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What Do You Find Beautiful about Viruses? A Post-COVID Assessment Strategy

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INTRODUCTION

Including one simple assessment question asking students to identify where they found beauty in the course topics, whether in the classroom or laboratory, can assess student learning while granting students agency, metacognition, and an emotional connection to the course material.

In the wake of the 2019 coronavirus disease (COVID-19) pandemic, universities are reporting a "stunning" level of student disconnection (1), as students struggle to process the losses they experienced (2, 3). Learning works best when there is a positive emotional connection and investment in the topic and material (4–7). In terms of the seven primary emotional systems (8), educators would like students to be in the "seeking" mode to engage curiosity and hopefulness (9), rather than the "panic/grief" mode that the pandemic potentially induced.

The idea of using beauty to engage students in science, technology, engineering, and math has been described in other disciplines. Mathematics has been described as "the unity of truth, goodness, and beauty" (10). Wang wrote that "Experiencing mathematical beauty is of great significance to students' learning and growth," and this includes "discovering mathematical truth with beautiful thoughts as well as discovering mathematical laws and solving mathematical problems with beautiful methods" (11). To address the challenges and inequities in the computing field, the Beauty and Joy of Computing curriculum was developed to teach computer science to high school students to "learn to create beautiful images and realize that code itself can be beautiful" (12). Medical topics like pathology can also be viewed through the beauty and wonder of the human body (13).

The current viral pandemic has also given some students a general fear of viruses that needs to be addressed in courses covering this topic. In an attempt to regain a positive connection with virology concepts, an assessment question asking students to identify the beauty in the topics covered was added to the final exam in a virus biotechnology course at a large public university.

This assessment fits with the inclusive teaching guidelines set out by Dewsbury and Brame (14), which outline evidence-based teaching recommendations to support students' sense of belonging, competence, and interest in a course, by allowing students wide agency over the topic of their response (developing empathy) and helping to promote positive affective experiences (pedagogical choices). Students from all backgrounds are given space to tell their story of what resonated with them.

PROCEDURE

In the pilot study, the last question on the final exam for an upper-level virology course was: "What is one concept that we covered that you found beautiful, and why? Include specifics discussed during the course." Responses were threshold scored out of 6 points for identifying and accurately describing a course concept. There were no safety concerns for implementation of the beauty reflection question.

It is important to ask students to "include specifics" in order to ascertain if they understood the concept and to have students self-explore the concept that resonated with them to build that connection and sense of wonder. A word count could be added to ensure that students expand on their chosen topic.

This question could also be implemented in a variety of ways throughout courses at all levels. Starting the first day, students could be asked what they find beautiful about a scientific topic related to the course. It could also be used as a weekly reflection to have students elaborate on a topic through the lens of what connected with them. The audience could also be changed, such as a tweet or discussion aloud with their lab partner, to practice different modes of scientific communication. Providing positive feedback would be key to ensuring a positive affective experience and continued student engagement.

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TABLE 1
Student response theme coding (n = 12)[a]

Category (n)	Response code	Frequency	Example quote excerpt
Pharmaceuticals (9)	Gene therapy	5	"Gene therapy peaked [*sic*] my interest the most because it was the idea of taking a virus that would normally cause harm and transforming it into something that could potentially save someone's life."
	Oncolytic viruses	3	"Oncolytic viruses are being studied as a means of treating cancer. I found it very interesting how viruses, something commonly associated with disease, can actually be used to prevent and treat certain diseases."
	Phage therapy	2	"The most beautiful concept that we covered in my opinion was the use of phage! . . .I think it is really awesome how they are being engineered to treat bacterial infections in phage therapy and how they are also used for detection of bacteria in food and water. It just seems like there is so much biotechnological use for phage and that is very exciting to me!"
	Vaccines	1	"Because of my interest in pharmaceuticals, I am fascinated how many creative ways there are to repurpose viruses into treatments for various diseases. For example, modified viruses can be highly effective in vaccines."
Engineering (6)	Engineer	6	"The fact that we can engineer viruses to target a cell different from its usual host cell and use a virus' natural method of inserting itself into a host cell's genome to cause it to insert a gene of interest into the host cell genome is incredible and shows how creative humans are and how complex the interactions in the human body between cells and foreign objects are."
Other (6)	Diversity	2	"I actually found the first few lectures discussing the diversity of viruses the most beautiful. I was amazed at a number of aspects such as the diversity of size (10-1000 nm), shape, genome type, genome replication, structure, etc."
	Structure	1	"From adenoviruses, to T4 phages, to HIV all of these viruses have vastly different morphologies. In the words of Darwin viruses are a perfect example of 'endless forms most beautiful.'"
	Methodology	1	"I really enjoyed the qPCR unit because of its relation to how we detect SARS-CoV-2 currently."
	Replicative cycle	1	"I think the way all these different viruses go through the same replicative cycle of attachment and entry, trafficking, gene expression and replication, and finally assembly and release, is 'beautiful' in a sense, because they are strictly motivated to make more of themselves through infections and using the host cell machinery even though they are not considered to be 'alive.'"
	Balance of pathogenicity	1	"In the lectures about pathogenicity, we talked about how there is often a precise balance between infectivity and pathogenicity where the 'best' viruses 'know' how to spread without causing too much damage to their new home. There is a certain elegance in this balance."

[a]Note that the category totals sum to greater than 12, as each student's response may have coded into more than one category. Frequency totals may also sum to more than the category total, as the category total is indicated once per student, whereas more than one Response code could appear in the same student response.

Starting in Spring 2021, the beauty question was implemented on the final exam in the 8-week lecture-laboratory course Virus Biotechnology: Pathogens to Therapeutics. Students were retroactively asked to give informed consent for their coursework in Spring 2021; for the Fall 2021 and Spring 2022 semesters, students consented during the first week of the course, as approved by NCSU IRB 24474.

Of 46 enrolled students across the three semesters, 13 consented to participate in the study (~28%). Consistent with the dual-level course, 8 participants were earning bachelor's degrees, 4 were earning a master's degree, and 1 was earning a Ph.D. Students were from a variety of majors, including biochemistry, biology, biomanufacturing, chemical engineering, crop and soil sciences, microbial biotechnology, microbiology, and physiology. Responses to the beauty question were analyzed for themes using MAXQDA. One student who consented did not receive the beauty question on the exam due to question randomization used in Spring 2021, and so 12 students' responses were coded. Responses could receive more than one code, but each code was only counted once per student response.

CONCLUSION

The results of implementing the beauty assessment question on the final exam during three COVID-affected semesters

TABLE 2
Weekly topics in the course

Topic	Response code	Frequency
Variety of viruses	Diversity, structure	3
Viromics	Methodology	1
Replication	Replicative cycle	1
Bacteriophage	Phage therapy	2
Pathogenesis	Balance of pathogenicity	1
Vaccines	Vaccines	1
Antivirals	None	0
Gene therapy	Gene therapy	5
Oncolytic viruses	Oncolytic viruses	3

revealed that students embraced a wide range of viral features as personally beautiful (Table 1). The most popular topic was repurposing viruses for therapeutics, a major theme of the course. The next most popular theme was engineering viruses; this code often overlapped with pharmaceuticals. Other themes included diversity, structure, methodology, the replicative cycle, and the balance of pathogenicity with host immunity. These topics aligned well to the lecture topics presented in the course (Table 2). Since students were asked to choose one topic, it is also possible that students may have found more than one topic beautiful, which was not captured here.

Responses also contained a variety of emotionally positive words (Table 3). While "beautiful" was part of the question prompt and therefore expected, the remaining terms were completely student-driven, indicating that students were emotionally connecting with the course content and able to reflect on that experience.

All students received full credit for their responses. Responses ranged from 53 to 264 words (138 average). The joy and curiosity displayed by the students made this an easy and fulfilling question to grade from the instructor perspective. The feelings of impact and connection were very welcome during some very distanced semesters.

In the future, it would be interesting to implement the beauty question throughout various points during the semester and collect feedback on the emotional states of the students who participate as well as whether their learning, sense of wonder, or overall perceptions of virology shift as a result. As data are collected from more students, it will also be interesting to see if the main themes remain or if there is a shift or wider spread in their interest areas. This activity would be expected to engage positive emotions and counter fear of viruses among students in the course.

TABLE 3
Positive words found in student responses (n = 12)

Positive word	Frequency
Beautiful	10
Enjoy/enjoyed	2
Amazed/amazing	2
Excited/exciting	2
Fascinated	1
Interesting	1
Incredible	1
So cool	1
Elegance	1
Awesome	1
Liked	1

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REFERENCES

1. McMurtrie B. 5 April 2022. A "stunning" level of student disconnection. Chronicle of Higher Education, Washington, DC.
2. Pedrosa AL, Bitencourt L, Froes ACF, Cazumba MLB, Campos RGB, de Brito S, Simoes ESAC. 2020. Emotional, behavioral, and psychological impact of the COVID-19 pandemic. Front Psychol 11:566212. https://doi.org/10.3389/fpsyg.2020.566212.
3. Balta-Salvador R, Olmedo-Torre N, Pena M, Renta-Davids AI. 2021. Academic and emotional effects of online learning during the COVID-19 pandemic on engineering students. Educ Inf Technol 26:7407–7434. https://doi.org/10.1007/s10639-021-10593-1.
4. Cavanagh SR. 2016. The spark of learning: energizing the college classroom with the science of emotion. West Virginia University Press, Morgantown, WV.
5. Volet S, Seghezzi C, Ritchie S. 2019. Positive emotions in student-led collaborative science activities: relating types and sources of emotions to engagement in learning. Studies Higher Educ 44:1734–1746. https://doi.org/10.1080/03075079.2019.1665314.
6. Coleman TC. 2014. Positive emotion in nature as a precursor to learning. Int J Educ Math Sci Technol 2:175–190.
7. Park S. 2004. Building bridge between learning and positive emotion: how to apply emotional factor in instructional designing

process? Association for Educational Communications and Technology, Washington, DC.
8. Panksepp J. 1998. Affective neuroscience: the foundations of human and animal emotions. Oxford University Press, Oxford, United Kingdom.
9. Tyng CM, Amin HU, Saad MNM, Malik AS. 2017. The influences of emotion on learning and memory. Front Psychol 8:1454. https://doi.org/10.3389/fpsyg.2017.01454.
10. Fu X. 2019. Truth, goodness and beauty in mathematics teaching. J Innovative Technol Educ 6:25–29. https://doi.org/10.12988/jite.2019.984.
11. Wang C. 2021. Exploring the educational value of mathematical beauty and effective ways of discovering mathematical beauty. J Contemp Educ Res 5.
12. Garcia D, Harvey B, Barnes T. 2015. The beauty and joy of computing. ACM Inroads 6:71–79. https://doi.org/10.1145/2835184.
13. Barker N, Lacobuzio-Donahue C. 2014. Hidden beauty: exploring the aesthetics of medical science. Schiffer Publishing Ltd., Atglen, PA.
14. Dewsbury B, Brame CJ. 2019. Inclusive teaching. CBE Life Sci Educ 18:fe2. https://doi.org/10.1187/cbe.19-01-0021.