The Journal of Teaching and Learning 2018
Vol. 11, No. 2 (The STEAM Issue). pp. 1–10
http://dx.doi.org/10.22329/jtl.v11i2.4932
http://www.uwindsor.ca/jtl

Visualizing Cancer: A Transdisciplinary Art and Biology Collaborative

Camilla McComb
Eastern Michigan University

Gretchen Otto
Eastern Michigan University

Deborah Omens
Eastern Michigan University

Jennifer Garvey
Eastern Michigan University

Philip J. Smaldino
Ball State University

Abstract

It would be safe to say that nearly every student enrolled in college knows someone who has been impacted by cancer. After all, cancer killed nearly 8.2 million people worldwide in 2012 (International Agency for Research on Cancer, 2014). Using this fact as the impetus for change, we decided to make cancer the focus of a "transdisciplinary" (Marshall, 2014) collaborative effort to simulate a reciprocal-learning experience between undergraduate biology and visual art students attending a university in Southeastern Michigan. The goal of the 2015 project was to create an active and authentic collaboration utilizing the university visual arts and biology curricula. By engaging and connecting scientific and artistic critical thinking processes, we wanted to know: could we design a class structure that would enable collaborative teams of art and biology students to create a visual model that represents a hallmark of cancer designed so that the model could also stand alone on artistic merit? In other words, could cancer visualization be transformed into works worthy of gallery display while maintaining scientific accuracy? In this paper we discuss the planning, implementation, results, and impact this work has had upon the way we now envision transdisciplinary collaboration.

Getting Started

This project began as a collaboration between the instructor of an upper level molecular biology of cancer course and the instructors of a visual arts course. Through this collaboration we wanted the biology to come alive through art, and the art to come alive through the biology. We wanted to achieve a reciprocal learning experience for both the art and the biology students. We did not want either the science or the art to be an afterthought, but rather we sought to create a situation that stimulated a mutual exchange of expertise in which the art and science flowed freely from each other. Not only did we want this project to be authentic and collaborative, but we also wanted it to be an active learning experience that would challenge "conventional discipline-specific habits" (Marshall, 2014, p. 107).

Active learning can be defined as meaningful classroom activities which engage and stimulate students to critically think and differs from traditional lecture strategies where students passively receive material from the instructor (Bonwell, 1991; Prince, 2004). Previous studies have shown that complementing traditional lectures with active learning activities significantly increases learning outcomes including comprehension and retention of concepts (Prince, 2004). This project fully embodied the spirit of active learning in four ways: (a) the biology students had to actively teach the art students about the cancer hallmark; (b) the art students then had to similarly teach the biology students how to use artistic expression to represent the biology that they had just learned; (c) through a joint effort between the art and biology students, aesthetically appealing artistic pieces were created that visualized a hallmark of cancer; and (d) the pieces were presented orally by the groups at the end of the semester in which the biology students presented the art behind the project and the art students presented the biology behind the artwork. This conceptual framework also met the standard for transdisciplinary design as it enabled discipline-specific content and principles to remain both separate and connected to the final product created by each group of students (Marshall, 2014, p. 106).

Hallmarks of Cancer Background

The hallmarks of cancer were first described by Hanahan and Weinberg (2000) and were comprised of six capabilities that healthy cells acquire to allow them to ultimately become and remain a malignant tumour. The original six hallmarks included *self-sufficiency in growth signals*, *evading growth suppressors*, *resisting cell death*, *limitless potential to divide*, *sustained angiogenesis*, and *ability to invade surrounding tissue and metastasize* (Table 1). This list was amended in 2010 to include *deregulated metabolism* and *evasion of the immune system* as emerging hallmarks, while *genome instability* and *inflammation* were added as cancer-enabling hallmarks (Hanahan & Weinberg, 2011). For our purposes, we have included *loss of contact inhibition* as a sub-hallmark. Through a collaborative process, the art and biology students created artistic representations of each of these hallmarks (Figure 1).

Table 1
Typical Acquired Biological Capabilities of Cancer Cells (Hallmarks)

Typical Capabilities of Cancer Cells*	**Lay Description**
αSelf-sufficiency in growth signals	Normally a cell needs cues from outside of itself (i.e., neighbouring cells) to grow; cancer cells acquire the ability to grow and divide without consultation from its neighbors.
[α]Evading growth suppressors	Normally cells cease to replicate themselves at defined points; cancer cells have defective “brake pedals” and replicate themselves beyond these checkpoints.
[α]Resisting programmed cell death	Normally cells that become defective in the body are eliminated in order to protect the whole organism from the potential negative consequences that can arise from defective cells; cancer cells are “defective” but they are able to avoid being eliminated.
[α]Cellular Immortality	Most normal cells can replicate themselves (divide) a limited number of times; cancer cells have the ability to divide indefinitely and essentially become “immortal”.
[α]Sustained angiogenesis	Cancer cells must recruit blood vessels to the tumour site so that the tumour can maintain a sustained food supply. Without recruitment of blood vessels, the tumour would starve.
[α]Tissue invasion and metastasis	Cancer cells become mobile and spread from the original tumour site to other organs and parts of the body.
[β]Deregulated metabolism	Cancer cells abnormally generate energy from sugar.
[β]Evading the immune system	Cancer cells become “invisible” to the immune system and thus avoid being eliminated.
[Δ]Genome instability	Chromosome abnormalities, which become more severe as the disease worsens and subsequently promote cancer formation and disease.
[Δ]Inflammation	Long-term immune responses (chronic inflammation) at a particular locale in the body that can create a situation that promotes tumour growth and formation.
[γ]Loss of contact inhibition	Normal cells will stop growing once surrounded by other cells; cancer cells will continue to divide despite contact on all sides by neighbouring cells.

Note: [α]Classic hallmarks, [β]Emerging hallmarks, [Δ]Enabling characteristics, [γ]sub-hallmarks.

Figure 1. Example visual representations of cancer hallmarks. *Tissue Invasion and Metastasis*: papier-mâché, acrylic, colored milk, and pump. *Resisting Programmed Cell Death*: block printed paper, ribbon, and wire. *Self-sufficiency in Growth Signals*: cast metal on wood. *Cellular Immortality*: acrylic on canvas. *Genomic Instability*: wire, nylon, paper, and acrylic. *Loss of Contact Inhibition:* Monopoly pieces, model fencing, artificial grass and trees.

Discussion and Reflections

Although science and art have become increasingly isolated from each other in recent years, historically speaking, art and science were often considered one-in-the-same or at least significantly overlapping (as displayed in Figure 2). One cannot help but to think of Renaissance men such as Leonardo da Vinci, who not only painted the infamous *Mona Lisa* and *The Last Supper* masterpieces, but also made countless scientific contributions to the fields of aviation, astronomy, anatomy, botany, and others. More recently, Mae Jemison, a doctor and dancer who was also the first African American woman to enter space, said in her 2002 TED Talk:

> The difference between science and the arts is not that they are different sides of the same coin, even, or even different parts of the same continuum, but rather, they are manifestations of the same thing. . . . The arts and sciences are avatars of human creativity. (Jemison, 2002)

Through our collaboration, we came to understand that a scientist sees visual models as a way to *reveal* thinking whereas an artist sees models, otherwise known as artworks, as a way to *provoke* thinking. By combing these two ways of understanding, we believe that we facilitated a working environment that supported diverse thinking modalities and in so doing, provided a rich and rewarding "new perspective on information" (Marshall, 2014, p. 107) and learning for all involved, including the instructors.

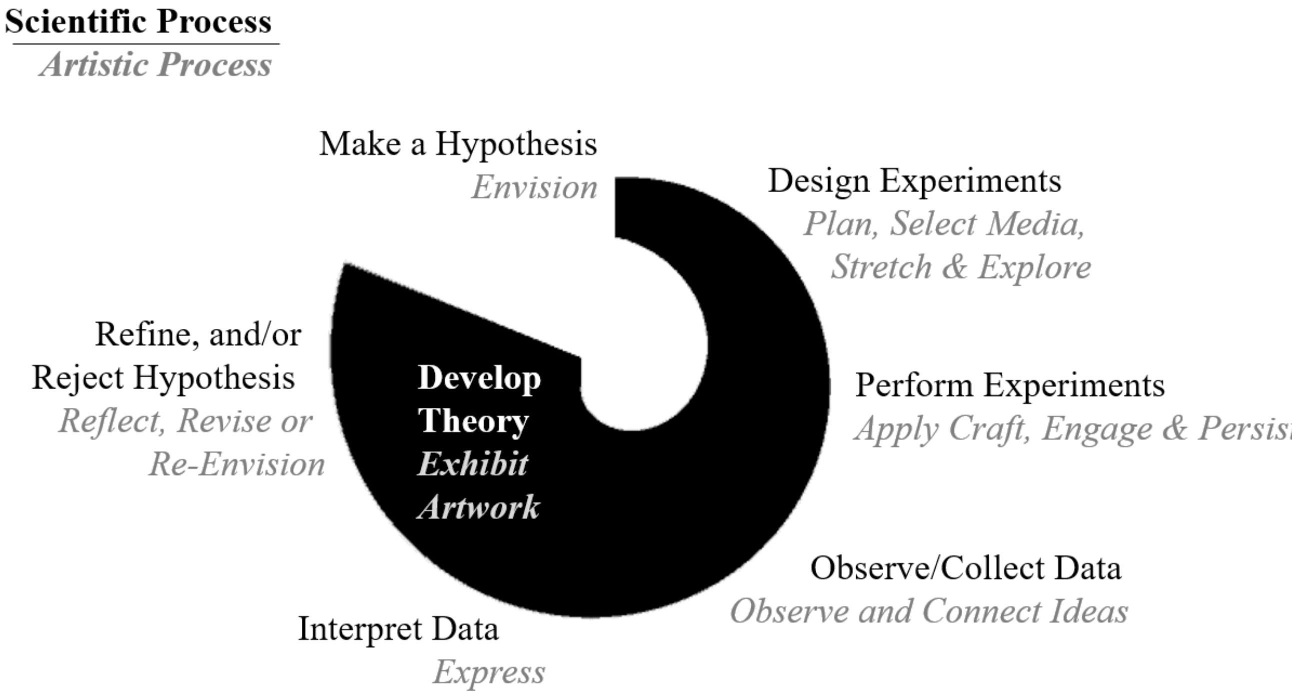

Figure 2. Scientific process vs. artistic process. Illustration demonstrates the cohesiveness of scientific and artistic processes. Studio processes are based upon the *Studio Habits of Mind* codified by Hetland et al. (2007).

We introduced students to the project in a biology lab, which allowed us to set a scientific tone for the project. Cancer is a serious topic and we wanted to establish from the start that we were looking for thoughtful, innovative, and scientifically correct models. We then held the next sessions in the art studio. This room gave us space to work with materials and tools that enabled us to better collaborate and design. We believe that this provided an environment that stimulated creative thought, which assisted students in envisioning ways to best represent their assigned cancer hallmarks (see Table 2 for a suggested timeline).

Table 2
Suggested Timeline for Project

Session #	When to meet	Purpose for meeting	Meeting location(s)
0	Before the semester starts	• Have art and biology courses scheduled to meet on same day/time • Instructor organizational meetings to set goals and timeline.	Coffee shops, restaurants, faculty offices, etc.
1	Week 3	• Introduce art and biology students • Introduce project • Assign groups • Assign cancer hallmarks • Begin to brainstorm ideas and teach the biology and art to each other	Biology Lab
2	Week 5	• Students settle on an idea and come up with a supply list needed to create piece • Instructors/TA's order and gather supplies	Art Studio
3	Week 8	• Begin work on piece	Art Studio
4	Week 10	• Continue work on piece	Art Studio
5	Week 12	• Finish work on piece	Art Studio
6 and 7	Final Exam Week	• Student presentations	Biology Lab
8+	Post-semester	• Present and/or create a display for exhibition on campus or in community	Campus art gallery, biology department, local hospital lobby, local high school, etc.

Note: We suggest that the groups meet for a 7 total sessions, each being ~1 hour 15 minutes, including two sessions during final exam week where the students present their pieces.

Watching art and biology students learn to communicate was fascinating. Both groups initially exhibited signs of insecurity and apprehension. Art students felt undue pressure to instantly be creative. They worried about having to make the model by themselves, and some felt that biology students were at times condescending in the language that they used to describe the topic. Similarly, at times some biology students felt that the art students were unwilling to share the creative aspect of the project. Initially, biology students struggled with the open-ended process of idea development. They were quick to settle on a solution and seemed frustrated when art students challenged the aesthetic or expressive qualities of the idea. Since we as the instructors had an agreed upon focus for the projects, we were able to assist our students at these moments and helped to dissuade initial anxieties. By the third meeting, students had settled on a plan of action, were working well together, and were able to submit an order for supplies that they would need to create their visual models (Figure 3).

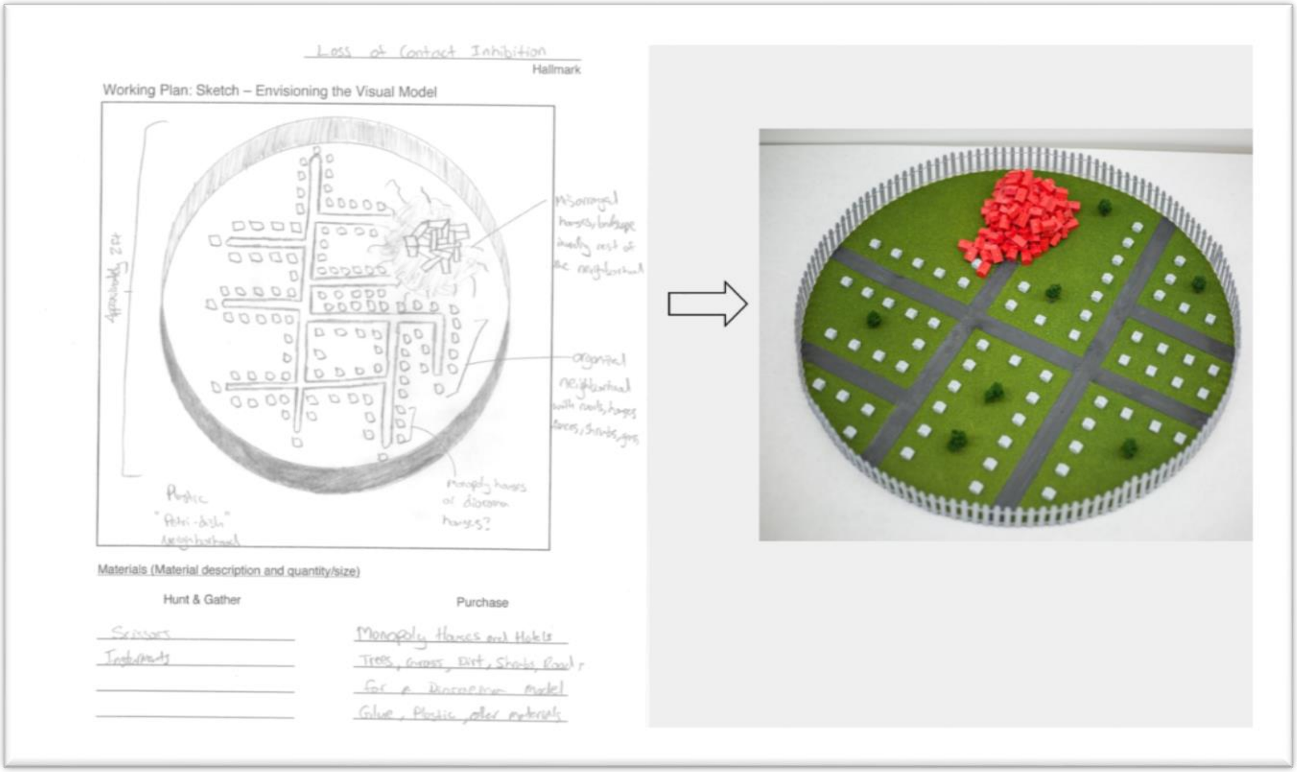

Figure 3. *Loss of Contact Inhibition:* Students worked as a team envisioning how to represent the cancer hallmark (left) and then constructed their vision using Monopoly pieces, miniature model fencing, grass, and trees (right).

This pilot project included a group of 35 students, and which 11 different hallmarks of cancer models were created for a budget under $1000. Most of the supplies were purchased online from art supply companies or local hardware stores. Due to an imbalance in the biology-to-art student ratio, we assigned two to three biology students for every art student. Although this worked out for our purposes, we believe an ideal ratio would be 1:1.

The collaboration was successful, in large part, because our classes were scheduled at the same time. This time-sharing feature enabled us to combine classes of students and to share our workspaces. For these reasons, we strongly recommend that collaborative courses be scheduled beforehand to meet on the same day and time.

Assessment

Strong products are the result of clear and effective rubrics. We developed two such rubrics for this collaboration: one for the visual model and one for team collaboration (see Tables 3 and 4). In designing the rubrics, we were careful to avoid the three indicators of poor rubric design: (a) confusing learning outcomes with tasks; (b) confusing rubrics with requirements or quantities; and (c) confusing rubrics with evaluative rating scales (Brookhart, 2013). Instead, we looked to the core standards we expected to meet through the project and wrote *performance-level descriptors* (Brookhart, 2013) to explain each criterion. Through these explanations, we described and emphasized how students might know that they had represented scientific accuracy and artistic integrity, while also prompted students toward creative and innovative solutions that emphasized visual metaphor over realism.

Table 3
Rubric for the Visual Model Production

Assessing the Visual Model	100%	92%	85%	75%
Conceptual Accuracy	Visual model clearly exemplifies all functional aspects of the assigned hallmark	Visual model conveys the primary functional aspects of the assigned hallmark	Visual model simulates functional aspects of the assigned hallmark, yet it could be confused with other hallmarks	Visual model looks scientific, yet the visual elements are contrary to the functional aspects of the hallmark
Ingenuity	Model integrates technology with metaphor to create a visually compelling interpretation of the assigned hallmark	Model utilizes metaphor to create a visually compelling interpretation of the hallmark	Model is complex, focusing on a physical/literal interpretation of the hallmark	Model is simplistic and focuses on a physical/literal interpretation of the hallmark
Visual Appeal	Materials used are of high quality and craftsmanship making the model worthy of public academic display	Materials used are of high quality and craftsmanship yet the model is not yet ready for public display	Materials used convey visual thinking yet fall short in creating a quality final product	Use of materials makes the model look as if it were thrown together at the last minute

Performance-level descriptors were developed so that participants could better understand the visible behaviors associated with effective collaboration. Knowing that students are often asked to work with others, yet are seldom taught how to do so, we were explicit in describing what *working together* would look like. Because we wanted all students to be involved in designing the project, we encouraged them to not only read and think about ideas but also to bring sketches of their ideas with them to class (see Figure 3). It is much easier to begin the design process while looking at a drawing than it is while listening to a possible idea. We also knew that students could get possessive of their own ideas, so we encouraged them to step back and look for ways to expand, blend, and merge their ideas with the ideas of others. With rubrics developed and in place we also wanted students to understand that their artistic/scientific thinking would be part of an "ongoing, public conversation," (Hetland, Winner, Veenema, and Sheridan, 2013, p. 30) which is a key aspect of the *exhibition* learning structure. Hetland et al. (2013) emphasize the value students place on work that they know will be placed on public display. This understanding was a factor in the design of team collaboration, as students knew that their work could be selected for display at the university undergraduate research symposium.

Table 4
Rubric for Collaborative Effort

Assessing Team Collaboration	Highly Professional	Professional	Novice	Developing
Conceptual Preparedness	You come to each group meeting with notes, sketches, and ideas ready to share	You come to each group meeting with notes and ideas ready to share	You participate in group discussions, yet do not bring "artifacts of thinking" to share	You offer affirmation to others' ideas yet struggle to offer ideas of your own to the group
Collegiality	You assert your own ideas, listen well, and look for ways to value and merge ideas of the group into a cohesive approach	You assert your own ideas, yet also listen well to the ideas of others	You continually assert your own ideas, struggling to account for the ideas of others	You assert your ideas yet withdrawal when the group decides to take a different approach

Six Tips for Successful Interdisciplinary Collaborations

This project led us to develop the following tips for successful interdisciplinary collaborations:

1. Allow project leaders to engage one another as equals and meet multiple times before the project begins.
2. Schedule classes to meet at the same time so all participants can be present.
3. Develop the rubric first to help establish common understanding and project expectations.
4. Expect standards from both disciplines to be evident in the final products and assessment rubrics, in equal measure.

5. Allow extra work time so students have enough time to navigate through multiple thought processes.
6. Project leaders should assess completed work as a team.

Conclusion

At the beginning of this project we wondered whether art and biology students could work together to create visual models that would hold up to both scientific and artistic scrutiny. The quality of the resulting models that were created (Figure 1) and presentations given by the students strongly suggest that the answer is a *qualitative*, yet confident, "yes". We therefore recommend this practice to others wishing to provide an active learning experience for biology and art students in which they work together to create gallery-worthy, biologically accurate visual models. Furthermore, we envision that this collaborative approach could easily be adapted to topics beyond cancer biology, to include areas such as infectious diseases, diabetes, heart disease, and other chronic illnesses.

We walked away from this reciprocal/collaborative endeavor understanding that "transdisciplinary . . . practice . . . rises above the disciplines and dissolves their boundaries to create a new social and cognitive space," (Marshall, 2014, p. 106) and we now find ourselves yearning for more.

Funding Acknowledgement: This work was funded by the Eastern Michigan University Summer Undergraduate Research Fellowship (SURF) and Creative Science Inquiry Experience Fellowship.

References

Bonwell, C. C., & Eison, J. A. (1991). *Active learning: Creating excitement in the classroom*. ASHE-ERIC Higher Education Report No. 1. Washington, D.C.: The George Washington University.

Brookhart, S. M. (2013). *How to create and use rubrics for formative assessment and grading.* Alexandria, VA: ASCD.

Hanahan, D., & Weinberg, R. A. (2000). The hallmarks of cancer. *Cell, 100*(1), 57–70.

Hanahan, D., & Weinberg, R. A. (2011). Hallmarks of cancer: The next generation. *Cell, 144*(5), 646–674.

Hetland, L., Winner, E., Veenema, S., Sheridan, K. M. (2013). *Studio thinking 2: The real benefits of visual arts education* (2nd ed.). New York, NY: Teachers College Press.

International Agency for Research on Cancer, World Health Organization (2014). *World cancer report*. Retrieved from http://publications.iarc.fr/Non-Series-Publications/World-Cancer-Reports/World-Cancer-Report-2014

Jemison, M. (2002, February). Mae Jemison: Teach arts and sciences together [Video File]. Retrieved from https://www.ted.com/talks/mae_jemison_on_teaching_arts_and_sciences_together

Marshall, J. (2014). Transdisciplinarity and art integration: Toward a new understanding of art-based learning across the curriculum. *Studies in Art Education, 55*(2), 104–127.

Prince, M. (2004). Does active learning work? A review of the research. *Journal of Engineering Education, 93*(3), 223–231.