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Multiliteracy, Multimodality, and Meaning

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Graphic Design in Flux: Multiliteracy, Multimodality, and Meaning

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Abstract: Undergraduate graphic design students at Western Carolina University in North Carolina, USA, engaged in two multimodal projects on subjects outside of art and design, required technical skills using a range of media, involved partnerships with professionals, and new ways of thinking when designing learning experiences. The goals were to engage students in the larger dialog of interdisciplinary graphic design, its applications, and implications. The first project, presented in spring 2016, involved graphic design students working in teams to design and develop non-digital Cherokee word games for the Eastern Band of the Cherokee Indians to use in their language classes. The games focused on learning, reading, and speaking Cherokee pronouns and using them in various contexts. The second project, assigned in the following fall 2016 semester, included the same students each assigned to design and build animations introducing various aspects of nanotechnology to the general public. This project was in partnership with the National Nanotechnology Coordination Office, Community Idea Stations—Science Matters, National Public Radio and the National Public Broadcast Stations in central Virginia. This article considers the contexts within which graphic design education exists and situates the graphic design program at Western Carolina University within this environment.

Keywords: Graphic Design Education, Multimodality, Multidisciplinary, Multiple Literacies, Non-digital Language Games, Explaining Science through Animation

Introduction

The breadth of graphic design professional practice expands and evolves with changes in technology and its impacts on cultures in which we are immersed. Graphic design education must move to include systems thinking, a broader understanding of people, social sciences, physical sciences, engineering, technologies, and integrated processes across disciplines (Norman and Klemmer 2014). Included in this article is research related to modes of communication, contemporary design, and technology. This article attempts to identify relationships between this research and two undergraduate graphic design projects presented over two semesters with the same group of students during the second semester of the sophomore year and the first semester of the junior year in the graphic design program at Western Carolina University (WCU).

Both projects were ambitious. They were multidisciplinary, involving subjects outside of art and design, required a range of media skills, and were collaborative. One project resulted in printed media, and the other was time-based designed for the screen. The projects were multimodal, requiring students to work with different modes of communication: printed text, spoken word, still and moving images, sound, and various levels of interaction. The projects provided opportunities to address multiple objectives within single assignments such as: using art and design to communicate complex concepts, developing multiple literacies, researching, and designing products for learning for diverse audiences.

The first project focused on making non-digital games for learning Cherokee pronouns and included collaborations with the founding director of Cherokee language program and Cherokee language students at WCU, and various members of the Eastern Band of Cherokee Indians (EBCI). The goals were to make fun and engaging language learning games and to give the games to schools in and around the Qualla Boundary, home to the EBCI in Western North Carolina, for use in Cherokee language classes.

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The second project centered on designing and making sixty-second animations on various aspects of nanotechnology. This collaborative project involved graphic design and music students and faculty at WCU, the education outreach coordinator at the National Nanotechnology Coordination Office (NNCO) in Washington, DC, and the Science Matters program manager at the Community Idea Stations, National Public Radio (NPR), and Public Broadcasting Stations (PBS) in central Virginia. The goals of these animations were to engage viewers on the subject of nanotechnology and, possibly, to encourage viewers to want to learn more about the subject. Selected animations would be presented on the Science Matters website and shown between features on PBS stations in central Virginia.

Designing Experiences

In efforts to design meaningful experiences, it is necessary to understand, at some level, the manner in which stimuli are patterned in the brain and how humans recall the stimuli/experience (Tulving 1993). Experiences must be evoked by a stimulus that is coded in the same way as the stored information was coded (Schwartz 1974). New research in cognitive neuroscience reveals that humans remember life events through retrieving essential elements associated with an event. When retrieving the experience, the person need only to be directed toward one of the associated elements for the reactivation of the other elements associated with the experience. The pattern in which the experience was encoded can be recalled and evoked. Although this process is subject to errors, it is important to note that "the key to creating holistically bound event representations lies in the associative structure created between the constituent elements" (Horner et al. 2015, 2).

In designing the non-digital Cherokee word games, the graphic design students developed concepts around experiences that might be common to potential players hoping to evoke an emotional connection. Additionally, the face-to-face interaction and competition to win the games was also important. Research supports that things are better remembered when conditioned or accompanied by emotional and motivational factors (Bergado, Lucas, and Richter-Levin 2011). Although the games were designed for middle and high school students, it was later discovered that Cherokee language learners of all ages, elementary school age children to adults, engaged with and enjoyed the games.

The concept developed for the card game titled "What are you doing?" focused on creatures that live in and around the geographical area familiar to the EBCI. The creatures included the cardinal bird, the turkey, the white tail deer, and the mallard duck. To make the game fun, these creatures represented the pronouns (I, you, he, she, they). The idea was to connect the players to the animals and to experience their habits while learning to read, speak, and construct sentences of varying levels of complexity.

The game "The Store" was designed as a board game to connect the players to the experiences of shopping in a "big box" store. The emotional, fun-factor of this game was built upon the interaction between players, competition to complete a shopping list first, bartering among players for items to purchase, and the unexpected surprise of "good" and "not so good" things that might happen when shopping.

The process for designing experiences through the animations on nanotechnology was more challenging. The audience was unknown and would passively watch the animations on a screen via a website (ideastations.org/sciencematters), or on a television screen between features on PBS in central Virginia. All of the design students were familiar with qualities that made an animation interesting, having watched many. They relied heavily on research, art, and design; interesting graphics, animation, and transitions; the voice of the narrator; and the music to engage viewers and to present the subject.

The Audience and Context

Technology

"The medium is the message," a phrase coined by Marshall McLuhan, is apt and continues to be relevant. The technology humans use affects their lifestyles, behaviors, and expectations; it affects how they participate in conversations, in the workforce, and how they relate to others. The medium and its affordances shape the experience and the meaning(s) of the messages (McLuhan 1964). "The audience's language and level of visual literacy, which means skill in comprehending and using visual forms, must be taken into account if the designer is to communicate successfully" (Meggs 1992, 4). However, as technology and the practice of graphic design has evolved, literacy skills required for students of design must go beyond language-based literacies and the visual to include the audio and the gestural, all of which are components in computer-mediated information systems (The New London Group 2000).

Since 1992, the cellphone, now referred to as a smartphone, has emerged as a mobile device for communicating, accessing the internet, recording images and sound, participating in social media, receiving news, and it is rarely turned off nor leaves the body of its owner. Smartphone ownership has surpassed adult ownership of laptops and desktop computers (Anderson 2015). American teens ages 13–17 that own or have access to smartphones is about 88 percent. Teens heavily use texting, and girls outnumber boys in the use of image-oriented social media such as Instagram, Snapchat, Pinterest, and Tumblr (Lenhart 2015). In 2016 research revealed that 86 percent of adults, ages 18–29, use at least one social media site, with 80 percent of adults, ages 30–49, and 64 percent of adults, ages 50–64, doing the same. Social media use, at least one site, has even increased with adults 65 and older hovering around 34 percent (Pew Research Center 2018a). Mobile device use for receiving news is on the rise among people in various income levels with more than eight-in-ten adults in the US receiving news on a mobile device (Lu 2017). Over the past decade, the social media site Facebook has remained the most popular social media platform with 79 percent of internet users (Greenwood 2016). "For some demographic—such as young adults, college graduates and those from high-income households—internet usage is near ubiquitous. Even so, adoption gaps remain based on factors such as age, income, education and community type" (Pew Research Center 2018b). With the use of smartphones seemingly ubiquitous among many populations in the United States, especially among Non-Hispanic whites and Asian populations collectively, this is not the case with American Indian/Native populations (Parhurst et al. 2015). While it is important to know how people use technology and the impact it has on lives, it is also significant to be aware of how data collected from human interactions with technology are used in shaping messages and in marketing to affect behavior. Psychographics, individually targeting messages based on personality types evoking experiences and emotions, is based on data collected from a wide range of digital transactions and interactions (Grassegger and Krogerus 2017; Concordia 2016).

This research is significant for design educators; it provides insight into the experiences of students, potential audiences, and the contexts in which projects will exist. In relation to the two projects addressed in the article, many design students admitted to having had little experience playing non-digital games, although most had experiences playing digital games. It was observed that the students found it challenging to design and develop a game involving face-to-face interaction, and make it fun and engaging. All of the design students were familiar with watching videos and animations online; although some of the students had developed animations, none expressed having had experience in visualizing aspects of science. They admitted a preference for watching an explanation of a process, rather than reading a description of a process. It was discovered near the end of the Cherokee word game project how difficult it was for the students to write and present clear instructions and game objectives. It was also challenging for the students when working with the nanotechnology animations to present the science accurately. It

is not clear to the author if there is any direct connection between the design students' experiences with technology, and the challenges they encountered in designing and developing the Cherokee word games and the nanotechnology animations. However, it is clear that designing using different modes of communication requires unique literacy skills.

The Projects

Models for future thinking design education can be found at the STEM to STEAM initiative at the Rhode Island School of Design, the OpenLab for collaborative research at the University of California Santa Cruz, and the MIT Media Lab. They provide collaborative laboratories (spaces) for academic communities, arts and design communities and industry. They are about innovation, exploring possibilities, and making new discoveries, and served as inspiration for the author to integrate the projects discussed in this article into the graphic design curriculum.

Collaborative learning spaces are growing within WCU, however, none such space existed for the projects during the time in which they occurred. The lack of multidisciplinary spaces affected the projects to some extent; however, most problematic were conflicting class schedules that limited the time available to work directly with some collaborators. Nevertheless, collaboration did occur. Digital communication through email and posting in-progress work online via class websites and video conferences were important in implementing the projects.

Cherokee Word Games: Overview

The Cherokee Word Games project began as a conversation initiated by the WCU founding director of the Cherokee language program and the author. The director was and remains committed to working with the EBCI to revitalize the Cherokee language. This is significant since the elder speakers are passing more quickly than new speakers have been emerging (Cherokee Preservation Foundation 2014). We discussed developing non-digital card games for learning parts of the Cherokee language. The audience for the games would be middle and high school students. We narrowed the scope to focus on Cherokee pronouns and how to use them in the present tense, in various contexts.

In spring 2016, sixteen students enrolled in Graphic Design 1 were presented with an eight-week project, the Cherokee Word Games. Faculty in the Cherokee language program presented information about the EBCI and their culture. Digital resources related to the history, language, arts, and crafts unique to the tribe were identified, such as the Cherokee traditions online digital collection at WCU's Hunter Library.

The design students worked in four teams and collaborated with students enrolled in a Cherokee language class and their faculty, the Founder of the Cherokee language program and another instructor in the program, to develop ideas for card games that would be visually interesting, challenging, and fun to play while learning to read and speak in Cherokee. There was excitement among the design students to be working with a "client" and producing a real-world product. At the same time, they were very concerned about developing games around a language with which they were unfamiliar and could not read. Although two design students were Cherokee tribal members, they were not fluent in the Cherokee language. The graphic design student teams primarily developed the concepts for the games. However, the face-to-face interactions during critiques between the graphic design students, the students enrolled in the university's Cherokee language class, and the Cherokee language faculty were important in helping to refine the concepts, figure out the mechanics of playing the games, and obtaining critical feedback on a range of issues: the scale of the game components, the style of visual imagery, the implied meaning of graphical content, the layouts of visual elements, correct spelling and usage of Cherokee words, and their English translation as applied to each game. The only design decision made solely by the "client" was the selection of the typeface to be used for the Cherokee words: aboriginal serif. This typeface is available for free download and could be

assigned to the computer keyboard. By the end of the semester the teams developed four games: "Collectible Cards," "Flash Cards," the "What are you doing?" card game, and a board game, "The Store."

The "Collectible Cards" consisted of four sets of cards distinguished by the different graphics appearing on the backs of the cards. Each set included pronoun, verb, and noun cards. The goal was to arrange the cards within a set into correct sentences by combining the pronoun, verb, and noun cards correctly. The team felt potential players would want to collect the cards based on the graphics.

The "Flash Cards" focused on the unique context of using pronouns in Cherokee when referring to objects that are flexible, long and rigid, and solid. Each card displayed an image in the center of the card representing people engaged in holding various objects. Along three margins around the central image, the students included a sentence describing the image in Cherokee, how to pronounce the sentence, and the English translation of the sentence. The goal was for the player to correctly describe the image in Cherokee. The backs of the cards depicted a graphic pattern loosely based on Cherokee basket patterns.

"What are you doing?" is the title of three card games in one, each game progressing from easy to more difficult, and was designed for two to four players. The game contains four sets of cards: the cardinal bird, the turkey, the white tail deer, and the mallard duck. Each set includes fifteen pronoun cards and four cards displaying the creature engaged in an activity, a reference sheet for each set, and instructions for the three games. Players are dealt some of the cards, depending on the game. One card from the remaining cards is displayed face up. Players try to complete a sentence by matching cards within a set. If a player is unable to make a play, then he or she draws another card from the deck. The degrees of difficulty are related to the contexts in which some pronouns are used. The goal is for the players to get rid of the cards first by speaking and assembling his or her cards into correct sentences.

"The Store" board game represents a store with various departments: home, food, health, and clothing, and several places in which good or bad events might occur. The game components include: play money, cards displaying items that can be purchased within each of the four departments at the store, shopping lists, cards with surprise events that might occur when shopping, four game pieces, the game board, an answer sheet, and game instructions. The game is designed for two to four players. Each player receives a game board piece, a disc with a shopping cart on top designed and printed using a 3D printer. Each player receives $150.00 in play money and a shopping list. The game begins with the first player rolling a die and moving his or her game piece along the board squares. Depending on where the player's game piece lands on the board, he or she draws a card from the corresponding department. If the player needs the item appearing on the card, he or she must first choose the correct sentence referring to the item from the sentences listed on the card, speak it in Cherokee, and purchase the item. A player can choose to not purchase the item and to "sell" it to another player. The first person to complete his or her shopping wins the game.

Cherokee Word Games: Challenges

The project was ambitious and provided many challenges for students early in the graphic design program. Technical skills working with vector-based drawing and page-layout software were limited. This was the first team project students had experienced in the design curriculum and collaboration did not come naturally. Working with an unfamiliar language and the inability to work more hours directly with collaborators during scheduled class times proved frustrating. Students struggled in understanding basic semiotics of visual elements and implied meanings of images. Designing the games was the first project requiring systems thinking. It was challenging for some of the teams to integrate the various graphical and physical components of the games. The ability to integrate the elements of the games was directly related to the interactivity among the students in the design teams. Teams working effectively together had more success. A needed

skill that was not anticipated was that of writing and presenting game directions. Translating game objectives and the sequence for playing into easily understood written steps with clear examples, and visual hierarchy required a different set of analytical skills not previously addressed in the class or curriculum. The eight weeks allowed for the project was too brief to allow for significant revisions, user testing, and feedback. Most of the user testing and feedback of the four games occurred during the summer, after the spring semester had ended. Funding through an internal award provided support for a research assistant, one of the undergraduate design students involved in the games project, to make significant revisions, and to cover printing costs.

Cherokee Word Games: Feedback

Feedback received for the "Collectible Cards" and the "Flash Cards," the two games not selected, related to the lack of playability and graphic design issues. These games were found to be underdeveloped as learning games and missing a level of fun and engagement. In some instances, graphic representations were difficult to interpret, inconsistent stylistically within the game, and, in one case, found to be culturally insensitive. Although the fundamental concepts were interesting and viable, too much time and additional resources were needed to pursue them further. Two games were selected pending some revisions: the card game "What are you doing?" and the board game "The Store." Both games were perceived as having a high level of playability and fun factor, while remaining challenging.

The concept of using creatures to represent the pronouns in the "What are you doing?" card game was found to be clever and appealing to all ages of learners and related to common experiences. The theme was thought to be culturally connected and appropriate for the geographical location of the EBCI. The style of the graphical signs used throughout the cards was consistent. The scale of the cards, 3 ½ inches by 5 ¾ inches, was easily handled and allowed for the visual elements to be separated with plenty of white space, making each element easy to interpret. Reference sheets and detailed directions were included. Users participated in refining the directions and adding to the game strategies. Several examples from the "What are you doing?" card game can be seen in Figures 1–6.

Figure 1: "What are you doing?" card game box label design (left), and design for backs of the cards (right).
Source: Faub, Garcia, Handy, and Johnson 2017

Figure 2: “What are you doing?” card game. An example of a sentence using the Cardinal card set. He (pronoun card on left) is sleeping (verb card on right). Pronunciation of the Cherokee word is located at the top of the cards and the Cherokee word appears on the bottom of the cards.
Source: Faub, Garcia, Handy, and Johnson 2017

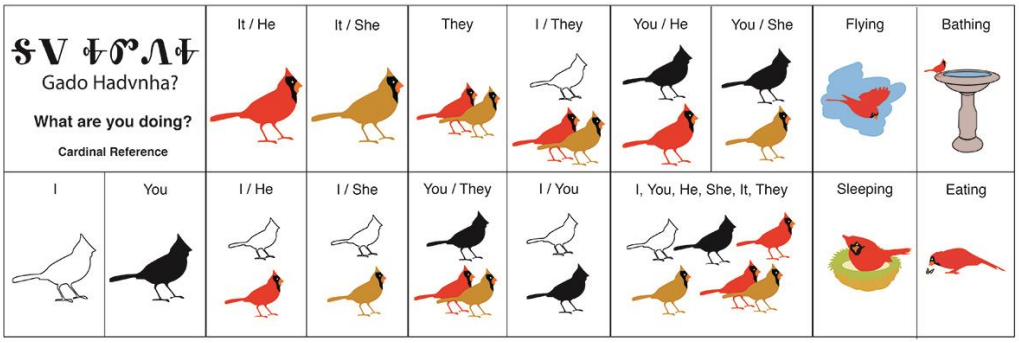

Figure 3: “What are you doing?” card game. Example of reference sheet for the Cardinal cards with English translations.
Source: Faub, Garcia, Handy, and Johnson 2017

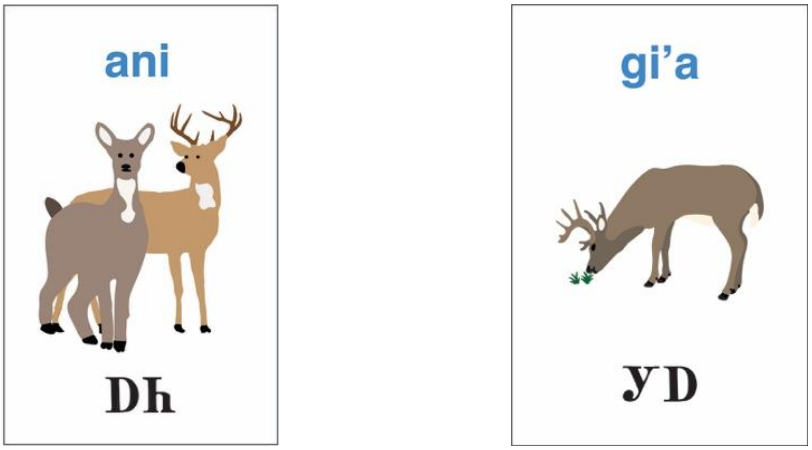

Figure 4: “What are you doing?” card game. Example of a sentence using the Deer card set.
He and she (pronoun card on the left) are eating (verb card on the right). Pronunciation of the Cherokee word is located at the top of the cards and the Cherokee word appears on the bottom of the cards.
Source: Faub, Garcia, Handy, and Johnson 2017

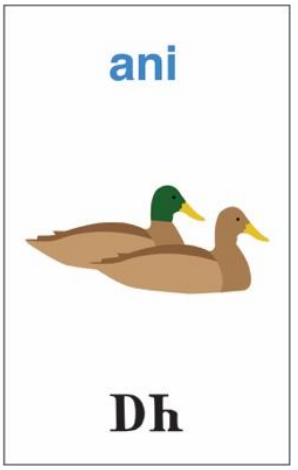

Figure 5: "What are you doing?" card game. Example of a sentence using the Duck card set.
He and she (pronoun card on the left) are flying (verb card on the right). Pronunciation of the Cherokee word is located at the top of the cards and the Cherokee word appears on the bottom of the cards.
Source: Faub, Garcia, Handy, and Johnson 2017

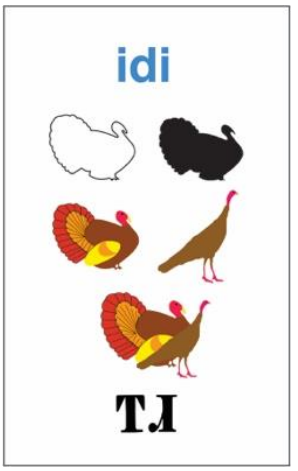

Figure 6: "What are you doing?" card game. Example of a sentence using the Turkey card set.
I, you, he, she and they (pronoun card on the left) are eating (verb card on the right). Pronunciation of the Cherokee word is located at the top of the cards and the Cherokee word appears on the bottom of the cards.
Source: Faub, Garcia, Handy, and Johnson 2017

"The Store" board game was found to be very fun to play. Although the original instructions developed and written by the design students were somewhat unclear, users participated in refining them and added particular strategies not originally envisioned by the design team. The concept for the game, to reflect and evoke experiences people might have when shopping at a "big box" store with different departments, was thought to be significant and easily connected to players' experiences. The many levels of interactivity added to the fun factor: rolling a die and moving game pieces around the board, selecting cards, reading and speaking Cherokee, trading and competing with others players to purchase needed items, playing with money, and the surprise factor of the "good" and "not so good" events that might happen when shopping. The design patterns used to identify each of the departments within the store referenced Cherokee basket patterns. The game challenges, such as requiring players to read, select, and speak the correct sentence appearing on the item card before purchasing the item, were thought to be clever and fun. Images from "The Store" board game can be seen in Figures 7–10.

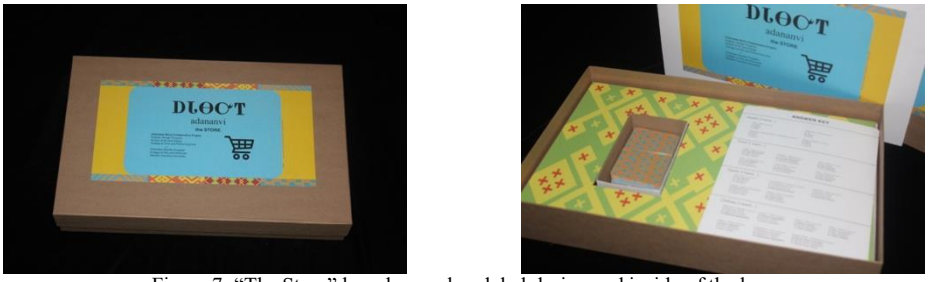

Figure 7: "The Store" board game box label design and inside of the box.
Source: Kicinski, Noble, Swimmer, and Thompson 2017

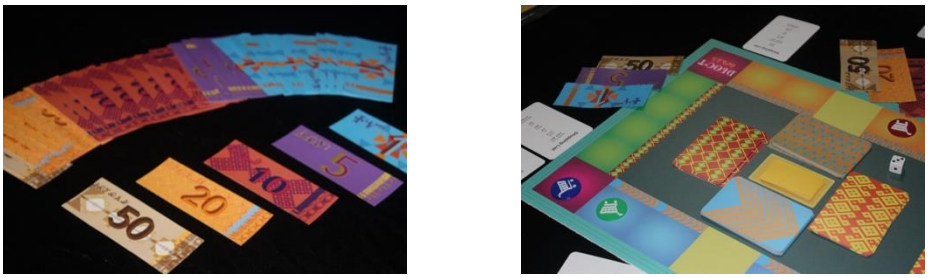

Figure 8: "The Store" board game components.
Source: Kicinski, Noble, Swimmer, and Thompson 2017

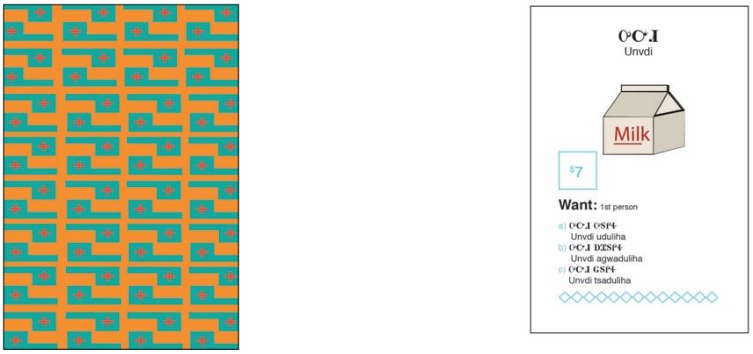

Figure 9: "The Store" board game. An example of an item card in the food department.
The pattern on the back of the card (left) represents the Eastern Cherokee basket peace pipe pattern. The front of the card (right) has the Cherokee word for the item on the top with the pronunciation below it. A graphical representation of the item appears in the center, followed by the price, a verb and a tense, and three sentences from which the player selects the correct one using the verb and its tense and speaking it in Cherokee before purchasing the item.
Source: Kicinski, Noble, Swimmer, and Thompson 2017

Figure 10: "The Store," examples of different department item cards and a shopping list.
Source: Kicinski, Noble, Swimmer, and Thompson 2017

Cherokee Word Games: Successes

The games addressed many modes of communication: tactile texture and scale, image, text, and interaction, and provided opportunities to develop multimodal literacy skills, as well as technical and visual literacy skills. Students were excited to design and develop a product that would fulfill a particular need. Although the process was more involved than many imagined, the learning experience gave insight into the scope of the design process and its many layers of details and concerns.

Of the four games developed, two were successfully revised and printed (eighteen copies) and distributed: the card game "What are you doing?" and the board game "The Store." These two games were introduced into the adult Cherokee language immersion class at the New Kituwah Academy in Cherokee, North Carolina, during fall 2017. Since that time they have been introduced to lower level language classes at the academy, as well as to Cherokee language classes at Cherokee Central High School and Middle School, Swain County Middle and High Schools, and the Snowbird Summer School, all in western North Carolina. The board game was found to be a fun way to practice an extensive vocabulary of everyday items and shopping phrases and has been used to prepare for actual shopping trips, for practicing numbers, money, and teaching financial literacy. The education curriculum developer at Kituwah Academy (formerly the founding director of the Cherokee language program at WCU and a project collaborator) stated, "The [design] students have beautifully blended complex grammatical structures, culturally inspired design, and playability into learning objects that we will be benefiting from for a long time."

"What are you doing?" and "The Store" were shared with the imagiNATIONS Activity Center at the Smithsonian National Museum of the American Indian in Washington, DC, the Cherokee Nation in Tahlequah, Oklahoma, the WCU Cherokee Center and the Museum of the Cherokee Indian in Cherokee, North Carolina, and the WCU Hunter Library special collections.

Nanotechnology Animations: Overview

The same graphic design students that participated in the Cherokee word game project were enrolled in Motion Graphics 1 the following fall semester. This class introduces students to time-based software and concepts related to working with text, image, sound, and gesture as modes of communication. During the last six to eight weeks of the semester the students participate in an interdisciplinary project to design and make animations related to the subject of nanotechnology. Partnerships were previously established with the collaborators, the education and outreach coordinator at the NNCO in Washington, DC, and the Science Matters project manager at the Community Idea Stations in central Virginia, as well as with students and a faculty member in the School of Music at WCU. This project and collaboration has occurred during the fall semester for three years.

At the beginning of the semester the NNCO provides two written scripts, approximately sixty seconds to read aloud, addressing different aspects of nanotechnology. These scripts are divided among the design students allowing time for research. At the same time, the scripts are given to a colleague and his students in the School of Music. The music students professionally recorded speakers of various ages and gender reading the scripts, and composed original music to accompany the animations. There was no direct interaction between the music and design students. The sound files were given to the design students after mid-semester. The designers choose a single voice recording and a musical score to accompany their animations. Providing the designers with multiple recordings of narrators reading the same script and various musical scores from which to choose, allowed them to experience directly how a voice and music influences the message and can affect the style and the pacing of the visual elements in the animations.

Each design student was responsible for designing and producing an animation and encouraged to interact with other students working on the same script to explore visual ideas, share research, and technical discoveries. The design process included drawing storyboards, participating in technical demonstrations and presentations during class, exploring tools and effects available in the software, visualizing ideas, getting feedback, and making revisions. All students have university server accounts and were required to upload their work in progress throughout the semester prior to scheduled critiques. The education outreach coordinator at the NNCO accessed the animations online and would prepare feedback for each student. This feedback was shared with the design students through several video conferences throughout the project during class critiques.

Nanotechnology Animations: Challenges

Motion Graphics 1 is the first class in the graphic design curriculum to work specifically with time-based software. The process of working with and combining image, type, gesture, transitions, the spoken word, and music was challenging on several levels: timing and coordinating the various elements, developing technical skills, and drawing. The ability to draw using vector-based software was extremely important. At this point in the curriculum students had two previous semesters working with vector drawing software. Those lacking drawing skills struggled to make images in their animation meet the concepts he or she had in mind. Students with the ability to draw image elements from various points of view and angles had significant advantage. Unanticipated was the students' lack of understanding of and skills related to using a camera and editing techniques (both available within the software) for creating a narrative. Although examples were provided, without direct experience in using a camera and editing for creating narratives, many students were unable to grasp the concepts. The students' unfamiliarity with nanotechnology did not seem to be as challenging as developing a visual narrative around which to shape the content of the scripts.

Nanotechnology Animations: Feedback

Vital to understanding the various aspects of nanotechnology was the collaboration with the education outreach coordinator at the NNCO. Her expertise in physics, nanotechnology, communication, as well as filmmaking was a good combination and valuable to the students on many levels. She provided input on subjects such as depicting the science accurately, representing scientists, pacing, how the voice and music affect the message, providing clear communication, and even addressing subjects such as color, use of screen space, and smooth transitions. The face-to-face communication through video conferences, a first for most of the students, was effective, friendly, and comfortable. Each student's work was addressed individually during each of the two-and-half-hour video conferences. There were three to four video conferences within the time allowed for the project. Students' questions were always answered during the video conference or in a timely manner through email. The music students involved in the project did not attend the video conferences.

A team of scientists at the NNCO determined which animations met the project goals. They selected one animation to represent each of the scripts. The selected animations were announced during the final video conference during the last critique of the semester. Reasoning behind the decisions was shared with the students. Also shared was constructive feedback related to the works not selected and addressed subjects such as use of stereotypes, the quality of graphics, incorrect visualization of the science, and choppy transitions. Of the animations selected, generally minor revisions had to be made and were resubmitted early the following semester. The revised selected animations are then sent to the project manager for Science Matters at Community Idea Stations and shared with their production teams. Upon approval the animations are added to the ideastations.org/sciencematters website within the next several months and aired

between features on the public television stations in central Virginia throughout the following year. Stills from the selected animations designed and created during fall 2015 and fall 2016 are included in Figures 11–16.

Figure 11: Animation stills from, "How Do You See the Nanoscale?"
Source: Cook, Simmons, and Williams 2017

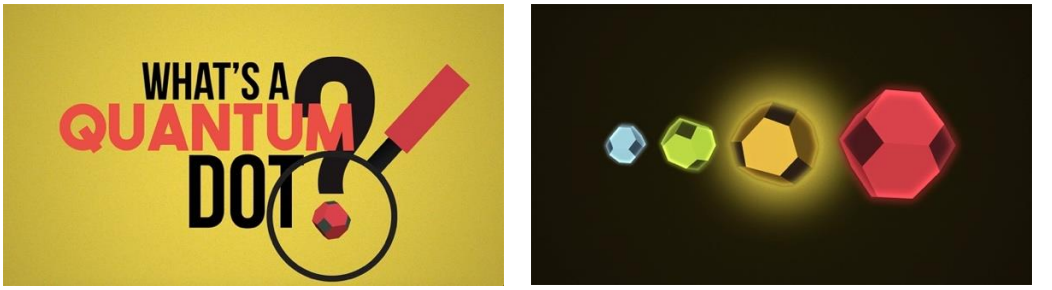

Figure 12: Animation stills from, "What's a Quantum Dot?"
Source: Burke, Forbey, Johnson, and Williams 2017

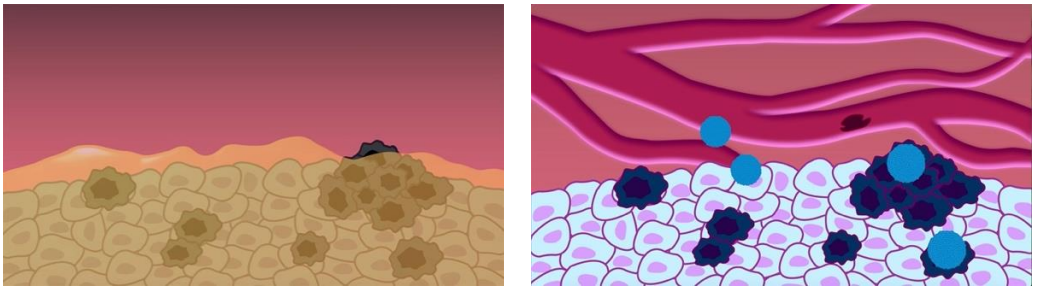

Figure 13: Animation stills from, "How Do Doctors Target Cancer Cells?"
Source: Handy, Forbey, and Whitaker 2016

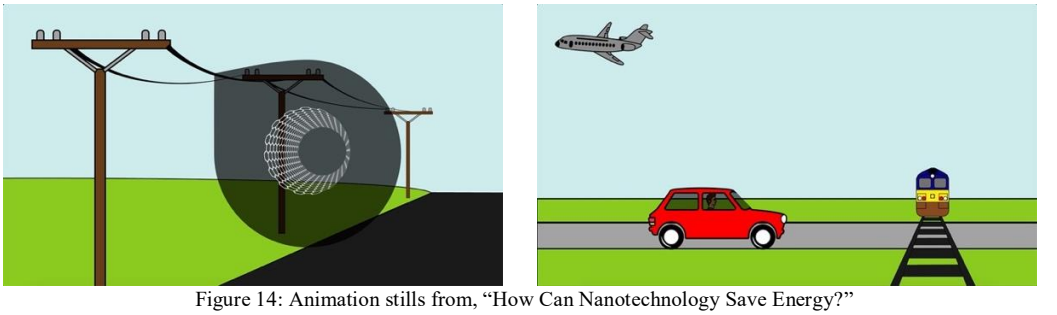

Figure 14: Animation stills from, "How Can Nanotechnology Save Energy?"
Source: Maness, Martin, and Sink 2016

Figure 15: Animation stills from, "What Can Nanotechnology Do For You?"
Source: Warren, Lucore, Sink, and Turnmire 2016

Figure 16: Animation stills from, "How Will Nanotechnology Improve Your Health?"
Source: Giarette, Bell, and Martin 2016

Nanotechnology Animations: Successes

The nanotechnology animations project provided an opportunity for students to expand their technical skills and further develop multiple literacy skills. The experience revealed how to break apart a motion sequence concept into mini-compositions and put them together into a whole, seamless visual experience. As the animations evolved, the experience of viewing their work in real-time allowed the students to understand how meaning is shaped in the in-between spaces where communication modes overlap and are juxtaposed (Duncum 2004). The professional review and acceptance of the animations is significant for both the design and music students and important additions to their portfolios. Having work aired and broadcast qualifies the music composers for membership in performance rights organizations such as the American Society of Composers and Authors and Publishers. The animations are peer-reviewed by professionals and exposed to large audiences through presentation on the ideastations.org/sciencematters website, and aired on PBS in central Virginia. Additionally, the animation "What Can Nanotechnology Do for You?" was selected and included in the PBS Learning Media website, which is a resource for classroom teachers and learners worldwide. Another animation "How Can Nanotechnology Save Energy?" was selected and included in the National Science Foundation 360 Video website.

The relationship with the project partners continues to grow as does the need for visualizing complex subject matter. The education outreach coordinator at the NNCO stated, "The collaboration between the students and nanotechnology experts has helped to ensure the accuracy of the science and the manner in which it is being depicted. It has been interesting to see how the students imagine nanotechnology and its applications. It has also been very satisfying to help them learn about nanotechnology, as well, as they receive feedback on the animations. Additionally, this project has shown the graphic design students that the field of science communication needs their skills."

Conclusion

Technologies have affordances, characteristics, and attributes that affect interactions among players, users, and audiences, and shape the content, messages, and experiences. Interestingly, in relation to the development of non-digital and digital games, research conducted by Geoff Kaufman and Mary Flanagan compared the play of non-digital and digital versions of the same game with students ages 11–17. The results revealed significant differences in player experiences and outcomes, such as: the players of the non-digital version of the game had higher success rates in winning the game, the playing time interacting with the digital version was shorter, and players of the non-digital game engaged in significant discussion related to strategies and possible outcomes. The researchers state the distinct affordances of each platform are significant in regard to cognitive processes related to the digital and non-digital experiences. The digital game players may be more accustomed to solitary use, while non-digital game players may expect a shared experience. Their findings imply digital platforms may activate more concrete and less abstract mindsets and processing styles (Kaufman and Flanagan 2016). Additionally, research conducted by Daphne Bavelier and Shawn Green on the brain benefits gained in playing video action games include improving attention and reaction times and the ability to switch from one task to another. It is important for designers to understand how humans process and interact with various media to participate in the larger practice of contemporary design. Bavelier and Green express the need for scientists with expertise in learning, psychology, and neuroscience, to partner with graphic designers, game designers, and producers to develop and deliver action games that have therapeutic content (Bavelier and Green 2016).

"Many of today's problems are too big and too consequential to be solved by an individual or even a single field of expertise. They require teamwork among designers and between designers and professionals in other disciplines" (Davis 2017, 107). The possibilities for graphic designers to work across disciplines in collaboration with others are perceived as significant and should be integrated into design curricula at the undergraduate level. The breadth of design practice continues to expand, working collaboratively, combining disciplines, and requiring an understanding of multimodal communication and multiple literacy skills.

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