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"Fake it until you make it": Lessons learned from the design and implementation of a high school summer research internship program (Evaluation)

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‘Fake it until you make it’: Lessons learned from the design and implementation of a high school summer research internship program (Evaluation)

Research has shown that engaging high school students (grades 9-11) in STEM activities increases their chances of choosing STEM-related disciplines when entering college. This has led to the development of several amazing university-sponsored opportunities including week-long camps, university tours, and faculty/student outreach to local schools to engage, excite, and educate high school students about STEM degrees. One area of engaging high school students that has the greatest impact, and the most likely success in encouraging students to choose a STEM path, is a research experience under the direction of a faculty mentor. One of the authors has witnessed this firsthand having mentored >25 high school students during summer research experiences that ultimately led to the students electing to major in a STEM field; however, the potential overall impact was limited as the author could only mentor so many students per year. The challenge with increasing the number of students getting an experience is that many faculty mentors do not have the time or knowledge on how to recruit and mentor high school students. To address this challenge, the authors developed a high school summer research internship program. The program is designed to minimize the administrative burden on the faculty mentors while also providing a rich educational experience for the students. The program occurs during the summer where the students volunteer in the labs for ~140 hours working on their research project. The research experience is supplemented with workshops led by the authors and other members of Louisiana State University including safety, research ethics, how maintain a lab notebook, how to read scientific literature, how to analyze data, and effective written and oral presentation. The program has been offered three times during the summers of 2020-2022. 60 students completed the program (17 in 2020, 20 in 2021, and 23 in 2022) with 82% of these students coming from traditionally under-represented minorities in STEM (females, ethnic minorities). Evaluations at the end of the program have indicated that participation in the program strongly influenced the students’ desire to explore a career in engineering. This paper will detail the lessons learned, and future plans, by the authors during the implementation of the program including how to provide the students with a research experience virtually as the first year of the program was dramatically altered due to the COVID-19 pandemic.

Introduction

With the everchanging landscape in higher education recruiting, Louisiana State University’s College of Engineering recruiting team created a high school summer research program as another way to engage with the greater Baton Rouge area high school student population. LSU was motivated in pursuing something like this as high school student research experiences in the College of Engineering were not formalized and available to all Louisiana high school students. According to the National Science Foundation data collected in 2012, 33.5% of female freshmen, 36.4% African American freshmen and 41.6% Hispanic freshmen intended to pursue a science or engineering degree program [1]. At Louisiana State University, the College of Engineering’s non-white freshmen enrollment was almost 39% in 2022 and 21% female enrollment. In 2019, the recruiting team along with a faculty member who facilitated their own research opportunities with local high school female students came together to create a structured program and engage with all majors within the COE to start the program in summer 2020. This is based on prior

successful studies and programs showing how afterschool activities can increase student self-confidence in STEM [2]. The COE supported this initiative, admitted 20 students into the first cohort of this program, then the global pandemic began. This paper focuses on the lessons learned in the development and roll out of this high school research program. A particular area of emphasis are the challenges associated in starting, and running, a high school research program during the COVID-19 global pandemic and how the authors were able to address some of these issues to still provide students with a college-level research experience. This paper examines the different ways LSU admitted students into the program, which high schools they targeted for application recruiting, and how this program benefited students in high school science fairs and applying to college.

Program Design

The goal of the High School Summer Research (HSSR) program was to create a research experience that (i) allowed high school (HS) students to perform hands-on, cutting edge research, (ii) provided HS students with training essential to successfully performing research, (iii) exposed HS students to the different types of work performed (and different areas of expertise) across engineering disciplines, (iv) gave the HS students content to successfully compete in regional, state, and international science fair competitions, and (v) encouraged HS students to consider engineering as a potential major in college. The design of the program was similar to how NSF funded Research Experience for Undergraduate (REU) programs are organized with a main focus on performing the research itself while also providing necessary training on safety, ethics, and effective communication. Students applied to the program (see next section on lessons learned from student recruiting) and were paired with a tenured or tenure-track faculty member with an active research group in the LSU College of Engineering to work on an existing or new project. To date, the program has had faculty participation from 22 mentors from eight departments including Biological, Chemical, Civil, Electrical, Environmental, and Mechanical Engineering in addition to Computer Science and Construction Management. The HS students were paired with graduate or undergraduate students currently working in the labs who also function as additional mentors to the HS students. The faculty mentors were responsible for designing the research project and crafting a research experience such that the students had goals/objectives to complete during the summer, similar to in scope to an REU program, whereas the program directors handled all of the administrative components of the program. The program was designed this way as the authors found that many faculty members were hesitant to mentor HS students due to the paperwork and training burdens.

The initial design of the program for the 2020 and 2021 summers had the students starting to perform research part time during the spring academic semester (~5 hours per week) and full time during the summer (~120 hours during the summer). The idea behind starting during the spring was for the students to start getting trained on experiment and experimental design so that they could dive into the research at the beginning of the summer while also contributing more data/effort to the project. Unfortunately, this model was found to be unsustainable due to several reasons. First, many of the HS students were involved in clubs or other extracurricular activities that prevented them from coming to the lab after school. Second, because of these commitments the students could not come to the lab until after 4-5 pm which is the time that most faculty and graduate students are leaving for the day. Based on these observations it was decided to shift

nearly all of the program activities to the summer (~140 hours in total) when the students were off of school. The 2022 summer had the students perform research mostly during the months of June and July.

In addition to performing research, the students participated in several workshops to provide additional training. The first workshop took place on a Saturday morning in early May and included presentations on lab safety, library resources, research ethics, and how to maintain a lab notebook. The lab safety lecture is given by a member from Louisiana State University's Environment, Health, and Safety department while the library resources lecture is given by the COE's dedicated librarian. One of the authors (a faculty member) gave the lectures on ethics and notebooks. The reason for this workshop being held before the summer is that is allowed the students time to complete all of the online training courses for safety and ethics so they can immediately start working in the lab after school gets out. The remaining workshops were held every week on Wednesday mornings during the summer. The workshops included a variety of topics such as how to read scientific literature, how to use Excel, how to compete in regional/state science fair competition, and how to apply for college. There are two separate workshops on effective oral communication and effective scientific poster design as most HS students have not yet had the opportunity to present to an audience. To help develop these skills, the remaining workshops were dedicated to every program participant giving an oral presentation (5-8 min) on their project. The number of workshops, and their content, increased every year of the program based on feedback from both the HS students and the mentors. Each workshop presenter was someone from the COE with the exception of the how to apply for science fair workshop which is given by a science fair coordinator from a local school.

The program culminated in a poster competition in early August where the students got the chance to present their work to family, friends, teachers, faculty, staff, and the public. The 2020 competition was held virtually on zoom due to the COVID-19 pandemic (see later section on lessons learned during the pandemic). The 2021 competition was held in-person on a Friday whereas the 2022 competition was held in-person on a Saturday. Greater attendance was observed on the Saturday competition as families, friends, and teachers did not have to work that day. During the competition each HS student was judged by COE faculty, staff, and graduate students using a rubric similar to one used in the regional and state science fair competition. The judges' scores were standardized to the average score for each judge instead of using a raw numerical score. This was performed to avoid bias from judges who only score high or low. While the program officially ended at the poster competition in August, the students were encouraged to continue working with their mentor into the fall semester to get more data for the science fair competition or make significant contributions to earn authorship on a peer-reviewed manuscript.

Student Recruiting and Mentor Matching

The approach to recruit and admit students to the HSSR program evolved during the three summers. Since the 2020 program was a pilot program it was decided to restrict applications to four dedicated schools that have historically had students working in professor's labs. The 2021 and 2022 programs opened up the application portal to all high school students in the state of Louisiana. The application and admission timelines also evolved during the course of the

program. The 2020 and 2021 programs had the applications due in October of the previous year (e.g., October 2019 for the 2020 program) with students being admitted to the program by December and then getting matched with their mentors by February. The rationale for this was because the students were supposed to begin working on the project during the spring semester. This application timeline was also found to be unsustainable. First, total application numbers and applications from a diversity of schools in the state were both low due to the expedited due date of the application so close to the start of the semester. The 2021 program had participants from only 6 schools with ~50% of students coming from a single school. This was because many students were unaware of the program until applications had closed. Three steps were taken to address this. First, the application due date was shifted to January of the program year. Second, the authors held information sessions during the fall semester to allow potential students (and their parents) an opportunity to learn more about the program. For the 2022 program, three information sessions were held using a hybrid, synchronous format due to COVID-19 restrictions still being in place. Recruiting efforts for the 2023 program consisted of three in-person information sessions and one zoom information session. Third, enhanced recruiting efforts were put into place including advertising the program on social media and directly contacting high school to spread the word about the program. This resulted in a greater number of applicants from a greater number of schools for both the 2022 and 2023 program.

Once students were admitted to the HSSR program they were then matched with the faculty mentors. A similar model was used for all three summers to allow the students an opportunity to interact with the faculty mentors and provide insight and feedback on who they would be paired with. Mentor matching kicked off with a 'Mentor Meet and Greet' session that occurred during the evening in mid-January (2020 and 2021 offerings) or mid-March (2022 and 2023 offerings). During this session the faculty mentors would give an ~5 min presentation on their research group and the project(s) being offered. After the presentations were finished, the session switched to a break-out discussion format where the HS students could individually chat with the mentors and ask any questions they had about the project. The HS students then had ~3 weeks after the 'meet and greet' to have follow-up meetings with the mentors to learn more about the project and the expectations of the mentor in addition to tours of the mentor's research labs. The HS students then submitted their top five mentor selections to the program administrators who then did their best to achieve the highest number of top choice matches. The faculty mentors were also consulted during mentor-mentee matching, especially in cases where one mentor was selected as the top choice by more than one student. This model has worked quite well during the four offerings (2020-2023) with ~80% of students being paired with their top 1-2 choices.

Lessons Learned from the COVID-19 Pandemic

A major challenge that the authors encountered in the roll out of the HSSR program was the COVID-19 pandemic. The first cohort of students had just been admitted and paired with their mentors in March 2020 when Louisiana State University, like many others across the country, closed down. Initially, the program was put on hold during the remaining two months of the spring semester as it was unclear if/when the research labs would open back up. In mid-May of 2020 it was decided to move forward with the program even if it meant that the students were going to only be able to work virtually. The program administrators reached out to the mentors and HS students from the 2020 cohort to determine (1) if they were still interested in

participating in the program and (2) if any of the projects could be performed virtually. 17 out of the 20 students in the program elected to continue participating in the program. At this point it was up to the mentors to devise a virtual research experience for the students. This transition was easiest for the faculty who performed computational-based research as this work could already be performed virtually. This was slightly more challenging for some of the experimental faculty; however, nearly all of the mentors were able to devise some type of work that could be performed virtually. This included running numerical or computational simulations using programs like COMSOL, ANSYS, or MATLAB or performing image analysis on microscope images using ImageJ. Only one mentor had a project that could not be transitioned to a virtual research experience. In this case, the student performed a detailed literature review on the research topic. Using this model, the students were able to perform research through the month of June while the research labs started to open back up for in-person experimentation at a limited capacity (e.g., two students were allowed in the lab at a time). Due to the strong support of the LSU COE, mentors with an HS student were allowed to staff an additional/third worker in the lab so that the HSSR students could still have an in-person experience. Because of this, the students were able to get into the lab in the month of July and perform hands-on research following all COVID-19 safety guidelines. Due to COVID-19 restrictions, the final presentations were given as oral presentation (instead of the designed poster presentations) and held on Zoom. The presentation day was split up into three one-hour sessions with each student getting 10 min to present (~8 min for the talk and ~2 min for questions). Three different groups of three faculty judges attended each session to evaluate the students. While this was more formal than a typical poster session, it was still well received by the students as an opportunity to be acknowledged for the work they were able to accomplish in the middle of a pandemic.

One major advantage of learning how to perform virtual research was that it showed the authors that students could participate in the program remotely. This was a major strength as we had previously thought only HS students who lived near Louisiana State University could participate due to the in-person nature of research. However, using the COVID-19 virtual research model we were able to recruit mentors who performed computational research and match them with students who lived all across the state. In fact, two students from the 2022 cohort lived ~4 hours away from Louisiana State University. Another advantage of the virtual research model was that students who travelled during the summer (e.g., family vacation, summer camp, mission trips, etc.) could also still work on the project even if they were not on campus.

The safety restrictions associated with the COVID-19 pandemic also impacted some of the logistics related to mentor matching and the summer workshops. For the 2021 cohort we could not perform an in-person ‘Meet and Greet’ due to Louisiana State University’s safety guidelines. To accommodate this, we arranged a virtual zoom ‘meet and greet’. This included the same ~5 min presentations to introduce the mentors; however, instead of informal break out discussion in the classroom we created individual breakout rooms for each faculty mentor. The program administer would manually add students to each room they were interested in so they could chat with the mentor followed by the HS student returning to the main zoom room. The HS students were able to select which mentor they wanted to meet with by changing their name in the zoom meeting to include the name of the mentor they wanted to speak with. While it required a good bit of work for the program administrator, it still allowed students the opportunity to meet with all of the mentors they were interested in. While we did not revert back to this model in 2022, the

lessons learned from this virtual 'meet and greet' offers potential for how to handle increasing numbers of students who live far away from Louisiana State University as we look to grow the program to a research experience for all HS students across the state.

While the summer of 2021 did transition back to nearly all in-person research, there were still safety restrictions in place limiting the number of students that could be in a room at a time. This resulted in challenges for how to deliver the professional development workshops during the summer. To accommodate this, we decided to record all of the presentations using zoom so that students who could not attend were still able to have access the material. This model had a highly desirable side effect, in that it allowed us to provide workshop material to students who were out of town for a variety of reasons. So, what initially was designed to support COVID-19 restrictions turned into a model that allowed all students in the program access to all professional development material throughout the summer.

Program Evaluation

Program evaluation has occurred to various degrees during the three summers that the program was offered with a full assessment being conducted in 2020 and limited assessments being performed in the 2021 and 2022 summers. The reason for the lack of assessment in the 2021 and 2022 summer was due to changes in program administrators (e.g., every summer had a different program administrator from the COE while the faculty administrator remained the same). This staff turnover was due to personal changes associated with the COVID-19 pandemic. As result, some institutional knowledge related to assessment was lost between administrators resulting in limited assessment being performed in the 2021 and 2022 cohorts. The authors are able to report on the general statistics of the students who were enrolled in the program during the summers of 2020-2022. The breakdown of the number of students who participated in the program in shown in **Table 1**.

Table 1. Summary of participants in the HSSR Program. *Only 17 students continued in the program due to the COVID-19 pandemic.

Year	Number of Students	Percent URM	Number of High Schools	Students Enrolled in College	Students Enrolled at LSU
2020	20*	75%	4	14	6
2021	20	85%	6	7	1
2022	23	70%	7	--	--

All three years of the program saw high engagement from students from traditionally underrepresented minorities in STEM (URMs). The program was also able to increase the number of students in each year and the diversity of high schools in Louisiana that the students were coming from. Each year of the program had participation from ~15 mentors from eight departments in the college of engineering including biological, chemical, civil, environmental, electrical, and mechanical engineering in addition to computer science and construction management. Informal assessment on the alumni from the program found that many of the students elected to enroll in college; however, this assessment was unable to determine if the students elected to major in STEM disciplines. The reason why some students from the 2020 and 2021 cohort were not enrolled in college is that they are still in high school (e.g., 6 students from

the 2020 program are currently high school seniors). Additional efforts are underway to connect with program alumni to track their career path into college to determine the overall effectiveness of the program. In addition to directly assessing the students, the authors were able to indirectly assess the impact of the program by tracking participant performance in regional and state science fair competitions. The competitions took place during the spring semester in the year following the program (e.g., the 2020 cohort competed in the 2021 competitions). Students from the 2020, 2021, and 2022 cohorts performed well at both the regional and state science fair competitions (**Table 2**). Additionally, one student from the 2020 cohort who continued to work with their faculty mentor took overall first place in both the 2022 regional and state science fair competitions

Table 2. Summary of student performance from HSSR program at regional and state science fair competitions. *Year indicates when they competed in the science fair competitions

	2021	**2022**	**2023**
Top 1-3 Placement at Regional Science Fair	10	10	12
Special Awards at Regional Science Fair	9	4	4
Top 1-2 Placements at State Science Fair	9	--	6
Special Awards at State Science Fair	2	--	9

Data from the full assessment data from the 2020 cohort strongly supported the overall success of the program (**Figure 1**). All of the HS students were satisfied with the program, believed it would have a long-term benefit on their career, and would recommend the program to future students. Similarly, we found that a majority of the mentors shared a similar positive experience as the students. This was important as faculty buy-in is essential for successfully running these types of program. Moreover, nearly all of the faculty who were not satisfied by the experience expressed that their negative experience was not due to the program but due to trying to perform research under COVID-19 guidelines. Moving forward, the authors intend to perform similar assessments in the 2023 cohort and beyond.

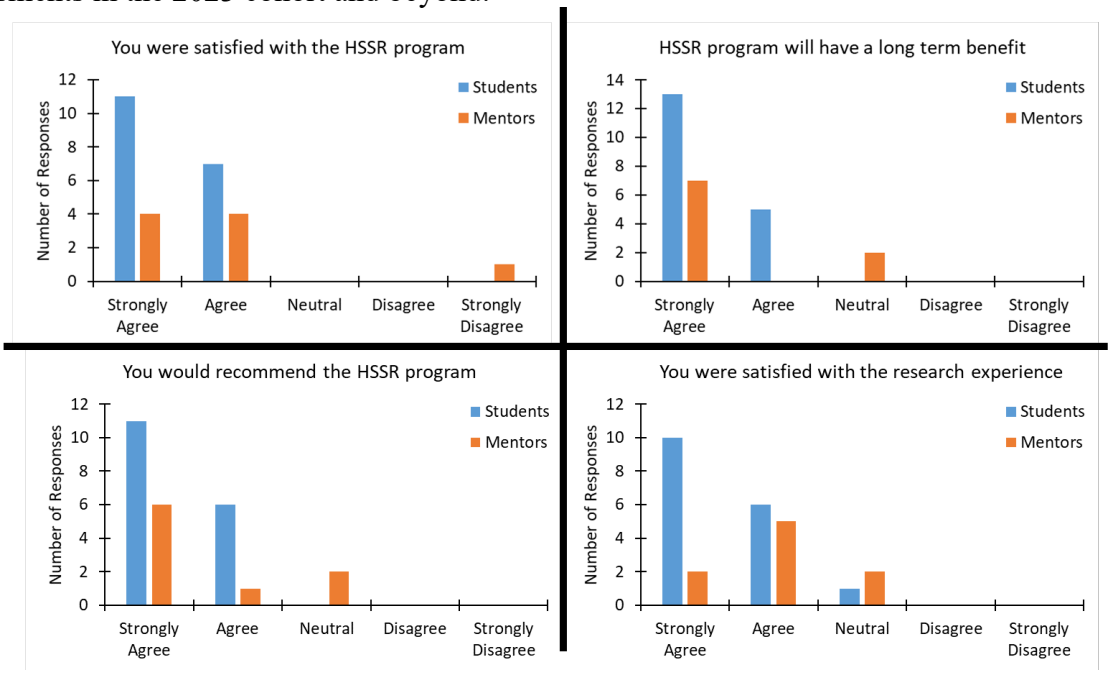

Figure 1. Assessment of the 2020 HSSR Program.

Conclusions and Future Work

During the past three summers the authors have learned a lot from running the HSSR program and implementing changes based on student feedback and author observations. The authors have made adjustments spanning nearly all aspect of the program from recruitment to admissions to the research timeline to the final poster competition to ultimately make a highly impact program based on the informal assessment from the students. The authors hope that this paper can serve as a roadmap for other colleges as they look to implement a similar program at their schools and hope that the lessons learned here will help to guide and shape these new programs. Additionally, the authors believe that the lessons learned during operating a program during the COVID-19 pandemic can help to direct future programs to provide research opportunities for students who live in the state of Louisiana but do not live close enough to Louisiana State University to participate in person. Moving forward, the authors are still working to increase the number of mentors from the college from all of the department to be able to increase the number of students who are admitted to the program. Additionally, one area of improvement for the program is a greater emphasis on the assessment of the program itself. This include additional assessment using five-point Likert scale questions (strongly agree to strongly disagree) on the impact of the program with both the mentors and students. Moreover, the authors are implementing plans to better track the alumni of the program to determine (i) if they elect to attend college, (ii) if they major in a STEM discipline, and (iii) the impact of the program on their decision on attending college and choosing their major.

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