A Summer Program Goes Online: How BEAM Served Students from Marginalized Backgrounds During COVID

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Cover Page Footnote
We would like to thank the BEAM community for working tirelessly to make BEAM Summer 2020 happen. We would also like to thank Dan Zaharopol and Stevie Bujold for their editing support, and many other BEAM staff for contributing to the development of the article.
A Summer Program Goes Online: How BEAM Served Students from Marginalized Backgrounds During COVID

Ramya Ramaswamy* and Javier Ronquillo Rivera

1Bridge to Enter Advanced Mathematics

Most summers, Bridge to Enter Advanced Mathematics runs free summer programs for mathematically talented middle school students from low income, historically marginalized communities. Our programs are designed to deepen students’ problem solving and mathematical reasoning skills, to foster their love of math, and to build a community centered around peers all interested in mathematics.

This summer, in response to the pandemic, we made the decision to shift our summer programming online and operate virtually for the first time. We crafted a program that we hoped would sustain many of our original programming goals.

This paper outlines the decisions made, the variables that affected implementation, and the learnings gained as a result of running our programs for rising 8th graders virtually. Utilizing student feedback as recorded by staff members during and at the end of the summer to note overall trends, this paper highlights topics such as virtual learning structures, student engagement, technology, and academic and non-academic community building.

Keywords: Summer, online, enrichment, math

1 Introduction

Bridge to Enter Advanced Mathematics (BEAM) is a nonprofit organization that works to create pathways for students from low-income and historically

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marginalized communities to become scientists, mathematicians, engineers, and computer scientists. BEAM’s academic offerings are focused on access to advanced mathematics, which is often a barrier to success for STEM majors. The organization also works to foster positive self-identity, joy in doing mathematics, and community among its students. Since its founding ten years ago, BEAM has built a longitudinal program that supports students from 6th grade through college graduation with programs in New York City and Los Angeles. BEAM is also in the process of building a national initiative that will both reach students beginning at a younger age and increase the range of access to BEAM’s programs nationwide.

Most summers, BEAM runs free summer programs in New York City and Los Angeles for mathematically talented middle school students. The programs balance discovering deep and interesting math through classes taught by experienced faculty and becoming a part of a community of peers all interested in mathematics. The summer programs continue into year round programming with the goal of preparing students academically, socially, and emotionally to continue to other programs for advanced study with more affluent peers, and to go to college and succeed in STEM majors.

In 2020, in response to the COVID-19 pandemic, BEAM made the decision to shift its summer programming online and operate virtually for the first time. We then crafted a program that we hoped would sustain many of our original programming goals. The aim of this paper is to share takeaways from our first summer running virtually in the hopes that it will benefit organizations, schools, programs, and individuals hoping to run similar programming. We hope by candidly discussing our challenges and adjustments, we will contribute to the overall learning of the mathematical community. For more about lessons learned and adjustments made at BEAM’s 2020 Virtual Discovery program, our program for rising 7th graders, see the whitepaper referenced in the References section.

2 Overview of BEAM’s Programmatic Goals

People from low-income and historically marginalized communities are dramatically underrepresented in science, technology, engineering, and math (STEM), which has serious ramifications for their individual success and for society. In 2016, Black students earned just 1.8% of all physics doctorates, 3.8% of all mathematics and statistics doctorates, 3.7% of all doctorates in computer science, and 4.1% of all doctorates awarded in engineering. Roughly 13% of the US population is Black [2].
In 2015, 2016, and 2018, the U.S. won the International Math Olympiad (and tied for first with China in 2019); each year, all six team members were white or Asian (and male). In New York City, the percentage of seats in specialized high schools offered to Black and Hispanic students continues to drop [4]. While Black and Hispanic students represent 70% of the public school system, they make up only 10% of the enrollment in specialized high schools, the nine selective public high schools, established and run by the New York City Department of Education to serve the needs of academically and artistically gifted students. On the National Assessment of Educational Progress, a low-stakes nationally representative assessment, only 1.78% of Black 8th graders and 3.63% of Hispanic 8th graders score at the Advanced level, while 12.93% of white 8th graders and 31.89% of Asian 8th graders score at this level. By 12th grade, the percentage scoring at Advanced has dropped to a staggering 0.65% of Hispanic students and 0.25% of Black students [5].

Bridge to Enter Advanced Mathematics (BEAM) works specifically to create realistic pathways for students from low-income and historically marginalized communities to do advanced study in STEM. BEAM focuses on students within communities whose families may not be “in the know” on enrichment opportunities or the benefits they afford. High-income households are able to invest significantly more in their children’s education and enrichment than low income households. In fact, families in the top income quartile spend more than six and a half times as much money on enrichment as families in the bottom quartile (a gap that has surely widened during the COVID pandemic) [3].

The students who attend BEAM represent a very different group than is typically seen at advanced math programs. The majority of BEAM students come from 35 partner schools across New York City and 13 in Los Angeles, all in high-need areas.¹ In 2020, 80% of students identified as at least one of African American, Latinx, or Native American, and 85% of students reported family income, under federal guidelines, to be eligible for free or reduced-price lunch. The median family income is $27,000. Seventy percent will be the first in their families to go to college.

Zaharopol (2020) further describes the organization:

¹BEAM defines ‘high need’ using a combination of family financial resources and student math access. Typically, family financial resources are calculated from household income and students’ math access is determined by their school’s math classes and performance on district-based assessments. BEAM makes a particular effort to draw students from Black, Latinx, and Native backgrounds by intentionally seeking partnerships with schools that serve these communities.
[BEAM works to build] a vibrant, engaging, and challenging environment for studying mathematics, which is a critical foundation for all STEM subjects. Throughout BEAM’s work with students (from 6th grade through college graduation), the emphasis is on building abstract thought, mathematical reasoning, and problem-solving skills. BEAM’s initial summer programs (BEAM Discovery and BEAM Summer Away) focus on doing challenging mathematics to prepare students for continued advanced work. Thereafter, weekend programs provide mathematical content and broader academic skills while students are encouraged to join other STEM programs based on their individual interests.

Beyond academics, BEAM works to build students’ identities as mathematicians. BEAM seeks to develop a community of young people who enjoy math (“kids like me”) who will stay friends and support one another following the program. Thus, each BEAM program is designed with two distinct goals in mind: one goal is about the development of academic skills that students need to be successful; the other is about building a sustained community and fostering social and emotional growth.

BEAM’s programmatic goals were strongly considered when building virtual programming. To understand the programmatic choices for Virtual Summer Away, we find it valuable to first know the components of the in-person program.

3 BEAM’s Summer Programs Before the COVID Pandemic

BEAM Summer Away is a three-week, residential summer program for rising 8th graders. At Summer Away, students dive deep into real proof-based mathematics (they do seven hours of math a day), build a rich community of peers genuinely interested in math, develop independence, and have fun. It is also the beginning of nine years of committed support through the BEAM Pathway Program. BEAM’s programmatic goals are represented in the program design of Summer Away. Below are some of the highlights of the program:

- **Student choice and program variety.** Choice is central, helping students learn to budget their time and take responsibility for their education. At Summer Away, students choose a different topics course each week, which cover topics in theoretical and applied mathematics — for example: graph theory, logic, combinatorics, or astronomy.
Students also experience a large variety of non-mathematical programming over the summer. Students have at least two hours of activities a day, where they can participate in familiar activities like basketball and crafts, as well as popular pastimes in math communities (like chess and Rubik’s cubes). Students not only select their activities, but often campaign for activities that meet their interests.

- **Rigorous and challenging mathematics.** There are many out-of-school STEM programs for students from low-income and historically marginalized communities; however, few are focused on pursuing advanced math. Many prioritize remedial instruction that develops basic skills needed for passing state tests; others focus on building interest in STEM, without presenting deeper mathematics [7]. However, research shows that mathematics is a key gateway to STEM fields. The President’s Council of Advisors on Science and Technology wrote in their 2012 report, Engage to Excel, that “closing the mathematics-preparation gap would enable many more students interested in STEM fields to attain STEM college degrees” [6].

To be admitted to BEAM’s programs, students take an Admissions Challenge for both 6th and 7th grade programs that requires minimal grade level content knowledge and is instead designed to primarily assesses three components: “insight [that] students have into difficult problems; their stamina for challenges; and their interest in solving such questions”[7]. In addition to the Admissions Challenge, prospective Pathway students are also considered based on the strength of their end-of-program reviews submitted by staff members who interacted with them at the 6th grade BEAM Discovery program that the majority of them attended, and their continued interactions with BEAM during their 7th grade school year. These reviews and ongoing interactions factor into admissions because, at the point of being accepted to BEAM Pathway Program, BEAM is making a commitment to support students for up to nine years, beginning with Summer Away, and prioritizes students who display evidence of being able to take advantage of the program opportunities.

For many BEAM students, these summers are the first time they are truly challenged mathematically. At the beginning of their time at both programs, students are asked: “What is the longest you have ever spent on a math problem?” This question shows how much students are ready for more challenge.
For BEAM Discovery 2019 (the most recent year of in-person programming) students the median answer went from 57 minutes at the start of the program to 5 hours at the end of the program, with 34% reporting an answer in days by the end of the summer. Most BEAM Summer Away 2019 students had already attended a BEAM program during the previous year. Thus, the median answer for how long these students had spent on a single math problem was already two days at the beginning of the summer. By the end of the summer, though, it still grew; the median increased to three days.

At Summer Away, students are tackling real proof-based mathematics; the style of instruction and type of mathematics taught are designed to mirror other programs for advanced study so our students are prepared to continue to other programs for advanced study. In addition to topics explorations, students have a problem-solving block each day; students either explore more abstract and proof-based problems that may require several hours or even days of thought and experimentation, or are introduced to contest-style problems and how to approach them.

- **Joy in Mathematics.** Doing math is a joyful activity at BEAM. Classes are highly collaborative and are designed to engage students’ natural interest and curiosity. At Summer Away, students pour energy into the proof-based Challenge Problems, which are presented as challenges to the whole program to solve collaboratively, with prizes given based on their solutions. Students also participate in relays, a fast-paced math competition-style activity that has students working either collaboratively to achieve team goals, or competitively to vie for first place.

- **An expanded mathematical community.** Outside of formative peer-to-peer relationships, students also become close with BEAM staff. At BEAM, students address adults by their first name; this is done to differentiate the environment from school, as well as to expedite the process of students becoming comfortable with staff.

Faculty for the programs consist of college professors, school teachers, and STEM professionals. This mix creates a vibrant atmosphere with diverse strengths among the instructional staff: a clear-eyed view of the importance of pushing students academically, and a deep knowledge of how to support students in developmentally appropriate ways. Meanwhile, our counselors are primarily undergraduates majoring in STEM fields. They serve as teaching assistants, work with students outside of class, lead activities, and form close bonds with the students, acting as
near-peer role models. BEAM recruits nationally for both roles: Summer Away staff for three sites hailed from 22 states and the District of Columbia in 2019, and 27 states and the District of Columbia in 2020.

BEAM encourages our students to talk about math with faculty both in and out of the classroom, leading to informal conversations over lunch, during evening free time, or after a soccer game. Faculty, counselors and students do mathematics together all the time, sometimes participating in activities like relays alongside each other. The academic and non-academic feed into each other to create a community that grows together, thanks to each other, mathematically and personally. BEAM also invites mathematicians and other STEM professionals to share their mathematical work at the program, both by giving talks and by interacting with students informally at meals and in other environments. Recent speakers have included Edray Goins (Pomona College), Nathan Alexander (Morehouse College), Anisah Nu-Man (Ursinus College), and Andrew Lee (St. Thomas Aquinas College).

• A unique once-in-a-lifetime experience. While there are many academic programs that serve low-income and historically marginalized students at no cost, these programs are often budget-constrained. They often utilize subsidized food programs to provide free meals to students and have limited off-site experiences. BEAM aims to re-create the specialness present at elite STEM math programs; while the program is free, we want it to feel expensive. Summer Away students live on a college campus a few hours away from their city. For many students, this is their first experience being away from home; students sleep in the residential dorms and eat at the dining halls. On days off, students have field trips like Six Flags, a water park, and going on a hike. The goal of these trips is to expose students to potentially new experiences and to give them powerful memories to carry into the school year, as their peers ask, “What did you do this summer?”

4 Maintaining the Unique Programmatic Experience

Using our in-person programming goals as guideposts, BEAM began to design our virtual programs. We created several staff-led committees, each in charge of different aspects of the program. For example, committees focused on topics like technology, classes, other academics, and community-building activities.

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2BEAM is a non-profit supported by a mix of individuals and private foundations.
These committees operated independently but with frequent collaboration. Because they involved many of our instructors and counselors, many staff entered as “experts” in one area of the program or another, and they built buy-in for our solutions. They also helped us successfully implement a complex program well from the beginning, rather than scaling down our ambitions for the summer.

In short, by engaging our staff deeply in the planning process, we ensured that they had a deeper understanding of why we made each choice we did and the ins and outs of each element of the program. This did come at the cost of staff bandwidth; many full-time staff reported feeling overstretched by the time programs began. We strove to maintain the unique experience that drew students to BEAM. Ninety-four percent of students at Virtual Summer Away were returning to BEAM programs; they had attended BEAM Discovery, our non-residential program, in summer 2019.

Table 1

<table>
<thead>
<tr>
<th>City</th>
<th>Number of Students</th>
</tr>
</thead>
<tbody>
<tr>
<td>Los Angeles (1 site)</td>
<td>39 out of 40</td>
</tr>
<tr>
<td>New York City (2 sites)</td>
<td>81 out of 87</td>
</tr>
</tbody>
</table>

Students not only had familiarity with the program and its culture, but with other peers and BEAM staff. This served as a benefit in some ways: many students already trusted BEAM and its staff. On the other hand, much of what students were looking forward to with Summer Away had to do with its in-person experience: doing math collaboratively, living on a college campus, and weekend excursions. During the admissions season, our staff was peppered with questions about how much math they would do each day, or if they could pick their roommates on campus. Hence, when Summer Away moved online, we focused on building a program that students would still be excited to log into each day, despite the loss of the in-person experience.

Prior to the start of the program, students received care packages filled with materials needed for their classes and activities such as their laptop and other technology accessories, a yoga mat and origami paper. Students also received care packages mid-program with additional activities supplies and any materials they would need for the second half of classes. At the end of the program, BEAM made a similar effort to celebrate the community in
a memorable way that often did not involve additional cost. For example, to close out the program, Summer Away students put on a virtual talent show, and displayed talents like TikTok dances and shared skills learned from activities like American Sign Language.

A few weeks after the end of Virtual Summer Away, students were mailed BEAM summer t-shirts and invited to a reunion pizza party, where food was delivered to students and they did activities over Zoom. Older alumni of our program have often shared that their relationships with peers are some of their biggest takeaways from the program; by having a post-summer event, we are able to support students in continuing friendships that began during the program.

It is worth noting that these experiences were logistically difficult to coordinate and required a large amount of staff labor; for programs with more limited resources, we recommend selecting just one or a few ways of investing in student experience. However, we found that finding specific and tangible ways to invest in students at a virtual program was important to making the program, and therefore the experience, feel real. These experiences built and maintained excitement about the program, and demonstrated to the students that they were valued at the program, which strengthened their own investment in BEAM.

5 Holistic Student Support

BEAM’s programs have always considered what supports the students we serve may need that might vary from those that serve more affluent students and those in majority groups; historically, we do this through actions like providing transportation to and from our programs, welcoming families to visit with the understanding that this might be the first time students have been away from home, and extra support with paperwork and other necessary bureaucracy. In the summer of 2020, in addition to typical considerations, we also noted the fact that we were supporting students in the midst of a pandemic and a national racial reckoning. BEAM sought to integrate holistic student support into staff training, student support, and program structure.

5.1 Increased focus on race equity training for staff

Staff pre-program training for BEAM’s virtual summer was divided into three parts: staff procedure and policy manuals for staff to read, pre-recorded training videos for staff to watch and answer questions about, and “live” training on Zoom for staff to engage in. In an effort to create an affirmatively anti-racist
educational environment for students and staff, BEAM placed an increased focus on developing our staff’s race equity understanding.

Even prior to the pandemic, BEAM had already planned to offer a free book from a pre-selected list of readings for each staff member prior to the summer; by offering several options, each staff member could direct their own development. In addition, because of the pressures students were likely feeling from the national focus on systemic racism, BEAM hired an outside facilitator to provide trauma responsive training for staff. The training covered topics such as recognizing physical and emotional manifestations of trauma and educators’ roles in providing trauma-responsive care.

Based on staff surveys, 66% of staff shared that the trauma-informed training contributed to their preparation for the program, but others noted that it did not contribute very much, as they had received similar trainings prior. For Summer 2021, BEAM utilized this feedback and allowed staff to guide their own learning by providing them with a menu of training options that ranged from trauma-responsive care to uncovering implicit biases to deepening mathematical conversations in the virtual classroom.

5.2 Family communication and support

In both in-person and online programs, BEAM works to make communication with families accessible and welcoming. We provide all materials and information sessions in English and Spanish, as well as other translations as needed. We also communicate with families during registration to ensure that forms are easy to fill out; for example, because families are required to share financial documentation to demonstrate program eligibility, the registration coordinator sometimes scheduled phone calls with families to help talk through options like pay stubs that can count as financial documentation, if tax documentation is not available.

For Virtual Summer Away, our pre-program registration materials included a number of questions about students’ home environment so that we could customize the program to their needs. For example, some of the questions included:

1. Do you have a quiet place to work?

85% reported that they do have a quiet place to work, while 8% said no and 7% did not respond. Access to a quiet space was important for two reasons. First of all, if a student’s surroundings were distracting, that would affect their focus. Background noise may also make students less likely to engage and use their microphone or camera, because they might be worried about drawing attention to themselves.
2. Is there anything about your family or your home situation that you would like us to know? We will keep confidential any information you disclose.

Families shared information such as adults’ change in employment status, other household responsibilities students might have during program hours, and more.

Gathering this information was a helpful starting point for navigating interactions with students and families. While we generally worked to preserve student privacy, we shared information with relevant staff members (such as class instructors or check-in group leaders), and site directors had access to the information for context in any conversations with the students’ families.

To address economic gaps that might prevent some students from fully engaging with the program [1], BEAM decided to redirect sections of the program’s summer budget. Instead of money going towards food, transportation and housing, BEAM provided each student and staff member who needed it with:

- A 2-in-1 laptop computer with a strong processor (and notably, ability to utilize virtual backgrounds if students were uncomfortable displaying their homes)
- A stylus
- A directional headset (for clear audio communications even in noisy environments)
- A mobile hotspot device provided by BEAM (for students without reliable at-home internet access)

Students were able to keep their laptops and other devices after the program ended, to support them with schoolwork and with ongoing remote learning. Additionally, to alleviate food insecurity, BEAM provided families with Visa gift cards at the beginning and middle of the program to be used towards food, or whatever other needs the family may be experiencing.

We understand the significant amount of funds we were able to put towards supplies is not possible for many out-of-school programs. We share this to emphasize the tools and supports prioritized for making the virtual experience a positive one. And, while we tried to alleviate some of the challenges students were facing, it simply was not enough to equalize student environments. Many
students still faced challenges in participating in a virtual program while in a non-school environment.

Below are several examples from faculty members’ end-of-program reports on students:

- [Student] felt uncomfortable with all the noise in her house, that is why she kept her microphone off almost all the time and she preferred writing in the chat. One day she went into the break out room just with the counselor (no other students) and then she unmuted herself and worked with [TA]. She did a great job discovering the bijection between the factor of a number smaller than the square root of the number and the factors of such number larger than the square root of the number. When she came back to the big group she unmuted herself briefly and explained a bit of what she discovered.

- [Student] was so quick in class! He was always quick to respond, and he understood the logic terms quickly too! He was also a very responsive student. Every once in a while, he would have to go help one of his siblings, but he would always ask before leaving class (even though I tried to tell him he didn’t need to ask!) [Student] missed a class due to family circumstances. [The] next day I asked him if he want[ed] to catch up in the main room with me while other students worked in the breakout rooms. He was very enthusiastic, caught up on operations in different mods very quickly, and worked independently very hard. He asked excellent questions and came up with lots of patterns and shortcuts. I think he would have been amazing in the class if his family situation would not have such an impact.

5.3 Communications-focused attendance policy

Normally, BEAM Summer Away has full attendance because it is a residential program. However, we had to develop an attendance policy for Virtual Summer Away as follows:

- Students received full attendance if they attended two classes (where students explored proof-based mathematics within faculty-chosen topics), modules (where students reinforce and expand their understanding of school-based math), and one activity.
• BEAM’s online attendance policy recorded partial (half-day) attendance; students who attended only one class were given only half-day attendance.

• Students who were absent four full days or fewer were marked as receiving full dosage of the program. Full dosage also excluded the first day of the program, when technical issues prevented some students from joining easily.

Across all Virtual Summer Away sites, the full dosage completion rate was 73.6% (although 94% of students who began the summer continued attending through the end even if they had four or more absences). The attendance rate was 92.3% among students who received full dosage. For context (not comparison, as completion was defined differently for in-person programs), the completion rate among students during 2019 in-person Summer Away program was 100%, as it is a residential program.

When designing an attendance policy, BEAM decided to have an attendance policy that focused on high dosage, while allowing flexibility; students were expected to attend all mandatory parts of the program and were strongly encouraged to try optional blocks at least once. This allowed students to experience a variety of choices present at the program, while making decisions that worked best for them. In particular, BEAM designed the schedule so that much of Wednesday was optional blocks of non-class sessions like Office Hours, Career Day, and relays; students who needed mid-week breaks were able to take them during parts of the day, while students who were energized by logging in were able to do so.
Table 2

2020 Virtual Summer Away schedule

<table>
<thead>
<tr>
<th>TIME</th>
<th>ACTIVITY</th>
<th>TIME</th>
<th>ACTIVITY</th>
</tr>
</thead>
<tbody>
<tr>
<td>9:00am–9:15am</td>
<td>Morning check-in</td>
<td>9:00am–9:15am</td>
<td>Morning check-in</td>
</tr>
<tr>
<td>9:20am–11:15am</td>
<td>Academic block 1</td>
<td>9:20am–10:15am</td>
<td>Math Circles or Career Day</td>
</tr>
<tr>
<td>11:20am–12:20pm</td>
<td>Activity (mandatory 1x a day, students may choose between morning and afternoon)</td>
<td>10:20am–11:15am</td>
<td>Office Hours: morning classes (optional)</td>
</tr>
<tr>
<td>12:20pm–1:15pm</td>
<td>Lunch</td>
<td>11:20am–12:20pm</td>
<td>Activity (optional)</td>
</tr>
<tr>
<td>1:20pm–3:15pm</td>
<td>Academics Block 2</td>
<td>12:20pm–1:15pm</td>
<td>Lunch</td>
</tr>
<tr>
<td>3:20pm–3:35pm</td>
<td>Afternoon check-in</td>
<td>1:20pm–2:15pm</td>
<td>Relays (mandatory first week, then optional)</td>
</tr>
<tr>
<td>3:40pm–4:40pm</td>
<td>Activity (mandatory 1x a day, students may choose between morning and afternoon)</td>
<td>2:20pm–3:15pm</td>
<td>Office Hours: afternoon classes (optional)</td>
</tr>
<tr>
<td>4:50 pm–5:50 pm</td>
<td>Bi-weekly staff meeting</td>
<td>3:20 pm–4:20 pm</td>
<td>Time to watch assembly videos or take surveys (time is optional, completing tasks is mandatory); Bi-weekly staff meeting</td>
</tr>
</tbody>
</table>

In order to support a variety of circumstances, BEAM was in regular communication with families and students to determine if a student’s situation warranted an excused absence. This level of communication often took significant staff time; TAs were often contacting families at the beginning of classes and activities, which unfortunately took them away from their classroom duties.

We encountered several additional challenges with this attendance plan. First, unlike in-person programs where students had minimal outside distractions, students were pulled in different directions because they were learning at
home. Some students were babysitting younger siblings during program hours, while others were called away from class for household responsibilities. Some families saw the non-academic portions of the program to be wholly optional (when, in fact, check-ins and one activity per day were mandatory), which led to inconsistent attendance throughout the program for some students.

There were also circumstances that were difficult to predict: on one of the program days in Los Angeles, staff reported student disengagement in class; students were arriving late and were generally unfocused. When staff probed, students said the heatwave in LA was making it challenging for them to work. In response, faculty adjusted their courses to be more relaxed for the day, and the attendance policy took the heatwave into account by excusing lateness or explained absences. In conclusion, we found that creating a program that prioritized flexibility and understanding was the right choice during this tumultuous time but was at the cost of staff time and more consistent attendance.

5.4 Check-in groups

At the end of the day at in-person programs, students have a nightly hall meeting where they check in with their peers and counselors who live on the same floor. This is a time to share announcements, discuss what happened that day or what is coming up, and play games and enjoy time together before lights out. In an effort to replicate these interactions, Virtual Summer Away students had twice-daily morning and afternoon check-ins with a consistent small group of counselors and peers throughout the summer. Check-ins were often structured and covered a wide range of topics, ranging from playing social games, to talking about famous mathematicians from underrepresented groups, to sharing favorite songs and YouTube videos.

The rapport developed in this space was seen in other parts of the program. Relays, for example, are typically highly-energetic math competitions at in-person programs; students opt to participate in competitive teams, where they compete to solve the most problems, or collaborative teams, where they seek to reach a set goal number of problems solved. At virtual programs, staff saw the most engagement and student-to-student collaboration when students competed with their check-in groups.

While check-in groups were found to be very successful, BEAM has several learnings that have led to adjustments for our second virtual summer. Virtual check-ins were 20-minutes long, while hall meetings tended to be 30 minutes long, with flexibility to go longer for chattier halls. The virtual check-in scripts were written for counselors with the intention of creating as little additional
work as possible; this led to check-ins being relatively structured and quite brief, as often a few minutes were given at the beginning for students to join the call. While this required minimal planning and allowed counselors to efficiently pass along information, it did not replicate the informal conversational flow of hall meetings, where relationship building occurred with more freedom and a greater amount of time.

5.5 One-on-one conversations

We found that scheduling or seeking out individual conversations with students allowed staff to have a better understanding of students, and provided a safer space for students to share more about themselves. BEAM met with students individually in a few different settings. Before Virtual Summer Away began, counselors met with each student in their check-in groups individually to introduce themselves, help students set up their computer, and orient students to the various platforms they would use at the program. The counselor also played a “get to know you” game with the student and discussed students’ excitements or fears about the program. Family members sometimes dropped in to ask additional questions or introduce themselves; this created an atmosphere similar to BEAM’s family welcome lunches which were typically held in spring to orient admitted students to the program and answer questions. Last, these check-ins gave counselors the opportunity to follow up on any concerns or notes that families left in registration forms; for example, for students who noted that they don’t have a quiet space to work, counselors may help them plan how to stay focused in a louder environment.

By the end of the student check-in, BEAM’s goal was for students to know they had a staff member who knew their name and was expecting to (and excited to!) see them on Day 1. We found this to be especially important prior to programs beginning because of some of the engagement challenges we faced during programs; if students were hard to get in touch with, or missed class one day, we had additional information from conversations, as well as staff members who had strong relationships with the students and may be the best people to reach out.

Students also had the opportunity to engage with staff in Wednesday Office Hours. Office Hours served multiple purposes. Office Hours provided an additional time and place for students to seek academic support; as faculty adjust to being able to note student confusion in a virtual classroom and as students adjust to comfortably verbalizing their questions, having an additional space to seek help was important. Relatedly, Office Hours fostered student independence, building their confidence and preparing them for similar academic
structures they will encounter in their college career. Last, Office Hours provided time for faculty/student relationship building, which was a piece that happened organically at in-person programs. In the online format, faculty rarely interacted with students outside of the class setting, unless they opted into non-academic parts of the day. Staff reported that Office Hours provided a more informal and social space where staff and students could explore problems and play games together. Below are excerpts from staff’s end-of-program comments on student engagement with Office Hours.

- [Student] was the only student present in [Office Hours] ... during the last Wednesday. She asked great clarifying questions about tilings and making triangles with six line segments. However, what was even more memorable was the fact that she stayed after her questions to just chat with [the faculty member] and I [TA]. I will cherish that time because I felt like I learned a lot about [student]!

- [Student]’s questions were on point — during week 3, she was ill on Tuesday and missed the class where we introduced coding in python for the first time. She came to office hours on Wednesday, and worked with me 1-on-1 — in an hour, she more than made up the material she missed, and asked so many insightful, thoughtful questions along the way.

- [Student] was the only student to come to Tessellations office hours in the second week, and she was FULL of incredible questions that made it clear she was really absorbing and reflecting on the material. She asked about the conditions under which non-regular polygons could form tessellations (something we didn’t have a chance to get to in class due to time constraints) and so we spent a whole hour experimenting in GeoGebra and developing some ideas about the differences between quadrilaterals, pentagons, and hexagons in this regard. We had a lot of fun!

Attendance at Office Hours was generally low, as was attendance with many optional blocks. While we found the time valuable, we think that billing it as a less structured time to do math students are interested in (which is, in fact a scheduled block called Open Math Time at BEAM Discovery) may appeal more to students, who we suspected may have a minimal or negative relationship with the term Office Hours. Other faculty also considered that it was not students who had a relationship with the phrase “Office Hours,” but
faculty themselves; some were self-imposed college-style Office Hours because of the name and its typical framework.

6 Community Building and Risk Taking

Much of BEAM’s programming focuses on the idea of mathematics being challenging, and that same challenge being what drives fun. Students at the beginning and end of the program are asked how long they’ve ever worked on a problem; this shows growth in stamina and increased persistence in problem solving. In 2020, the median answer at Virtual Summer Away went from two hours at the beginning of the summer to five hours at the end of the summer. Although we are pleased with this outcome (the time more than doubled!), it is still substantially lower than typical outcomes at in-person programs, which often result in answers measured in days.

For many students at the program who have been highly successful in their school math classes, struggling with mathematics could be viewed as embarrassing. One of the main ways we enable risk taking at the program is via community building; when students are surrounded by peers, near-peer mentors, and faculty that enable a feeling of belonging, we have found they experience an increase in self-confidence. BEAM designed the program structure and components, and introduced the chat platform Zulip, as tools for community building.

6.1 Designing a balanced schedule

When designing the schedule, BEAM considered the balance of giving students flexibility and choice with group cohesion. We know that group cohesion is likely easier in programs where students move from class to class together and participate in the same activities. But, this comes at the cost of students choosing their classes and schedule flexibility. BEAM prioritized choice and flexibility in the schedule, and relied on engaging and collaborative classes and the chat platform Zulip to create a strong community.

BEAM created a flexible schedule for students and staff. For students, the schedule had a balance of mandatory and optional blocks; on class days, students were able to select between one of two activity blocks and could opt into the lunch block. Wednesday was a non-class day and was designed to hold many of the optional blocks for students. Students were able to participate in relays, Office Hours, and special events like Career Day, guest speakers, and high school and college panels. These choices were often required for the first round, then optional afterwards; this encouraged students to explore the
choices available, while having the agency to opt out when they needed to take breaks. Wednesdays were also important for instructors, many of whom were newly adapting to teaching online; they were able to use this day to reflect on their class and make adjustments needed before continuing teaching on Thursday and Friday. We found that the optional blocks had lower attendance, and that families were often unsure about what parts of the program were mandatory and what was optional; in particular, families sometimes assumed that all non-academic portions of the program were optional.

Both students and staff had choice at Virtual Summer Away. On their registration paperwork, students were able to note if they preferred mixed-gender or single-gender check-in groups, and what level of energy they preferred their check-in groups to have (high energy or quiet and reflective); this was done with the goal of creating groups that students would be more comfortable in from the beginning, as well as introducing them to potential friends that shared their energy level. Just like at in-person programs, students ranked their preferred classes prior to the program and chose their activities on a daily basis; this exposed students to the optionality available in high school and college, as well as creating buy-in.

<table>
<thead>
<tr>
<th>Enumerative Combinatorics: Counting and Partitions</th>
</tr>
</thead>
<tbody>
<tr>
<td>If I had a pentagon and used only two lines that never crossed each other, how many ways could I split the pentagon into 3 triangles? How about a 6 sided shape using 3 lines?</td>
</tr>
<tr>
<td><img src="image" alt="Diagram of ways to split a pentagon" /></td>
</tr>
<tr>
<td>Here are some ways to split a pentagon. Did I find them all?</td>
</tr>
</tbody>
</table>

*Figure 1. Course description from a 2020 BEAM Summer Away site.*

During in-person programs, faculty write their own courses at Summer Away and are encouraged to write a course about a topic that they are excited to share with students; this continued for Virtual Summer Away. Counselors are encouraged to design and lead activities that they were passionate about; this summer, counselors designed live role playing games and taught origami using materials mailed to students in their care packages.

The Virtual Summer Away schedule was designed for students with a similar balance of academic and non-academic options as in-person programs. Each day, students had two activity blocks and one lunch block. During lunch, stu-
Students had the option to opt in to various Zoom rooms or take their lunch offscreen.

Activities ranged from online Set to arts and crafts to Rubik’s cube solving; they were selected based on usability in a virtual environment, student and counselor interests, and exposure to games or activities popular in the math world. The activities gave students a chance to interact with students outside of their classes and check-in groups and build relationships across shared interests. Students even took initiative to develop their own activities; one site’s students established a book club that read *Children of Blood and Bone* by Tomi Ayademi while a student at another site began their own activity for advanced Minecraft players.

![Figure 2. Students in Virtual Summer Away’s book club](image)

[Student] was one of my most frequent visitors to my board game activities, from Day 1 playing checkers and every other board game at least once. She was also super excited about book club and the book they were reading. Last I heard, she already ordered the second book.

Nearly 100% of students surveyed noted that they had a good or great experience with activities at the program, and many noted that activities were a key in feeling connected to the BEAM community. Despite this positive feedback from students, we noted several challenges and lessons learned. First, some activities encouraged interaction more than others. Activities such as Marvel movie watching spoke to students’ interests, but did little to deepen relationships. Second, activities did not provide relief from screen fatigue; outside of book club, finding ways to build relationships while giving students
time away from the screen was hard. This challenge also applied to lunchrooms, where we struggled with the balance of providing additional spaces for students to hang out with wanting to encourage healthy screen habits. This was in contrast to in-person programs, where, at the residential sites, students spent time together bonding during walks to classes, at breakfast, winding down with their hallmates, and more.

### 6.2 Academic engagement

When preparing for the summer, considerable energy and time was devoted to finding ways to help students participate and share their ideas in a virtual setting. Virtual Summer Away’s policy was that students were expected to have their cameras on and to participate verbally, unless they communicated their personal situation with a staff member. BEAM also provided clear expectations for online etiquette, such as not playing music in the background and staying muted unless speaking; these expectations were expanded as the programs continued and new situations came up. Expectations were reinforced in settings like check-in group conversations and via private Zoom chats during class by TA’s. During staff meetings, faculty and TA’s shared strategies that they used that helped them participate more. Each Summer Away site also had a Social Worker, who was meant to be a trusted individual focused on students’ socio-emotional well-being; the Social Worker used Zulip to touch base with students to see how their program experience was and if students raised any concerns that would lead to expectations being altered for them.

Even with expectations in place, students opted to participate in a variety of ways; while some felt comfortable using both video and microphone in all settings of the program, many opted for videos off, or only turned their videos on in small group settings like breakout rooms.

Staff navigated the range of engagement in several ways. During classes, faculty used a variety of structures to provide low-effort ways to engage that can build up to bigger engagement. For example, some faculty utilized mathematical thinking icebreakers such as “Which One Doesn’t Belong?” from [https://wodb.ca/](https://wodb.ca/). Others utilized polls or engagement moves like having everyone write an answer in chat and press send together. Faculty found that these strategies did not rely on students’ cameras being on to participate, and allowed students to build up to the confidence needed to begin to share their mathematical ideas. One challenge that faculty expressed was recreating a virtual way to understand the reasons behind students’ varied levels of engagement: was an off-video student being quiet because they were processing information, or did they need additional support with the material? The in-
structor for the course “Circuits and Programming” shared, “Normally, I’d walk around the room and give hints and corrections as students interpreted circuit diagrams or edited code. It’s possible to do something similar...with screen sharing and video, but it’s just not as easy.”

Staff also found success in adjusting the size and composition of groups. Many found that small group settings like breakout rooms were spaces where students felt more comfortable expressing themselves, thereby allowing them to collaborate more closely. Many students also were more comfortable collaborating in spaces with peers that they were familiar with; for example, staff found that the most collaborative relays were ones where students were on teams with peers from their check-in group.

However, adjusting to online student engagement was challenging for many staff members. Staff had varying degrees of comfort with engagement outside of cameras and microphones. In end-of-program surveys, some staff expressed that they never grew comfortable with non-visual and non-verbal participation and chose to enforce cameras on for the duration of camp. Others allowed students to make choices around videos and microphones, instead requiring participation in non-visual or verbal ways; for example, one staff member shared: “I personally took advantage of the online format [and] had them all join an interactive whiteboard and they each had to use a specific colour they chose. If they haven’t written then I know they aren’t there.”

Also, material moved slower online; discussions that typically took 5–10 minutes in person used 20–25 minutes of class time when virtual. This caused many faculty to readjust the goals for their class. In one class, “Analytic Number Theory,” one of the in-person academic goals is to talk about Dirichlet’s Theorem on Arithmetic Progressions. But because of pacing in the online setting, the class goal shifted to proving that there are infinitely many prime numbers.

One of the main factors that seemed to impact the teaching experience was variance in comfort with using technology. BEAM’s technology training was primarily focused on explaining how some of the featured technology tools worked and methods of using them; some staff shared in end-of-program surveys that they felt unprepared for using the tools required to teach successfully online. In the survey, staff noted that having working sessions where staff collaborated on classes and practiced classroom technology together would have been more beneficial than explaining the tools themselves. In 2021, in response to staff feedback, BEAM added training around transitioning a class designed for in-person to the virtual setting; this allowed staff more space to think about how and when to apply technological tools.
6.3 Zulip

One of the primary culture-building spaces for sites was the chat platform Zulip. Zulip, which works similar to messaging platforms like Slack or Discord, allows students to continue conversations that began in Zoom settings. Zulip allows topics-based channels to be established, and students and staff established channels to discuss interesting puzzles and problems, sports, anime and more. This informal engagement outside of class time allowed students to pursue interests in threads of their choice and develop relationships with peers and staff. Staff members started channels for classes to continue conversations, and used the platform to check in individually with students about topics that began in class.

"[I would follow up] with students by shooting them... a message saying something like "hey did you finish that Perplexor yet?" or "I really liked your solution to the PSet problem I saw on Classkick. Nice job!" Students will reply and it [helped] to mimic that “pass in the hallway” talk. - Virtual Discovery staff member

As with most online communities, inside jokes were quickly established; students made memes about the program and played online pranks like the Rick Roll.

[About a student] I don't know anyone more dedicated to Rick Rolling folks on Zoom.

We found that having an online chat platform was integral to community building. First, it encouraged student-driven conversations by providing space for students to gravitate towards the channels that interested them and to start conversations of their own. Second, it allowed students to talk outside of class time. Students who had been working together on a Problem of The Week would sometimes take the conversation they were holding in a class to a Zulip chat to finish their thinking. Others came to see math as something they can pursue on their own time because of the accessibility Zulip provided to staff outside of the program; students would sometimes message Site Directors after program hours with thoughts on a problem they decided to continue independently. Last, Zulip allowed for quick troubleshooting for issues like attendance and technology; if a student was missing from class, counselors would first quickly message them on the platform before calling home. This allowed counselors to initiate problem solving attendance issues without step-
ping away from their TA’ing responsibilities. This also encouraged student independence; by reaching out to the students first, they were able to explain their absence for themselves.

7 Reflections on Student Growth

To measure academic growth, Summer Away students take prior years of the American Mathematics Competition (AMC) 8 as a pre-test/post-test. In 2019, students showed significant growth, as shared in the table below. This year, we again administered the same pre-test/post-test.
Unfortunately, only one of our three sites showed this same level of growth. We are still considering why this happened. There may be several reasons: for one, data from this exam has always been noisy (a single multiple-choice problem has a large impact on each student’s score), and a few in-person years have had sites that did not show any growth. Another (likely) possibility is that online learning simply brought about less student growth. We are also considering that the online administration of the pre-test/post-test might have created a less focused environment for students. In any case, we are thinking carefully about how to best measure student growth going forward, especially if our programs remain online.

Table 3

*American Mathematics Competition (AMC) 8 national median percentile scores.*

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<thead>
<tr>
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<th>2019</th>
<th>2020</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Pre-Summer</td>
<td>Post-Summer</td>
</tr>
<tr>
<td>Away</td>
<td>Away</td>
<td>Away</td>
</tr>
<tr>
<td>Site 1</td>
<td>35%</td>
<td>41%</td>
</tr>
<tr>
<td>Site 2</td>
<td>46%</td>
<td>56%</td>
</tr>
<tr>
<td>Site 3</td>
<td>36%</td>
<td>46%</td>
</tr>
</tbody>
</table>

However, when we asked students at BEAM Summer Away during their closing surveys how much they felt their math skills grew this summer using a scale of 1-7, 97% of students answered 5 or higher, with 38% of students answering 7. In 2019, 92% of students answered 5 or higher, with 48% of students answering 7. One possible reason for a greater number of students experiencing skill development may be due to the difficult transition for many to online learning in Spring 2020.

Students’ perceived growth is echoed by faculty observations. Below are some examples of the variety in virtual engagement at Virtual Summer Away; these examples also offer additional context for why students may have opted to engage in certain ways and not others.
• [Student] was in [faculty member’s] class and he was a bit quiet, to the extent that we were a bit concerned because of his short responses. After a few classes and some technical errors, we found that [student] performed best when in breakout rooms and in small groups because this allowed him to express his ideas more freely. By week 2 he was coming up with some great ideas. I do think his mic was having trouble throughout the entire BEAM.

• Although generally quiet, [student] always made it a point to participate in the chat. Moreover, whenever unclear about a topic, she would ask questions for clarification.

• By the end of camp [student] was the student about whom I was most concerned. I do not think that he actively participated in any class discussions or small group work (other than the daily icebreakers). He would not even respond when students were asked to vote on something or contribute to something in writing. There were also a couple of days when he turned his camera off and was unreachable during times when students were supposed to be working on problems...

Students also experienced growth in other ways. First, when we asked students, “how much fun was this summer?”, using a scale of 1-7, 96% of Virtual Summer Away students answered 5 or higher, with 36% of students answering 7. This is a strong signal that we had significant success with community building. Faculty also saw growth in confidence, both mathematically and socio-emotionally.
• [Student] is on his way to building his mathematical confidence. He knows much more than he shows, but with support and reassurance he will more freely share his thoughts.

• [Student] was a fantastic student in my Infinity class. Although she preferred working by herself, she was persistent and confident in her problem-solving ability and would work away at, for example, trying to come up with explicit bijections between infinite sets, or solving logic problems involving set union and intersection.

• [Student] sometimes seemed to lack confidence in her ideas—she didn’t like to present her thinking to the whole class, and she would occasionally get discouraged or disengaged while working on a challenging problem. I think [Student] could really benefit from a supportive, small-group problem-solving environment that would help her develop a stronger mathematical identity on her own terms.

And, examples from students themselves:

• “I was able to have my skills grow and was able to step out of my comfort zone and talk to new people” and “I was able to come out of my shell and talk to new people.”

• I learned new things, I participated and took risks more often than I do at school. I also managed to make a proof about the sqrt of 5 being irrational, which I’m very proud of.”

However, an overall and recurring challenge was that the students who were comfortable with communicating online received greater support; as one staff member shared: “You noticed the students who posted a lot, but you didn’t notice those who didn’t.”

For example, resolving attendance issues quickly relied on students clearly, and sometimes proactively, communicating their situations and their evolving needs. For students with stronger communication skills, we were able to not only better address their needs, but also get to know them better. For students who were still developing communication skills, it took increased staff time and
effort to understand their attendance, academic and non-academic needs, and more broadly, to build deeper connections with them.

[Student] rarely participated in whole-class discussions or small group work. She would work on problems independently, but even when she struggled with them we could not get her to talk to us about it, so we were unable to determine where the difficulty was coming from.

In addition, the in-person atmosphere of the residential program led to students having a broad social network; students had roommates and hallmates that they shared meals with, and classmates who they bonded with during classes and activities. Counselors were able to follow up with a student who they noticed was quiet during breakfast, or struggled during a class. Faculty lived with students and counselors; the intensity of classes was coupled with lunch conversations and sports after classes. The informality of interaction allowed students to receive support in a variety of ways, and from a variety of people.

In a virtual setting, students’ networks were not only much smaller, but also less deep. For example, during in-person programs, the site’s Social Worker is often a trusted resource for students; they are often turned to for issues like homesickness and or peer-to-peer conflict. In the virtual program, site Social Workers noted that they didn’t have many informal opportunities to interact with students and were primarily utilized for attendance support. Faculty generally only interacted with students during class time; while faculty were able to opt into activities, it was more difficult to “hop into” what was going on each day.

8 Conclusion

We are ultimately pleased with the outcomes of transitioning BEAM Summer Away to a virtual setting in 2020. Students and staff had the opportunity to explore interesting and challenging mathematics, and to build relationships during a tumultuous time. While we believe that our in-person summer programs are still the best option for both developing a mathematical community and for academic growth, lessons learned from the virtual setting will apply to future BEAM programs and help to create better experiences when meeting in-person is not possible. We hope that community organizations, schools and universities, Math Circles and more can learn from our experiences to bring similar programming into their own settings.
Acknowledgements

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References


