ARTICLE
Effective Development of a Remote Full-Day Summer Neuroscience Program at the University of Pennsylvania

Kristen A. Hipolit
[1]*Critical Writing Program and Summer Neuroscience Research Academy, University of Pennsylvania, Philadelphia, PA 19104.*
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Online education programs are becoming increasingly prevalent, with the COVID-19 pandemic greatly accelerating their prominence. Even as colleges and universities have returned to in-person learning, the need for effective remote learning options remains relevant. Importantly, online programs can increase access for non-traditional students, international students, and under-represented minorities. While information has been published about methods to successfully transition traditional lecture and laboratory courses online, one area that has received less attention has been that of summer programs. Because these programs are typically full-day programs, they present a unique challenge for online engagement. In this study, I describe the development of an online full-day summer neuroscience program that was taught over a three-week period. The main goal of the program was to promote students' future interest in the field of neuroscience. Three additional goals were to introduce them to neuroscience content, give them exposure to reading scientific journal articles, and give them practice with oral presentations. In order to promote these goals, four complementary components were incorporated into each day's programming: 1. Synchronous full-group lectures, 2. Synchronous small-group Journal Clubs, 3. Synchronous small-group Neuroethics Clubs, and 4. Asynchronous lab activities. Student evaluation feedback showed that the program was successful in stimulating the students' future interest in neuroscience. These levels of interest were similar to past in-person versions of the program. Students also gained increased experience with neuroscience content, journal articles, and presentations. Therefore, this program can serve as a template for the design of an effective online neuroscience summer program.

Key words: Summer Program; Full-Day; Distance Learning; Virtual Teaching; Online Education; Neuroscience Labs; Journal Club; Neuroethics Club

The COVID-19 pandemic has re-shaped many components of higher education and continues to present many educational challenges (Ramos, 2021). One major adjustment that most instructors and institutions had to face was shifting their courses to an online format. While initially, many online learning adjustments were anticipated to be a short-term solution, it is now clear that in the long term, effective online teaching tools are an important pedagogical component that can offer several educational advantages. Specifically, virtual learning offers both increased flexibility in dealing with potential public health events, as well as allows for greater outreach to a larger number of students, including under-represented minorities, international students, and non-traditional students.

From a public health perspective, even as campuses have resumed in-person instruction, it is clear that effective virtual learning strategies remain relevant as a tool to flexibly adapt to ever-changing scenarios. For instance, the Omicron variant of SARS-COV-2 led campuses such as Cornell to shut down at the end of the Fall 2021 semester (Rosenberg and Oza, 2021). Additionally, at the start of 2022, many colleges that have a January term moved those courses to a virtual format (Jaschik, 2022), and several other colleges and universities re-adopted online instruction for the first several weeks of the Spring 2022 semester (Charlton and Parks, 2021; Jaschik, 2022).

In addition, online learning has the potential to reach a larger and more diverse student population. Compared to in-person education, online courses are able to be offered at a lower cost (Bowen et al., 2014; Chircov et al., 2020). This could allow them to be adapted by colleges and universities who have resource constraints and can also encourage enrollment from a more diverse student population given that they can be offered at lower tuition. Online education can increase participation from underserved communities. Data from the National Postsecondary Student Aid Study (NPSAS) showed that students who enroll in online education are more likely to have lower levels of parental education and are more likely to be working full-time while enrolled in school (Deming et al., 2015). In addition to lower costs, the remote nature of online learning programs also allows for greater temporal and geographical flexibility which can increase accessibility for many students such as non-traditional students, working students, and geographically distant students (Porter et al., 2014). Additionally, since in-person classes have enrollment constraints in terms of classroom space, lab space and housing, online courses are able to have higher enrollment numbers (Bowen et al., 2014). This allows for these courses to impact a greater number of students overall.

Even before the pandemic began, online learning had been growing dramatically in popularity, with the National Center for Education Statistics (NCES) reporting that in

2018, 35.3% of college students in the United States were enrolled in distance education courses (Wallis, 2020; Ruiz and Sun, 2021). Additionally, the number of students enrolled in online learning has been steadily increasing over time. For instance, Oregon public universities reported that the number of students taking online courses increased by 151% between the 2008-09 school year and the 2018-19 school year (Wallis, 2020). While the vast majority of this growth in online learning has been in the form of traditional undergraduate courses, one new and additional area that could benefit from online course development is the area of summer programs.

Many colleges and universities offer summer programs to college or high school students that allow students to advance their understanding of a particular discipline through an immersive program over a short period of time. Studies have shown the effectiveness of these summer programs in improving student knowledge of scientific content and research methodologies, as well as promoting collaborative relationships with others (Gould and MacPherson, 2003; Yates and Stavnezer, 2014). Summer undergraduate research experiences have also been shown to improve students' motivation to learn, increase their active participation in future science courses, clarify their interest in the sciences and promote their desire to pursue a career in the sciences (Russell et al., 2007; Lopatto, 2017). While many of these studies have focused on the impacts on undergraduate students, similar effects on motivated high school students can be inferred as well.

Since these summer programs are typically only a few weeks long and have the ability to draw from a diverse pool of students both domestically and internationally, having online options available for these programs increases accessibility. Given the need and desire to increase the number of underrepresented minorities and non-traditional students within the STEM fields, online summer programs that are more accessible to these demographics have the potential to spark a lasting interest in neuroscience in these students. In particular, summer programs targeting high school students can build a formative initial interest in the field and encourage a greater number of students to enroll in neuroscience programs in college and beyond.

One of the biggest challenges with remote learning is ensuring that students are getting a full pedagogical experience from the program. In other words, ensuring that students are engaged with the material, absorbing the course content, and also enjoying their experience (D'Souza et al., 2020). While these challenges are true of any course, they are exacerbated by the nature of a summer program. In contrast to a typical semester-long course that only meets for an hour or two at a time, summer program content typically lasts a full day. Expecting students to stay engaged in an online format for an eight-hour stretch of time makes it unreasonable to simply adopt the previous in-person lectures and activities into a virtual format with no further adaptation. Additionally, an essential component of these summer programs is often hands-on laboratory-based activities, which typically involve access to specialized equipment that isn't found in most students' homes. While many lab activities have the potential to be designed or adapted at an at-home space without specialized equipment, design of such activities for a neuroscience summer program has not been previously described.

Oliver et al. (2021) have recently described one strategy for transitioning their Summer Science Academy, which is an undergraduate biomedical research program at Vanderbilt University, to a virtual format. Their approach involved removing the research component of the program and instead focusing on the interpersonal connections that students would make with post-undergraduate trainees through narrative seminars. While their approach was successful at promoting students' sense of belonging and connection to STEM disciplines and points to the clear importance of the interpersonal connections that are formed during these programs, it was not able to re-create the typical research environment of their conventional program. Given that performing hands-on lab activities at home increases student academic performance, self-efficacy, and engagement (DeBoer et al., 2017; Hanzlick-Burton et al., 2020; Ho et al., 2021), we wanted to explore whether it would be possible to develop an alternative model for summer programming that incorporated more features of a typical in-person program, such as labs, lectures, and clubs in an attempt to more fully replicate the typical in-person programming experience.

In this study, I adapted a 3-week high-school neuroscience summer program at the University of Pennsylvania to a remote format. By using a complimentary combination of 1. Whole-group synchronous lectures, 2. Small-group synchronous journal clubs, 3. Small-group synchronous neuroethics club activities, and 4. Asynchronous at-home labs (followed by a full-group synchronous post-lab discussion), we were able to deliver this neuroscience program content to students virtually. Given the important role that summer high school programs play in developing a student's initial interest in a field, the main goal of the program was to promote future interest in the field of neuroscience.

Student surveys indicated that the program was successful in fostering the students' interest in the field of neuroscience. This level of interest appears similar to the past years of the program, when instruction was conducted in-person, which indicates that the online nature of the program did not detract from students' interest in the field. Additionally, students were able to gain valuable experience learning neuroscience content, reading scientific journal articles, and delivering presentations. Therefore, this indicates that the measures taken to adjust the program to an online format served as a successful template for the design of a remote full-day neuroscience summer program.

MATERIALS AND METHODS

Program and Students

This online neuroscience curriculum was developed for a selective three-week immersive full-day neuroscience summer program for high school students at an Ivy League Research University (Neuroscience Research Academy, University of Pennsylvania) during the summer of 2021. The program enrolled 61 students through a selective application-based process. The admitted students included

12 international students and 49 domestic students (who participated from across a variety of time zones, including both EST and PST). Program funding was provided by student tuition from 51 students, which was $5,049 per student. The final 10 students were admitted as scholarship students. These scholarship students attended a School District of Philadelphia public or charter high school and demonstrated financial need. Six of these scholarship students were admitted directly through the Neuroscience Research Academy program, with funding provided by the tuition of the other enrolled students. The final 4 students were admitted through a second scholarship program, the PENN LENS program, which offers students the ability to attend an University of Pennsylvania research academy summer program in addition to working in a research lab during the remainder of the summer.

Synchronous components of the course took place over the Zoom video conferencing platform. Online learning management, such as the posting of readings and other documents, took place via the Canvas Learning Management System.

Program Design

In order to facilitate student engagement and learning, the program was designed to have four main daily components that each provided a different style of delivery: (1) whole-group synchronous lectures, (2) small group synchronous Journal Clubs, (3) small-group synchronous Neuroethics Clubs, and (4) asynchronous at-home lab activities (with a synchronous post-discussion).

The decision to provide these different forms of delivery allowed us to still engage with students directly (during synchronous sessions), but also allowed for more flexibility in accommodating different time zones of learning (by offering asynchronous activities and by staggering the timing of different small-group synchronous meetings). The small group synchronous activities also allowed students to have more opportunity for participation and engagement than they otherwise might have had in a large-group online meeting. Additionally, the different formats allowed for learning to be broken up into more manageable chunks and for students to have off-screen time (especially during the asynchronous lab activities) so that students weren't just stuck staring passively at a screen for an 8 hour stretch. The design of each of those components was as follows:

(1) Whole-Group Synchronous Lectures

Two one-hour synchronous lectures were delivered each day. The two lecture components were held at 11am EST and 4pm EST to accommodate the largest number of time zones. All students were required to attend. These lectures were presented by a select small group of faculty from the Undergraduate Neuroscience Program at the University of Pennsylvania and followed the past program curriculum. These lectures introduced students to the fundamentals of an introductory neuroscience course (Appendix 1). Stylistically, lectures were presented in a standard powerpoint-driven "lecture" format, similar to what would take place in-person.

Time	Topic	Articles
9am	**Hippocampal Injury: Battle of the Sexes?**	Schwarz, J. M., Sholar, P. W., & Bilbo, S. D. (2012). Sex differences in microglial colonization of the developing rat brain. *Journal of neurochemistry*, *120*(6), 948-963.
		Smith, A. L., Alexander, M., Rosenkrantz, T. S., Sadek, M. L., & Fitch, R. H. (2014). Sex differences in behavioral outcome following neonatal hypoxia ischemia: insights from a clinical meta-analysis and a rodent model of induced hypoxic ischemic brain injury. *Experimental neurology*, *254*, 54-67.
10am	**How Glia Can Help Protect You from Neurodegeneration**	Liu, L., Zhang, K., Sandoval, H., Yamamoto, S., Jaiswal, M., Sanz, E., ... & Bellen, H. J. (2015). Glial lipid droplets and ROS induced by mitochondrial defects promote neurodegeneration. *Cell*, *160*(1-2), 177-190.
		Liu, L., MacKenzie, K. R., Putluri, N., Maletić-Savatić, M., & Bellen, H. J. (2017). The glia-neuron lactate shuttle and elevated ROS promote lipid synthesis in neurons and lipid droplet accumulation in glia via APOE/D. *Cell metabolism*, *26*(5), 719-737.
5pm	**The disconnected brain: Is Schizophrenia caused by removing too many neural connections?**	Schafer, D. P., Lehrman, E. K., Kautzman, A. G., Koyama, R., Mardinly, A. R., Yamasaki, R., ... & Stevens, B. (2012). Microglia sculpt postnatal neural circuits in an activity and complement-dependent manner. *Neuron*, *74*(4), 691-705.
		Sellgren, C. M., Gracias, J., Watmuff, B., Biag, J. D., Thanos, J. M., Whittredge, P. B., ... & Perlis, R. H. (2019). Increased synapse elimination by microglia in schizophrenia patient-derived models of synaptic pruning. *Nature neuroscience*, *22*(3), 374-385.
6pm	**"Just checking...one more time": How do striatal circuits mediate OCD-like behaviors?**	Welch, J. M., Lu, J., Rodriguiz, R. M., Trotta, N. C., Peca, J., Ding, J. D., ... & Feng, G. (2007). Cortico-striatal synaptic defects and OCD-like behaviours in Sapap3-mutant mice. *Nature*, *448*(7156), 894-900.
		Burguière, E., Monteiro, P., Feng, G., & Graybiel, A. M. (2013). Optogenetic stimulation of lateral orbitofronto-striatal pathway suppresses compulsive behaviors. *Science*, *340*(6137), 1243-1246.

Table 1: Journal Club Topics and Articles

(2) Small Group Synchronous Journal Clubs

For this component, students were divided into four groups of approximately 15 students each. Each of these groups met for a one hour synchronous block each day. The specific time at which each group met varied (9am, 10am, 5pm, 6pm EST) in order to accommodate students from different time zones. Each Journal Club was run by a qualified graduate student and focused on a particular topic that was selected by the respective journal club leader (Table 1). Students were able to select their preferred journal clubs by ranking them via a Google Forms survey that was sent to the students before the start of the program.

Over the course of the three week program, each journal club leader guided their students through reading two journal articles from the primary scientific literature (Figure 1). The very first journal club meeting involved a discussion of "how to read a scientific journal article". Subsequently, students were expected to read parts of each journal article as homework each night and then discussed the article in their synchronous group session with the guidance of their journal club leader. The journal club culminated in the journal club leaders helping their students prepare a "scientific poster" in which they presented the findings of one of the journal articles that they read. These poster presentations were presented to the other students of the summer program who were not in their journal club group and took place in the following format:

Each journal club was divided into 4 groups of 3-4 students each. Each group made a scientific "poster" to present in Zoom breakout rooms. Out of those 4 groups, two groups made a poster about the first paper (ex. "Group 1A and Group 1B") and two groups made a poster about the 2nd paper (Group 2A and Group 2B). During the last day of the program, all of "Group A" members (aka Group 1A and Group 2A) presented first, and all of group B members from one particular journal club rotated around to the presentations hosted by the other 3 journal clubs as “spectators”. Therefore, each spectator visited a total of 6 breakout rooms (two posters for each of the other three journal clubs). Spectators visited with each poster (each breakout room) for approximately 10 min. In this time, the presenting students explained their poster and visiting students were able to ask questions. I then rotated the visitors through to the next poster. After a short break, we then switched, and everyone in a "B" group (Group 1B and Group 2B) presented, and everyone in group A rotated through the rooms as “spectators” to visit the posters from the other journal clubs.

These journal clubs were designed to replicate the journal clubs that had existed during the in-person versions of our program. Their structure was largely identical, with the only difference being that the poster presentations replaced a previous more generic “powerpoint presentation” on the papers the students had read.

(3) Small-Group Synchronous Neuroethics Clubs

The neuroethics clubs were a component that had not previously existed as part of our summer program, but were added in order to give students an additional opportunity to engage with one another in a small-group discussion setting. For the neuroethics clubs, students were divided into six groups of approximately 10 students each. Each of these groups met for a one hour synchronous block each day and was led by a qualified undergraduate student. The specific time at which each group met varied (two 9am sections, 10am, 5pm, 6pm, 9pm EST) in order to accommodate students from different time zones. Students were able to select their preferred neuroethics club time by ranking them via a Google Forms survey that was sent to the students before the start of the program.

Each Neuroethics club followed the same topics, with each day focusing on a different neuroethical dilemma (Table 2). Each night, students were assigned readings related to that neuroethics topic that would be discussed the following day (Appendix 2). The next day, the neuroethics leaders guided their students through small-group discussion of these neuroethics topics. The neuroethics leaders were provided with a set of stock questions to help them guide the discussion, but were welcome to use their own pedagogical discretion to guide the discussion as they desired.

On the last day of their neuroethics club, students gave a final presentation to the rest of their neuroethics group. For this final presentation, they were asked to choose one of the following: (1) find a real-world example of one of the neuroethics issues that had been discussed and present this example to the class along with a discussion of how it has been handled by policymakers, (2) Form a small group with other class members to participate in a two-sided debate about one of the neuroethics issues presented in class, (3) make a movie or skit acting out one of the neuroethics issues discussed, or (4) find a new neuroethics topic that hasn’t been discussed yet and explain it to the group.

Session	Neuroethics Topic
1	Artificial intelligence
2	Neuromarketing
3	Disorders of consciousness and when to terminate care
4	The opioid crisis
5	The COVID-19 pandemic and mental health
6	How expectations shape performance: The Pygmalion effect and implicit bias
7	Does free will truly exist?
8	Trauma across generations
9	Mental illness and autonomy in regards to consent
10	Neurolaw: The brain in court
11	Smart pills
12	Memory erasing
13	Should autism be cured?
14	Ecstasy and psychedelics as treatments for psychological disorders

Table 2. Neuroethics Topics.

(4) Asynchronous At-Home Lab Activities (With a Synchronous Post-Discussion)

In order to provide students with hands-on learning activities to complement what they were learning in the lecture component of the course, daily lab activities were assigned to students. The labs were designed to take approximately 2 hours to complete and were designed to be able to be completed asynchronously. Lab instructions were provided online for students. In addition to this asynchronous time, a daily 45 min time block was also allotted for a post-lab discussion and debrief. This took place as a whole-group synchronous meeting guided by faculty from the Undergraduate Neuroscience Program.

Due to the lack of feasibility of designing 15 different neuroscience lab activities that could translate directly to an at-home format, some labs were active hands-on labs (6 labs) while others involved watching a documentary or doing a reading (8 labs) (Table 3). There was also one lab where students were paired with a partner and designed a one-slide powerpoint presentation about a particular brain region.

These labs largely replicated the lab activities that students completed during the in-person version of the program. There were three main differences: 1: Some lab instructions that had previously called for a lab partner had to be adapted to be a single-person activity. However, these

Hands-On Labs	
Lab	**Description**
Membrane Potential Lab	Students began by practicing a few Nernst potential questions. They then used computer simulations to illustrate the Nernst and Goldman equations. They first saw how changing the concentrations of sodium and potassium change the membrane potential of the cell. They then saw how changing the permeability to the differentions changes the membrane potential of the cell. Finally, they watched a simulation of an Action Potential after stimulation of a neuron and observed the process of channel opening/closing/inactivation
Cranial Nerve Lab	Students performed a variety of activities that tested each of their different Cranial Nerves. These included activities such as smelling objects with their eyes closed, shining a pen light in one eye to observe changes in pupil dilation, biting down on a tongue depressor, and performing the Romberg test for vestibular balance, as well as others
Sheep Brain Dissection Lab	Students were mailed a sheep brain (from Carolina Biological's "Young Scientist Brain Dissection Kit") and were provided with instructions that guided them through a dissection of different regions of the sheep brain. International students or students who were not comfortable performing the dissections were instead prompted to watch an online video of a faculty member dissecting a sheep brain
Taste Lab	Students were mailed a "Miracle Berry" tablet (mberry.us), which is a tablet made out of berries that contain the compound miraculin, which makes sour foods taste sweet. Before eating the tablet, students were instructed to eat a few bites of a variety of sour or tart foods, including lemons, oranges, apples, grapefruit, and sour candy. Students were then instructed to eat the Miracle Berry tablet, and then taste the sour foods again
Sensation and Perception Lab	Students performed a variety of activities that tested different aspects of their sensation and perception. This included testing color opponency, the motion after-effect, the Pulfrich effect, somatosensory touch discrimination, motor reflexes, and the retinal nerve blind spot
Memory Lab	Students performed a variety of memory tasks. These included a short-term vs long-term recall task, an eyewitness memory task, a short-term digit recall task, a recall task of an everyday image (Apple logo), a task testing the effect of "storytelling" on recall of a series of images, a task showing the effect of thematically similar words on mis-remembering whether a different target word was present, and finally an implicit memory task where they practiced tracing a star by looking in a mirror

Media Based Labs (Readings/Videos)	
Lab	**Description**
"In Search of Memory"	Students watched the "In Search of Memory" documentary about Nobel Laureate Eric Kandel
Opioid Crisis	Students watched the PBS documentary "Chasing Heroin" about the opioid epidemic
New Sign Languages	Students watched two short videos about the birth of the new sign language in Nicaragua. They also watched a short clip by Ann Senghas about "How Language Evolves"
Sleep	Students watched a series of videos about 1. a sleep deprivation experiment, 2. the effect of alcohol and caffeine on sleep, 3. REM sleep behavior disorder. Additionally, they read an article about teen sleep and kept their own sleep log for a week
Hormones	Students watched a series of TED talks about sex differences. These included talks about sex differences in medical diagnosis, the effects of certain chemicals on hormones, the sex lives of insects, and helping transgender teens
Memory Dysfunction	Students watched a TED Talk by Elizabeth Loftus about memory fallibility. They then read 3 articles about times of memory loss: "The Lost Mariner" by Oliver Sacks, a New Yorker article called "Face Blind" by Oliver Sacks, and the article "My Mysterious Lost Month of Madness" by Susannah Cahalan about her experience with Anti-NMDA-Receptor Encephalitis
Autism	Students read the *Atlantic* article "The Coming Care Crisis as Kids With Autism Grow Up" and then watched the HBO documentary "Autism: The Sequel". They then also read the *Scientific American* article "Autism - It's Different in Girls"
Mental Health	Students watched the HBO documentary "The Weight of Gold" about mental health in Olympic athletes
Brain Region Powerpoint Blitz	Students signed up for a particular brain region in pairs. Together, they then designed a single powerpoint slide that provided information about a particular brain region. They were encouraged to use images rather than text. They then presented their slide to the rest of the group

Table 3: List of labs with a description of the activities

adaptations were minor and did not affect the overall activities assigned. 2: One of the hands-on labs, the "membrane potential lab" was a new lab that replaced a previous in-person electrophysiology lab. 3: The "media-based labs" that involved watching a documentary or doing a reading were newly added to this remote program and replaced time in the schedule that had otherwise been spent doing things like field trips.

For the hands-on lab activities, we assembled a "lab kit" that contained all of the materials that students would need to perform the lab in their own home and mailed these kits to each of the students. A list of the materials that were mailed for each of the labs is provided in Table 4, as well as the cost of each of these materials. Additionally, for one of the labs, which was a "taste" lab in which students tasted different foods before and after eating a "Miracle berry" (miraculin), students were asked to purchase several fruits on their own, as those would not be stable for shipping. "Miracle Berries" were purchased from Fruit Me via Etsy.

For the sheep brain dissection lab, the "Young Scientist Brain Dissection Kit" from Carolina Biological (Item # 228756) was used. The University of Pennsylvania Environmental Health and Radiation Safety (EHRS) was consulted regarding shipping and disposal procedures, and approved of the lab protocol and safety procedures. Students were provided with specific, labeled bags for disposal of the specimens. Students were also provided with a distance learning laboratory safety agreement, lab safety manual, and SDS sheet for the solution in which the brains were fixed. Students were also required to complete a brief online safety "quiz" to reinforce the safety procedures before dissecting their sheep brains.

For the membrane potential lab, students used two online simulations. The first was the Nernst/Goldman Equation Simulator developed by the university of Arizona (https://apps.apple.com/us/app/the-nernst-goldman-equation-simulator/id1022504095). The second was the "Neuron" simulation developed by PhET Interactive Simulations and the University of Colorado Boulder (https://phet.colorado.edu/en/simulations/neuron).

Learning Objectives and Assessment

There were several learning objectives for the program which were addressed in a complimentary fashion across the four main components of the program. The main objective of the program was to encourage interest in the field of neuroscience beyond the confines of this program. This included promoting student interest in majoring in neuroscience in college and wanting to work in a neuroscience research lab. Students (n=52) voluntarily completed an online survey on the last day of the program that assessed this component. The survey was distributed as a Google Forms document and responses were collected via that platform. Questions prompted students to either respond on a 10-point scale (with 1 being low and 10 being high) or with free response. The results were then compared with survey data from past years of the program (2016, n=42; 2017, n=40; 2018, n=41; 2019, n=41) (the program was not run in the summer of 2020 because the director, KH, was on maternity leave).

Lab Name	Supplies Provided	Supplier	Cost Per Student
Membrane Potential Lab	*(no supplies needed)*		
Cranial Nerve Lab	Cotton Balls	Coviden Company	$0.10
	Tongue Depressor	Thomas Scientific	$0.13
	Pen Light	PrimaCare Medical Supplies	$1.42
	Plastic Pipette for tasting liquids	Samco Scientific	$0.30
	** Additionally, students were asked to provide a few household items of their own: ~ 3 items to smell (such as ground coffee, a bar of soap, vanilla extract), and 2 or 3 liquids to taste (ideally something sweet like juice, sour like lemon juice, or salty like salt dissolved in water).	N/A	*These were intended to be household things they would not have to buy*
Sheep Brain Dissection Lab	Lab Goggles	Thomas Scientific	$7.65
	Lab Apron	Carolina Biological	$0.50
	Nitrile Gloves (1 pair each of S, M, L)	Thomas Scientific	$1.50
	Carolina's "Young Scientist Brain Dissection Kit" (Includes: sheep brain, plastic storage bag, plastic knife, plastic forceps, ruler, hand lens, wooden probe, disposable dissection tray, moist towlettes)	Carolina Biological (Item#228756)	$18.75
Taste Lab	"Fruit Me" Single-Serve Miracle Berry Tablets	Fruit Me (via Etsy)	$3.00
	"Sour Patch Kids" sour candy	Sour Patch Kids	$0.23
	"Jelly Belly" jellybeans	Jelly Belly	$0.50
	** Additionally, students were asked to purchase on their own: 1 lemon, 1 orange, 1 grapefruit, a few strawberries, 1 green apple, and a few sips of white vinegar	N/A	~$6.00
Sensation & Perception Lab	Ruler	Chuangdi	$0.60
	Plastic Sunglasses with one lens removed	Tigerdoe	$0.73
	Ball and String	Gejoy	$0.50
	Paper Clips	Office Depot	$0.08
Memory Lab	Plastic (non-breakable) mirror	Emsco/Fisher	$1.00
	Plastic Mirror stand	Thomas Scientific	$0.36
	2 manilla file folders taped together	Office Depot	$0.20
	Papers with star outlines for tracing	N/A	$0.15
TOTAL			**$43.65**

Table 4: Lab materials mailed to students

An additional program objective was introducing students to the fundamentals of neuroscientific content. While the lectures, labs, neuroethics clubs, and journal clubs all contributed to this effort, the lecture and lab components most directly addressed this objective. Within the lecture component of the course, the learning of neuroscientific content was assessed indirectly by student questions and participation. The lab component of the course provided for a more direct assessment of student learning and involved the completion of lab manual questions on the Canvas online learning management system.

A third objective was for students to gain experience reading a scientific journal article. This was addressed during the journal club component of the course. The main assessment of this objective came from instructor and TA viewership of the student poster presentations that took place on the last day of the program.

The final objective was to give students experience with oral presentations. This was achieved through both the journal club and neuroethics club components. As mentioned above, both of these components culminated in final presentations, which were able to be assessed by the TAs and program director. Additionally, one of the "Media based labs" was a powerpoint "blitz" in which pairs of students gave a one-slide powerpoint presentation about a particular brain region.

RESULTS

Interest in Neuroscience

Overall, the program appeared to be successful in fostering an interest in neuroscience amongst the students. A survey administered to the students on the last day of the program indicated that on a scale of 1 to 10 (with 10 being the highest), student interest in neuroscience was a 7.58 prior to completion of the program, and was a 9.08 after completing the program. This indicates a strong final interest in the field of neuroscience. Additionally, these numbers are in-line with the results of program from the 4 prior summers in which this program had been run in-person (Table 5).

Survey Question	2021 (Remote)	Average for 2016-2019 (In-Person)
Prior to coming into this program, how would you rate your interest in the field of neuroscience?	7.58	7.49
After completing this program, how would you rate your interest in the field of neuroscience?	9.08	8.74
How likely do you think you will be to choose a neuroscience major while at college?	8.10	7.39
How likely do you think you will be to try to work in a neuroscience research lab while at college?	8.44	7.52
Please rate your enjoyment of the synchronous lectures	8.40	8.06
Overall quality of the professors giving the lectures:	9.08	8.65
Were lectures delivered at an appropriate level, or were they either too basic or too difficult? (1=too basic, 10= too hard)	6.18	5.97
Labs: To what extent did you enjoy or not enjoy the hands-on labs?	8.73	8.35
Labs: To what extent did both of these types of labs help you learn about the concepts covered in lecture?	8.52	7.95
Journal Club: How useful was the process of learning to read scientific papers?	8.75	8.87
Journal Club: How useful was the process of learning to read scientific papers?	8.71	8.55
Neuroethics Club: To what extent did you enjoy the neuroethics readings and discussions?	9.46	N/A

Table 5: List of survey questions given to students and the averaged responses from the remote implementation of the program (2021) as well as the in-person years of the program (2016-2019)

Furthermore, students ranked their future likelihood of choosing a neuroscience major as 8.10 and their likelihood of trying to work in a neuroscience research lab while in college as an 8.44, which shows that this program succeeded in stimulating interest in the field. These values were also similar to past in-person years of the program (Table 5), indicating that the online format did not detract from the ability of the program to cultivate this interest. The range of student responses regarding their interest in the field of neuroscience, interest in majoring in neuroscience, and interest in working in a neuroscience research lab are shown in Figure 1.

Throughout the program, students remained engaged and positive in their demeanor. We did not encounter any

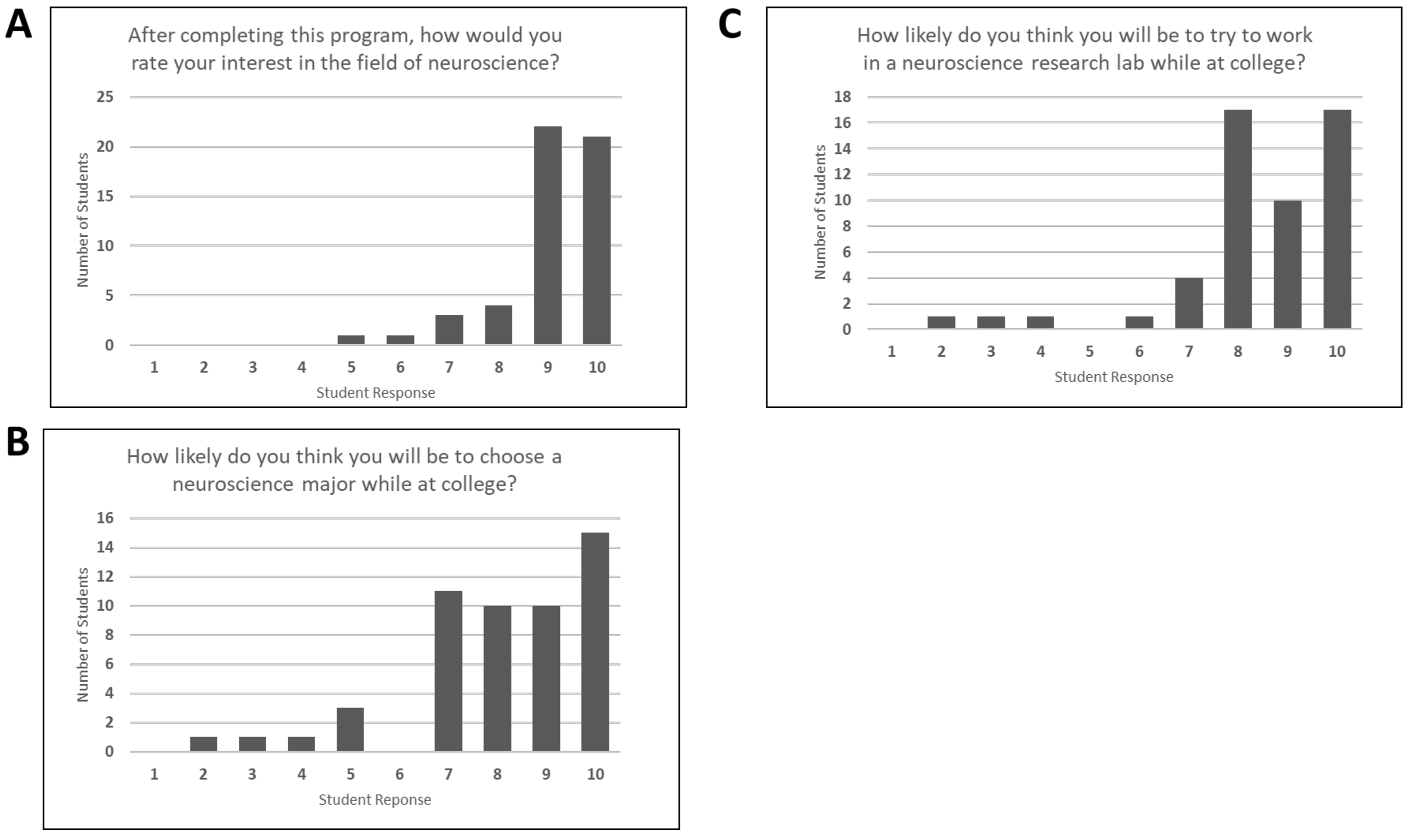

Figure 1. Individual student survey responses about their interest in neuroscience studies following completion of the program. *A*. Students reported a strong interest in the field of neuroscience as a whole. *B*. The majority of students reported an interest in pursuing neuroscience as a major while in college. *C.* The majority of students reported being interested in working in a neuroscience research lab while in college.

attendance problems with students regularly skipping any of the synchronous meetings or not participating in their final projects. Students ranked their enjoyment of the lectures as an 8.40 and their ranking of the quality of the professors giving the lectures was a 9.08. These values, along with their similarity to the scores of past years, shows that the online program was able to promote interest in neuroscience to a similar degree as the in-person program (Table 5).

Evaluation of the lab component of the course similarly showed that neuroscientific interest extended to this aspect of the program and was similar to in-person iterations of the program (Table 5). This was particularly true of the hands-on labs, reinforcing the fact that students perceive active learning to be the most engaging method of instruction (Score of 8.73).

Overall, this highlights that the program was successful at reinforcing an interest in neuroscience in these students and suggests that these students will be likely to continue to pursue neuroscience studies in the future. This signals that the remote version of the summer program was successful at replicating this aspect of the in-person experience.

Neuroscientific Content

As this program was designed to be an introduction to the field, rather than a credit-earning course, the goal of the program was to provide a preliminary foundation of knowledge that students could then build upon more formally in the future in college. As a result, grades and exams were not given for a quantitative assessment of content learned. However, qualitative feedback indicated that students were intellectually stimulated. For instance, one student wrote that “I really liked the lectures and all the reading recommendations! My favorite part, by far, was taking notes to the two hour lectures each day. I feel like I learned so much information.”

The level of student engagement and participation during the synchronous lecture sessions varied, as is the case in any classroom. With that said, many students did ask insightful questions during these lecture sessions, demonstrating that they were paying attention and engaged. When asked whether they felt that the lectures were delivered at an appropriate level (with a score of 1 meaning they were too basic, 5 meaning they were just right, and 10 meaning they were too hard), students gave a score of 6.18, which is similar to, but slightly up from past years’ average of 5.97. This indicates that the content was being delivered at an appropriate level, though also suggests content delivered online might be slightly harder to digest than in-person.

The asynchronous lab activities were tracked via the Canvas Learning Management platform. The lab activities were designed so that students accessed the lab manual on Canvas and entered in their lab manual responses on that site as well. Student participation in the labs was high. Out of 61 students, only 2 students consistently struggled with turning in their lab assignments. Across all labs, an average of 93% of students turned in their lab reports.

The student answers to lab manual questions were intended to be pedagogical in nature, rather than grade-based. In other words, the responses were intended to reinforce concepts rather than provide a numeric assessment of student learning. For instance, the questions in the memory lab asked students to record their responses after different memory tasks and then discuss the memory phenomenon at work. Another example is the cranial nerve lab which asked students to document what sensations they felt as they tested their different cranial nerves. However, the high degree of relevant student entries on Canvas shows that the students were appropriately working through the labs in a similar manner to how they would have participated in the in-person program.

Additionally, the synchronous lab de-brief that students participated in daily after the asynchronous lab session allowed instructors to evaluate student comprehension of the material. These sessions involved strategies such as proctored small-group discussions and active response tools (ex. Jam boards, surveys) that required students to actively enter in information and participate. Student participation in these activities was high, indicating that they had completed the labs and were retaining the information.

Students also reported that the labs helped reinforce the concepts covered in the lecture (8.52) (Table 5). This shows that the different components of the program succeeded in complementing one another and that the labs were a worthwhile way to reinforce student learning.

Learning to Read a Scientific Journal Article

Most high school students have not had previous exposure to a scientific journal article. Learning to read a scientific paper can teach them about how data is presented and how the scientific community asks questions and conducts research. It can also help students learn to think critically and can improve their ability to read a similar article in the future. When asked about how useful the process was of learning to read scientific papers, students gave an average score of 8.75 (Table 5), which shows that they perceived this as being a valuable experience. Given that this score was similar to the scores from in-person years of the program, this indicates that the quality of learning was not impacted by the online delivery of content.

Assessment of the student's ability to read these journal articles came in the final poster presentation that the students prepared. All students were expected to contribute to the creation of their group's poster. Given that these posters were made in small groups, the individual journal club TAs were able to ensure that all group members did participate. Additionally, all group members were expected to speak when presenting their poster. During the poster presentations, the program director (KH) and journal club TAs rotated through the different breakout rooms as students were presenting their poster presentations and ensured that all members of the group were speaking and participating. Additionally, we asked questions to the presenters to gauge their understanding of the material and student responses indicated that they had absorbed the content. While it is obviously unrealistic to expect high school students to achieve proficiency at reading the scientific literature, we were able to achieve our goal of giving students initial exposure to this genre.

Presentation Skills

The final goal for the program was to give students practice with presentations. There were three different opportunities for presentations: 1. A one-slide powerpoint "blitz" about a particular brain region, done in partnership with another student during lab time; 2. The final journal club poster presentations; and 3. The neuroethics final presentations.

Students rated the journal club poster as being valuable, receiving a score of 8.71 (Table 5). Through this process, they learned about this specific genre of scientific communication. Also, by having them present their posters to several small audience groups, the repetition in presenting allowed them to work out "kinks" in their presentation style and practice their delivery, while the small-group format for an audience encouraged students to actually ask questions and speak up since they couldn't just blend into the background of a large group. Instructor assessment of these presentations, as well as the powerpoint "blitzes" indicated that students were participating in the exercise and gaining valuable practice in both designing and delivering a presentation.

The neuroethics club presentations were assessed by the individual neuroethics TAs. They reported that their students were engaged with this delivery and, especially given the small-group nature of this delivery, enjoyed sharing what they had learned with their group-mates. This past summer (2021) was the first year that we included neuroethics clubs as part of the summer program curriculum. This component received the highest score out of the different components of the program, with students giving the neuroethics club an average ranking of 9.46 (Table 5). This reflects the high level of interpersonal interaction and discussion that was able to take place during these sessions and highlights the success of this particular component. Overall, the ability of students to deliver three different presentations, all of which were observed by TAs or program instructors, shows that the program was able to successfully help students practice their presentation skills.

DISCUSSION

Program Objectives

The program was successful at stimulating students' interest in the field of neuroscience, introducing them to neuroscience content, introducing them to the process of reading scientific articles, and giving them practice with presentations. Furthermore, student feedback indicated that the online program was both instructive and engaging.

An important role of summer high school programs is to encourage student engagement in a discipline, and the results indicate that student interest in the field of neuroscience was successfully stimulated by the content of the program. When assessing student interest, it is important to note that the students participating in this program had already self-selected for having some degree of interest in neuroscience, by virtue of the basic fact that they applied to a summer neuroscience program. With that said, reinforcing this interest and retaining students in STEM fields is crucial, and these results indicate that these summer programs can effectively further this initial interest.

One interesting area for future study would be to follow student matriculation and retention into neuroscience programs at the college and university level, particularly for traditionally under-represented student populations.

One component that appeared to be particularly relevant for the design of future summer programs was the neuroethics clubs. These clubs successfully stimulated student interest, provided the students with an opportunity for interpersonal engagement, and encouraged a sense of community. One student pointed out: "I loved getting to know people beyond working with them on assignments, particularly in smaller groups like within my neuroethics class. In neuroethics it was nice to not only discuss topics, but the experience was enhanced since we got to know each other better than we could in the larger classes." When considering the possible role of an online summer program in reaching non-traditional or underrepresented students, the ability to form a community, particularly a community of similar individuals, is crucial, as this can be vital in attracting and retaining students within the field.

In assessing the effectiveness of the learning outcomes of this program, one area for future research is to incorporate more quantitative analysis. As the program was designed to be a preliminary introduction to the field of neuroscience, rather than a credit-earning course, quantitative assessment of learned content was not conducted. However, this would be an important area for future study to validate the effectiveness of online delivery of information.

Student Perceptions

Student perceptions of the program were very positive overall. One important consideration to take into account when assessing the student perceptions of the program is student expectations and alternative opportunities. The course was clearly marketed as being an online course when students signed up for it, and during this time period, the majority of university programs were all being run virtually. As a result, students may have inherently taken this into account when evaluating their satisfaction. In other words, they may have been reporting that it was essentially "good for what was possible given the circumstances". Executing a virtual program during a time when in-person programming is possible may present additional challenges in terms of satisfaction. However, given that students would still be aware of the remote nature of the course when signing up, and thus have their expectations in line with this fact, it is unlikely that satisfaction would greatly decrease.

When asked about the extent to which the online nature of the course detracted from their experience, (with 1= it did not affect my experience at all; 10= it greatly detracted from my experience), students reported an average score of 5.65. Therefore, students do believe that the online nature of the program does not fully replicate an in-person experience, though not to an extreme degree. Ultimately, given that the overall satisfaction with the program was high, the evaluation of each of the individual components was high, and learning objectives were achieved, this signals that an online summer program following this design has the potential to provide a quality educational experience to students.

Ability to be Implemented Across Schools

Accessibility

One important advantage of the online nature of the program was that it allowed for a larger enrollment than in past summers. Typically, our in-person summer program is capped at approximately 40 students, since we are limited in the amount of lab space that we have available to use. However, due to the flexibility of online learning, we were able to accommodate 62 students this summer, which is a large increase compared to past years. Therefore, virtual learning provides an opportunity to reach a greater number of students, which can increase accessibility and potentially diversity for different student groups. Additionally, this provides an opportunity for schools that might have resource constraints on campus (for instance, limited classroom or lab space, or limited housing) to offer a summer program.

Financial Feasibility

One important consideration for the implementation of this program template at different schools is the cost of the program. Particularly when considering the adaptation of this program to different types of institutions or demographics of students, the cost of these features is pertinent.

While the program described here was funded by student tuition, which was substantial, the cost per student was approximately half (53%) of the in-person program tuition. Therefore, online programs are significantly more affordable for a participating student. While not all students or institutions would be able to afford a full tuition program, there are grants available through organizations such as the National Science Foundation (NSF) and National Institute of Health (NIH) that support education programs for under-represented populations.

Furthermore, while the four components of the program were designed here to complement one another and work together, it would be possible for a different institution to adapt a partial model depending on the resources and desires of their particular institution, which could cut down on costs. For instance, if a school wanted to cut staff costs by minimizing the number of TAs, they could consider cutting out the Journal Club component. Alternatively, given that labs represent a per-capita expense per student enrolled (and thus don't become cheaper with a larger number of enrolled students), a school could consider cutting or re-designing the lab component. In such a model, a school could consider designing their own virtual labs that do not require supplies to be shipped.

One thing to note is that students did report appreciation for the effort of sending the lab kits, saying that it helped them feel like they still got the "experience" of the traditional program. Given this information, another option for cutting costs is that a particular institution could consider keeping some of the less expensive labs while removing or replacing the more expensive ones. As indicated in Table 4, the total cost of lab supplies per student was $43.65 (plus shipping). However, removing just the sheep brain dissection lab would decrease the cost to just $15.25 per student (plus shipping).

When considering the relative cost / value relationship of different components of this program, the sector of the program that received the highest scores was the neuroethics discussion groups. As mentioned above, this component could be particularly valuable in an online summer program targeted at non-traditional students or underrepresented minorities, where a sense of community could be particularly useful to student engagement and retention. This is encouraging, as the relative cost of this component is low since there are no additional tools or supplies needed beyond undergraduate TAs.

Staffing

While a number of staff are required for the current program setup, including lecturers, lab instructors, lab TAs, journal club TAs, and neuroethics club TAs, these positions could all be filled by the individuals at a variety of different types of institutions. The lecturer and lab instructor positions can be filled with current instructional staff from the neuroscience program at that college or university. And the TA positions could be filled by undergraduate students. While our program used graduate students for the Journal Club TA position, we used undergraduates for all of the other TA positions, and they were able to successfully perform their roles. The Journal Club TA position could still be successfully executed by a later-stage undergraduate (Junior or Senior) who has experience working in a research lab and reading journal articles.

One of the advantages of the remote nature of the program was that TAs had greater temporal and geographical flexibility. They were able to schedule their Journal Club and Neuroethics Club meetings at times that worked for their schedule. As a result, these TAs were able to hold other summer jobs or internships and still juggle this commitment. They also did not face the constraint of having to physically be on campus. Therefore, it was easier to find interested TAs than during past in-person iterations of the program. Alternatively, if the quantity of TAs was a concern, an institution could consider a model in which a single TA ran multiple sessions (occurring at different times of day), making it a more substantive commitment for a fewer number of individuals.

Challenges and Shortcomings

While the program was overall a large success, there were several challenges that were faced that should be taken into consideration for future implementation of a remote summer program.

Workload

Despite the workload for this program being similar to past years when the program was in-person, more students complained about the workload during their evaluation than in past years. One potential reason for this is that when the program is in-person, it is largely residential, with the majority of students living on-campus during the program. As a result, students are unlikely to have outside time commitments such as part-time jobs, family engagements, or appointments such as doctors visits that they are trying to juggle with the program. Additionally, residential living on campus encourages a social component to completing the homework for the night (ex. students can study together), which is not possible to replicate remotely. Time zone differences likely exacerbated some of this feeling of additional work and stress as well. For students who were in hardship time zones and were having to stay up very late to participate in the program, additional homework probably felt more draining than usual given how tired they were.

Moving forward, careful consideration should be given to the amount of reading or other work assigned each night, with an effort made to minimize this as much as possible without compromising the learning outcomes of the program.

Time Zones

One of the biggest challenges that some students faced were time zone differences, which presented a challenge for the synchronous components of the class. While efforts were made to provide a variety of meeting times for the small-group synchronous sessions (journal club meetings and neuroethics meetings), and scheduling of the whole-group synchronous sessions attempted to be at a time that could work across a variety of time zones, it was ultimately very challenging to deliver content at a time that worked for every student. While the timing of the program tended to work well for domestic students across the different U.S. time zones, it didn't work as well for international students. Students in China were most acutely affected, as the whole-group synchronous sessions took place very late at night for them.

Looking ahead, it is ultimately difficult to truly accommodate every domestic and international time zone with a remote program that meets synchronously. However, one possibility could be to run a version of the program just targeting students from a particular time zone or range of time zones. For instance, limiting applications to domestic students would allow a program to just have to manage a small range of time differences.

Similarly, an international-focused program could be designed specifically for that group of students. One challenge with this latter option is that this would be taking place at a time that would possibly be challenging for the instructor. However, this could potentially be done in collaboration with a foreign institution. This could help to increase educational access to students in some countries who do not currently have opportunities to addend these types of programs.

An additional possibility would be to allow students in hardship time zones to watch a recorded version of the lecture content. This could potentially be supplemented with an additional short synchronous discussion section based upon watching those recorded lectures that they could attend at a time that works well for their time zone (for instance, a 9pm EST session, which would take place at 10am in China) and that could potentially be facilitated by a student TA. In doing this, the students would miss out on some of the interaction with other students in the program and with the faculty delivering the lectures, but would still allow them to gain the main benefits of the program and have some interpersonal interactions.

Ultimately, if nothing else, it is important for online programs to clearly publish the intended times of their synchronous sessions so that students from different time zones that are enrolling in those programs can make the decision about whether or not those times work for them.

International Shipping

One big challenge that was faced with the lab component of the program was shipping the lab supplies to international students. Domestic shipping went smoothly to students within the United States. However, for international students, the lab supply shipments were subject to customs regulations which presented several challenges. The first challenge was an increased amount of time that the packages take to ship. We anticipated that this would be the case, and shipped international packages out a month before the program began. However, some packages still encountered some delays or holdups.

Additionally, some items were not able to clear customs. The most obvious of these was the Sheep Brains, which were omitted from all of the international lab kit shipments. As a result, the international students had to watch a video of an instructor performing a sheep brain dissection, rather than performing one themselves. While this was just one day's lab, it still is not ideal that some students have a different experience than others. Food-based items (such as jelly beans and sour patch kids) were also not able to be shipped internationally, as they would increase the chances of the package getting held up in customs. Therefore, students were asked to purchase those items themselves. Similarly, the Miracle Berry tablets were shipped to the students directly from a supplier so that they did not affect the customs clearance of our own lab kits. Furthermore, some items additionally encountered more unexpected customs holdups. For instance, the lab kit that was shipped to an international student living in Costa Rica was not able to clear customs because it contained a Wooden Tongue Depressor (used in the Cranial Nerve lab) and Costa Rica requires a special permit to import wood. With additional experience shipping specific items to different international destinations, some of these challenges could be better anticipated in the future, but is something that instructors should be aware of and should plan accordingly.

More Labs

As mentioned above, we did not have hands-on labs for every single day of the program, with some "lab" time being spent watching videos or doing readings. While these videos and readings were still engaging and enriching, they are more similar to other components of the program. Meanwhile, hands-on lab activities provide a different form of pedagogical engagement, and one that has been found to aid in the learning of concepts (DeBoer et al., 2017; Hanzlick-Burton et al., 2020; Ho et al., 2021).

Therefore, moving forward, it would be ideal to be able to incorporate additional hands-on lab activities that could be easily performed at home with the shipment of some simple "lab supplies". Further development of these activities in additional years would provide even more enrichment for the students.

Conclusion

Overall, through the incorporation of Synchronous full-group lectures, Synchronous small-group Journal Clubs, Synchronous small-group Neuroethics Clubs, and Asynchronous lab activities (with a synchronous full-group post-discussion), it was possible to deliver a full-day remote summer program. Student interest in neuroscience was effectively supported. Furthermore, students were introduced to the principles of neuroscientific content, gained experience reading journal articles, and practiced their presentation skills. This is, therefore, a successful format for future implementation of remote full-day summer neuroscience programs.

REFERENCES

Bowen WG, Chingos MM, Lack KA, Nygren TI (2014) Interactive learning online at public universities: Evidence from a six-campus randomized trial. Journal of Policy Analysis and Management 33(1):94-111. doi: 10.1002/pam.21728

DeBoer J, Haney C, Atiq SZ, Smith Smith C, Cox D (2017) Hands-on engagement online: using a randomised control trial to estimate the impact of an at-home lab kit on student attitudes and achievement in a MOOC. European Journal of Engineering Education 44(1-2):234-252. doi: 10.1080/03043797.2017.1378170

Charlton J, Parks D (2021) Penn moves classes online for first two weeks of spring semester, delays campus move-in. The Daily Pennsylvanian, December 23. Available at https://www.thedp.com/article/penn-spring-semester-delay-omicron.

Chirikov I, Semenova T, Maloshonok N, Bettinger E, Kizilcec RF (2020) Online education platforms scale college STEM instruction with equivalent learning outcomes at lower cost. Science advances 6(15):eaay5324. doi: 10.1126/sciadv.aay5324

Deming DJ, Goldin C, Katz LF, Yuchtman N (2015) Can online learning bend the higher education cost curve? American Economic Review 105(5):496-501. doi: 10.1257/aer.p20151024

D'Souza MJ, Fry K, Koyanagi L, Shepherd A (2020) COVID-19 Impacts at a Small Mid-Atlantic Liberal-Arts College with Implications for STEM Education. J Educ Elearn Res 7(4):407-420. doi:10.20448/journal.509.2020.74.407.420

Gould DJ, MacPherson B (2003) Evaluation of an Undergraduate Neuroscience Research Program at the University of Kentucky J Undergrad Neurosci Educ 2(1): A23–A27 Available at https://pubmed.ncbi.nlm.nih.gov/23494130/.

Hanzlick-Burton C, Ciric J, Diaz-Rios M, Colgan W, Gage G (2020) Developing and Implementing Low-Cost Remote Laboratories for Undergraduate Biology and Neuroscience Courses. J Undergrad Neurosci Educ19(1):A118-A123. Available at https://pubmed.ncbi.nlm.nih.gov/33880099/.

Ho Y, Roeser A, Law G, Johnson BR (2021) Pandemic Teaching: Using the Allen Cell Types Database for Final Semester Projects in an Undergraduate Neurophysiology Lab Course. J Undergrad Neurosci Educ 20(1):A102-A112. Available at https://pubmed.ncbi.nlm.nih.gov/35540944/.

Jaschik S (2022) Dealing With COVID-19. Inside Higher Ed, January 3.

Lopatto D (2017) Undergraduate Research Experiences Support Science Career Decisions and Active Learning. CBE Life Sci Educ 6(4):297-306. doi: 10.1187/cbe.07-06-0039

Oliver KH, Keeton C, Chalkley R, Bowman E (2021) Virtual Vanderbilt Summer Science Academy highlighted the opportunity to impact early STEMM students career knowledge through narrative. PLoS One 16(11):e0258660. doi: 10.1371/journal.pone.0258660

Porter WW, Graham CR, Spring KA, Welch KR (2014) Blended learning in higher education: Institutional adoption and implementation. Computers & Education 75:185-195. doi: 10.1016/j.compedu.2014.02.011

Ramos RL (2021) Continued Challenges for Neuroscience Education During the COVID-19 Pandemic. J Undergrad Neurosci Educ 20(1):E12. Available at https://www.ncbi.nlm.nih.gov/pmc/articles/PMC9053431/.

Ruiz R, Sun J (2021) Distance Education in College: What Do We Know From IPEDS? NCES Blog, February 17. Available at https://nces.ed.gov/blogs/nces/post/distance-education-in-college-what-do-we-know-from-ipeds.

Rosenberg M, Oza A (2021) Cornell Shuts Down Campus Facilities, Moves Finals Online. The Cornell Daily Sun, December 14. Available at https://cornellsun.com/2021/12/14/cornell-shuts-down-campus-facilities-moves-finals-online/.

Russel SH, Hancock MP, McCullough J (2007) The pipeline. Benefits of undergraduate research experiences. Science 316(5824):548-9. doi: 10.1126/science.1140384

Wallis L (2020) Growth in Distance Learning Outpaces Total Enrollment Growth. State of Oregon Employment Department: Asset. Available at https://www.qualityinfo.org/-/growth-in-distance-learning-outpaces-total-enrollment-growth.

Yates JR, Stavnezer AJ (2014) Engaging Undergraduate SummerResearch Students and Faculty in a Regional Neuroscience Network. J Undergrad Neurosci Educ 13(1):A45-A5. Available at https://pubmed.ncbi.nlm.nih.gov/25565919/.

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Address correspondence to: Dr. Kristen A. Hipolit, Critical Writing Program and Neuroscience Summer Research Academy, McNeil Building, 3718 Locust Walk, Room 116, University of Pennsylvania, Philadelphia, PA 19104. Email: malkus@sas.upenn.edu

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APPENDIX 1
Lecture Topics

Day	1	2	3	4	5	6	7	8
Morning Lecture	Introduction & Program Welcome	The Resting Potential	The Synapse	Neuroanatomy 1	Drugs: Opioids	Neuroanatomy 2	Taste	The Visual System 2
Afternoon Lecture	Fundamentals of the Brain and Neurons	The Action Potential	Neuro-pharmacology	The Somatosensory System	Drugs: Alcohol	Olfaction	The Visual System 1	The Auditory System

Day	9	10	11	12	13	14	15
Morning Lecture	Language	Sleep	Sex and Hormones 2	Moral Decision Making	Learning and Memory 2	Brain Development & Developmetal Disorders	Anxiety and Depression
Afternoon Lecture	Emotion and the Limbic System	Sex and Hormones 1	Stress	Learning and Memory 1	Song Learning in Birds	Autism Spectrum Disorders	Attention

APPENDIX 2
Neuroethics Topics and Readings

Neuroethics Topic	Readings
Artificial Intelligence	"There is a blind spot in AI research" by Kate Crawford and Ryan Calo
	"Four ethical priorities for neurotechnologies and AI" by Rafael Yuste and Sara Goering
Neuromarketing	"Neuromarketing could make mind reading the ad-man's ultimate tool" by Nick Carr
	"Neuromarketing: Ethical Implications of its Use and Potential Misuse" by Steven J. Stanton, Walter Sinnott-Armstrong, and Scott A. Huettel
Disorders of consciousness and when to terminate care	"Forty Years of Work on End-of-Life Care — From Patients' Rights to Systemic Reform" by Debra Malina
The opioid crisis	"Primary Care and the Opioid-Overdose Crisis — Buprenorphine Myths and Realities" by Sarah E. Wakeman and Michael L. Barnett
	"The Prescription Opioid and Heroin Crisis: A Public Health Approach to an Epidemic of Addiction" by Andrew Kolodny, David T. Courtwright, Catherine S. Hwang, Peter Kreiner, John L. Eadie, Thomas W. Clark, and G. Caleb Alexander
The COVID-19 Pandemic and Mental Health	"Mental Health and Clinical Psychological Science in the Time of COVID-19: Challenges, Opportunities, and a Call to Action" by June Gruber et al.
	"Op-Ed: The kids who aren't all right — the pandemic's lasting toll on youth mental health" by Lala Tanmoy Das
How expectations shape performance: The Pygmalion effect and Implicit bias	"Teacher Bias: The Elephant in the Classroom" by The Graide Network
	"Why do we Perform Better When Someone Has High Expectations of Us?" by The Decision Lab
Does free will truly exist?	"There's No Such Thing As Free Will" by Stephen Cave
	"Neuroscients Says Humans are Wired for Free Will" by Bill Platt
Trauma across generations	"A Painful Legacy" by Andrew Curry
	"Breakthrough: The Trauma Tracer" Video by Science Friday (available on YouTube)
	"What is Epigenetics?" From the CDC
Mental illness and autonomy in regards to consent	"Influence of Psychiatric Symptoms on Decisional Capacity in Treatment Refusal" by Joshua M. Baruth and Maria I. Lapid
	"Incapacity to give informed consent owing to mental disorder" by C W Van Staden and C Krüger
Neurolaw: The brain in court	"Can we Predict Crime Using Brain Scans" by Joshua Gowin
	"How I Discovered I Have the Brain of a Psychopath" by James Fallon
	"Lighter sentence for murderer with 'bad genes'" by Emiliano Feresin
Smart Pills	"Like It or Not, "Smart Drugs" Are Coming to the Office" by Carl Cederström
	"The Quest for a Smart Pill" by Steven S. Hall
Memory erasing	"Erasing Painful Memories" by Jerry Adler
Should autism be cured?	"How About Not 'Curing' Us, Some Autistics Are Pleading" by Amy Harmon
	"Parents of children with autism on what a 'cure' means to them" from "The Guardian"
	"The "Cure" for Autism, and the Fight Over It." by John Elder Robison
Ecstasy and psychedelics as treatments for psychological disorders	"The Rise of Psychadellic Psychiatry" By Paul Tullis
	"A psychedelic drug boom in mental health treatment comes closer to reality" by Eric Rosenbaum