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ART + COMMUNITY SCIENCE

chapter THREE

MICROBIAL ART: AN INTEGRATION OF ART AND MICROORGANISMS

MICROBIAL ART

An Integration of Art and Microorganisms

a chapter by

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Introduction

The term "arts" refers to a wide range of human activities involving cultural involvement, storytelling and creative expression. It includes a variety of media, including photography, installation, decorative arts, printmaking, drawing, and painting. Using cross-disciplinary education to engage students in creative and critical thinking is an excellent way to encourage active learning. By incorporating creative art activities into science lessons, educators can help students develop their attention to detail, skills and creativity while also enhancing their enjoyment and motivation. Students and scientists can use art to express their own cultural and uniqueness into their work experience, creating a higher level of engagement in the successful completion of a project. For example, scientists rely on data visualisation to explain their findings, and using creative design principles to these visualisations can considerably increase their ability to transmit information to readers (Friendly and Denis 2001). Students' involvement in laboratory settings can also be improved by incorporating multidisciplinary, innovative activities such as painting, creative writing, and music into existing teaching materials.

Students sometimes believe science is boring and does not involve creativity. In reality, the cognitive skills required to create unique work are just as important in science as they are in art. STEM (science, technology, engineering, and mathematics) pedagogies, which offer novel multidisciplinary approaches, were developed to engage young learners in science and science careers. The arts were subsequently included in STEAM (science, technology, engineering, arts and mathematics) to promote creativity, which enhanced cognitive capacities and stimulated the interest of young minds in science (Colucci-Gray *et al.* 2017). Visual art increases attention to detail and fosters creative thought, as well as enjoyment and motivation, all of which are prerequisites for scientific discovery. Creating a piece of art can be more than just painting or drawing. Students can use art to express their emotions, cope with intense ones, and reduce stress. Additionally, viewing art can improve viewers' health and wellbeing in a variety of ways, from reducing anxiety and depression to enhancing critical thinking and problem-solving abilities.

Microbiology and art have long coexisted. During his career as a microbiologist, Alexander Fleming, the scientist responsible for the discovery of penicillin in the 1920s, began creating "germ paintings" featuring microorganisms. By creating "germ paintings" with living bacteria, he was one of the first to investigate microbial art (Dunn, 2010). Agar art has grown in popularity as a result of internet exposure and initiatives made by professional societies such as the American Society of Microbiology's (ASM) agar art competition, which has been running for the past several years. The competition enables participants from all over the world to use scientific methods to express their artistic side. The participants use a palette of microbials such as bacteria, fungus, and yeast to produce images on agar plates or other creative medium. According to Adkins *et al.* (2018), who observed a classroom activity employing agar art, visual art can be a valuable addition to course-based student research, and scientific instructors should consider incorporating artistic innovation into their own teaching practises.

Microbial Art Activity

Microbiology can be a bit abstract as it is the study of microscopic organisms that are usually only visible under a microscope. Due to the said factor, microbiology has a reputation of not being enjoyed by most students. With many students enrolled in the microbiology course (70 to 120 students per year), it has been a continuous challenge to actively engage students and facilitate their interest in the subject and topics being addressed in the course. In order to improve diploma in pharmacy students' learning, creativity and interest in microbiology, an initiative has been taken to introduce a "Microbial Art" activity in the microbiological laboratory practical. The practical activity presented here were created in collaboration with students enrolled in the Microbiology course during their third year of Diploma in Pharmacy at University of Teknologi MARA (UiTM) Cawangan Pulau Pinang Kampus Bertam.

The "Microbial Art" activity provides a hands-on experience for the students in which they must create agar art with microorganisms by drawing on the agar in Petri dishes using cells from different bacteria. In the microbial art activity, each student will be given one nutrient agar and one MacConkey agar plates as their canvas and five different types of bacteria that produces.

Students' Artworks and Feedbacks

A total of 216 plates of agar artworks were produced from this activity, with various subject matters. Some of the subjects chosen by the students were a collection of inanimate objects, natural scenery and an image of a person or animal. Seeing the students' creative artworks throughout this activity were just amazing. The artworks produced through this activity reflected the ability of the students to think and integrate concepts learnt in the microbiology lessons with the arts. Figure 1 shows an artwork of a maple leaf on a nutrient agar plate. In this art piece, a strain of *Escherichia coli* (*E. coli*) has been inoculated onto the agar to outline the maple leaf. The agar was then seeded with *Serratia marcescens* (*S. marcescens*) to give the colour of pink to the maple leaf using a cotton swab. Each bacteria has different nutritional needs and can produce different colours. The student has successfully combined two different types of bacteria with different colours to differentiate the structure of the leaf. This demonstrates students' understanding of temperature-dependent pigment production made by the bacteria used (Serratia produces pigment only below 35°C; Serratia will be non-pigmented at temperatures above 35°C).

Figure 1: Maple leaf on a nutrient agar, by Nur Nabilah Binti Ahmad Mazhar (2021)

Students' ability to apply basic microbiology concepts and laboratory skills in creating artwork were also observed on MacConkey agar. Figure 2 shows an art piece of a butterfly on MacConkey agar. The butterfly in this artwork symbolises hope and transformation. MacConkey agar is a selective agar that only grows Gram-negative bacteria and inhibits the growth of Gram-positive bacteria. It can further differentiate the Gram-negative bacteria into lactose and non-lactose fermenters based on their lactose metabolism. In this artwork, the student used S. marcescens to give the colour of light pink to the butterfly. Using an inoculating wire loop, students have shown good microbiological skill in spreading the bacteria onto the agar. This is evident from the student's use of delicate, sweeping strokes to outline the butterfly's shape and pattern all over its wings.

Figure 2: A butterfly on MacConkey agar, Nurshafikah Binti Ahmad Marshidi (2021)

Figure 3: Merry-go-round on MacConkey agar, Siti Nor Balqis Binti Sohib (2021)

Another artwork that demonstrates students' good culturing technique can be seen in Figure 3. The outline of the merry-go-round was painted with *E. coli*, whereas the colourless colonies at the base of the merry-go-round were colonised by *Pseudomonas aeruginosa* (*P. aeruginosa*) by using inoculating wire loop. The dark pink colour of *E. coli* growing on a MacConkey agar is a result of the bacteria's ability to ferment lactose present in the agar. On the other hand, *P. aeruginosa* does not ferment lactose, hence the colourless colonies produced on the agar. The various merry-go-round structures were successfully distinguished by the students' successful creation of distinctive strokes. According to de Ondarza (2019), investigating and comprehending how microorganism pigments function can result in a variety of cross-disciplinary learning opportunities involving physics, chemistry, biology and art. It can also be set up as an inquiry-based learning module for active learning experiences.

Figure 4 shows an agar art of a dinosaur painted on MacConkey agar using only *E. coli*. In this art piece, the student used an inoculating wire loop to create fine outlines of the dinosaur. The entire dinosaur was then painted pink using a cotton swab.

Figure 4: Dino on MacConkey agar, Nur Nabilah Binti Ahmad Mazhar (2021)

Figure 5 shows an image of a heart painted on a MacConkey agar plate with the title "Heart and Soul". This artwork represents the student's passion to strive for the best as a student and to do it full-heartedly. The heart structure was made using *E. coli*. The light pink blood vessels on the surface of the heart were created using *S. marcescens*, while the colourless blood vessels at the base of the heart were inoculated with *P. aeruginosa.*

Figure 5: Heart and soul on MacConkey agar, Nur Sarah Khadijah Binti A Manja (2021)

Figure 6 shows two artworks of a burning candle on nutrient and MacConkey agar. The metaphor of the burning candle refers to a teacher who sacrifices themselves in order to guide others. These works of art demonstrate the student's appreciation for the teachers who put so much effort into educating her. The student displayed a good understanding of basic microbiological principles and laboratory techniques in creating these agar arts. This is evident by the selection of pigmented and non-pigmented bacteria that were used in the two different agars. The student also demonstrated good laboratory skills in combining two different techniques to distinguish the shape, flame and colour of the candle. An *E. coli* strain was used to outline the shape of the candle using inoculating wire on the MacConkey agar. A cotton swab inoculated with *S. marcescens* was then used to colour the candle and the flame. As for the nutrient agar, an *E. coli* strain was used to outline the candle and the flame to get an off-white colour. *S. marcescens* was used to get the pink colour candle using a cotton swab.

Figure 6: Burning candle on MacConkey agar (left) and nutrient agar (right), Siti Nasuha Binti Mat Esa (2021)

Based on the students' feedbacks at the end of the session, most of the students loved the activity and considered it to be engaging and exciting:

"I find microbial art interesting in giving me knowledge that I can apply while having fun completing it."
"I loved the Microbial Art activity because it is something different and requires students to be creative."
"I really enjoy myself during the process in making the microbial art because I found out it is really fun and exciting. I never know we could make art using microorganisms before and I hope I can explore more about microbiology topic."

Most of the comments suggest that this activity made it easier to understand the basic microbiological laboratory techniques. One of the comments stated that the activity was intriguing and that the participant had learned a lot from it:

"Microbial art activity was very interesting. I learnt a lot from this activity, from choosing which type of microbes should I use and finally the reason why certain circumstances inhibit the growth of the microbes on the agar. I would love to participate in this activity in the future."

Overall, it appears that such investigative work enhanced the learning experience of our Diploma in Pharmacy students and created a general sense of confidence in their academic performance.

Conclusion

In conclusion, by planning activities that purposefully incorporate learning from other fields, art and science can be integrated to create the most successful and aesthetically pleasing communities.

The easiest and most popular way to introduce art into microbiology education is to let students paint with bacteria. The "Microbial Art" activity is an excellent learning activity because students can practise basic microbiological skills such as aseptic technique creatively in a more enjoyable and creative way. In this activity, students used their artwork to elicit their emotions. These artworks can also give viewers a place to examine their feelings and thoughts. Additionally, they can be used to educate, motivate, and most importantly, have fun. This project was designed to see how well our Diploma in Pharmacy students could apply and integrate microbiological principles and art, foster critical thinking and problem-solving abilities, and express their feelings. The fact that the students were successful in achieving these goals demonstrates how well the arts and sciences methods can be used in an introductory microbiology course to improve student learning in a fun and cost-effective manner.

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References

Adkins, S. J., Rock, R. K., & Morris, J. J. (2018). Interdisciplinary STEM Education Reform: Dishing Out Art in A Microbiology Laboratory. *FEMS microbiology letters*, 365(1), fnx245.

Colucci-Gray, L., Trowsdale, J., Cooke, C. F., Davies, R., Burnard, P., & Gray, D. S. (2017). Reviewing the potential and challenges of developing STEAM education through creative pedagogies for 21st learning: how can school curricula be broadened towards a more responsive, dynamic, and inclusive form of education?.

de Ondarza, J. (2019). The Color of Survival: An Inquiry-Based Inter-Disciplinary Study of Bacterial Pigments. Bioscene: *Journal of College Biology Teaching*, 45(3), 22-30.

Dunn, R. (2010). Painting with penicillin: Alexander Fleming's germ art. *Smithsonian. com: Science & nature*.

Friendly, M., & Denis, D. J. (2001). Milestones in the history of thematic cartography, statistical graphics, and data visualization. *URL http://www. datavis. ca/milestones*, *32*, 13.

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