



BEAM Virtual Summer Programming: Adjustments & Lessons Learned

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Introduction

Bridge to Enter Advanced Mathematics (BEAM) is a nonprofit organization that works to create pathways for students from low-income and historically 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 in STEM majors. We also work to foster positive self-identity, joy in doing mathematics, and community among its students. Since our 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 has additional plans to expand to more regions of the US.

In April 2020, as the world grappled with the impact of the Coronavirus pandemic, BEAM made the decision to shift its summer programming online and operate virtually for the first time. While we were initially reluctant to compromise the successful format of in-person programming, BEAM made the choice to move online for several reasons. First, affluent schools and families would have systems and access to technology that would allow them to continue learning with less disruption than the students BEAM served; we had the resources, knowledge and staff to help mitigate this inequity.

Second, as BEAM considers expanding nationally and serving students in a primarily virtual capacity, experimenting with online enrichment and community building would be a valuable learning experience for the organization. Finally, our exceptional faculty and counselors had been almost 70% hired and committed to in-person summer; being able to employ almost 180 individuals for a summer was a responsibility that we held carefully.

With this in mind, we crafted virtual programming that we hoped would sustain many of our original programmatic goals. This whitepaper shares some of the decisions we made, the strategies we implemented, and learnings and insights our staff gained as a result of running BEAM Discovery, our program for rising 7th graders, virtually.

The purpose of this whitepaper is to record lessons learned from our online program in the hope it will help others doing similar work. In order to contribute to overall learning in the community, we feel it's important to be direct about our successes and honest about the places we want to improve.

For more on the need for BEAM in the STEM enrichment space and BEAM's approach, as well as more on the research conducted by Mathematica Research Policy this summer, see the resources provided in the bibliography.

A note: this whitepaper is based on research funded by the Bill & Melinda Gates Foundation. The findings and conclusions contained within are those of the authors and do not necessarily reflect positions or policies of the Bill & Melinda Gates Foundation

Academic Summer Adjustments and Learnings

BEAM's programs are designed to create a rich mathematical environment for students; for many of our students, it is the first time in their lives that they are surrounded by a community of peers and adults interested in mathematics. Academically, as an enrichment program, we get to choose how to best teach students, and our focus is learning concepts and skills that provide a foundation for future growth. Since we don't have an obligation to standardized tests or state standards, we focus instead on building mathematical reasoning, abstract thought and problem-solving skills. This practice also allows our faculty to take their time with material and allow the pursuit of deeper learning, without external pressure to "get through" the material. Student curiosity informs the flow of a class just as much as a pre-set plan would. Moreover, beyond classes, additional opportunities for student engagement in math suffuse the program, from guest talks to communal challenge problems, giving students flexibility for how to engage with math.

Schedule

Overview of the Virtual Discovery daily schedule

When planning for BEAM Discovery online, we considered several tradeoffs as we designed a schedule. These were our primary goals for the virtual program:

- **Student choice**, which we believe improves student engagement, self-direction, and motivation among our students;
- **Community building**, so that students can meet each other, build connections, and feel a sense of belonging in math;
- **Non-math fun** to further connections between students and to the program; and
- **Clear breaks** so that students can step away from their screens.

The schedule we designed balanced academic and non-academic components, as well as mandatory and optional components. Virtual Discovery held classes four days per week, and Wednesdays were a mid-week break from instructional classes.

On Monday, Tuesday, Thursday, and Friday, students participated in two classes a day. These alternating classes were held on an A/B schedule, for a total of four different classes. Students also had daily additional math components such as Open Math Time (a block for students to work on math of their choosing from recommended options) and relays (a fast-paced math competition).

Monday, Tuesday, Thursday & Friday		Wednesday	
TIME	ACTIVITY	TIME	ACTIVITY
9:15am -9:30am	Morning check-in	9:15am -9:30am	Morning check-in
9:35am-10:30am	Class (alternates every other day on an A/B schedule)	9:35am-10:30am	Math circles or Career Day
10:40am - 11:10am	Open Math Time	10:40am - 11:10am	Open Math Time (optional)
11:15am- 12 pm	Activity (mandatory once a day, students may choose between morning and afternoon sessions)	11:15am-12:00pm	Activity (optional)
12pm- 1:10pm	Lunch	12pm- 1:10pm	Lunch
1:15pm- 2:10pm	Class (alternates every other day on an A/B schedule)	1:15pm- 2:10pm	Relays (mandatory first week, then optional)
2:20pm-2:50pm	Open Math Time	2:15-3:10	Time to watch assembly videos or take surveys (time is optional, completing tasks is mandatory)
2:55-3:10 pm	Afternoon check-in	2:15-3:10	Bi-weekly staff meeting
3:15-4 pm	Activity (mandatory once a day: students may choose between morning and afternoon sessions)	<i>End of day</i>	
4:10-5:10 pm	Bi-weekly staff meeting		

Learnings from the Virtual Discovery schedule

In general, we were happy with the overall schedule design. Between students choosing their classes and activities, a number of optional schedule events, and the flexibility of Open Math Time, we felt like there was a good balance of student choice. Similarly, as discussed later on in the non-academic section of this paper, daily check-ins and activities were quite successful with students. They enjoyed these non-academic elements and we felt successful at creating a vibrant community. The daily energy level was good, and breaks were well-placed to re-energize students. Some students even stayed for optional lunch socializing.

Alternating days

As discussed above, we used an alternating A/B schedule so that Mondays and Thursdays had different classes for students than Wednesdays and Fridays. We found this decision to have several trade-offs and are reconsidering it for future summers.

In person, the alternating-day schedule has three primary purposes:

1. To give students the opportunity to explore as many different types of classes as possible early on in the program;
2. To extend the time of their learning, as we believe that learning is better processed if it happens over a more extended period rather than a concentrated period;
3. To give instructors the space to be thoughtful about their classes.

An alternate schedule design is to have classes repeat twice over the summer: running in the first half of the summer for one group of students, and then repeating in the second half for a different group of students. However, this design creates a very uneven workload for instructors. The instructors will have to prepare their curriculum for the full class in the first half of the summer, but then are left with a disproportionately light workload in the second half of the summer. On the other hand, with an alternating schedule, they can prepare each new session of class while they're repeating the instruction from the previous day.

However, in Virtual Discovery, alternating days made it challenging for students to quickly form relationships with faculty and other students in their class. Students would see each other just twice in the first week, sometimes with their video off. Although the overall time they spent with their peers was similar to the in-person programs, during the in-person programs, relationships form more quickly. This is because in-person informal spaces—like lunchrooms, hallways, or Open Math Time—create organic opportunities for relationships to grow outside of the classroom. In virtual programming, no one is walking by a lunch room, even if we have Zoom lunch rooms open. Because of these dynamics and drawbacks, we are considering switching to a block schedule rather than an alternating schedule at some of our sites.

The Role of Wednesdays

Another unusual element is our Wednesday schedule. Every Wednesday, students had a range of stand-alone academic blocks and special events, as well as optional activities. To encourage exploration, students were asked to attend the first time each activity was offered to see if it was appealing. After that, the following weeks were generally optional.

Wednesdays proved useful for both students and staff. Students designed their own schedules and opted into Wednesday activities of their choice. Staff had time to reset and adjust their lesson plans based on how online learning was going. However, because attendance was generally optional on Wednesdays, the community building aspects of activities like relays were most strongly experienced by consistent Wednesday attendees.

We think that our mix of optional sessions helped students to customize their schedule to their own home life and needs. All days of the schedule had a balance of optional and mandatory sections. For example, activities were held at two different times of the day, and students were able to opt into the timeslot that was best for them on that day.

While we found that the optional/mandatory balance of the schedule helped fulfill many of our programmatic goals, it did require increased labor on the part of staff. Counselors invested significant time at the beginning of the program contacting families about attendance and finding different ways to encourage students to try some of the optional activities available before deciding whether or not to attend them regularly. Despite this additional labor, the options and flexibility were so valuable to program stakeholders that we will continue this structure for 2021, although we may clarify our messaging to students about participation.

Student engagement and attendance

Overview of Virtual Discovery policies

Student engagement

Like many, BEAM anticipated that student engagement would look different in a virtual environment.

In staff training, we discussed how video captures nonverbal communication like nods or confused expressions, and how these can be used as cues to students' understanding of material. Microphones

“...There are a lot of fun activities and we can also request for [activities] we like that [were] not there before.... [and] BEAM is always [open] to our ideas and that BEAM always [asks] about our opinion on making things better.”

-BEAM Discovery Student, End of Program Survey

add nuance to students' tone and lets the instructor and class hear students' thought process; both tools can allow instructors to utilize some of their in-person pedagogical strategies online. However, these tools are tempered with equity issues surrounding internet speed and technology access, housing or family situations, as well as middle schoolers' slower development of trust. All of these factors result in varying degrees of comfort with being on video.

With this in mind, Virtual Discovery's attendance and engagement policies were designed to encourage student collaboration while clearly communicating that flexibility was possible according to students' personal needs.

Students were expected to have their cameras on, unless they talked to a staff member about their personal situation. We 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. For example, no chat spamming was added one week into Virtual Discovery.

We purchased technology with equity concerns in mind: all laptops were able to run virtual backgrounds if students did not want to show their home environment; all headsets had directional microphones so that students could be heard clearly, even if they were learning in a noisy or shared space. During pre-program individual check-ins and morning and afternoon check-in groups, BEAM staff initiated conversations around engagement policies. Staff also reinforced expectations in private chats on Zoom and our program-wide chat platform (Zulip). Students were encouraged to voice their needs as they evolved, and all sites had a social worker. The site social worker's purpose was to provide a trusted individual who could check in with students on their socio-emotional needs. Regardless, in practice, students demonstrated a dramatic range in how they engaged with the program.

While some students always had their cameras on, others only did so in smaller groups such as breakout rooms, or in settings with peers that they had deeper relationships with, such as check-in groups. Engaged students who did not utilize the camera function regularly often participated in their classroom primarily via microphones or the chat function.

Below are some examples of faculty observations from Virtual Summer Away, BEAM's program for rising 8th graders.

A. was great to have in Infinity class. She was an eager participant in Zoom chat-- even when microphones were turned off and screens were dark, A. was always busy lighting up the chat with questions, comments, jokes, and memes-- all about the math that was being discovered!

On the first few days in Combinatorics, D. was very enthusiastic to participate in class. However, due to his busy household and absence of a quiet working space, circumstances not in his control, he was not able to keep up the enthusiasm shown in the beginning... [Later in the program,] D. was often unresponsive in class.

Attendance

BEAM staff spent a significant amount of time discussing how to define “full attendance” for a day of the program: BEAM staff discussed whether to designate daily attendance based on the number or type of components attended. They considered questions like: does attending at least one component a day constitute a full day? What type and/or arrangement of classes and activities would constitute a full day?

BEAM decided to focus on program dosage or receiving a minimum level of instruction. Below are details of the Virtual Discovery attendance policy:

- Students received full attendance if they attended two classes, Open Math Time, 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 three days of the program, when technical issues prevented some students from joining easily.
 - According to the Mathematica report done on BEAM Summer 2020, this structure allowed students who struggled to maintain good attendance to stay in the program if they continued to make efforts at attendance.

BEAM implemented several strategies to have a more thorough understanding of students' situations before and during the program. Prior to the program beginning, registration materials included a question asking, “Do you have a quiet place to work?” and, “Is there anything about your family or your home situation that you would like us to know?” This allowed us to make individual adjustments and provide or offer specific resources to the family.

During the program, we also committed a large amount of staff time to communicating with families about attendance issues. While this led to class TAs spending much of the beginning of class time problem-solving attendance issues rather than being fully present in the class, it allowed BEAM to determine if the student situation warranted an absence, as well as if there was anything staff could do to prevent future attendance issues.

Across all BEAM Discovery sites, the full dosage completion rate was 65% (although 96% of students who began the summer continued attending through the end even if they had four or more absences).¹ The attendance rate was 90% 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 the 2019 in-person Discovery program was 97%, and attendance among completers was 92%.

Not unexpectedly, BEAM experienced lower attendance at optional events, although we view this as appropriate (that is, after all, the point of student choice). Staff spent time individually reaching out to students, encouraging them to try optional events like office hours or relays so that they were able to experience them before deciding to opt in or out. This had mixed success, and it required significant staff time. One of our challenges for the future is balancing moderating staff time investment against our desire to fully engage students.

Lessons learned

The online learning environment was certainly a challenge. We are proud of the flexibility our students had at such a difficult time, although we also acknowledge the challenges this presented to the program's structure.

Variety of engagement options

While staff generally expanded their understanding of engagement in a virtual context as the summer continued, many expressed having a harder time noticing and solving for student understanding of the material, as well as building deep student relationships. While 80% of staff noted that they were satisfied or very satisfied with their ability to connect with students in lessons, understandably 65% of returning staff noted that the experience of connecting with students in virtual lessons was worse than that of in-person classroom interactions. With in-person programming, students are either physically present or not; staff then use their math and pedagogy knowledge to maintain student engagement. In the virtual world, it was harder to gauge if students who had their cameras off were fully present. As one student shared in their end of program survey, “In most of [my classes], I’m

¹ This data is based on only the students who consented to the study run by Mathematica in November 2020. The goal of the study was to develop new evidence on implementation of BEAM Discovery at BEAM-run and partner-run sites and early indication of success in improving student outcomes.

the only student with [my camera] on, and it's kinda awkward. It's also hard to work together when everyone has a black screen.”

This student's experience and the higher level of engagement we noticed in smaller group settings resulted in another lesson learned: students would be more successful if they were placed in consistent breakout groups, and if they had the flexibility to decide the type of workspace they preferred.

This year, we're making several recommendations and information to our faculty: one, in breakout rooms, offer students the choice of a collaborative or quiet breakout room; and two, create consistent breakout groups with the same students and TA for a week (or longer!) at a time. This way, students who want to talk will have someone to talk with, and students who want quiet will have it. It will also help faculty foster space for their students to create trusting relationships that lead to stronger collaboration.

Interestingly, 50% of returning staff noted that their experience of connecting at this time was the same or better than in-person interactions (although 50% of returning staff noted that it was comparatively worse!) Anecdotally, staff's comfort level with technology and the variety of engagement options is likely to have contributed to this. Some staff expressed that they never grew comfortable with talking to students with their videos off; for the duration of the program, they continued to reinforce expectations around cameras and urge students to participate by unmuting. Others opted to allow students to make choices around videos and microphones and instead incorporated virtual workspaces like Jamboard, Padlet and online whiteboards, as well as tools like Zoom polls to hear students' thoughts without verbally gathering them; these tools transitioned staff from asking the question of “are cameras on today?” to “do my students have a way to show engagement?” To support staff in future virtual summers, we plan to use program anecdotes and lessons from Summer 2020 to showcase a variety of engagement options for staff to utilize. We also anticipate that a year of online teaching will have given many of our staff tools to drive student engagement that they can use and share with their colleagues.

Impact of attendance on engagement

Student engagement was also made challenging by attendance. When running in-person programming, BEAM's attendance policy is that students can miss at most four days of the program; the question of partial days is less relevant because students are generally either present or not. If students do not follow this attendance policy, the student would be asked to leave the program only after multiple attempts to communicate with and troubleshoot the issue with the family and student.

While the online attendance policy made clear which portions of the program were mandatory and which portions were optional, strong attendance was impacted by students' various levels of independence and decision making skills, as well as their learning environments.

For example, in order to mitigate screen time, Virtual Discovery had scheduled breaks into the weekly program; this led to some students stepping away from their computers and sometimes returning to the program late or not returning for the day. Although BEAM tried to troubleshoot this by coaching students to set alarms on their phones for class times, or even mailing alarm clocks home, timeliness and consistency remained an ongoing issue.

In addition, students sometimes needed to babysit siblings or help out at home and occasionally they lacked the skillset to proactively communicate their needs. Staff would learn this information only after a phone call home, again requiring regular labor of the class TA.

Ultimately, we believe that in the midst of a global pandemic and a summer marked by stark reminders of systemic racism, it was the correct choice to extend as much flexibility, understanding, and grace to students as possible. We simultaneously recognize that this impacted student attendance and other factors. We continue to wrestle with how best to reconcile these conflicting needs.

Classes

Overview of Virtual BEAM Discovery classes

BEAM's classes are designed to be highly interactive, with time set aside for students to directly work on mathematics so that they are actively thinking while learning. They typically have a short presentation, with lots of time for individual or group work and support for students' problem solving. The challenge for Virtual Discovery was how to deliver a similar experience remotely.

Many BEAM faculty members develop their own classes, but we have recently been moving more towards providing pre-written curricula from prior successful classes that can be adapted by our summer instructors. (These courses will be available for free, with the goal of providing access to BEAM-style courses for the math enrichment community at large.) However, none of the prepackaged courses were designed to be used online, so all of them required adaptation.

BEAM felt that logistics were a key part of making online classes successful. Consequently, we focused on providing technology that would fulfill key roles in the classroom and be intuitive for both students and teachers to use. We used a variety of technological tools and platforms. These included the following:

- **Zoom for video communication.** We chose Zoom because it is a widely accepted standard, has high-quality video that adapts relatively well to low bandwidth, and offers a number of features (such as polls, breakout rooms, and on-screen annotation) that improved the classroom experience and allowed for more interactivity.

- **A course management system to allow students to access materials from their classes** at any time, and which also included "badges" students could earn. (However, we found that the system we selected was sometimes too complicated for our instructors to learn easily.)
- **Several tools to facilitate the classroom experience**, including Desmos (which allows faculty to design sophisticated online math experiences) and Classkick (which allows staff to quickly create shared worksheets that, among other things, facilitate groupwork).
- **A chat platform** called Zulip, a free and open source solution, was primarily used for student socializing and announcements, but it could also be used by staff to reach out to individual students.
- Finally, we provided staff with **computers, internet, and writing tablets as needed** to facilitate their classes.

BEAM had a high staff-student ratio. Class sizes at Virtual Discovery were, on average, 14-19 students with one teacher and 2-3 college student teaching assistants, which was a higher staff-to-student ratio than our in-person programming. This high staff-student ratio allowed for individualized attention and facilitated group work similar to the experience at our in-person program and was made possible because our college student staff had fewer non-teaching duties during the summer. Teaching assistants supported in classrooms and also reached out to any students who were not present at the start of class.

Classes at our virtual program met 10 times, for one hour per meeting. (Compared to 11 meetings, one hour per meeting, for the in-person program). While class time was comparable, Open Math Time (a freeform academic time when students can work on math of their choice) was considerably shorter, and we avoided giving required problem sets; as a result, more work had to be done in class.

Lessons learned

Ultimately, our summer programs were successful academically, and students showed significant growth in problem solving. However, we gained a number of lessons from this first online learning experience.

Time with technology

One of our biggest takeaways is around technology training for staff. A strength of our setup was focusing our support on a limited number of technology solutions while also allowing instructors to use their own if they preferred. This gave newer instructors guidance on where to spend their time looking at possible tech solutions, while experienced instructors could use the tools they were familiar with.

However, staff noted in surveys that we should have provided more training and time to experiment with those tech solutions before the summer began. In particular, they wanted time for "dry runs" or "at-bats." Many of our trainings were provided at the last minute, in part because we were

scrambling to put the program together in less than 10 weeks due to COVID. As a result, staff were often on their own (or nearly on their own) to learn them.

Below is an example of a Virtual Summer Away programming class in progress using some of these tools.

[Using Classkick and breakout rooms in programming class at Virtual Summer Away](#)

Integrating technology into classes

Another adjustment we plan to make in any future versions of the online program is giving more in-depth instruction on how to best use the technology platforms to run a successful class, rather than providing just the nuts and bolts on how they work. For example, in the video above, the instructor uses technology effectively to monitor each student's progress and support them on their work. We could likely have improved outcomes with more training on good practices in the online classroom for all staff.

Ultimately, while the majority of BEAM's staff reported that they were satisfied or very satisfied with the online experience, BEAM noticed two trends that may be relevant for other online programs. The first trend is that satisfaction varied with a staff member's comfort with technology. This trend aligns with our plans to increase training time and to provide time for staff to experiment with the tools. The second trend is that faculty members wished they were observed and given more feedback both more frequently and earlier in the program. While that was difficult last summer while our leadership was also "figuring things out," we plan to incorporate this lesson into future summers. In some sense, it is even harder to understand how one's lesson is impacting the students when it's through Zoom, and so observations are even more important than usual to staff member's development.

Pacing of material

Finally, we noted that online classes seemed to move more slowly than in-person classes. Students required more time to start work on some problems; it took them longer to communicate their solutions; and students were often more reticent to speak up. Faculty that taught our pre-packaged courses reported that their lessons were often shortened to one or two of the proposed activities, or that they spent two program days on one lesson's materials. One faculty member reported that they were only able to cover the first four lessons in the 11-lesson curriculum and noted that "it was much harder to get through material online, as everything just naturally moved at a slower pace." While students still made significant progress and a slower pace likely allowed for deeper understanding and critical thought to happen in the virtual setting, the faster pace seems to be a significant benefit of face-to-face programs.

Other academics

Overview of Virtual Discovery standalone academic blocks

BEAM's standalone academic blocks are often high-energy spaces that encourage student independence and agency. Students are able to make choices around which groups they opt into or what work they will focus on, with support tools in place to foster self-regulation. We also want to expose students to the concept that math can be done with friends and done for fun. Hallways are often chaotic during relays, when students rush to have a problem checked; an Open Math Time room can have both a group of students working on problem sets and another group solving a puzzle on whiteboards, all with music playing in the background. Open Math Time, in particular, helps students not only enjoy independent math work (and hopefully develop habits of continuing to do math for fun), but also promotes independence and time management.

When BEAM decided to transition many of its additional academic offerings online, it was challenging to maintain the focus on collaboration and student choice and to replicate the energy of those spaces.

The standalone academic blocks include:

- **Open Math Time** – Students are able to work on math of their choice from a bank of recommended options ranging from classwork, bonus problems and online platforms to assorted games. Students used their portal to select the Zoom room of their choice that day. The rooms, which were themed based on the bank of options, were staffed with counselors and faculty monitoring the space and working with students.
- **Relays** – Relays are a math competition in which students solve problems either collaboratively or competitively. Relays transitioned from physical classrooms to breakout rooms, where faculty and TAs checked problems, monitored team progress, and fostered excitement and energy.
- Activities such as the **100 Problem Challenge and Problem of the Week** – The 100 Problem Challenge has students working alone or with others to solve 100 problems before the end of the program in order to win a program-wide prize. Both the 100 Problem Challenge and Problem of the Week transitioned from a hallway bulletin board to the chat platform of Zulip, where problems were publicly posted for students to work on, and solved problems were announced.
- **Math Circles** normally replace one day of individual classes to deliver fun and unusual math lessons. At Virtual Discovery, we featured events such as Career Day, a talk by BEAM's founder, and high school and college conversations with counselors.

We focused on organizing our virtual environment to be a space where one, students were regularly challenged to make decisions around how to use their time, and two, student camaraderie was fostered. This led to:

- Using Zulip channels to build excitement and progress around the 100 Problem Challenge. This included posting problem updates, celebrating the problem solvers themselves, and drumming up excitement around progress by working towards a program-wide prize that translated well to the virtual setting. At one site, a Site Director shaved his head on Zoom during the end-of-program assembly!
- Creating designated breakout rooms during Open Math Time for students to make intentional choices around what they want to focus on. These rooms included: spaces focused on specific topics like class problem sets or 100 Problem Challenge; spaces for working on a specific online platform such as Art of Problem Solving's Alcumus; and spaces that provided a specific learning atmosphere such as the Quiet Room. Additional supports like beginning and end of block check-ins in private Zoom chats or via the Zoom poll feature gave students a chance to set personal goals. This tool worked well for some students, but not all. This mirrored the in-person programming experience, in which students filled out paper slips with their goals for the block; similarly, in-person goal-setting was a tool that worked well for only a portion of students
- Creating relay teams that built upon existing relationships like student check-in groups. (We found out that, without existing relationships, active participation in this activity was inconsistent.) In addition, students could select what type of relays atmosphere they wanted to participate in, based on whether they wanted to collaborate to reach team goals or compete to vie for first place; this is available during in-person programs as well, and was continued online.
- Altering some of the goals of the competition-based activities of the program to allow students to experience success earlier on. We added a greater number of simpler problems to Virtual Discovery's relays so that students would not opt out of the optional event too early and many sites set the bar for success for the 100 Problem Challenge at finishing a subset of problems.

Lessons learned

We found that the variety of miscellaneous academic activities provided a virtual space of mathematical camaraderie and growth for many students. We learned a number of lessons through designing and structuring our activities for a virtual space.

Student collaboration

We observed that students were hesitant to participate in spaces that required collaborating with peers whom they had not previously closely interacted with. Relays, in particular, had lower attendance after the first week. Similarly, we saw less engagement with our 100 Problem Challenge

than in previous summers. During previous in-person summers, the 100 Problem Challenge had 78 unique solvers (77% of the program). This demonstrated collective buy-in to the challenge. Instead, interest in the 100 Problem Challenge, when made virtual, was concentrated in some very dedicated students. While there were several students who were extremely engaged (solving 20+ problems), many students did not engage with the challenge. In 2020, the same site had 16 unique solvers.

Experiencing success

We realized that students needed to experience success early on and regularly in the virtual program in order to continue engaging with activities. Without the informal, relationship-building spaces of the in-person program, trying new activities or solving challenging problems were higher stakes than many students were willing to risk. We made two shifts that led to a more positive experience for students: one, we used check-in groups to make relays teams; and two, we shifted the bar for success in competitive activities based on student progress during the program.

Similar to the pace of classes, solving problems in both relays and the 100 Problem Challenge happened more slowly in the virtual setting. To mitigate this, we adjusted the number of problems needed to meet group goals for relays. We also set the bar for success on the 100 Problem Challenge to solving a subset of the total problems. Both adjustments happened at the discretion of site leadership and were based on the progress that groups had made in relays or that the site had made a week or two into the program (for example, for the 100 Problem Challenge, one site had the goal of solving 70 problems by the end of summer). Working towards more realistic goals contributed to lowering the stakes for students to work with others. Beginning with easier problems allowed their groups to experience success early on and set the foundation for positive group interaction.

We saw several positive engagement indicators later into the program:

1. In relays, staff reported that students were more comfortable collaborating and participating and opting for different ways of engaging, like taking themselves off mute rather than relying on chat.
2. In Open Math Time, students began revisiting solved problems simply because they found them fun.

Students were sometimes messaging Site Directors outside of program hours on the chat platform with challenge problem solutions. This was a tangential benefit of the chat platform: it allowed students to continue math outside of program hours, if they wanted to.

We are likely to implement these changes from the start of online summer programs in future years.

Non-Academic Summer Learnings and Adjustments and Learnings

Overview of non-academic components

As mentioned in the scheduling portion of our paper, Virtual Discovery was designed around the following goals:

- **Student choice** that improves student engagement, self-direction, and motivation among our students;
- **Community building**, that builds students' social connections and a sense of belonging in math;
- **Non-math fun** that furthers relationships between students and commitment to the program; and
- **Clear breaks** so that students can step away from their screens.

The primary non-academic and community building-focused components of the schedule were centered around check-in groups and activities. In addition to scheduled components, the online chat platform Zulip was both a tool for community building and a space where community building took place. While we walked away with some questions and lessons learned, we ultimately felt that these three components were successful at creating a vibrant community.

Check-in Groups

Overview

When BEAM was in-person, students in Los Angeles and New York City would form travel groups that commuted to their program site together with assigned counselors. This was a safe way of getting to and from the program, it gave students a consistent group of peers and counselors that they formed tight-knit relationships with over the course of the summer.

We designed Virtual Discovery check-in groups with the goal of providing a travel group-like space. These groups opened and closed the day together, and students had a consistent circle of peers and counselors that they bonded with throughout the program. Check-in groups were run by counselors (undergraduate college students) and consisted of 5-10 students that met in the morning and afternoon for 20 minutes. The groups, which operated similar to homeroom-style spaces, were meant to offer predictability and routine, and function as a catch-all space for miscellaneous communication.

A wide range of topics were covered in check-in group. A few examples of these topics include the following:

- Icebreakers or “get to know you” activities during the first weeks of the program
- Program logistics and announcements for the day or week
- Famous mathematicians from underrepresented groups
- Favorite problems or classes they are taking
- Math journeys of program faculty and counselors
- Sharing more about themselves, through favorite YouTube videos, music, and more

In their closing program survey, students gave feedback that the groups providing a valuable relationship-building space for them, with many noting their check-in counselors amongst “adults who made their summer more awesome.”

“The morning check in and afternoon felt nice to come back to a place after a long day of work.”

– BEAM Virtual Discovery student

Lessons learned

While check-ins were a very positive addition to the program schedule, we found that the virtual groups did not fully emulate the relationship building that took place in travel groups. For one, travel groups in NYC and LA could travel up 60-75 minutes together on the subway or bus; this time together led to tight-knit groups that were hard to replicate in the 40-minutes total that were slotted for morning and afternoon check-ins.

In addition, the in-person travel groups were often unstructured time together, which led to student-driven conversations that evolved based on the group’s personality. While this happened to some degree in virtual check-ins (for example, groups skipped activities that they didn’t enjoy or repeated them several times if they really enjoyed them), the time was more structured. This was in part due to the brevity of the meeting. For future virtual summers, we are considering extending the length of check-ins to allow for more time and greater flexibility in how to use the time.

Activities

Activities provided low-stakes ways for students to get to know one another, as well as to explore interests outside of mathematics. Before the start of programs, BEAM sent each student a summer care package. These included a laptop and headset for them to keep, as well as items needed for counselor-led activities: beads and string for bracelet making, a yoga mat, drawing, origami paper, and more. We found that the care packages not only ensured students had needed materials for the summer, but also built excitement and buy-in.

Activities were a mix of in-person-tested activities such as board games and Zumba, counselor-selected activities such as Anime watching and online Set, and student-championed activities such as

Minecraft or Book Club. Most activities transitioned well to the online space, thanks to online platforms that host virtual versions of many physical games. BEAM also used Zoom for non-platform-based activities such as yoga, Mafia and Hack'n'Slash.

The activities that had the greatest success were ones where Virtual Discovery college-aged counselors brought their personal passions to share with students: origami and American Sign Language consistently had full sign-ups. These were activities that also naturally encouraged students to turn on their cameras and helped them bond over the shared experience of learning a completely new skill.

Lessons learned

One challenge of activities was that certain activities did not translate as well to the online environment. For example, this summer, there was a lack of sports and other physical activities. One of BEAM's goals is that students are able to bring their whole selves to the program: for example, they do not need to choose between attending a math camp and attending a basketball camp. While we had Zumba and yoga, other sports such as basketball and soccer were missed. Similarly, other activities did not lend themselves as well to relationship building virtually as they did in person. For example, watching a movie with friends in-person is engaging; watching Netflix as an online group doesn't capture the same spirit.

Activities were semi-optional in that students were required to attend one out of two activity blocks of the day (but had the option of attending both). Participation in activities was mixed; while most students participated with regularity, we did have a few students who did not attend a single activity all summer. Parents sometimes saw the activities as optional and would sometimes schedule personal things during the time. To help with predictability and lessen confusion, next summer we are considering making the morning activity mandatory (with exceptions considered) and the afternoon activity optional.

Zulip

Overview

BEAM used the chat platform Zulip to interface about logistics, as well as to provide an organic relationship-building space. BEAM installed Zulip on a private server, which allowed us to monitor the platform, as well as locally store chats. Since many BEAM students are under 13 years old, other closed platforms like Slack or Discord were not viable options.

Zulip works similarly to other chat interfaces by allowing users to create channels for topic-based discussions and use emojis as reactions for comments. BEAM set up logistics-related channels, channels for academic activities like the 100 Problem Challenge or relays, channels driven by student

interest like sports or anime, and by far the most popular, a channel for memes. Staff also used Zulip to check in with students about any connectivity or attendance issues they were having, as well as to check in with other staff about logistics and share student anecdotes.

We found Zulip to be a huge success for several reasons:

Community and culture building

- Students had space to be silly and creative, share inside jokes, and build and site-specific culture. Some sites saw Rick Rolling make a comeback, while others iterated on memes throughout the summer.
- The platform provided space for students to share more of their interests and for peers to gravitate towards those with shared interests. One student began a Minecraft thread that talked about his love of Minecraft and shared tips for the game, which eventually led to him running his own activity for those who considered themselves Advanced players.
- Students utilized the platform to continue conversations that had begun in other virtual spaces like classes, activities, or Open Math Time. Staff shared interesting puzzles or problems and students would connect with a peer or staff member for support with classwork or challenge problems. Staff found that this promoted individual relationship building and allowed for casual interactions that happened in person to be replicated.

"[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**

Skill-building and knowledge-sharing

- One staff member said that Zulip was also a vehicle for math happening outside of program hours. One Site Director added that he would get messages from students in the evening about a problem they had been working on earlier in the day. This not only opened students to the experience of working on problems for a prolonged period of time, but also exposed them to the idea that math is something that can be done for fun, outside of school.

This anecdote was also reflected in program data. Students were surveyed on the question of “What is the longest you have spent on a math problem?” This summer, the median answer went from 50 minutes at the beginning of summer, to 180 minutes by the end of summer.

- Technology support was also provided in the space, which led to student growth in technology skills. For example, at the beginning of the program, some students missed alerts on Zulip that led them to missing events or activities. Program staff used the platform to share out how to turn on notifications, and how to download it as an app rather than using it via a desktop browser. Students emerged from the program with skills for virtual learning that likely benefited many of them in their online learning environments in the subsequent 2020-2021 school year.
- Zulip promoted knowledge-sharing amongst staff and students. Channels like “College and Career” were spaces where students asked counselors and faculty questions about what college is like and what they liked about the school they attend.

Lessons learned

Although the community was powerful, it was still not as strong as in-person summers. In particular, students who were shyer or less quick to engage were harder to support; as one Site Director commented, “you noticed the students who posted a lot, but you didn’t notice those who didn’t.”

Students’ social network—both on Zulip and at Virtual Discovery at-large—was more limited than that of an in-person program, and students had weaker social interactions. At in-person programming, students would interact with many staff and students during unstructured times, whether in the hallways or chatting in the lunchroom. At lunch, one table would have games of paper football happening, Yu Gi Oh at another, and chatting with favorite counselors at another. Students would gravitate to spaces that interested them and meet new peers there.

At Virtual Discovery, students’ circles were relatively limited to people they interacted with in classes, activities, and check-in groups. Even then, the level of interaction that happened varied. For example, in more passive activities such as Anime Watching, students were rarely chatting with each other or getting to know one another. Virtual Discovery created spaces such as lunchrooms for students to gather, but the spaces were opt-in, in order to combat screen fatigue. Spaces that had mixed groups, such as relays or Open Math Time, were spaces where students expanded their circles. However, the staff found that students engaged most deeply with other aspects of the program when working in groups they already had strong relationships with. As noted in the academic section of this paper, activities like relays had strong participation when students’ teams were their check-in groups; students were more comfortable taking themselves off mute and collaborating with each other.

It is important to put these lessons in perspective. The social environment at a typical BEAM program is very close-knit, and students form deep relationships. Although Zulip and other mechanisms didn't fully live up to BEAM’s in-person programs, we are still extremely pleased with their ability to build and develop our community.

While students felt that they had a variety of spaces to build strong relationships at the program, our staff also noted that they wanted time to build relationships amongst themselves. Although staff had access to chat platforms like Zulip and Slack, there was only one social event that took place at the end of the program for them to spend time together. Sixty percent of staff noted that building relationships with other staff was worse than previous experiences at BEAM.

Looking forward

Ultimately, we are very pleased with how BEAM's first foray into virtual programming went. While we have many lessons learned, we also saw students thriving and enjoying themselves in the midst of a pandemic. In a short time, we were able to put together a successful program that supported students along a number of dimensions.

With additional improvement, we see virtual programs as a way to reach students who do not live near an existing BEAM site. However, we still feel like both the community and academics at an in-person program remain stronger. In short, we see this as a tool on our belt, but unlikely to replace the power of in-person programming anytime soon. Which program we will choose depends on the context.

For others considering similar work, we hope that the frank and honest self-appraisal in this whitepaper is helpful. If it does influence your thinking, we invite you to reach out and talk to us, either for elaboration or just to tell us that it had an impact. We can be reached by email at info@beammath.org.

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