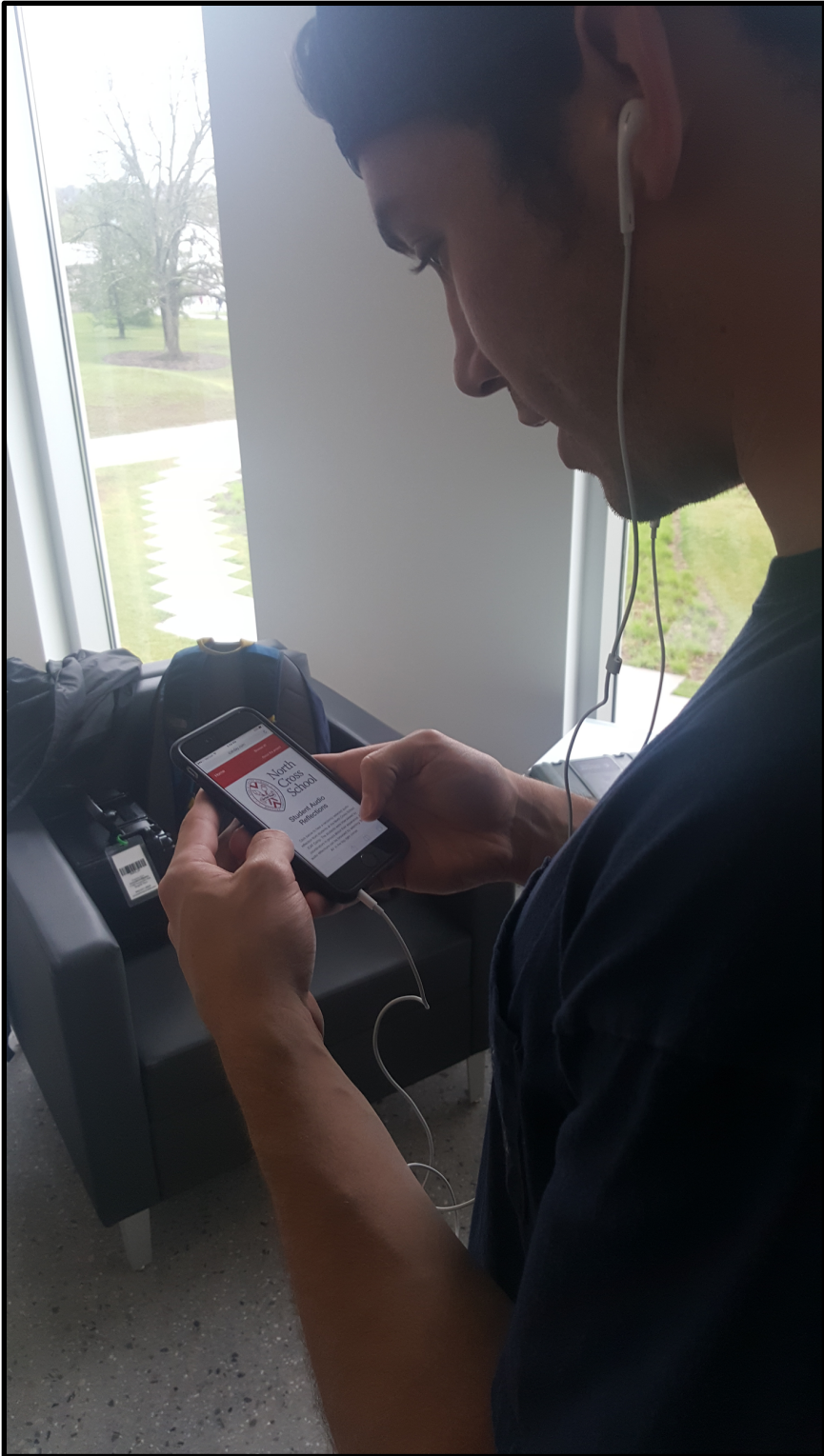


Figure 19: Web Application Participant completing Task 1 of study



Figure 20: Participant completing Task 3 of study

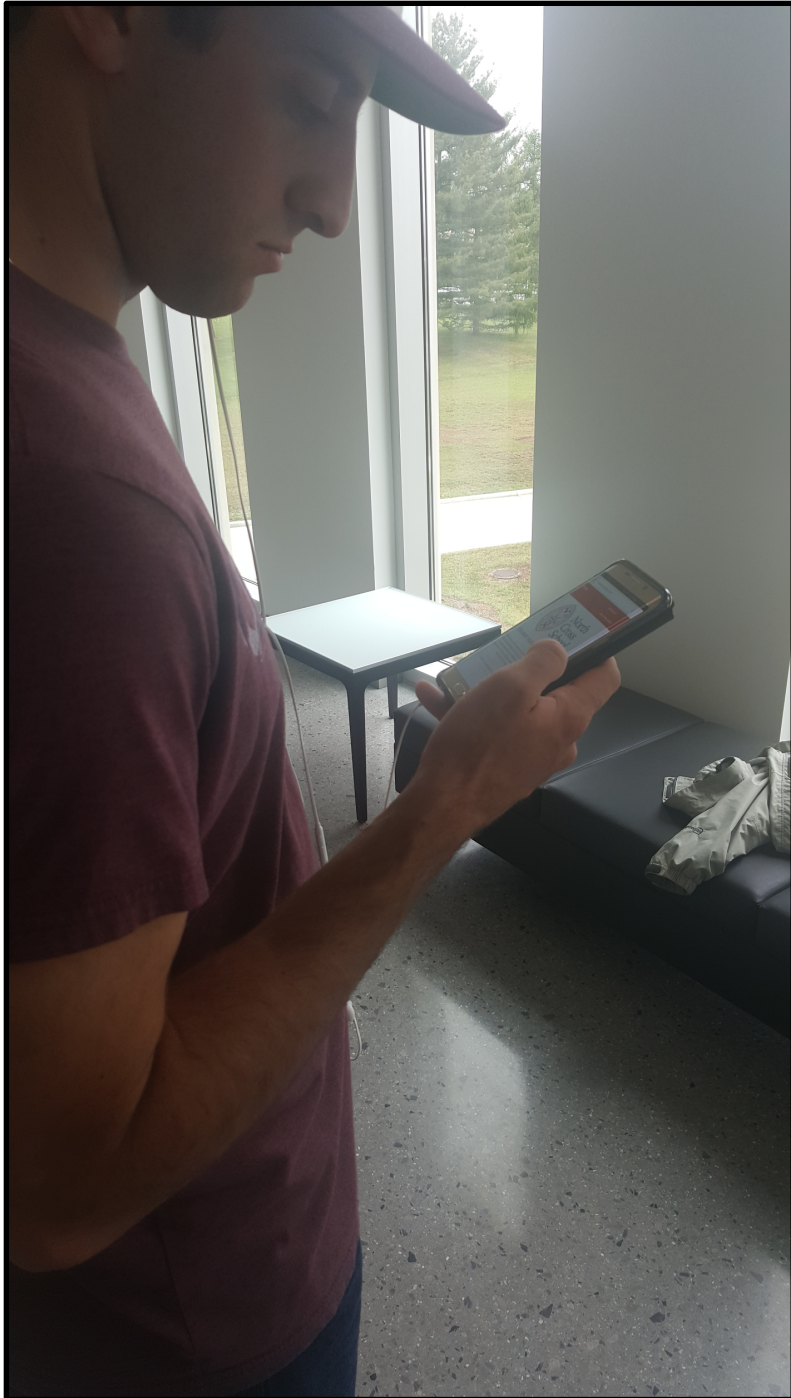


Figure 21: Participant completing Task 2 of study

Refinement

After running the study, and analyzing results, we decided on a few changes to the website. While comments and ratings were favorable with respect to most aspects of the website, a few of the comments suggested design issues and confusion. First off, we addressed small design issues that we encountered because of multiple screen sizes like needing to scroll to see the action button. Next, we tried to combat the comments of interview naming conventions as “generic and descriptive”. This naming was because of the information provided by the audio and video files

provided to us. We could not glean the names of the children, or any more information than the workshop group. We approached our client, Liesl, with this issue. She acknowledged the confusion by participants and suggested that by splitting interviews by question, and adding in the details of which teacher/volunteer was interviewing the students, the naming and descriptions would be more helpful to visitors. We then worked to split all of the audio interviews by the question asked, using Audacity, and renamed all of the files on SoundCloud and on the website to include the name of the interviewer and the question asked. Final results for the website can be seen below in Figures 22, 23, 24, and 25.

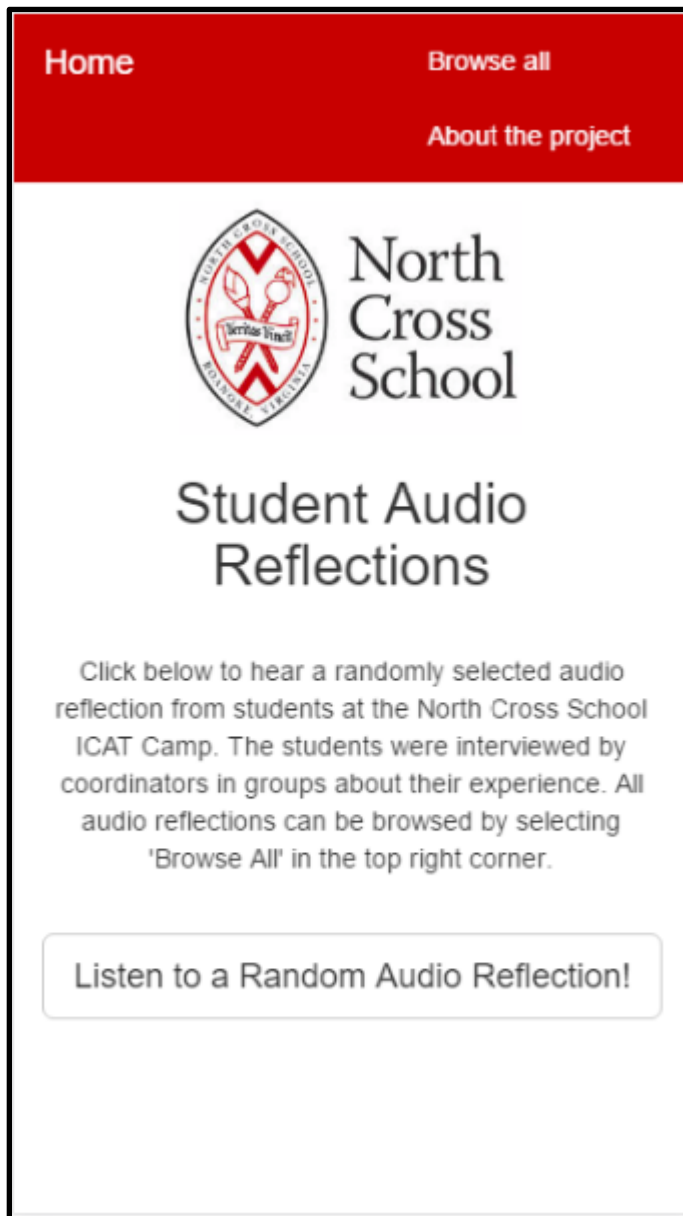


Figure 22: Title page of web application



Figure 23: Reflection view page of web application

Home

Browse all

About the project



North Cross School

About this project

This project was conceived to communicate the experience by students at the [North Cross School](#) in Roanoke, VA. The program was structured to stimulate cross-grade, multidisciplinary exploration of literature, performance, communication, and design. The common component to the program was the poem "If" by Rudyard Kipling. This was the first time a

Figure 24: About page of web application

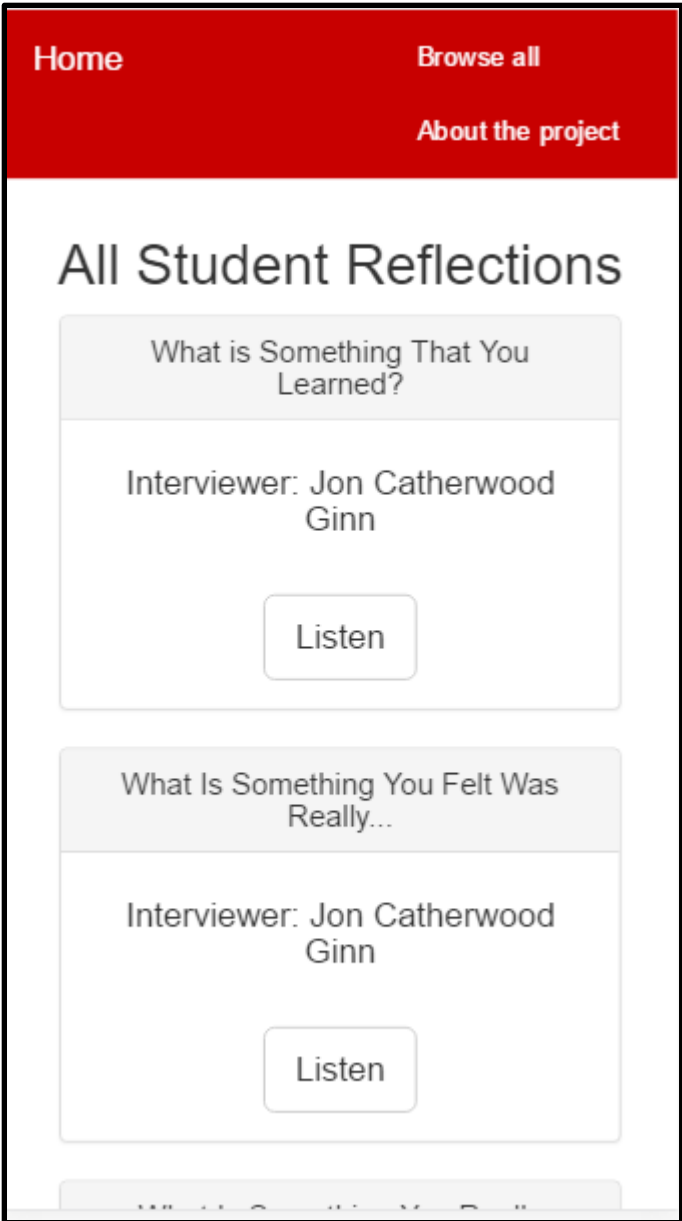


Figure 25: Browse all page of web application

Lessons Learned

4.1 360 Degree Video Lessons

Filming

In constructing something as complicated and uncharted as a 360 degree video, we ran into a number of unforeseen problems, the first of which was related to the filming process. In discovering that the second day of filming was happening outdoors amongst the minor chaos of students running around randomly, we elected not to place microphones in various places around the campus. We made the decision that the motion of the activities transpiring (students presenting their artwork and interpretations of Rudyard Kipling's poem "If") was enough to keep a user occupied without an augmented spatial audio experience. It would have been difficult to place the microphones in a location that captured any conversation with so much motion happening.

Post-Production

The issue of syncing video and audio was compounded by the problem's existence in both filming and post-production. In an attempt to mitigate problems in post-production, we attempted to start all audio recorders at the same time with the video remote. In hindsight this was unnecessary as Adobe Premiere Pro handles syncing with an algorithm that corrects for this anyway.

In stitching and editing the video, we encountered problems in using the Unity environment to integrate audio and video in 3D space. First, it takes Unity over an hour to import a 334 megabyte MPEG4 video file; this slowed our development process, although we were able to do various things while this was happening. Our second major problem was confusion over Unity documentation of using vectors and quaternions. To calculate angles between vectors required the use of the forward facing vector from the Oculus camera, not the rotation vector that we had originally supposed. Luckily, Zach Duer was able to help us in better understanding Unity's scripting documentation so that we could complete the spatial audio portion of our project.

Decision to Remove Spatial Audio for ICAT Day

Because of difficulties in importing large video files into Unity3d, building the project from Unity causes there to be a large amount of lag in the third section of the video involving more motion of the cameras. Additionally, both testers of the video commented about this issue somewhat decisively, in that they both concluded that the lag was confusing or disorienting. One of the testers also commented that they couldn't tell that spatial audio was present. In lieu of this problem, we have elected to forgo building through Unity with spatial audio and view the video in Kolor Eyes, a native viewer made by Kolor that responds to the Oculus Rift.

4.2 Student Reflections Lessons

Decision to Remove Database

Originally, in designing the architecture for the application, we included a MySQL database to hold information about images. When it came to prototyping the application, it became obvious that a database would not be necessary for this project. We made the decision to omit a database from the application, for a few reasons.

The first reason we chose not to include a database was because we conceived of a way to handle the server-side logic that maps an ICAT Day attendee's name to a child's reflection without querying a database. This could be done by storing all of the children's names in a static array, instead of querying the database to look for the identical names each time. We took advantage of the knowledge that the database would effectively hold a small number (10) of strings and would not change. Therefore, having the application query the database for all of these strings each time an attendee used the application was a waste of processing time for the attendee and of development overhead for our team.

Second, we realized that this application would only be used this year, and for this exact camp and exhibit. Because of this, we did not have to worry about the extensibility of this application in the future. Therefore, if reflections would never be added to the database in the future, we can simply make the database a set of static strings in the business logic (Python) side of the application.

These are the primary reasons we made the decision not to have a MySQL database during the prototyping and refinement stage of project development.

Decision to Randomize Reflections

Originally in our design, we wanted to match an attendee to a reflection by using their first name. This could create a link to a student in an informal way. An example of this would be matching an attendee named Susie to a student named Sarah (their names both start with 'S'). After working with the administrators of the camp and our client to gather the best reflections, this concept was no longer applicable.

Meggin Hicklin, the gallery manager, stated her aim to display many of the physical artifacts that students made from the camp on clothesline throughout the exhibit. As well, Dr. Liesl Baum, our client, talked of how some of the best reflection the students did was through interviews with the camp coordinators. Thus, we decided the best way to help attendees experience the students' reflection was through audio interviews taken during the camp. There was no way for us to predict which type of reflection would fit best in the exhibit until after the camp. As a result, this decision had to be made after the camp, and our design would need to be malleable to adapt.

This led us to incorporating audio into the web application, for attendees to hear what the students thought of the camp. This audio was taken in groups, and there were only nine clips of audio ranging from two to five minutes. After testing, those clips were split into twenty separate audio clips of questions answered by the group of students. The length and number of clips does not lend itself to an algorithm to match an attendee with a group interview, because students named were rarely noted and the small number of clips would result in poor matching. Thus, we

adjusted our design to randomly select an audio reflection for the attendee to hear, with the opportunity to choose between all reflections as well.

This choice was made to most effectively represent the camp at the exhibit, adapting to feedback from our client and other stakeholders.

Future Developments

5.1 360 Degree Video

There are various efforts to produce 360 degree video at Virginia Tech, most notably within ICAT and TLOS (Technology-enhanced Learned and Online Strategies). Those efforts have not involved 360 video in an Oculus Rift, rather they have used other virtual reality technologies like GearVR. Our implementation described in this report will be useful for any future groups wanting to use the Oculus Rift in conjunction with 360 degree video.

At the culmination of our project, the 360 degree video contains minor issues for both the video and audio components due to the nature of 360 degree video in Unity. The video component drops frames when there is large amount of motion, most notably in the last third of our video. There are various third party libraries that can theoretically solve these problems, but the well-known libraries work mostly with mobile devices and GearVR. It is known amongst online forum communities that 360 video in conjunction with Unity3d is in experimental stages, and that solutions for framerate problems are work-arounds.

The current implementation of the spatial audio component, although functioning, can be further modified to provide a clearer listening experience. The sound works as intended but there could be different ways to modify the sound to hear the spatial component clearer. Most audio recordings in the multipurpose room are white noise since there were many children making lots of noise. This means it is harder to hear the audio levels switching as you look around. Our implementation of spatial audio would work best if background noise was less prevalent.

5.2 Student Reflection (Web Application)

The web application and its components are available for future use in the case ICAT or Virginia Tech would like to use them. While the Amazon EC2 instance that ran the flask web application will be turned off after the semester and ICAT Day concludes, all of the code for the website will always be available on GitHub at <https://github.com/seantg/NCReflections> and the audio interviews used in the website will always be available to the public for listening on SoundCloud at <https://soundcloud.com/sean-goodrich-3/tracks> . As a result, all components and code for the website will be public and viewable after ICAT Day, and deployable to a permanent domain if ICAT decides it is necessary. While this application was intended for use only during ICAT Day, and we did devise a necessary strategy for developing a similar site in future years or camps, all materials are in place in the case that this intention is reversed.

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Study Participants

Sebastian Welsh
Adam DiMatteo
Gregory Scott
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References

1. Institute for Creativity, Arts, and Technology. "Maker Camp." *Maker Camp*. Web. 19 Feb. 2016.
<<http://www.icat.vt.edu/idea/project/maker-camp>>.
2. Institute for Creativity, Arts, and Technology. "Longitudinal Study." *Institute for Creativity, Arts, and Technology*. Web. 19 Feb. 2016.
<<http://www.icat.vt.edu/content/icat-outreach-program-forms>>.
3. Kipling, Rudyard. "If." *Poetry Foundation*. Poetry Foundation. Web. 19 Feb. 2016.
<<http://www.poetryfoundation.org/poem/175772>>.
4. "About the Museum." *United States Holocaust Memorial Museum*. United States Holocaust Memorial Council. Web. 19 Feb. 2016.
<<http://www.ushmm.org/information/about-the-museum>>.
5. Zamanian, Kavon. "Creating 360 Video in Adobe After Effects." *RocketStock*. 21 Oct. 2015. Web. 19 Feb. 2016.
<<https://www.rocketstock.com/blog/creating-360-video-effects/>>.
6. Subong, Jong. "360 Degree Video Making (Oculus Rift, Unity3d, Blender)." *Vimeo*. 26 Feb. 2015. Web. 19 Feb. 2016. <<https://vimeo.com/120757981>>.
7. Burtey, Nicolas. "360 Video for Oculus." *360 VR Video Software - VideoStitch*. 25 Nov. 2013. Web. 19 Feb. 2016.
<<http://www.video-stitch.com/360-video-oculus-vr-player/>>.
8. Vi. "Audio for VR Film (Binaural, Ambisonic, 3d, etc)." *Elevr*. 31 Aug. 2014. Web. 19 Feb. 2016.
<<http://elevr.com/audio-for-vr-film/>>.
9. Pearce, Alex. "360 Video Production and Post Production Tutorials." *Alex Pearce Productions*. 5 Nov. 2015. Web. 04 Mar. 2016.
<<http://www.alexpearceproductions.com/#!/blog-page/tiwo6>>.
10. "Let's Get Spherical... Spherical: GoPro Acquires Virtual | GoPro News." *GoPro*. 28 Apr. 2015. Web. 04 Mar. 2016.
<<https://gopro.com/news/lets-get-sphericalspherical-gopro-acquires-virtual-reality-start-up-kolor>>.
11. "Autopano Video Documentation." *Kolor Autopano*. 2014. Web. 04 Mar. 2016.
<http://www.kolor.com/wiki-en/action/view/Autopano_Video_Documentation>.
12. Baum-Combs, L., K. S. Cennamo, and P. L. Newbill. *Developing Critical and Creative Thinkers: Toward a Conceptual Model of Creative and Critical Thinking Processes*. Publication. Educational Technology Publications, Sep. 2009. Web. 20 Feb. 2016.
<http://www.archive.icat.vt.edu/IDEAS/TeacherResources/Critical_Creative_Thinking.pdf>.
13. Ronacher, Armin. "Flask Documentation." *Flask Python Microframework*. N.p., 2013. Web. 30 Mar. 2016. <<http://flask.pocoo.org/docs/0.10/>>.
14. Zhvillues. "Creating a 360° Viewer Using Unity." *Zhvillues*. 10 Aug. 2015. Web. 30 Mar. 2016.
<<http://zhvillues.tumblr.com/post/126331275376/creating-a-360-viewer-using-unity-3d>>.
15. "Unity Manual." *Unity*. Web. 30 Mar. 2016.
<<https://docs.unity3d.com/Manual/index.html>>.
16. Grinsberg, Miguel. "An Introduction to Flask." *The Flask Mega-Tutorial, Part II*. Miguel Grinsberg, 7 May 2012. Web. 30 Mar. 2016.
<<http://blog.miguelgrinberg.com/post/the-flask-mega-tutorial-part-i-hello-world>>