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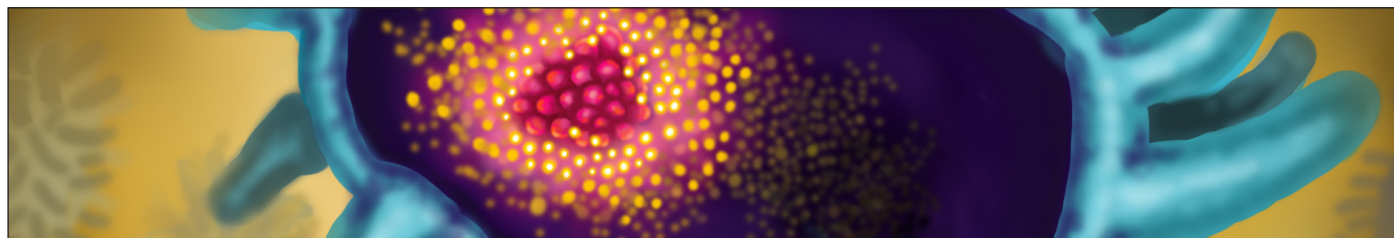
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Developing curriculum for teaching scientific visual communication

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Abstract

As we have observed with the current epidemic, there is a significant amount of scientific and medical information that must be delivered to an audience that does not necessarily have the educational background to readily understand and take necessary action to remain safe and healthy. Where many people lack the vocabulary to understand the scientific details of viral transmission and vaccine development, visuals offer the opportunity to cross language and academic barriers to more easily communicate critical health information. We have seen the use of scientific and medical visualization on social media platforms and in the news as a way to share information on Covid-19 outbreaks, safety protocols, and now vaccine distribution. This reliance on strong visual communication indicates a need for universities to be engaged in training students to be effective visual communicators and to enhance visual literacy on their campuses and in their communities. Here we share our experience in developing a course in digital painting that led to academic programs in scientific visualization and pre-medical illustration and a positive impact on the community.

1. Introduction

Communicating health information across diverse populations is critical to improving public health and sustaining health-related practices within a community. Literature indicates that for patients to make truly informed decisions they must have an understanding of their medical condition, health risks, and treatment options (Lipkus, 2007). Additionally, the most effective methods for communicating and ensuring understanding often involve a combination of verbal and visual methods of delivery (Kearns, 2015; Lipkus, 2007; Shankar, 2003; Williams, Davis, Parker, & Weiss, 2002). Although equipped with the information, physicians and medical staff are not always able to adequately explain a condition, symptoms, and treatment regimen. Moreover, they do not always have access to the proper visual aids for sharing information with the patient population they serve.

Visual literacy is the integration of sensory experiences with visual knowledge. Visual literacy requires individuals to call on what they already know, either through passive or active learning, and apply that to visual aids in order to understand simple and complex messages (Avgerinou & Ericson, 1997; Debes, 1969). Visual literacy is necessary for the successful navigation of today's imagery-saturated world. Visuals can overcome language barriers and provide a deeper understanding and retention of materials. With over 65% of the population being visual learners (Bradford, 2004), this method of information delivery is especially critical when describing complex medical information or the scientific background needed to understand a clinical diagnosis or treatment plan. Through a combination of effective visuals and text, information can be clearly described in a step-by-step format rather than a continuous block of text. This allows for grouping of ideas with paired images that enhance overall retention and recall. This is often achieved by using images that carry a memorable emotional message, show a particular action, and overcome word recognition and field-specific vocabulary (Doak, Doak & Root, 1995). Indeed, as we have witnessed with the recent Covid-19 pandemic, visuals are being used on social media and in the news to communicate how the virus is transmitted, what action needs to be taken to prevent transmission and infection, and now to describe the development and efficacy of vaccines. We are being inundated with visuals and, without thinking about where they come from or determining our own level of visual literacy, these images are effective (Amidon, Nielsen, Pflugfelder, Richards, & Stephens, 2021; de la Fuente, Bedia, & Gortázar, 2020; Hamaguchi, Nematollahi, & Minter, 2020; Saraiva & Ferreira, 2021). In order to continue creating informative and impactful illustrations,

like those we see across Twitter and Facebook, it is critical that we continue to teach visual literacy, elements of design, and collaborative initiatives that engage students of all ages in generating valuable imagery.

For many, information delivered by physicians or shared by scientists is incomprehensible, making it the message much more overwhelming and frightening. By both teaching students to create visuals and using those visuals to inform the community, the VISTA Center at Louisiana Tech University is reaching a broader audience and directly affecting the overall health and medical literacy of the community. Through the Visual Integration of Science Through Art (VISTA) Center, faculty and students from areas of art, science, and engineering work together to create imagery that communicates complex medical and scientific information. This partnership yields imagery in the form of graphical figures and illustrations that are universally understood, thereby eliminating barriers created by education and language. Students work with research faculty and community partners to develop visuals to communicate research ideas, new technologies, and critical health information. In turn, those visual pieces are then used in publications, proposals, and various patient communications in the form of posters, illustrated children's books, website infographics, and social media posts. Through the formal education of students and more informal education of the community, including community leaders, the VISTA Center is engaging others in developing visual literacy to improve health outcomes.

Here we describe the methodology for teaching college students to visually communicate complex scientific and medical information and how this has increased the overall appreciation for the visual arts at the university and community level. The University in which this took place is a public school in the United States where many students are the first in their family to go to college. Most students are from the geographical region and attend the University for its affordability and proximity to family. The largest college at the university is Engineering and Science with a significant number of students pursuing a degree in an engineering discipline. This makes the achievements and recognition of the arts that much more significant as they are traditionally a program that struggles with under enrollment in courses and majors. Through the creation of a single class, we are able to teach students elements of design, skills in digital painting, and introduce them to client-based work in the area of health and science. The success of this class resulted in the creation of two academic minors, and an increase in enrollment in studio art courses, and additional engagement of college students and K-12 students across the state, introducing the next generation to the opportunities and impact

that visual literacy has on communication and education.

2. Methodology

The first course that sought to engage undergraduate students from Studio Art of Graphic Design in visual scientific communication was ART 310: Digital Painting. This course was first offered in the spring of 2015 to a class of 11 undergraduates. This course was designed to fulfill elective requirements for majors within the Graphic Design and Studio Art degree programs. Students choose which elective courses to take, which can make new course development challenging when competing for enrollment.

Developed as a new course after realizing the value of the technique for client-based projects, ART310: Digital Painting offers students the ability to easily manipulate illustrations in order to be scientifically accurate and meet the client's desired goals. With the only pre-requisites being ART 116: Color Design and ART 126: Drawing 2, the course is available to many students pursuing a degree within the School of Design. Over the ten-week academic quarter, students learn how to apply core visual design and traditional drawing skills to a digital medium. The course begins with a series of assignments that focus on teaching basic digital painting techniques using the Wacom digital drawing tablet and Adobe Photoshop. Following introductory assignments, students complete an environment piece and a self-portrait (see Figure 1). In addition, throughout the quarter students work on a series of orbs to continue practicing various digital painting techniques and workflows (see Figure 2). Each of the assignments stresses the fact that in visually representing aspects of science or medicine artists must often generate representations of objects, mechanisms, and tissues that people cannot see, that are opaque or translucent, lack color, or are buried in the body and so no light source exists. These are basic elements of design, but the context and necessity of these considerations in scientific and medical illustration lead to their significant emphasis in the course. Conventional practice is intrinsically rhetorical, designers must select conventions based on their interpretation of the potential readers and the situational context in which those readers will use them (Kostelnick, 2003).

2.1 Technology

Students were loaned a Wacom Digital tablet for the 10 week quarter. These pressure sensitive tablets are the professional standard for digital artists. Students were required to have the latest version of Photoshop CC installed on a laptop computer. With a student license and borrowed tablet, the

class was readily affordable to students. In addition, during the course of the quarter, many students saw the potential for digital painting in their future career as artists that they purchased their own pressure-sensitive drawing tablet.

2.2 Elements of design

Assignments for the course include creating a collection of greyscale basic shapes, color mixing exercises, and object studies (Figure 1). These short assignments are designed to develop a deeper understanding of light logic and stress the importance of accurate measurement and observation. By starting with assignments that focus on direct observation and complement a student's understanding of traditional medium, students become comfortable with the tablets and gain confidence in their newly acquired digital skills.

2.3 Environment piece

The environment assignment challenges students to combine spatial elements from multiple photographic sources into one cohesive environment while considering scale, perspective and light logic (Figure 1). Scientific visual communication often requires artists to illustrate a space that does not exist in the way that we, as humans comprehend space. The inside of the human body or tissue at a cellular level are examples of this type of space. There is no visible light to create a perceivable volume or form, no truly definable color to differentiate a cell from its environment. Therefore, in order to clearly communicate a process at this level an artist must invent color and light logic based on the rules of the natural world.

2.4 Self-portrait

The self-portrait assignment allows students to be creative while expressing aspects of themselves (Figure 1). Requirements include working with a limited color palette and creating the illusion of texture all while maintaining control of organized layers in Photoshop. This results in interesting combinations of realism, abstraction and surrealism. The ability to create the illusion of a wide range of textures is important for creating a dynamic image, especially if a limited color palette is required and the artist must rely on textures to increase readability of objects and space.

Both the environment and self-portrait assignments allow the students to be creative and decide on what specific effects, textures, exaggerated colors or imaginative forms they wish to create. These techniques are important for students to master so that they may create clear and useful scientific illustrations. As many students come in apprehensive about

Figure 1. Examples of work representing elements of design, still life, environment, and self-portrait. These were pieces done strictly for class assignments, not for any other purpose in advertising or promotion. All work is property of the VISTA Center of Louisiana Tech University.

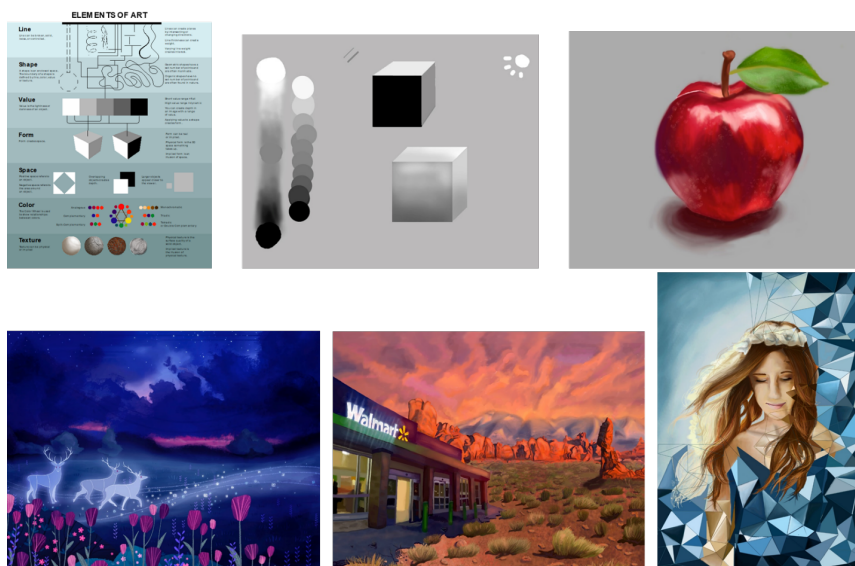


Figure 2. Examples of various orbs created by different students that demonstrate the concepts of texture, shading, and light source taught throughout the course.

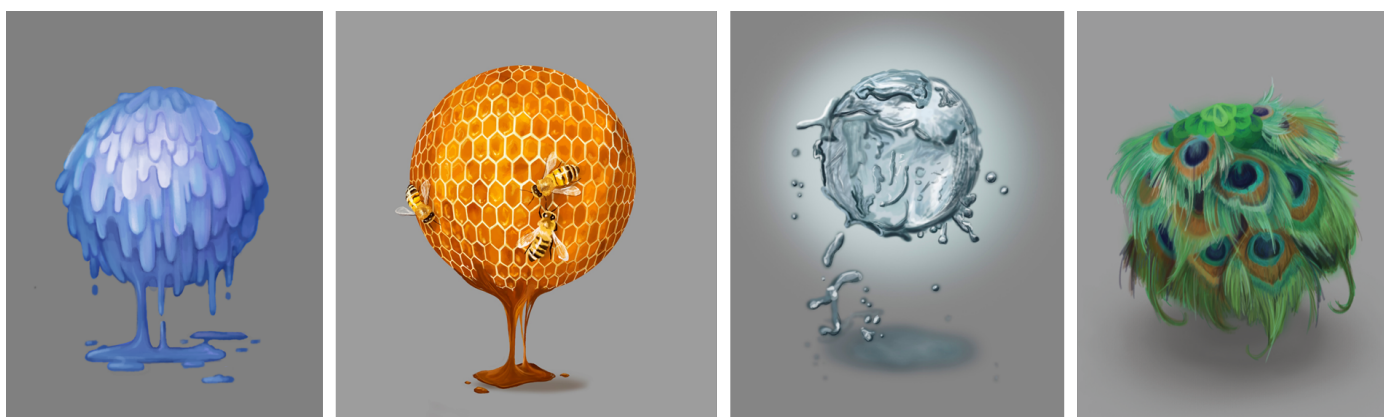


Figure 3. Students receive initial instruction from client (far left) and then have an opportunity to visit the research lab or clinical settings (not pictured).



the use of technology in art, these assignments develop a strong set of skills in digital painting while keeping the students engaged and gaining confidence leading up to the final client-based project.

2.5 Orbs

In addition to class projects, students are required to create an orb weekly. Orbs are required to have a believable texture and form and must include a digital painting technique covered during the course. The orbs reinforce digital painting techniques while allowing students to explore a wide range of styles and subject matter (see Figure 2).

2.6 Scientific illustration

The final assignment requires students to demonstrate the culmination of the skill sets learned earlier in the course. A professional scientist or health care professional is invited to participate in the class as a client. The client presents the class with a scientific concept that they need to communicate to a general audience. The client meets with students regularly to provide feedback in order to achieve an accurate representation of their topic and effective communication with their audience. This final assignment gives students valuable real world experience working with a client while still having a support system and mentorship (see Figure 3).

3. Results

3.1 Building a curriculum and interdisciplinary faculty team

The complex nature of modern society requires individuals to combine knowledge from different disciplines to solve difficult problems and to make meaningful contributions. For today's students, this means learning how to combine what they learn in different classes to meet the needs of the modern workplace and of society as a whole. This in turn requires faculty who can support and model that for them. Interdisciplinary education that teaches individuals how to integrate ideas from science and technology with visual design and communication will thus be essential to preparing the next generation to be engaged citizens and effective employees.

Over the past six years, the yearly enrollment of the class has increased to two offerings each year enrolling over 30 undergraduates. In addition, students have returned wanting to spend more time learning the intricacies of digital painting and engaging in client-based projects, leading to

the creation of ART 410: Advanced Digital Painting, along with ART 415: Special Problems and ART 302: Internship. Taken together, the number of students involved in digital painting and scientific illustration went from 11 to nearly 60 students, a significant increase for the Studio Art program, demonstrating the desire of students to create visuals that have an educational and positive impact on their community (see Table 1).

Following the success of ART 310: Digital Painting two academic minors were established to formalize the interdisciplinary collaboration and educational experience. Minors allow students to pursue a number of courses in a given discipline with an individual focus. This is an ideal way to foster and encourage interdisciplinary study as minors often bring together students from different majors who have a shared interest and so can approach problem solving from their own unique academic perspective. Where the minor in pre-medical illustration requires students to complete courses required for entry to an MS program in medical illustration, the minor in scientific visualization allows for any student majoring or minoring in a scientific discipline to take a series of art courses that provide opportunity for real-world scientific illustration and visual communication (see Table 2). Students often enter the minor in their sophomore year of college after they have taken some fundamental courses in both art and science and have a better idea of their long-term goals. Once they declare one of these two minors, their curriculum is as follows:

- Sophomore-level students take specialized science courses and ART 310: Digital Painting to begin developing digital skills and learn how to work with a client.
- Junior-level students take specialized science courses, a client internship and scientific portfolio course to gain additional experience and build up a professional portfolio.
- Senior year is largely dedicated to working with clients. Students gain valuable real world experience and have the opportunity to have illustrations published while still an undergraduate student. Students continue to complete any remaining courses and focus on an internship where they collaborate with an academic research scientist or clinician to illustrate critical scientific or medical information.

The basic format for this internship is:

- Meet to discuss prospective projects.
- Assess how the student's work will contribute to a successful initiative or goal.

Table 1. Yearly undergraduate student enrollment in digital painting courses

	2014-2015	2015-2016	2016-2017	2017-2018	2018-2019	2019-2020	2020-2021
ART 310 Digital Painting	11	15	22	28	32	30	34
ART 410 Advanced Digital Painting ¹	0	0	0	0	9	10	12
ART 415 Special Problems & ART 302 Internships ¹	0	1	3	5	8	11	11
Total	11	16	25	33	49	51	57

Table 2. Course Requirements for the Academic Minors offered at Louisiana Tech University

Pre-Medical Illustration		Scientific Visualization²
ART115: Design	BISC130: Biological Principles	ART115: Design
ART125: Drawing	BISC225: Human Anatomy and Physiology	ART118: 3D Design
ART220: Painting	BISC226: Human Anatomy and Physiology Lab	ART125: Drawing
ART225: Figure Drawing	BISC227: Human Anatomy and Physiology II	ART302: Studio Art Internship
ART302: Studio Art Internship	BISC228: Human Anatomy and Physiology II Lab	ART310: Digital Painting OR
ART310: Digital Painting	BISC315: Cell Biology	ART392: Digital Fabrication
ART449 Scientific Portfolio	BISC411: Developmental Biology	ART495: Scientific Visualization Portfolio
3 credit hours of ART Elective	BISC422: Molecular Biology	9 Credit hours of Art Electives
	3 credit hours of BISC Elective	

- Establish a plan for undertaking a project.
- Incorporate feedback and visit regularly with VISTA Center staff who represent both art and science to receive feedback prior to approaching the client.
- Meet regularly with client to review initial sketches and more polished pieces.
- Produce final work in format requested by client.

3.2 An example of effective community-based collaborations

For the project described below, students worked with the local non-profit Lincoln Health Foundation (2018a) to produce image-intensive communication materials for members of the community. The specific audience was the Parish's undereducated, indigent communities – a population that often cannot readily rely on text-based resources for information due to language barriers and lack of scientific or health literacy. In some cases, it is children or grandchildren accompanying family members to the doctor's office and so materials need to be directed towards an audience that ranges in age, education, and knowledge of the English language. Specifically, based on the 2017-2018 annual report for the Lincoln Parish Health Hut, the majority of patients are employed (53%), female (61%), over 40 years of age (63%), who are uninsured (64%). Approximately 14% of the

¹ Advanced Digital Painting, Special Problems, and Internship Courses all focus on offering students additional training in digital painting and client-based experience to further develop specific skills. These classes are tailored to focus on the individual student's goals and interests.

² Requires a minor or major in a scientific discipline

patients do not speak English and so require an interpreter to ensure proper communication. Additionally, while almost 88% of the residents of the Parish have a high school degree or higher, 14% of the population still lack basic prose literacy skills (Lincoln Health Foundation, 2018b; US Census Bureau, 2018). As a result, there is a continual need for materials that can provide information via methods other than text alone.

3.2.1 The client

The Lincoln Health Foundation is a non-profit foundation established on July 18, 1996 to “improve health care and outcomes for residents of the area” (Lincoln Health Foundation, 2018a). The Foundation is supported by investment interests generated following the sale of Lincoln General Hospital in 1996. A core aspect of this mission involves providing residents of the Parish with informational materials designed to promote healthy lifestyles or engage in different health-related activities. For example, a consistent concern for the citizens of this region is obesity and obesity-related risks including diabetes, heart disease, stroke, and diet. Some of the factors contributing to this need include sedentary lifestyle, health literacy, access to transportation, and socioeconomic status (Lincoln Health Foundation, 2018a). The Foundation, in turn, tries to provide materials that can help residents address such factors and engage in practices to address such factors. Additionally, the Foundation provides grants to a number of organization and funds various projects to address these health-related concerns. These

activities have led to the development of a partnership with Louisiana Tech University in order to better enhance patient education and access to information. The project described here represents one of these partnerships.

3.2.2 Student internship requirements

Over the course of a 10-week academic quarter, students were required to:

- Conduct research on the communication expectations and preferences of the target audience.
- Identify methods for sharing information on sensitive health issues with this community.
- Develop image-based brochures, website content, and illustrations to convey health information to these populations.

Through this internship, students engaged with the population for which they were designing materials. This process allowed them to collaborate with the community partner in order to produce work that effectively met the needs of all involved parties. Moreover, students did so in a way that taught them how to apply classroom concepts in various real-world scenarios and learned how to use their educational expertise to participate in and contribute to local communities. The final materials the students produced included illustrations depicting the health complications associated with diabetes, stroke, and related consequences of metabolic disease (see Figure 4).

Figure 4. Examples of student work created for the Lincoln Health Foundation and the free clinic in Lincoln Parish.



In creating this content for the Lincoln Health Foundation, the participants created a model for how community health organizations, educators, and students can collaborate to develop informational products for specific local communities. In addition, the students learned a number of skills that they can apply beyond this particular assignment including:

- Project planning.
- Project management.
- User research.
- Product development.
- Product planning.
- Illustration as a form of communication.
- Understanding audience.
- Crossing language and cultural barriers.

4. Conclusion

4.1 Model for student-client community internships

Over the past five years, the VISTA Center has worked with over 100 students to complete 36 Student-Client internship projects in scientific visual communication. These collaborations have demonstrated to the University, the community client, and students that there is a need for these types of partnerships and experiential learning opportunities that have a significant impact on improving conditions for local citizens. The mutually beneficial aspect of the project allows both entities to be actively engaged striving for a final product that helps the patient population who is being served by the community partner.

From these experiences, a plan for future project-based learning opportunities has been created with the following steps (see Figure 5):

- Initial meeting between faculty and client.
- Description of project and goals to students.
- Initial projects completed by students and presented to client to receive feedback.
- Regular assignments for students, evaluated by faculty, and presented to client.
- Final presentation of work to client at completion of academic period.
- Faculty and client assess next step and future needs for implementation in another internship or course offering.

4.2 Additional opportunities to teach visual literacy to college students

The model for a formal course and internships allows students to delve deeper into scientific visual communication and helps them to develop a portfolio for use in their careers. As most college students do not pursue this type of career path, but are still interested in and, in many cases, require a background and skillset in visual literacy, the VISTA Center has begun offering workshops to aid professors in teaching visual communication and literacy to students across disciplines (Iwasa, 2016; Nayak & Iwasa, 2019; Watson & Lom, 2008).

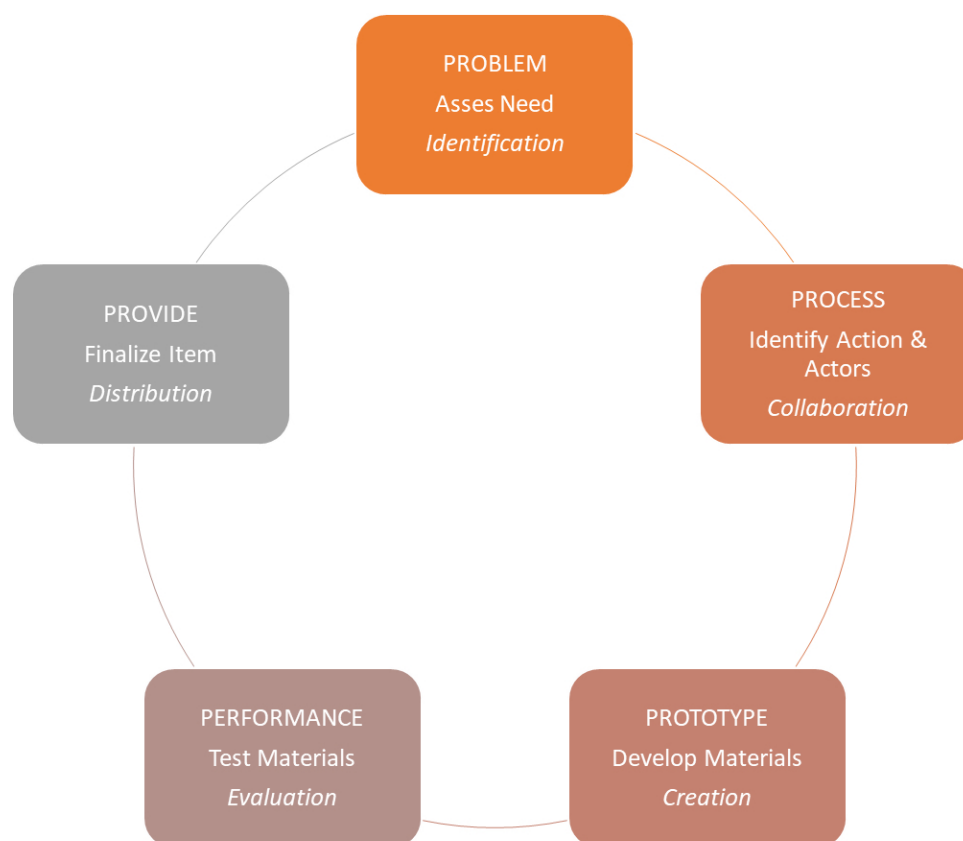
One area where there is a significant gap in visual literacy is in the design of posters for scientific meetings. Students in the sciences are rarely trained in elements of design, but rely on visuals for presenting their research to colleagues, peers, and the media. Through a series of 90-minute meetings once a week over the course of 8 weeks, students in the sciences are taught how to generate a poster for a scientific presentation of their research. The first two weeks provide students with a foundation of design and color theory. On the third week, students review and apply learned concepts to visually dissect already completed scientific posters. Weeks four and five are used to review drafts of individual student poster design and color layout. After a layout is approved, a revised layout is then presented to the faculty mentors of individual students to provide additional feedback. During weeks six and seven, students continue to work on the content and design of their posters. Students are also asked to provide critical feedback of their classmates' posters and provide suggestions for improvement. Completed posters are critiqued by a group of faculty and students on week eight. This series of workshops has been offered two years in a row to a group of eight biology students who have all presented with greater confidence in their design and ability to communicate their research.

Not all courses can allot this amount of time to visual literacy and so a single 90-minute workshop can still provide instruction on color and design theory and also lead a discussion where these lessons are applied to previously completed posters. Such workshops are currently being developed by the VISTA Center for students participating in the University's annual Undergraduate Research Symposium.

4.3 Teaching visual communication at the Middle and High School level

Today, more than maybe ever before, there are readily available examples of how visuals communicate critical

Figure 5. Proposed model for implementing internships. By initially assessing the problem and needs of the client (**Problem**), the student may begin to research and collaborate with the client to create preliminary drafts (**Process**). Images are then evaluated by the client (**Prototype**), tested in the population (**Performance**), and finally provided in print and/or electronic form to the client for future dissemination (**Provide**).



health information. It is important that students of all ages recognize this, understand it, and find opportunity for themselves in the area of visual communication. Early on, the VISTA Center recognized the need to share the integration of art and science with younger students so that if they were interested in the arts, they remained engaged, rather than feeling like they had to make a choice and pursue a more traditional career path. A goal of the VISTA Center is to show students that there are careers that value science, research, medicine, and artistry. The VISTA Center began this initiative through the creation of children's books about individuals and topics in science (see Figure 6). As part of the distribution of these books, the VISTA Center faculty and students were invited to participate in summer camps to show children ranging from 8-18 years of age the value and opportunity for combining art and science.

Through these activities, a model has been developed to introduce students to basic drawing techniques, review a relatable area of science, and work with them to generate

illustration for use in their own classroom or that of a local school (see Figure 7). With these events, the interest is not in how well a student can draw but in showing them that through visuals they can effectively communicate an idea. That by drawing viruses, a faucet, or a mask they are each contributing a visual element that enhances an audience's understanding, as well as their own.

For the past year, these camps and workshops have been offered remotely and so now are easily available to offer wherever there are interested students. The model will continue to apply to in-person camps and workshops that depending on amount of time allotted includes:

- Lessons in basic drawing including sketching techniques and practice with an object.
- Review and discussion of a topic in science or medicine that is relevant and of interest to the group of students; most recently this has been related to Covid-19.

- Instruction in how to create visuals from text.
- Breakout rooms to work through smaller, more specific pieces of a text to create individual illustrated elements.
- Submission of individual elements for coloring and compilation by faculty instructors (this may vary depending on time allowed and skill of participants).

Figure 6. The Journey of a Stem Cell was written by a graduate student in the Molecular Science and Nanotechnology Master's degree program and illustrated by an undergraduate double majoring in studio art and graphic design. Examples of the pages show the use of color, visuals, and text to communicate the role of stem cells in the human body.

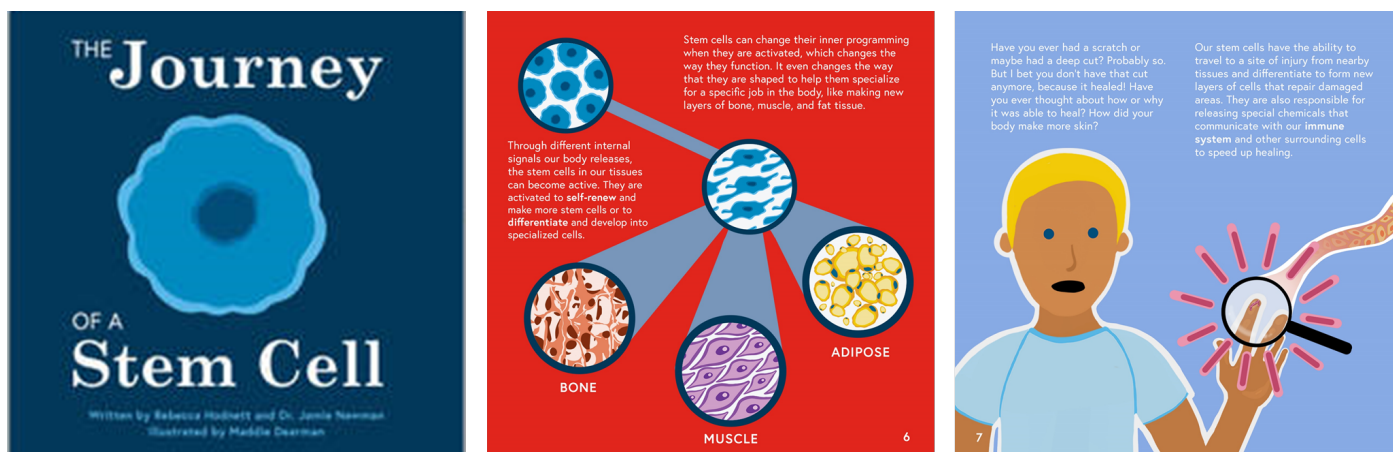
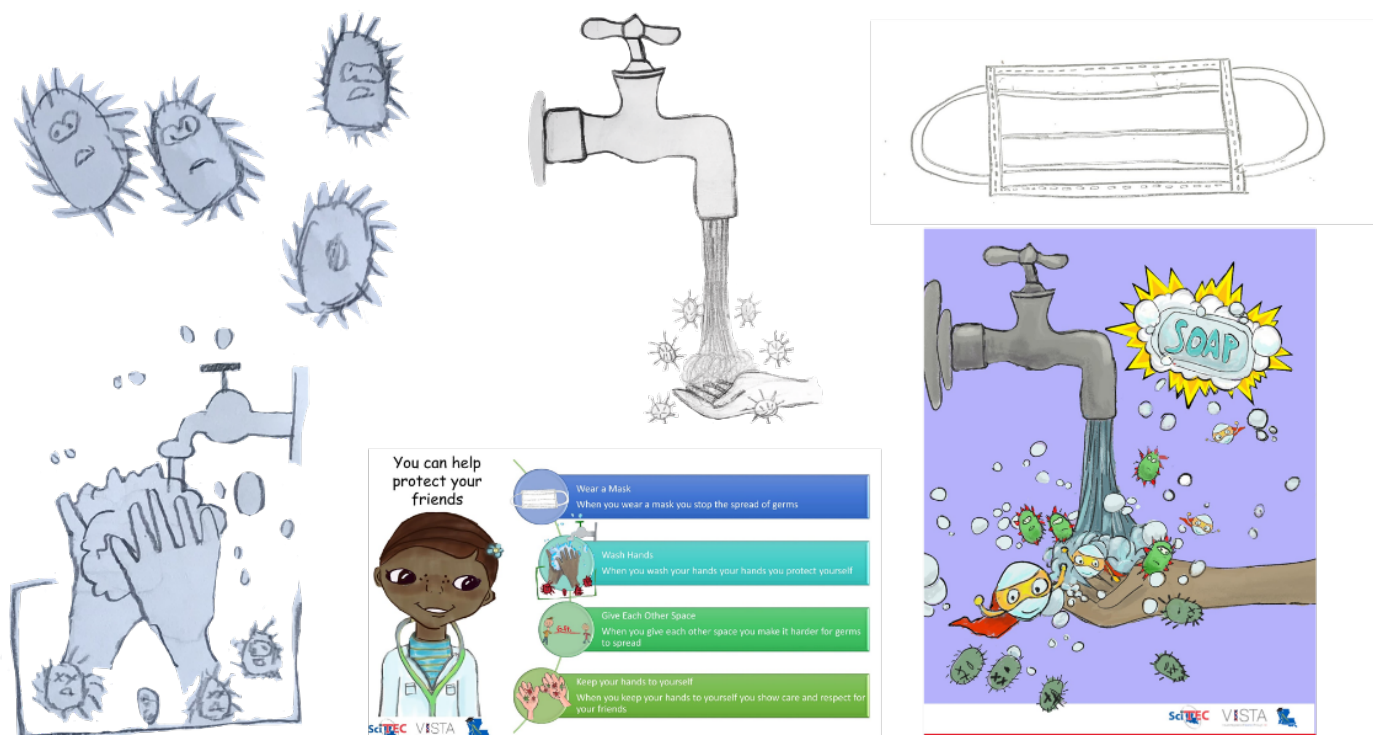


Figure 7. Sketch created by high school students in a Louisiana GEAR UP summer program resulted in the combined color images shown. This type of exercise has been repeated with a second group of ~20 middle school students with plans to continue workshops in the future.



Over the past six years, the VISTA Center at Louisiana Tech University has evolved to be an example of interdisciplinary experiential learning that engages students across campus with members of the local and state community. What began as a single offering of a digital painting class quickly grew to two academic minors and a University Center, demonstrating the desire that students, faculty, and administrators have for this type of educational experience and the value that visuals have in enhancing communication. The courses have raised the profile of art on campus, has brought art into more classrooms, and has directly affected the community. Before the creation of these courses, the Studio Art Program was struggling to stabilize student enrollment numbers and avoid being a low completer program. Over the past three years the Studio Art program has begun to grow and has seen a 23% increase in student numbers. The development of courses and curricula provides a model for others to follow so that more resources like those offered through Louisiana Tech may be available in other communities. As the VISTA Center is still relatively new there have not yet been enough students go through the program to determine outcomes. Over time, students who participate in VISTA internships as well as those students who participate in outreach internships will be followed in order to determine the effectiveness of our model in recruiting students to interdisciplinary programs. In addition, we will continue to track the impact that community-based projects have on the overall health of our parish and regions where clients are located.

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