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Engaging Secondary Students in Regionally Relevant Science Topics Through Videography - Lens on Climate Change

INTRODUCTION

The student population in the U.S. is increasingly more racially, ethnically, and linguistically diverse. Nationally, the white student population was 60% in 2001, while in 2011 it was 52% (NCES, 2015). This shift is mostly a result of an increasing Latino population, which, during the same period of time, increased from 17% to 24%, while African American, Asian/Pacific Islander, and Native American/Alaskan Native populations all stayed relatively stable. With the increase in the Latino population, the number of students in English Language Learning status has also increased from 8.7% to 9.1% between 2002 and 2011. These trends have been occurring for decades now and are predicted to continue into the future, making American schools much more racially and linguistically diverse.

Students in U.S. schools also are on average getting poorer (NCES, 2015). In the 2000-2001 school year, the national participation in school-based free and reduced lunch programs (FRL), a measure of family wealth, was 38%. By the 2010-2011 school year, 48% of students in U.S. public schools were enrolled in FRL programs. This change is significant as students in poverty may be less likely to have access to the same types of physical and cultural resources as more affluent students. For example, in terms of physical resources, impoverished students are less likely to have current computer technology, software, and stable Internet connections (Eamon, 2004). Additionally, in terms of cultural resources, economically disadvantaged students have challenges in fully accessing science-based forms of communication in the classroom that can often influence the way in which they see themselves as participants in these activities (Brown, 2006; see also Chapter 11 of NGSS Framework, NRC, 2012). To bridge these differences and address these challenges, schools can provide structural supports for students to help bridge language discourses (Gutierrez, Baquedano-Lopez, & Tejeda, 1999) and provide access to the latest technological resources (Vickery, 2014).

A digital divide developed in the 1990s between those with access to computers and the Internet and those without; however, that divide has shifted in more recent years. Initially, African American and Latino students had little access to digital resources, but with the increase in access to inexpensive mobile devices and mobile Internet, Latino and African American youth had increasing access to these forms of digital resources and were viewed as early adopters and mobile trendsetters (Horrigan 2009). However, the use of mobile devices by these populations may be limited to gaming, watching videos, and listening to music, and they may have limited participation in other forms of more creative digital literacy, resulting in another form of digital divide (Hargittai, E., 2011; Hargittai, E. & Walejko, G., 2008; Vickery, 2014).

While there are many ways to describe the digital divide, the term media literacy is used in this chapter to define the way that particular student groups are limited in their full participation of engaging with digital resources that promote critical thinking and problem solving (see Potter (2010) for a full range of definitions for media literacy and the skills associated with media literacy). This definition stems from work by Watkins (2012) on design literacy in which he describes this learning as the “capacity to engage in critical thinking, inquiry and discovery, and real world problem solving” (p. 9). Further, Hobbs (2010) describes five steps towards digital and media literacy: 1) Access, 2) Analyze and Evaluate, 3) Create, 4) Reflect, and 5) Act. The differential digital resource access found in different student populations impacts particular students’ abilities to engage in rich and deep ways with technology. For example, Miles (2007) discusses network literacy, the sharing of work through networks, which can be impacted by limited Internet or through lack of access to particular forms of technology. Resnick et al. (2009) add to this discussion with the term digital fluency, the need for students' technology work to "include designing and creating, not just browsing and interacting." To empower youth to produce and create digital media and build digital literacy, students need access to up-to-date computers, software, and technology, as well as training in media tools. Schools can play a critical role in providing access to technology and educational opportunities in order to level the playing field for all students to become literate in all aspects of digital media.

Another pathway for students to become media literate is through informal venues. Studies in informal learning environments centered on digital literacy have found that students value interest driven learning and value the choices they have to participate collaboratively with peers in media projects (Vickery, 2014). In contrast to formal educational settings, informal environments foster experimentation and allow failure without implications, because they are free from high-stakes assessments. The idea of *play* in digital learning, and of *learning from each other*, as highlighted in *Hanging Out, Messing Around and Geeking Out* (Ito et al. 2010), stands in contrast to traditional formal K-12 experiences of students (Stone & Gutierrez, 2007). While informal settings provide opportunities for students to experiment, play, and fail in ways productive to learning, these venues reach relatively few students. Formal K-12 settings have the greatest reach to students and, therefore, can broadly help breach the digital divide.

Recent shifts in Science, Technology, Engineering, and Math (STEM) educational policy have increased the need for schools to build towards digital literacy within formal K-12 settings. The Next Generation Science Standards (NGSS) highlight the practice of communication about scientific thinking (NGSS Lead States, 2013). In addition, the NGSS Framework (the policy document governing NGSS) specifies that youth's everyday discourses should be bridged to a scientific discourse in explicit and culturally relevant ways (NRC, 2012). Digital media provide one avenue for connecting youth culture to scientific discourses through the communication of interest driven projects relevant and engaging to today's students.

In this chapter, several types of student-interest driven media projects that can be implemented in the formal classroom setting or in informal settings are described. Specifically, the focus will be on two projects: the Lens on Climate Change (LOCC) program and the Climate Education in an Age of Media (CAM) Project. These projects promoted the engagement of students primarily from impoverished communities with the intention of breaking down the barriers of the digital and STEM divides.

CLIMATE CHANGE SCIENCE AS A VEHICLE FOR MEDIA LITERACY

The CAM and LOCC projects engaged students in media projects that were focused on climate change science partly because of this topic's strong potential to engage students with diverse interests and socioeconomic backgrounds in learning (Gold et al., 2015; Rooney-Varga, Brisk, Adams, Shuldman, & Rath, 2014). Climate change impacts virtually all aspects of human life, from agricultural productivity to the integrity of the built environment, human health, water supplies, national security, and economy (IPCC, 2014). Thus, unlike many other topics in STEM areas of inquiry, the relevance of climate change to the everyday lives of students is readily apparent, providing a natural means to motivate engagement in the topic (Forest & Feder, 2011). Its cross-disciplinary nature also makes it relevant to students interested in almost any career path, as demonstrated by the rapidly growing body of work across STEM fields, as well as in the social sciences (e.g., economics, political science, and sociology) and humanities (e.g., ethics, philosophy, and arts) that consider human impacts from and responses to climate change (there is an extensive body of literature; a few examples are Holm et al., 2013; Palsson et al., 2013; Rose et al., 2012; Van Langenhove, 2012).

Understanding and addressing climate challenges require a STEM lens, as scientific observations and concepts—from analyses of globally distributed temperature anomalies to measurements of atmospheric levels of greenhouse gases and projections of future climate trends—are beyond the observational capabilities of unaided human senses (Weber, 2010). Furthermore, the embedded equity, justice, and ethics issues in climate problems (Eakin & Luers, 2006) make the societal importance and relevance of these issues, especially to vulnerable populations, clearly evident. As such, the climate challenges provide an opportunity to make STEM-rich content relevant to students with diverse disciplinary interests and may also have strong potential to engage under-represented groups with STEM content.

The participants in each of the two projects described here became smart consumers of digital media, as well as contributors to digital media, thus decreasing the digital divide. The focus of the CAM Project was primarily on designing and developing a suite of resources that integrate media literacy and climate change science education through student-produced media projects (Rooney-Varga et al., 2014). These resources have been piloted in a range of educational settings, from middle school to graduate level courses, as well as in informal after-school programs with high schoolers (the latter will be the focus of this chapter). The LOCC program focused on student-driven media projects that engaged secondary students in digital literacy through the production of short 3-5 minute documentary videos on a locally relevant climate change topic (Gold et al., 2015)[1].

THE CAM AND LOCC PROJECTS

In order to engage students who may not have the means to actively participate in the full spectrum of media literacy, both projects targeted schools with a student body above the state average in FRL or which were located in rural areas (Table 1). The two high-poverty, urban schools—Whittier ECE-8 School located in Denver Public Schools and Cambridge Rindge and Latin School, a high school located in Cambridge Public Schools—will be highlighted at the end of this chapter.

Table 1. Summary of the socioeconomic and ethnic diversity of schools participating in the two programs (2013-2014 school year). Values that are above the respective state average are marked with an asterisk. Nederland and Estes Park are rural mountain schools. Data for the Colorado schools (above the row with the Colorado state average) are published by Colorado Department of Education (CDE 2013a, 2013b). The data for Cambridge Rindge and Latin High School are published by the Massachusetts Department of Education (MDE 2014).

Participating School, Type of School, School District	Total Students	Free and Reduced Lunch	American Indian or Alaskan Native	Asian	Black or African American	Hispanic or Latino	Other or Mixed Ethnicity	White
Alamosa High School, Alamosa RE-11J School District	507	57.6% *	0.7%	0.7%	0.4%	62.5% *	0.2%	35.3%
Arapahoe Campus, CTE Program, Boulder Valley School District	137	59.9% *	1.5% *	0.7%	1.5%	62.8% *	2.9%	30.6%
Estes Park Middle School, Estes Park R-3 School District	231	39.0%	0.9%	1.3%	0.4%	24.2%	1.2%	71.4% *
Greeley Central High School, Greeley – Evans School District 6	1,518	65.7% *	0.3%	1.0%	2.7%	63.6% *	1.8%	30.5%
Manhattan Middle School, Boulder Valley School District	547	29.4%	0.9%	6.0% *	0.9%	23.6%	2.9%	66.0% *

Nederland Middle/High School, Boulder Valley School District	308	23.1%	0.6%	2.3%	0%	8.1%	5.5% *	83.4% *
Poudre High School, Poudre R-1 School District	1,779	35.0%	0.8%	3.3% *	1.1%	23.0%	2.6%	68.7% *
Whittier ECE-8, Denver Public Schools	274	93.8% *	0.9%	0.9%	44.0% *	40.6% *	4.7% *	8.5%
Colorado State Average	876,999	42.2%	1%	3%	5%	33%	3%	55%
Cambridge Rindge & Latin School, Cambridge Public Schools	1,684	44.8%[1] *	0.6%	11.7% *	33.2% *	14.0%	3.0% *	36.9%
Massachusetts State Average	954,739	38.3%[1]	<1%	6.1%	8.7%	17.0%	2.9%	66.0%

[1]Referred to as Low Income rather than FRL.

The media projects produced by students participating in both of these programs were implemented in a variety of ways, which demonstrates the flexibility that these projects offer to educators. The CAM Project summer programs were informal and had 14 high school student participants; three undergraduate students served as mentors. In the second summer, different types of media projects were paired with different content learning outcomes, and curriculum materials were designed around each project type, engaging the high school teachers (who also participated in three weeks of the program) in the design of those materials. The LOCC Project team worked with the teacher sponsors to implement the program in a way that fit best into existing structures at their schools. As a consequence, the media projects were incorporated into the regular science classes, were combined with science and technology classes, or were offered outside the formal school day during the collaboration period of late-start days, during the lunch period, or after school.

Several elements were common to both of the programs. First, both provided mentors for the students to help them with their media projects. Each LOCC student group was paired with a graduate student in the sciences at the University of Colorado (CU) to help guide them on the science content of their video, as well as an expert in videography to help them with the technical aspects of their work. Similarly, in each of the CAM Project summer programs, three University of Massachusetts (UMass) Lowell undergraduates served as mentors for high school students. Second, both programs exposed the secondary students to college life with the intention of sparking interest in pursuing a college degree. The LOCC students spent a day on the CU campus. They toured the campus with their mentors, learned about the different types of programs and majors available, how to apply to CU, and how to find out about scholarships, and they ate lunch in the bustling student cafeteria, where they got a glimpse of the college experience. The culmination of the day and the program was the screening of their videos in the historic Old Main Building with an audience of more than 150 people. The Cambridge Rindge and Latin School students came to UMass Lowell and presented their videos at a meet-the-filmmaker event that was part of the annual Climate Change Teach-In, with an audience of more than 400 university students, high school students, and faculty members.

IMPLEMENTATION STAGES OF MEDIA PROJECTS

Using the video production process employed by the LOCC program as an example (Table 2), the general flow of a typical student media project is described in this section. The media production process generally has four phases: **pre-production**, **production**, **post-production,** and **dissemination**. While the focus generally is on the final product, be it a documentary video, animation, or other media product, learning occurs throughout the production process (Lumpe & Stayer, 1995; Johnson & Johnson, 1999), and students engage in many of the scientific practices outlined in the NGSS along the way (Table 2). Rooney-Varga et al. (2015) liken the process to an iceberg with the small exposed tip akin to the media piece and the massive underwater portion comprising all the unseen learning that occurs.

The first step of any media project is to **engage** students by showing them a series of media related to the project they will produce that employ a range of styles and techniques, such as wide shot, close-up, white board use, and animation. Students discuss with each other what the focus of each example is, how the media engages the students in the topic, what techniques they find interesting, and what they like and dislike about it. The responses are recorded for review later, when students begin scripting their projects.

Table 2. General components for the production of a media project, based on the short documentary video process used by the Lens on Climate Change program. Assessments that educators can use with their students are indicated by asterisks under Notes. The selected Scientific Practices satisfied by each activity in terms of the Next Generation Science Standards (NGSS, 2012) are included: 1. Asking questions and defining problems, 2. Developing and using models, 3. Planning and carrying out investigations, 4. Analyzing and interpreting data, 6. Constructing explanations and designing solutions, 7. Engaging in argument from evidence, 8. Obtaining, evaluating, and communicating information.

Components	Notes	Resources	NGSS
Engage & Explore			
Engage (30 min)	Expose students to video shorts	MinuteEarth YouTube (tinyurl.com/mej9gxx); MinutePhysics YouTube (tinyurl.com/laj289r); LOCC Videos (tinyurl.com/mhvwzl9); CAM Project (tinyurl.com/ner99aq)	1
Explore topics (30-90 min)	Choose topic; Concept map or storyboard*	Stanford University Storyboarding tutorial (tinyurl.com/pj6dueb); storyboard template (tinyurl.com/qfahjm9)	1, 2, 3
Topic research (1-3 hr)		CLEAN Collection (https://cleanet.org); Climate.gov (http://climate.gov/teaching); Learn More About Climate (http://learnmoreaboutclimate.colorado.edu)	1, 2, 3, 4, 6, 8
Pre-Production			
Write script (1-3 hr)	Write 3-paragraph story in 3-act structure*	Elements of Cinema.com (tinyurl.com/pkrrtsq)	3, 4, 6, 7, 8
Write interview questions (30 min)	Identify experts; Write questions*		1, 2, 3, 8
Identify shot list (30-60 min)			3, 6, 8
Production			
Technical workshop (1 hr)	Learn about equipment & techniques	Rule of Thirds (http://digital-photography-school.com/rule-of-thirds/)	3, 8
Filming day 1 (1-2 hr)	Shoot interviews		1, 3, 4, 8
Filming day 2	Shoot B-roll		8

(2-4 hr)			
Post-Production			
Footage inventory (1-2 hr)	Review footage; identify gaps		2, 3, 4, 5, 7, 8
Fill in gaps (1-2 hr)	Shoot missing footage	freeimages, a free image library (tinyurl.com/qxxe8qc); freesound, a free sound effect library (tinyurl.com/6847ht); AudioMicro, royalty-free music (tinyurl.com/2b5kphl)	2, 3, 4, 8
Edit video (2-6 hr)	First cut of media product		3, 4, 6, 7, 8
Final edits (2 wks before screening)	Teacher reviews media product*		8
Public Screening and Dissemination			
Decide where media will be screened	Classroom, school assembly, etc.		8
Disseminate media	Internet	YouTube channel; Vimeo	8

Building on this foundation, students **explore** relevant topics for their own project. Depending on the age/grade level, the educator can provide a selection of topics to the students, or students can brainstorm among themselves topics of interest that fit within the parameters of the class. To assure relevance to the students, the topics ideally have a local impact, could be centered on a relatively recent event (e.g., a recent storm), and should be easily accessible in order to make filming easy. There are a number of excellent reviewed resources on climate change that can pique student interest (Table 2). With a short list of topics in hand, students discuss the topics and select the one that incites the most discussion and enthusiasm. After the topic has been chosen, students brainstorm media ideas related to the topic and develop a concept map or storyboard to draft their media piece. Such a graphical guide will give educators an initial inventory of the student's knowledge, their misconceptions, and their general interests (e.g., more interest in local impacts versus the environment at large).

Using the concept map or storyboard as a guide, students continue to **explore** their topic through their own research and build their knowledge base of the topic and its impact on their community or local environment. This is another point where students can view more media to help them gain foundational knowledge, as well as to show them examples that they can emulate in their own production.

After students have moved through the **explore** and **engage** steps that are common to all media projects, they are ready to move into the **pre-production** stage. Armed with knowledge of their topic and their guide (concept map or storyboard), students develop their scripts. A common template to employ in writing a script is the traditional three-act structure used in most movies, books, and plays (Table 2). Students should answer the following questions and decide where they can plug their answers into the three-act structure. What is the purpose of your video (e.g., inform the audience, inspire change)? What story do you want to tell? Who is the audience for this video? How do you want to tell your story (e.g., straight documentary, animation, narrative)? It is helpful for students to write a three-paragraph story about their topic, matching the three-act structure. These short stories can be used as the inspiration for their project.

Regardless of the creative way students choose to tell their story, they may want to interview experts or the average person on the street for their project. Experts can be scientists, local government officials, emergency responders, or stakeholders to name a few. Students need to draft a list of questions for the interviews, including a mix of personal, professional, and topic-specific questions.

The final part of the **pre-production** phase is the shot list. A shot list is a spreadsheet where students list all the footage they need for their project. In addition to the shot list, they should develop a list of footage or images they will need to intercut between the interviews (this is called B-roll). For example, many of the LOCC student groups made videos about the great flood of 2013 in Colorado. Their B-roll contained shots of collapsed roads, cars toppled in streams, or still images from news sources.

For the **production** stage, students need to learn basic videography and photography skills, including aesthetic and technical aspects. Skills they learn in this phase include the use of their camera (still, video, or cell phone), setting up a tripod, framing the interviewees (using the rule of thirds, Table 2), and interview skills. Students can practice these skills by interviewing fellow students while filming them. Students often are scared to interview the experts, but they usually enjoy meeting and interacting with them. They also learn important professional skills, such as requesting an interview, proper demeanor when conducting an interview, and writing a follow-up thank you note.

To prepare for the filming days, each student should be assigned a "job" before filming on location. Jobs include cameraman, interviewer, and note-taker (who writes down detailed notes of the interviewee's answers). Duplicate jobs can be assigned to accommodate additional students; we suggest having students switch jobs during the filming. On the first filming day, students film the interviews with the experts. On a subsequent filming day, students collect the remaining footage on their shot list. This could be on-location B-roll or set filming with student actors. After the interviews, all footage files should be downloaded to a computer.

The **post-production** phase is the most time-intensive step of producing a documentary video. First, students watch the footage they have, identify how each section of footage fits into the video script, and take notes on where the footage goes and why. This step is key to understanding where gaps are in their video and to determine if they need to film additional footage, find photos, or record narration.

Next, students begin editing the video. Students use their scripts, along with their notes from the interview, filming day, and footage inventory stages, and they start assembling their video using video editing software (e.g., free software products such as iMovie and Windows Movie Maker). There should be one or two editors who are in charge of placing the footage in its proper place and assembling the video. Assigning different roles during this stage is important to keep all students busy, since only a few students can edit at once. Other roles can be selecting copyright-free music on a separate computer, studying their documentation, and directing the editors on what should come next in the video. The video will go through several "rough cuts" which are reviewed by peers, the educator, and/or a combination of the two. The final video should be reviewed two weeks before the final screening to facilitate any changes that are necessary, such as leveling the audio across the different segments or other technical details.

Table 3. Rubric used by jury to rate the student-produced films

	Beginner	**Novice**	**Intermediate**	**Expert**
Most Creative	Little evidence of creative planning	Some creative planning	Use of creative storytelling of topic	Very creative. I wish I could be as creative!
Most Entertaining	Little entertainment value	Some entertainment value	Fun and entertaining	Very entertaining. I didn't want it to stop!
Best Scientific Content	Little scientific information	Some scientific information	Essential scientific information and	Covers topic completely and in depth.

		with 2-3 facts and few citations of sources	sources properly cited	I learned a lot!

The final and important step in the video production process is the **public screening**. Public recognition of the students' work is a great motivator and boosts confidence because students have a product they can share, that can be celebrated, and that they can be proud of. Videos can be screened as part of school assemblies, in a festive setting where parents and friends are invited, or simply as part of a class. An additional incentive for the screening event is a ranking of the videos by a jury (the audience or external jury) using different criteria. The LOCC project used the following four categories and a scoring rubric to rank the videos (Table 3): "Most Creative," "Most Entertaining," "Best Scientific Content," and the overall "People's Choice Award."

Dissemination of the media products is an important part of media literacy. Students may want to share their videos on social media with their families and peers. To facilitate this sharing we suggest setting up a program website (see LOCC and CAM webpages as examples, Table 2). Local media channels such as newspapers, local TV stations, or radio stations also might be interested in reporting on the projects.

EXAMPLES OF DIFFERENT TYPES OF INTEREST DRIVEN MEDIA PROJECTS

Media projects can be readily adapted to suit diverse educational settings and goals, ranging from a short, single-class-period activity or homework assignment to a semester-long capstone event, and can be done in a formal or an informal setting. Here, examples of media projects that can be used to achieve different learning goals in a variety of settings are described. These projects can be completed in shorter time frames or expanded, depending on time and resources available. Most of the projects share a similar production sequence as that described above. A brief overview of all the different types of media projects is shown in Table 4.

Table 4. Overview of each type of student interest driven media project

Project Type	Minimum Time Needed	Minimum Media Tech Resources Needed	Key Science Learning Outcomes	Key Media Literacy Outcomes
Visual Storytelling[1]	3 hours	Still camera	Expose misconceptions Understand and explain key concepts	Framing Creating a shot list (Storyboarding) Script writing
Video Mash-Up[1]	1-2 weeks	Computer Microphone Video editing software	Research, understand, and synthesize content Create compelling and concise piece that communicates key content Find and manipulate digital audio and visual assets that accurately depict content	Storyboarding Recording and editing audio assets Video editing Digital dissemination

Animation[1]	~4 hours	Still camera Microphone Computer Video editing software	Systems thinking skills Understanding and depicting complex, dynamic processes with abstract components	Script writing Storyboarding Paper-mation, whiteboard Animation, and/or animation software Stop-motion photography Video editing Digital dissemination
POS and Mock Game Show[1]	1-2 weeks	Video camera Microphone Computer Video editing software	Research and understand content Devise relevant questions and research answers Identify misconceptions and correct them	Interviewing skills Script writing Storyboarding Filming Video editing Digital dissemination
PSA[1]	1-2 weeks	Video camera Microphone Computer Video editing software	Understand and synthesize concepts Identify societal relevance in scientific topics Understand how societal awareness, attitudes, and behavior connect back to science-informed problem Distill clear, concise, message that makes science and society connections clear	Script writing Storyboarding Filming Video editing Digital dissemination
Short Documentary	1 semester/ 1 hr 1-2/week	Video camera Microphone Computer Video editing software	Expose misconceptions Research, understand, and synthesize content Devise relevant questions Identify societal relevance in scientific topics Create compelling and concise piece that communicates key content	Script writing Concept map/storyboarding Interviewing skills Filming Video editing Digital dissemination

[1] How-to guides, learning goals and curriculum associated with these media projects can be accessed on the CAM website (http://cleanet.org/cced_media/index.html).

Media projects when time and resources are limited: Visual storytelling and video mash-ups

Both visual storytelling and video mash-ups are effective projects when in-class time and/or media technology resources are limited. In their simplest form, **visual storytelling** projects consist of a series of still shots, edited together with or without text or other graphic overlays, to convey a scientific concept. These projects can be executed with technology as common as a phone camera, although they can also be used as a means to introduce more sophisticated equipment and technology, from tablets with a camera and an editing app to sophisticated cameras and video editing software. Visual storytelling projects can be completed as a homework assignment or as an in-class activity, requiring as little time as one class period. Despite their simplicity, the projects provide an effective means to expose and correct misconceptions and to learn key media literacy skills, including creating a storyboard and shot list, using a camera and framing shots, video editing, and digital dissemination. For example, through the CAM Project, students were asked to use visual storytelling to identify key sinks and sources of atmospheric carbon dioxide in their everyday environment. In order to complete the project, students first needed to consider what defined a carbon dioxide source or sink, and then consider what objects or living things would fall under those definitions. They collaborated in small groups to research the question, brainstorm answers, plan a shot list, and consider a sequence and types of shots to create an interesting visual story that addressed the questions (e.g., an extreme close-up of a bird's beak may convey respiration effectively, while a long shot of a forest might be used to convey net ecosystem productivity). An interesting outcome of this assignment was that students' misconceptions about carbon sinks and sources were quite literally exposed during the production process. For example, many students wrongly assumed that because they associated an object with nature, it served as a carbon dioxide sink. Thus, their rough-cut included images of birds as carbon sinks and stimulated an in-class discussion of the scientific concepts and processes underlying carbon dioxide sinks and sources.

Although more involved, **video mash-up** projects can also be completed with little in-class time and media equipment. In these projects, students synthesize scientific concepts in an original script, but, rather than creating their own footage, draw on visual assets found online, bypassing the filming phase of production and therefore requiring less equipment and in-class time.

These video projects are well-suited to learning goals that include in-depth student research about a complex STEM topic. As with other media projects, the pre-production phase (i.e., student research, written scripts, and storyboards) can be expanded or contracted to meet educational goals. For example, at a middle or high school level, students might be given an accessible text about the content area and asked to synthesize key concepts in a script, while more advanced students conduct independent research. Unlike conventional research papers, video mash-ups challenge students to find and match visual assets to the concepts they wish to convey and to condense complex material in a compelling manner. The editing process provides an opportunity for iterative learning, discussion, and reflection on the content area, with students often commenting that they have a better understanding and longer term retention of science concepts as a result (Rooney-Varga et al., 2014). Last, unlike a written paper, these projects lend themselves to being shared online or face-to-face. Here, too, students have commented that when family and friends asked them what they learned in a class, they responded by sharing their video mash-up piece and effectively using it as a means to stimulate a discussion, revisiting the material once again by sharing it with others.

Animation to bring systems thinking into STEM learning

Educational goals that include understanding complex dynamic systems and abstract concepts can be met through **animation** projects (Rooney-Varga et al., 2015). Animation is inherently dynamic and not constrained to real-world objects, making it a natural fit for learning systems thinking skills, which are also increasingly seen as critical twenty first century skills (Trilling & Fadel, 2009) and are a core cross-cutting theme in the NGSS (NGSS Lead States, 2013). Systems thinking approaches take a holistic, long-term perspective that focuses on relationships between interacting parts, and how those relationships generate behavior over time (Sterman, 2006).

Animation projects can be executed using stop-motion photography and technology as simple as paper cutouts or whiteboards and still cameras, or as complex as sophisticated software packages like After Effects or VideoScribe. A growing number of apps for phones, tablets, and computers fall somewhere in between, such as Explain Everything, which enables users to create animations by capturing drawing, writing, and manipulation of images on an iPad. Animation lends itself naturally to depicting abstract complex processes that, like the medium itself, are inherently dynamic. Like other media projects, animation projects can be adapted to meet different educational goals and instructional settings by adjusting the pre-production content learning phase. In the CAM Project resources, animation projects are included which provide students with short, accessible explanations of feedback loops in the climate and energy systems. Students then use causal loop diagrams (CLDs; (Kirkwood, 2013) to visually depict the inter-relationships between system components and predict how key components may change over time. From their CLDs, students develop a storyboard and paper-mation or whiteboard animation, resulting in a project that can be completed in a few hours. As with other video projects, more advanced students may be asked to independently research content areas and identify causal relationships with less scaffolding.

Learning through questioning: Person-on-the-street interviews and mock game shows

Directly exposing and addressing misconceptions has been shown to be an effective pedagogical approach in STEM education (Engelmann & Huntoon, 2011). Two types of media projects that directly use this approach are **person-on-the-street (POS) interviews** and **mock game shows**. In both projects, students formulate questions relevant to the content area and explore and correct misconceptions as the questions are answered. In POS projects, students compare the beliefs of laypeople with those of experts, who may be scientists (if they are accessible), instructors, or the students themselves, after they have become informed through researching their content area.

In many ways, mock game shows dramatize learning that might otherwise occur through exams—with some important distinctions, such as students collaborating to generate the questions, as well as both incorrect and correct answers. Mock game shows also lend themselves to injecting humor and a bit of drama into learning and creating a vehicle to engage an audience. The CAM Project found that mock game shows produced by high school students had strong appeal to younger students, who found the humor and creativity of their older counterparts appealing.

Winning hearts and minds: PSAs to engage affective and analytic processing

Public service announcements (PSAs) are intended to be short, engaging pieces that deliver a message to raise awareness or influence attitudes and behavior that is in the public's interest. In these projects, students are challenged to bring metaphor, humor or emotion, and creative storytelling into science communication. Unlike technical science communication, PSAs intentionally engage the affective system, which plays an important role in evaluating uncertainty and risk (such as potential climate change impacts or mitigation), and is the primary motivator for action (Weber, 2006) and sustained commitment to difficult problems (Pidgeon & Fischhoff, 2011). While the affective system enables rapid responses, analytic reasoning requires us to learn algorithms for decision-making and apply them through conscious awareness and control. Importantly, these two processing systems work together: analytic reasoning is not effective unless guided by emotion and affect and, if the responses of the two systems are in conflict, the affective system almost always prevails (Damasio, 1994). Thus, emotion is integral to our thinking, perceptions, and behavior (Pidgeon & Fischhoff, 2011).

PSA projects in STEM education are described in more detail by Rooney-Varga et al. (2014). PSA projects are particularly effective for STEM topics with immediate societal relevance and provide an opportunity for students to foster science-informed decision-making among their peers, in their communities, and beyond. They can be used to generate high levels of intrinsic motivation and engagement among student producers, as well as critical thinking, social learning, and instilling students with a sense of empowerment and agency (Rooney-Varga et al. (2014).

Short documentary videos to engage students deeply in a long-term project

Student-interest driven **documentary video** production is an active learning technique that has been used successfully in both formal (Gold et al., 2015; Harrison-Pitaniello, 2013; Rouda, 1973) and informal (Levin, 2011; Vickery, 2014) settings. Thus, video production engages students in authentic learning (Herrington & Oliver, 2000) in which they collaboratively work towards a product—the video. This active learning process leads to strong student engagement and a sense of ownership of the product (Kearney & Schuck 2005, 2006; Hofer & Swan, 2008) and thus, indirectly, to a student-centered learning process (Vickery 2014; Dando & Chadwick, 2014). Through the video production process, student learning reaches the highest cognitive level in the Bloom pyramid of learning—creating (Bloom, Engelhart, Furst, Hill & Krathwohl, 1956; Anderson & Krathwohl, 2001)—and has even been described as transformational (Watkins, 2012; Kearney, 2011). Engaging students in video production may improve their ability to critically view videos produced by others, an additional aspect of media literacy.

The process of producing a short documentary video has been described in detail in the previous section. Students engaged in this type of long-term project learn the full suite of media literacy skills from consuming to producing and sharing their product, as well as practicing many key science learning outcomes (Table 4). In addition, during the production process, students can employ a variety of the techniques as described previously in the shorter media project examples. For example, the Nederland Middle and High School group's documentary focused on the shrinking Arapahoe Glacier, which is located near their homes and is one source of drinking water for the city of Boulder. They melded together both the POS and expert interview techniques to highlight the importance of the glacier through interviewing the watershed manager, and they exposed the lack of knowledge that students and teachers had about the glacier through the POS interviews. Another student group in the LOCC project used an animation to step through the history of the glacier and to show how much of its mass has been lost over the past century. It was not only the production groups who learned more about this critical water resource close to home; the whole school learned about it when the films were screened at a school-wide assembly.

FOCUS ON TWO HIGH-POVERTY SCHOOLS

Evaluation of the LOCC and CAM programs indicated that they were effective in many aspects (Gold et al., 2015; Rooney-Varga et al., 2014). First, students developed in-depth knowledge about a climate change science topic of their choice. Second, they practiced many other skills like teamwork and self-directed, goal-oriented work that straddled technology, artistic, and professional interaction. The programs were particularly impactful at two high-poverty urban schools with traditionally marginalized student populations. For example, after their successful completion of the LOCC program, students from Whittier ECE-8 School were asked to reflect on their experience throughout the LOCC Program[2]. The students highlighted the positive aspects of teamwork and collaboration (67% of respondents), as well as the perseverance (67%) required in sticking with the project and bringing it to a successful end. Fifty-six percent listed the campus tour as one of the highlights of their participating in the program. Having been recognized with an award during the final screening event (Most Entertaining Film), 44% of the students mentioned this accomplishment in their reflection statement. Other program aspects that students described in the reflection statements were the video skill training (33%), building of confidence (22%), and practicing communication skills (22%). The reflection of one 6th grade student captures these sentiments well:

> *The most beneficial thing that I got from making the video was . . . to be confident. Because when we first started making the video I was kind of thinking to drop out of the group and not do it. Then my teacher had a conversation with me that once you start something and you finish it you will feel good about it and it will help me in life. That really helped me because when we got the video done I was really glad that I made something and finished it. It helped me to be confident with myself because I am the kind of person who doesn't have confidence in doing something and finishing it.*

Insights from the sponsor teacher during the program and a follow-up interview corroborated what the Whittier students revealed in their reflection pieces. He mentioned that his students from impoverished backgrounds lacked role models who completed a task, and they lacked confidence in their ability to finish projects:

Building confidence is most likely my number one goal. And, boy howdy, they told me afterwards that they understand what I meant about confidence. I am going to try and build on this "get the job done" experience and help move more of my students forward.

I have several students who now want to participate in the NREL [National Renewable Energy Laboratory] solar and electric spring this May.

In addition, he said having contact with graduate student mentors and visiting CU had a noticeable influence on several of his students:

Those who think they will be going to college are beginning to see that it takes work and discipline.

We have noticed that 3 students have really picked up their efforts and have openly talked about going to college. What an amazing contribution that you have all made for our students!!

Like the Whittier students, several of the students from Cambridge Rindge and Latin School (CRLS) commented in their student focus groups about how they had not considered going to college before, and now they felt they would. At least one student applied to the University of Massachusetts at Lowell after the CAM summer program.

Participating students in the summer CAM Project consistently reported that the process of creating the media projects had substantially improved their understanding of climate change science[3]. Although not mentioned in the student reflection pieces, the teacher from Whittier also mentioned that his students increased their content knowledge on climate change topics, saying "*The kids absolutely didn't know anything about global climate change. They know more now.*"

As part of their focus group comments, the CRLS students said they enjoyed the process of making the videos and they learned a lot from the experience. They also spoke about the skills they had gained in the process, of which they were very proud. A few examples of students' comments demonstrate these outcomes:

The best part of the experience was taking the week of learning science from the instructors and putting it into media. It's really fun being able to learn something that relates to you, be able to use expensive camera equipment and programs.

Media can be put to a lot of important uses. It is one of the most compelling ways to get a message out to a large audience, and should be taken advantage of no matter what you are trying to show people.

A good way to teach the public about climate change is through media.

Survey results corroborate these reflections and indicate substantial learning gains in both the areas of video production and climate change science by the CRLS students (Figure 1).

Figure 1. Pre- and post-survey results of high school students who partipated in the summer CAM Project (n = 11). See Rooney-Varga et al. (2014) for the evaluation methodology.

The effect of interest driven media projects on their sense of empowerment was evident for the CRLS students. In the first summer, they were given free rein to create any type of media project they could realistically complete within the five-week program, enabling them to be key innovators for the

CAM Project as they created and piloted their media projects. By the end of the summer, the students themselves named the program, “YEP!” for “Youth Educating the Public!” which conveys the sense of empowerment they gained from their experience.

Teacher observations emphasized how these programs were empowering experiences for students who are often marginalized. One CAM Project teacher noted that using media projects was a particularly effective means of getting students who might not otherwise be interested in the topic of climate change to become engaged in learning the material; she was particularly impressed by the amount of knowledge that the students had retained in order to complete their projects. Furthermore, teachers from both schools commented that both artistic and more academically minded students could contribute their skills to the media projects. For example, the Whittier group had several artists who drew the animations that were filmed, and they felt validated by the recognition of the skills they brought to the production. These students typically were not interested in school, but the video production engaged them, and they were able to “get the job done.”

CONCLUSION

One of today’s equity challenges is the need to increase media literacy among all students, especially traditionally marginalized students. Watkins (2012) challenges educators when he states, “Tools literacy is foundational; design literacy is tranformational” (p. 9). In this chapter, implementation models for seven different types of media projects that have been successfully piloted with 78 secondary students primarily from impoverished backgrounds are provided (Gold et al., 2015; Rooney-Varga et al., 2014). Results from the evaluations show that students’ experiences while participating in these projects were transformational. The students felt a strong sense of accomplishment and pride, which translated to increased confidence and sometimes even an interest in attending college as reported by their teachers. Students who were typically not interested in science topics took an interest in their own projects, stepped up their participation, and worked hard to “get the job done.” Students with a broad array of interests—from artistic to more academically inclined—found a way in which they could contribute to the projects; thus, the projects provided an inclusive space.

While working on their media projects, participating students gained experience in the full spectrum of media skills—from the simplest form of consuming media in order to find inspiration from different genres to learning about their subject matter and acquiring higher order media skills, including the planning, executing, and sharing of media projects. Not only did students learn a variety of media skills, they also learned soft skills like the development of interview protocols, communication with professionals, interview techniques, and how to be a good listener. Students were required to organize their ideas and provide feedback internally to their team; in addition, each student needed to find their role in the process. Team members worked together and developed the ability to collaborate. All of these are important life skills.

Through their research, students learned about the challenges of climate change and how climate change will affect their local communities. The process of developing the concept map or storyboard and writing a script exposes misconceptions. It also forces students to make connections and to take the fragmented pieces (such as interviews, animations, and B-roll) and meld them together to create a cohesive and compelling story. As the students stepped through the components of their media projects, they also practiced the Scientific Practices described in the NGSS. These media projects allowed for a seamless integration of the practices in the classroom.

Although not explicitly an objective of the two projects, the work with teachers and students exposed the power of partnerships. For example, although it is generally believed that the majority of schools have bridged the “tools” divide, the LOCC program ran into this roadblock at a high-poverty school. The Whittier ECE-8 School did not have powerful enough computers to download large video files and allow editing of the footage. LOCC created a partnership with CU, which was able to provide the equipment necessary to carry out and complete the video project. (Of course, a lack of computing power and high speed Internet does not need to be a barrier to media projects; some of the media projects highlighted in this chapter require only a cell phone or an iPad to complete.)

More importantly, the partnership between the mentors and students provided the students with role models who were not much older than themselves; the mentors offered the students personal insights into academic careers. They also got to know these young scientists as "real" people who were not bespectacled, gray-haired, white men—the stereotypical image of a scientist. Bringing the students to campus was valuable and extended the experience of the media projects. It allowed students a glimpse into college life, and some of the students could see themselves as college students in the future. A possible way to develop such a partnership is to contact a nearby two- or four-year post-secondary institution to inquire about partnering and whether college students would be interested in mentoring. Most universities have an outreach program or department, which would be the first place to inquire about such a partnership.

Taking on a media project might be daunting to an educator. Shorter-duration media projects, such as visual storytelling or animation, can provide a means to gain first-hand experience in the field. Developing partnerships within the school and collaborating with a technology teacher or a technology class for the implementation of such a media project might provide another avenue to increase the available media expertise that students can access.

As the projects discussed here have shown, media literacy can be transformational for students. The guidelines described in this chapter will support schools as they incorporate media projects into their classrooms or informal program offerings, thus narrowing the media literacy divide.

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ENDNOTES

[1] Student videos may be viewed at http://cires.colorado.edu/education/outreach/LOCC/.

[2] In order to ascertain from the students what skills they felt they gained during the LOCC project, they were given a writing assignment in their literacy class to describe what they had learned from their experience. They were not given any prompts to guide their writing, and they wrote short essays of about five to eight sentences. The written responses were analyzed using quantitative methods (Patton 2001). Each of their essays was coded, with one coder developing a code book. Each essay was coded by two different coders, and they reached 85% intercoder reliability. The codes were then consensus-coded for each code that reached less than 80% reliability.

[3] External evaluation of the CAM Project included focus groups with students and pre- and post-surveys of students' knowledge and attitudes about climate change science and media literacy. Details of the evaluation are in Rooney-Vega et al. (2014). The evaluators also interviewed participating teachers during the second summer.