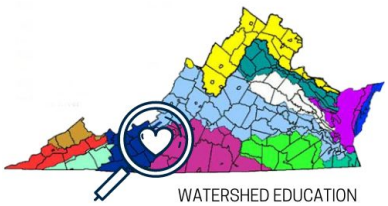


November 30, 2020

Dr. Robert “Bobby” Grisso
Professor in Biological Systems Engineering
306a Sietz Hall
Blacksburg, VA 24060

Dear Dr.Grisso,

Enclosed is the requested technology review for the project titled: “Development of an Interactive ESRI StoryMap for Watershed Education”. This review will be covering effective assessment techniques, interactive and engagement tools for online learning, and the effectiveness of StoryMaps. This technology review also contains sections detailing the reasoning for remote learning and the impotence of community-based learning. Furthermore, this review includes appendices to present brainstorming topics, anticipated challenges and solutions, a projected project timeline, and team member deliverables and responsibilities.

For further information please contact us.

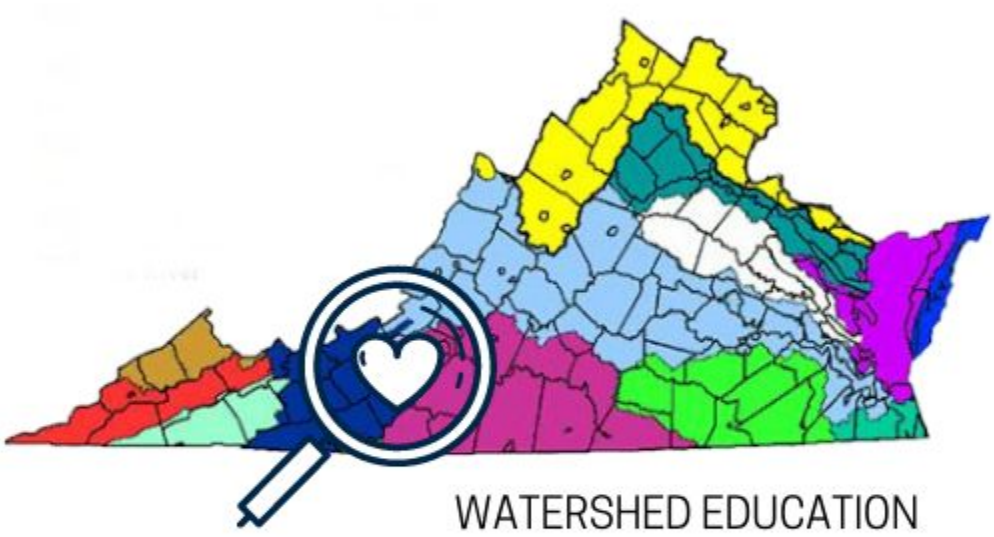
Sincerely,

Jesika McDaniel Sarah Moorehead

Enclosure: Technical Review

Development of an Interactive Story Map for Watershed Education

Technical Review



BSE 4125: Comprehensive Senior Design

StoryMap

Jesika McDaniel, Sarah Moorehead

Dr.Leigh-Anne Krometis, Erin Ling

Introduction

New River Valley MS4 permittees and Montgomery County Public Schools seek to develop interactive online content to meet permit obligations for MS4 public participation and provide content relevant to the Virginia Department of Education Standards of Learning (SOLs). The opportunities for close contact public participation events required under the General Permit for the Discharge of Stormwater from Small Municipal Separate Storm Sewer Systems (MS4) are periodically limited by weather conditions or other unforeseen conditions, including current social distancing guidelines due to the outbreak of COVID-19. Municipal Separate Storm Sewer System (MS4) permittees Virginia Tech, Montgomery County, Town of Blacksburg, and the Town of Christiansburg have historically engaged with Montgomery County School Systems to conduct annual "Stormwater Days". This event was canceled in the Spring of 2020 and faces due to the COVID-19 pandemic. Development of interactive virtual StoryMap can meet both MS4 permit requirements and provide curriculum content for use by Montgomery County Public Schools (MCPS) teaching staff.

The primary goal is to create an interactive online learning tool that educates middle school students in MCPS on watershed education that satisfies the permit obligations for MS4 public participation and provides content relevant to the school system's educational goals. Assessment will be necessary for the students in MCPS to complete in order to evaluate the effectiveness of the StoryMap. A secondary goal will be for the potential development of public education and outreach materials to be posted online for either students or the general public to convey information related to the MS4 permittee goals. This review will be covering effective assessment techniques, interactive and engagement tools for online learning, and the effectiveness of StoryMaps.

Remote Learning

During the COVID-19 pandemic, many schools across the nation had a significant change in operations. To reduce the spread of the virus, some schools had their students learning completely online or in a hybrid, socially distanced setting in the classroom. Montgomery County Public Schools had decided that as of Fall 2020 the students will return to the classroom in a lower capacity (MCPS). Some students may have the option for remote learning if they choose to do so. Some advantages of virtual learning are the ability to learn at your own pace, save costs on transportation, and the flexibility to learn in any setting. While each student has a different learning style, not all students are comfortable with a virtual learning environment (Hiranrithikorn). Some disadvantages to virtual learning are the lack of social interaction, engagement, and participation from students (Hiranrithikorn). User engagement and interaction are the two factors that must be incorporated into the selected virtual platform to retain participation and effective learning.

Community-Based Learning

Research conducted in secondary schools social studies classes (grades 7-12) shows that students quickly become bored and disengage with assignments that they feel lack applicable content. Problem-based learning is where students can build their knowledge through research and real-world experiences. Many of those who research educational tools have come to the consensus that this is the best teaching method for educators (Strachan and Mitchell, 2014). GIS serves as a helpful investigative tool to allow students to explore and interpret the world around them from a spatial perspective. It also allows students to both enhance spatial reasoning and foster the growth of problem-solving skills (Egiebor and Foster, 2018). Additionally, GIS works well in constructivist learning environments because it encourages students to critically engage with real-world data from many different subject areas such as geography, science, or math and apply different analyses to their local communities (Strachan and Mitchell, 2014).

User Engagement Using Story Maps

Although StoryMaps are a relatively new educational tool, there has been a lot of research about their usefulness. The Environmental Systems Research Institute (ESRI) provides educators, and all those wishing to use their Story Map tool, with what they call “the Five

Principles of Effective Storytelling" to help guide the creation of maps in the most engaging and educational way possible (ESRI, 2020). In a study using a map designed with these five points in mind, participants scored 8.2 out of 9 possible points on an assessment taken following the completion of the tool (Cope et al., 2018). This reinforced the effectiveness of these five principles. The first principle that ERSI states is the need to connect with your audience. To do this it is suggested to envision the audience of your map, and then craft everything else around it (ESRI, 2020). In this case, the primary audience is middle school students in 6th and 7th grades, however, this tool should be accessible and engaging to all members of the community. The second principle that ERSI sets forth is to lure people in using an eye-catching first slide (ERSI, 2020). A variety of opening slides have been brainstormed for this project. One possibility would be to open with the logo that the team designed for this project. Another option would be to use a picture of the New River or other iconic water body that students may recognize. A final option would be to make a collage featuring all the different schools so that the students will find the map relatable and engaging from the get-go. The third states to choose the most effective experience for the user by selecting the best style for the story you are trying to tell (ESRI, 2020). The Story Map Tour is a great option for this project as it works best when embedding photos and videos along with short text to tell a story. The Story Map Series layout is also a viable option as this template allows for the comparison of different maps by the user which could be an excellent way to highlight all of the different stream impairments The Story Map Cascade is also under consideration as it is designed for more lengthy projects, this layout, however, reads more like a webpage and less like a story. The next principle reminds creators to generate easy-to-read maps, as maps that are not simple and clear do not create a useful user-experience. The final principle is to strive for simplicity, and remove as many superfluous elements as possible (ESRI, 2020).

Certain techniques have been proven to enhance learning and engagement with Story Maps. One of the most important techniques is the addition of visuals and other types of media. Distinct labels on all images and maps are essential for users to understand and interact with the data they are being present (Berendsen et al., 2018). Participants in the aforementioned social studies research identified map layers as sources of inquiry, which means that different map layers should be targeted to answer specific, studies-based questions (Egiebor and Foster, 2018). Another way to improve learning on Story Maps is to organize ideas by theme, chronology, or

region, similar to what is found in a traditional atlas. This allows for the story to unfold naturally and allows the user to make connections between the maps and all the different media presented (Berendsen et al., 2018).

StoryMap - ArcGIS

Environmental Systems Research Institute (ESRI) Story Maps are web-based applications that use maps and other embedded media, which can be effectively used in education (Cope et al., 2018). Story maps are relatively easy to make and have a relatively simple, non-technical interface which makes them a useful educational tool. The visual nature of maps and the media embedded into them makes these maps the perfect tool to use to tell a geospatial story that is both engaging and reaches across barriers such as language or other cultural divides (Strachan and Mitchell, 2014). Story Maps are also appealing as they allow for the communication and visualization of large, complex bits of information in a compact, user-friendly format (Cope et al., 2018). Montgomery County Department of Stormwater Management has pre-existing maps from previous years that focus on the specific areas in Montgomery County that will be discussed in the Story Map. This will save the design team much time by not having to create these maps on their own.

When considering new and developing technologies such as Story Maps, there are many aspects to consider. An advantage of Story Maps is that they are constructed on a collaborative, cloud-based platform. This allows them to be accessed by the public via the internet without needing to download any specific software and can be accessed on computers, tablets, and smartphones (Cope et al., 2018). It is also favorable that the maps can be used on smartphones and tablets in case a student does not have access to a desktop or PC. Story Maps are also advantageous because they are easy to generate and require no coding experience, and can be created cost-free to the user (Cope et al., 2018). Students found Story Maps more beneficial than using traditional worksheets because they are more engaging due to the access to the variety of information found on the different map layers (Egiebor and Foster, 2018). This technology, however, is not perfect and has a few shortcomings. One of the main concerns is that educators are not trained on the technology, and therefore it will be difficult for faculty to engage with the tool (Strachan and Mitchell, 2014). To address this issue the team can create a guide for teachers on how the platform works and troubleshooting methods. Another solution would be to create a

'teacher version' of the tool which has all the same content as the student version but is annotated with learning goals and additional facts they may need to know. Teachers also need time to prepare lessons that integrate this tool if they do not want to use it as a stand-alone activity (Strachan and Mitchell, 2014). To circumvent this, the design team can prepare one or more lesson plans to give to the teachers to introduce the topics which are covered in the Story Map. A final concern is that there is no scientific, peer-reviewed process that has been proven to ensure the educational quality of Story Maps (Cope et al., 2018).

Google Earth

Google Earth is another web-mapping tool that is an alternative to the ESRI StoryMaps. Google Earth has launched an addendum to their web-based application known as Voyager (Berendsen et al., 2018). This update featured many KML layers which had been published by prestigious agencies such as a plate boundaries map from the US Geological Survey (USGS) and a topography map from the National Aeronautics and Space Administration (NASA) which can be helpful in the teaching of geography (Sawaguchi, 2018). Google is striving to bring story mapping to its popular platform, but as of right now, they have not fully developed this technology (Berendsen et al., 2018). This tool does, however, allow users to create their own data sets in predefined parameters which can be used to create virtual tours (Tooth, 2015). Sawaguchi recommends that Google Earth's Voyager tool be used to create geography lessons using a 'fly-over' approach. He suggests that students be given instructions such as selecting certain layers to highlight features such as active volcanoes, and have students 'fly-over' different volcanoes and compare them (Sawaguchi, 2018). Google Earth also has tools such as 'Street View' which allows for total 360-degree views from many different points around the globe (Tooth, 2015).

Google Earth has a variety of add-ons in terms of mapping layout and other features that some story mapping applications lack. One of the main advantages is that Google Earth provides free and instant access to high-quality images from all over the world. It also has searchability features on the interface which also allows students to search for different features by name. Lastly, students learn to identify different geological features and discuss them with their classmates (Sawaguchi, 2018). Google Earth also has some limiting factors that may not make it the ideal tool for this project. One of its greatest disadvantages is that it only uses aerial imagery,

with highly varying image quality. There is also the inability of the content creator to edit map datums or layers (Tooth, 2015).

Student Assessment and Evaluation

One of the key aspects of evaluating the effectiveness of the Story Map is the student assessment portion. The project will have an assessment conducted using the pre/post assessment model. An assessment piece will be added to the Story Map as tests serve as an effective means to determine whether an activity's goals are being met (Angelo and Cross, 1993). Recently, educators have concluded that the use of a pre/post-test can give an extremely insightful look into what students have learned during a course or program (Boyas et al., 2011). Research suggests that students work hardest to focus on and learn the material that they believe they will be tested on. Overall, the purpose of assessment is to empower both the assessor and the student, which should not be forgotten when designing this tool (Angelo and Cross, 1993).

The pre-test should be used to assess knowledge going into the assignment, which in this case, is the Story Map. It should be used as a baseline for student knowledge, and can therefore serve as a useful tool for further development of the map (Angelo and Cross, 1993). If the pre-assessment sent out with the beta version of the map reveals large gaps in knowledge, this can serve as a metric for what materials need to be covered in more detail before the final version is released to the public. Pre-assessments are a useful tool across many teaching disciplines because they provide the assessor with the base knowledge of all of those taking the test. In 2014 a study of 493 Spanish teachers from an international online teacher community who were teaching at different professional contexts, such as basic compulsory school, and diverse extra-school, were given a 40 question survey regarding how they view assessment. Nearly 85% of the respondents agreed that knowing an individual's starting point is an indispensable resource when it comes to measuring a student's progress (Remesal and Brown, 2015).

Another need for pre-assessment rises from the fact that many people walk around carrying many misconceptions in their heads. Angelo and Cross stated it best claiming "the greatest obstacle to new learning is not the lack of prior knowledge, but, rather the existence of prior knowledge". A misconception check can help to address which issues interfere with learning, how many students believe these things, and see how deeply embedded the problems are (Angelo and Cross, 1993). A misconception check could serve as an essential part of the

pre-assessment for this educational tool. An addendum to the pre-assessment for the beta launch could include a specific section that serves as a misconception check as there are many common misconceptions people may possess. This can either be presented as a separate ‘quiz’ or it can be a section in the pre-assessment. Some common misconceptions about watersheds and water quality include the presence of fecal coliforms always signifying a health risk in drinking water and just the fact that current drinking water monitoring practices do enough to mitigate risks to human health (Allen et al., 2014).

A study conducted between 2005 and 2015 at Harvard University involved in undergraduate forest research used a pre/post assessment model to measure increases in skills and confidence of undergraduate researchers through their program. Students who completed this assessment reported an 11% increase in the confidence of their skills throughout the program (McDevitt et al., 2016). This is important as many students become surprised, embarrassed, and frustrated when they realize how little they recall when they are forced to recite information that they had learned previously (Angelo and Cross, 1993). To encourage students to feel accomplished, the results of the Story Map pre-assessment will not be shown to them as a numerical value. Solutions to this include giving a rating from ‘watershed novice’ to ‘watershed master’ so students can have an idea of how they performed on the pre-assessments without knowing an exact number. Another proposed solution will provide students with how much better they did on the post-assessment than the pre-test, e.g 'Congratulations! Your score increased by 30%!’. The problem with this is that it does not provide students with a baseline that they can hold onto throughout their activity. In the aforementioned 2014 study by Remesal and Brown, almost 93% of respondents stated that students needed to be aware of their learning and knowledge in relation to where they started (Remesal and Brown, 2015). This implies that it may be a bad idea not to provide students with any feedback until the end of the map. The important takeaway is that lack of receiving a grade for this assignment will hopefully decrease student stress and increase their desire to learn in the areas they do not feel confident in (Angelo and Cross, 1993).

The other half of the assessment tool designed for this Story Map is the post-assessment, which will be completed after a student finishes exploring the activity. It is important to consider that students will be entering this activity with relatively little knowledge about watersheds. This may lead to skewed results that always show an increase in score in the post-assessment (Boyas

et al., 2011). The goals of the post-assessment are simple, it aims to answer the questions: did the student learn the content that they should have using this tool? Was the user engaged with the material as it was presented? Was the activity useful overall? (Angelo and Cross, 1993). There is, however, some research to indicate that post-assessments may not fully demonstrate the degree to which a student has mastered the learning objectives set forth by the pre-assessments. These disperates usually occur when the degree of difficulty of the questions changes from one to the other or if the assignment is graded or ungraded (Boyas et al., 2011). To address the first issue, questions will be identical on the pre-test and the post-test. The latter concern is out of the control of the Story Map and in the hands of the individual classroom teachers. Another purpose of the post-assessment is to close the feedback loop between students and the education tool. It is important that students see how they performed on the post-examination as this feedback can help them target learning goals for the future (Angelo and Cross, 1993). Ideas for feedback include adding a note at the saying something along the lines of 100%: wow you got a perfect score! You are now a master of watersheds! 90/80% you're on your way to becoming a master! Keep studying, 70/60% it looks like you missed some key concepts. Try going out and exploring your watershed to learn more!

Other questions about how to best create assessments that measure student engagement have arisen. Some of the questions generated can be answered by the features and limitations of the ESRI Story Maps tool that are still currently being explored. One important aspect of student learning is that students should receive feedback both early and often from their learning tools (Angelo and Cross, 1993). One thing that is currently being explored is the possibility of incorporating simple yes/no questions at certain points in the map that will serve as checkpoints. If a student fails to answer the question(s) correctly they will be directed to a mini-lesson which will go over the topic again in different words. Another alternative, if this solution is not possible, would be to send out several versions of the beta test, each improving on the one before. These versions will address the areas most missed on the post-test and keep improving on the learning outcomes. Another addition, which would be especially helpful in the beta version(s), would be to include a survey on how useful the students found the tool and how engaging the different areas of the map area.

Online Assessment Tools

Student feedback is hugely valuable as students are in the best position to judge their own learning and engagement (Angelo and Cross, 1993). It is also important to use the right kind of assessment tool for the proper scenario (Angelo and Cross, 1993). A variety of different assessment platforms are currently being considered and weighted on their pros and cons. The Story Map tool allows for the direct embedding of forms from Survey123. Although this may be more simple and aesthetically pleasing, the teachers would not have direct access to the student assessment results due to the platform not being under MCPS. Qualtrics is another survey platform that looks very professional. Qualtrics allows for more options for data visualization. The Qualtrics platform would be managed by Virginia Tech users which will not grant access to MCPS, therefore assessment results would be sent to the design team and this would not be sustainable for the future of this tool. The final tool being considered is Google Forms, which is currently the platform that is used by MCPS. This makes the platform user friendly and also allows for easy sharing of results. Google Forms also has a quiz feature within the program which will allow for quick grading. It does not present the data in a visually pleasing manner and may require the use of external tools.

Standards

Virginia Department of Education Standards of Learning (SOL)	The Standards of Learning (SOL) for Virginia Public Schools establish minimum expectations for what students should know and be able to do at the end of each grade or course in English, mathematics, science, history/social science, and other subjects. (VDOE)
Montgomery County Municipal Separate Storm Sewer Systems (MS4) Permit	Montgomery County is required to have a Municipal Separate Storm Sewer System (MS4) permit for urbanized areas to prevent the discharge of pollutants such as pet waste, trash, engine oil, and fertilizers into waterways.
Montgomery County Municipal Separate Storm Sewer Systems (MS4) - Minimum Control Measures	The Permit requires the County to develop a stormwater management program that demonstrates the County addresses 6 minimum control measures (MCMs). This project will be focusing on MCM 1 & 2. ***MCM 1 Public education and outreach on stormwater impact*** ***MCM 2 Public involvement and participation***
Montgomery County Public School Curriculum	The MCPS guidance document "Enduring Understandings related to Watershed Management" is provided and provides a template for the development of appropriate content for an interactive StoryMap and associated MCPS student learning assessment.

Summary & Conclusion

There are a variety of methods when using technology as a tool for education. The main three aspects that must be included are pre/post assessments, user interaction, and a community-based learning approach. In conclusion, the ESRI StoryMap Self Guided method provides the user with a self-guided experience and has the ability to connect the curricular content to their local community. As for the pre/post assessment piece, using Google Forms as an assessment tool is the most effective because of familiarity for the teachers giving the assessment and analyzing the assessment data.

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Appendix A - Brainstorm Session Results

When beginning the brainstorming process we came up with an initial idea of having the StoryMap be visual walk through. Meaning we would have the students click on a series of videos that would take them through different landmarks containing waterbody impairments. While this was a feasible idea, it was recommended that the StoryMap have more engaging features for the user instead of watching a sequence of videos. Later the team decided to have the locations in the StorMmap correlate to the middle schools in Montgomery County. This method would enhance community based learning and increase engagement, The users would have the ability to click and drag throughout the map to find nearby water bodies and learn more about the waters around them. The StoryMap would also contain info slides that will explain concepts such as water pollution, eutrophication, sedimentation, etc. Another thing that was considered was to add checkpoints throughout the map to ensure that the students are grasping key concepts. Check points would be two to three question quizzes to test the student's understanding of the section they just read.

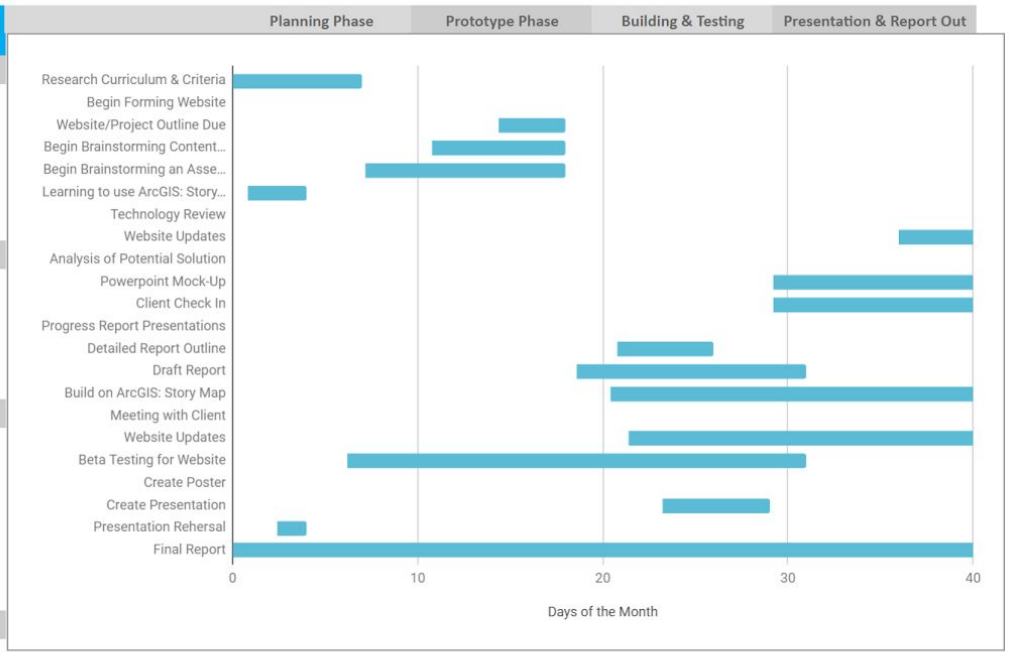
Appendix B - Challenges Encountered & Plans to Address

Challenge	**Plan to Address**
Having the ability to both have access to the ESRI StoryMap and have editing capabilities	Contacting Montgomery County ESRI Map specialist to help enable access for all team members
Filming and editing videos and pictures for the StoryMap	Contacting the Montgomery County Media Specialist to assist in videography and photography media to implement in the StoryMap
Finding pre existing footage of waterbody impairments to use in the StoryMap	Contacting the faculty in the BSE Department to use some of their drone footage
Ensuring that we have a platform that is engaging and effective for the student users and teachers	Producing a BETA version of the StoryMap by March of 2021 to receive feedback from both teachers and students about the content and level of engagement
How to make the StoryMap interactive for the user when ESRI StoryMap does not have many user interactive features available.	Use what is available on ESRI to simulate some type of interactive experience. Have interesting pictures and videos to retain user engagement

Appendix C - Project Timeline

Watershed StoryMap

TASK NAME	START DATE	END DATE	TEAM MEMBER
Planning Phase			
Research Curriculum & Criteria	9/16	9/23	Both
Begin Forming Website	9/24	10/4	Both
Website/Project Outline Due	9/16	10/4	Both
Begin Brainstorming Content for Map	9/16	10/4	Both
Begin Brainstorming an Assesment Tool	9/16	10/4	Both
Learning to use ArcGIS: StoryMap	9/30	10/4	Both
Prototype & Design Phase			
Technology Review	11/9	11/30	Both
Website Updates	10/26	12/10	Both
Analysis of Potential Solution	10/5	12/17	Both
Powerpoint Mock-Up	10/5	12/17	Both
Client Check In	10/5	12/17	Both
Building Phase			
Progress Report Presentations	1/13	1/26	Both
Detailed Report Outline	1/27	2/22	Both
Draft Report	2/23	3/26	Both
Build on ArcGIS: Story Map	2/23	4/15	Both
Meeting with Client	1/18	1/18	Both
Website Updates	1/20	5/7	Both
Beta Testing for Website	1/20	2/20	Both
Presentation & Report Out			
Create Poster	3/26	4/29	Both
Create Presentation	3/26	4/24	Both
Presentation Rehersal	4/21	4/25	Both
Final Report	3/26	5/10	Both



Appendix D - Team Member and Partner Responsibilities

This project has many different parts, our team has split up the responsibilities as follows. Sarah is responsible for researching the information contained in the technical review such as the best assessment practices and tools, the usefulness of Story Maps as an educational tool, and methods to make the most educational Story Map. Sarah also helps coordinate meetings with the client and takes weekly meeting notes. She is also responsible for writing the review section of the report. Jesika is responsible for creating the assessment tool and the BETA version for the StoryMap. Once the report is completed both Jesika and Sarah will work together to finalize the BETA version of the StoryMap. Later in the Spring semester both teammates will work together to film and photograph the media required to finalize the StoryMap. This is projected to be completed by late February or early March to ensure enough time for students to test run the platform and give feedback.