Implementing a Virtual STEM Camp for Middle- and High Schoolers in a Post-COVID Climate Leveraging Prior Experience

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Abstract

This paper discusses the impact of the COVID-19 pandemic on education and STEM learning, leading to the development and implementation of a virtual STEM camp. It highlights the benefits of virtual camps in providing accessible and inclusive learning experiences, breaking geographical barriers, and promoting equity. The paper also proposes the concept of a hybrid STEM camp for middle and high schoolers, combining the advantages of both virtual and in-person learning formats. Drawing from the experiences of the Nanomaterials group, under the guidance of Professor Shudipto K. Dishari, at the University of Nebraska-Lincoln, which successfully transitioned from in-person to virtual camps at the height of the pandemic, the paper provides an overview of the steps taken to prepare and organize the virtual camp. Feedback obtained from both virtual and in-person summer STEM camp participants is discussed, and key strategies for a successful implementation of a hybrid STEM camp are shared. The proposed hybrid STEM camp aims to create a nurturing and stimulating environment for young learners, fostering their passion for STEM, and preparing them for a successful future in these fields. The inclusion of in-person workshops, enriched with immersive experiments and hands-on projects, will solidify theoretical knowledge with real-world applications, while the virtual components ensure accessibility to a broader audience and promote collaboration between students across various geographical locations. The hybrid STEM camp is envisioned as an innovative and dynamic program, inspired by the experiences of the Nanomaterials group, to inspire and equip the next generation of innovators and problem solvers in the world of STEM.

Keywords:

STEM virtual camp, hybrid camp, nanoscience, renewable energy technology

Introduction

The COVID-19 pandemic has reshaped the way education is delivered, pushing institutions to adapt rapidly to online learning platforms [1], [2]. One area that particularly felt the impact was science, technology, engineering, and mathematics (STEM) education, where hands-on learning experiences were limited. An NSF (National Science Foundation) report indicated around 55 million students (about twice the population of Texas) in the U.S. were affected by the shift to virtual or alternative learning [3]. However, the pandemic also sparked creativity, leading to the development of virtual STEM camps. Exploring the possibilities of implementing a virtual STEM camp for middle- and high school students in a post-pandemic era while drawing from prior experiences of in-person STEM camps would serve as an avenue to create an enriching and engaging educational environment.

In a post-COVID climate, a virtual STEM camp holds a pivotal role in providing accessible and inclusive learning experiences [4]. They break geographical barriers, allowing participation from diverse regions. Moreover, they promote equity by accommodating different learning styles and cater to students with varying abilities/disabilities. With flexible schedules and reduced costs, a virtual STEM camp enhances accessibility and widens STEM education.

For the past seven (7) years, the Nanomaterials group at the University of Nebraska-Lincoln (UNL), led by Professor Shudipto K. Dishari (the group is also referred to as “Team Dishari”) has been facilitating summer STEM camps for students and instructors across various academic grades. Activities such as Young Nebraska Scientist’s program, Sunday with a Scientist, Solar Eclipse STEM expo, Engineering Readiness Academy, and UNL’s Women in Science conference to mention but a few are programs where STEM-based summer camps have been implemented by Team Dishari. In addition, the team has had the opportunity to visit UNL’s Children Center, Culler Middle school After-school Science Program, Columbus (Nebraska) nanocamp, and Bright Lights nanocamp amongst others to introduce nanoscience and renewable energy concepts to pre-K, middle- and high school students alike. With the onset of the COVID pandemic, the experiences and lessons learned through prior in-person camps were leveraged and implemented towards organizing a successful virtual camp. Thus, in this paper, we provide an overview of the approach we took to prepare a virtual STEM camp based on our prior in-person experiences. We also highlighted some strategies based on experience garnered that are key to successfully implementing a virtual camp. Lastly, we propose a hybrid STEM camp that combines the best aspects of both virtual and in-person learning to create an innovative and enriching experience for middle and high school students.

Methods

Through the years, participants enrollment has been facilitated through various programs such as the Young Nebraska Scientists (YNS) program, generously sponsored by Nebraska EPSCoR (Established Program to Stimulate Competitive Research), Emporia State Trio Talent Search, Advanced Chemistry Field Trip Team from High School etc. amongst others.

In 2021, the virtual STEM camp saw an enthusiastic response, attracting 19 students who registered to take part in the enriching educational experience. While in the 2022 in-person STEM camp, 75 students registered as participants.

Analysis

All data was collected at the end of the camp activities. The data obtained from survey responses provided by the participants were subjected to analysis using Microsoft Excel software.

Preparation for the virtual camp

This section describes the preparation and distribution process of the materials and resources utilized for the virtual camp focused on simple day-to-day experimentation in the Nanomaterials laboratory. A breakdown of the several aspects is as follows:

1. Materials procurement: The required materials for all experiments were purchased from Amazon and Walmart. These materials include safety goggles, hand gloves, anthocyanin powder, disposable lab coats etc. These items are essential for ensuring smooth operation of the camp and the safety of the participants during the hands-on experiments.
2. Experimental kits: The experimental kits, which contained all necessary materials for the specific experiments, were assembled by graduate students in the Nanomaterials laboratory (Figure 1). Hand-preparing the kits ensured that the participants received the correct materials for each experiment. A checklist was also made available, so the participants could inspect and verify that all materials needed were received.
3. Safety precautions: We prepared a basic laboratory safety manual and included it in the experimental kit. We did this to expound on the importance of safety and to ensure that all participants are familiar with basic safety protocols while conducting the experiments.
4. Packaging and shipping: Once all the materials and experimental kits were ready, they were boxed up and shipped to each participant via FedEx. Shipping the materials one week before the virtual camp's start date allowed the participant's enough time to receive the packages, go through the checklist to ascertain that they received all the necessary materials and then be prepared for the activities. Figure 1 shows individual kits prepared and boxed before they were shipped out.
5. Preparation for participants: To familiarize the participants with the experiments and ensure that they can follow the procedures safely, additional resources were provided in advance. These resources include instructional videos, Zoom/calendar invitations, and experimental protocols (detailed instructions for conducting each experiment). These materials were uploaded online and sent to the students before the camp started. Link to the instructional video: https://app.vidgrid.com/view/HwyroWNQnYWH

By providing necessary safety materials, pre-assembled experimental kits, and preparatory resources, we ensured that the virtual camp participants had a smooth and educational experience while exploring nanomaterials and conducting experiments from the comfort of their homes. Taking such an organized approach showed dedication and commitment from the Nanomaterials group members to providing a valuable and safe learning experience for the participants.

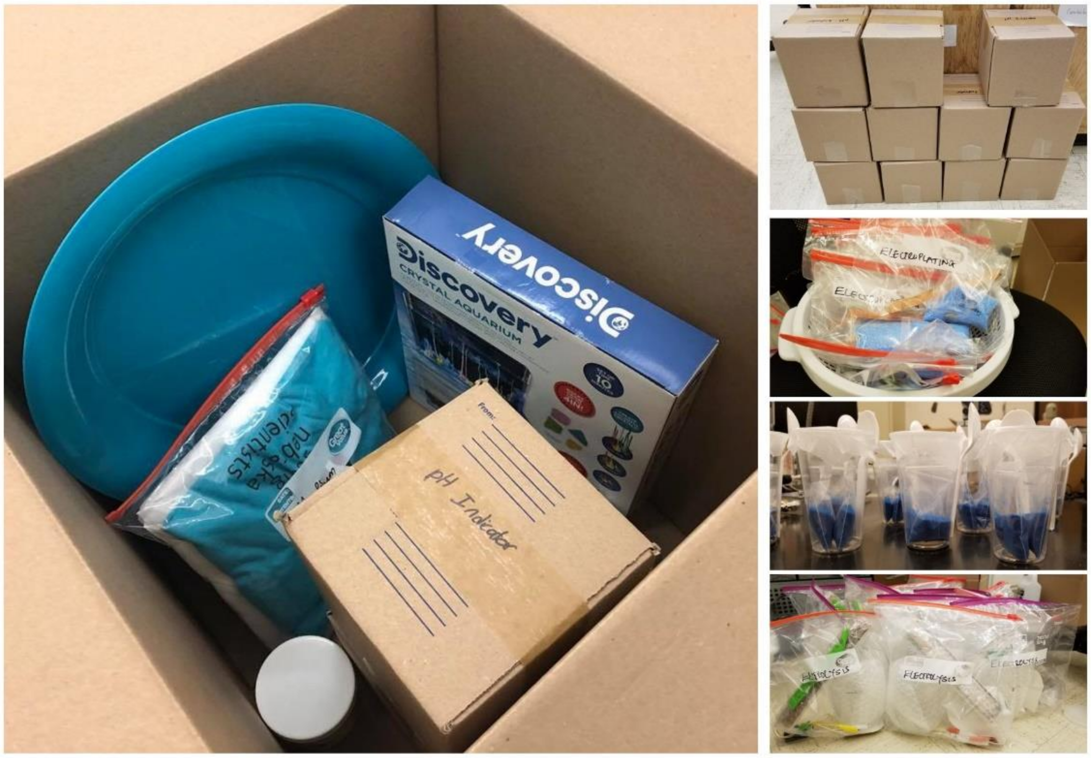

Figure 1. Hand-prepared experimental kits packaged in the Nanomaterials laboratory at UNL. The materials and resources used for all the experiments conducted were purchased from either Amazon and/or Walmart, prepared and packaged individually in a small-sized (5 × 5 × 5") corrugated box which was subsequently placed into a medium-sized (25 × 25 × 25") corrugated box before being shipped to the participants.

Student Responses and feedback

Virtual camp (2021)

The impact of the virtual camp on participants was highly significant, with over 70% reporting increased knowledge about renewable energy and newfound confidence in pursuing STEM-related fields (Figure 2). The camp's carefully crafted activities and engaging sessions successfully sparked interest and curiosity among the participants leading to a positive shift in their understanding of renewable energy concepts and the possibilities within STEM disciplines. The overwhelming majority, 83.3%, found the virtual camp to be extremely and remarkably interesting, highlighting the program's ability to captivate and engage its audience effectively. The mere 3% who showed slight interest suggests that the camp managed to maintain elevated levels of engagement and kept participants actively involved throughout the duration. These impressive results indicate that the virtual camp not only achieved its educational goals but also succeeded in cultivating a sense of enthusiasm and passion for renewable energy and STEM fields among the participants, leaving a lasting impact on their educational and career aspirations.

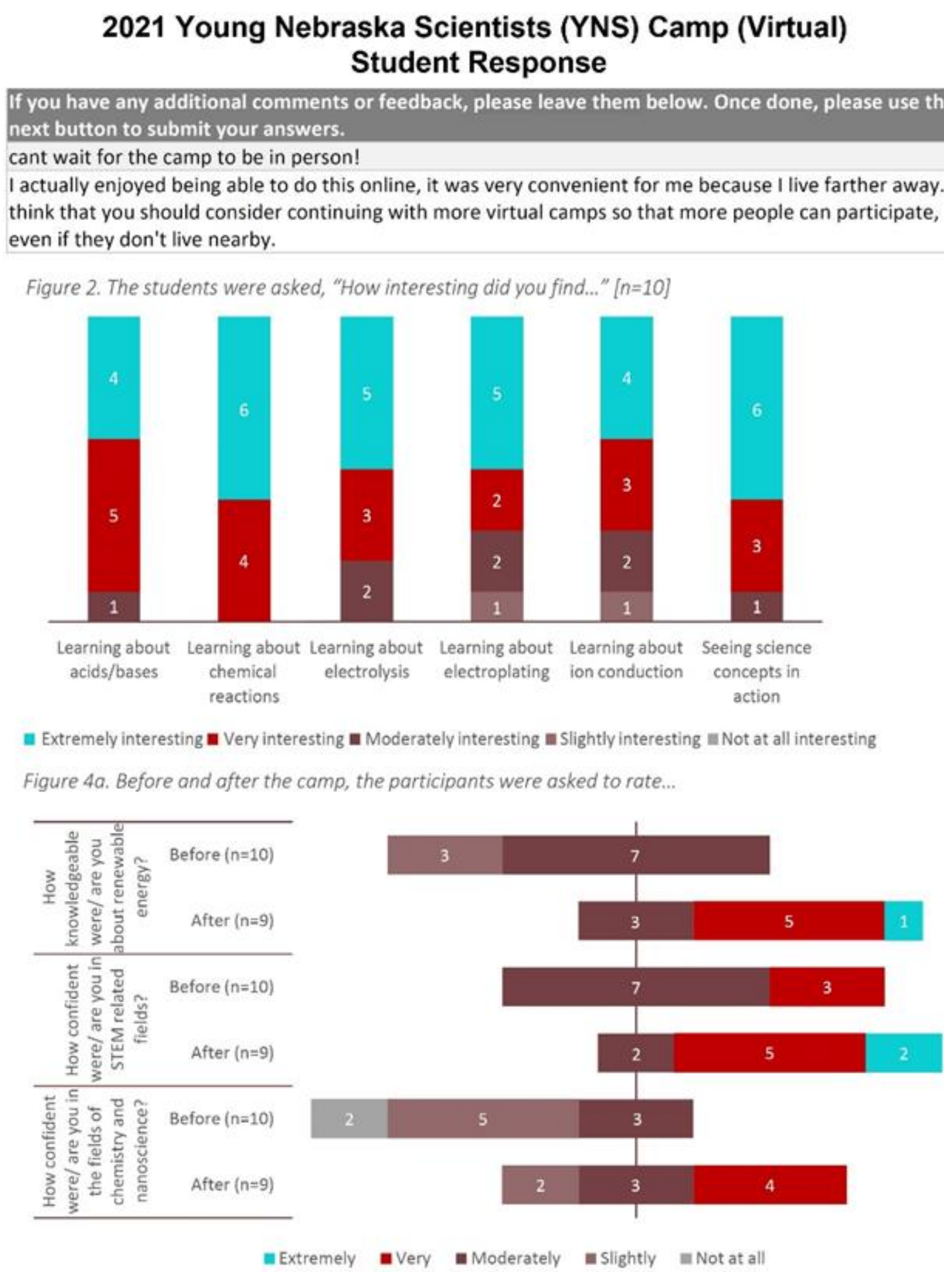

Figure 2. Student responses before and after the 2021 virtual STEM camp session.

In-person camp (2022)

The in-person session also proved to be highly effective in sparking interest among participants, with 90% expressing curiosity about witnessing science concepts in action (Figure 3). This demonstrated the camp's ability to captivate the participants' attention and engage them actively in the learning process. The impact of the camp, however, was also seen afterwards when there was an astounding 100% increase in interest in the fields of nanoscience and renewable energy. This remarkable surge in interest highlights the camp's success in inspiring and motivating participants to explore these specific STEM fields further. These results not only display the camp's effectiveness in fostering interest in science but also suggest its potential to influence career aspirations and academic pursuits, empowering the participants with newfound passion and knowledge in STEM domains.

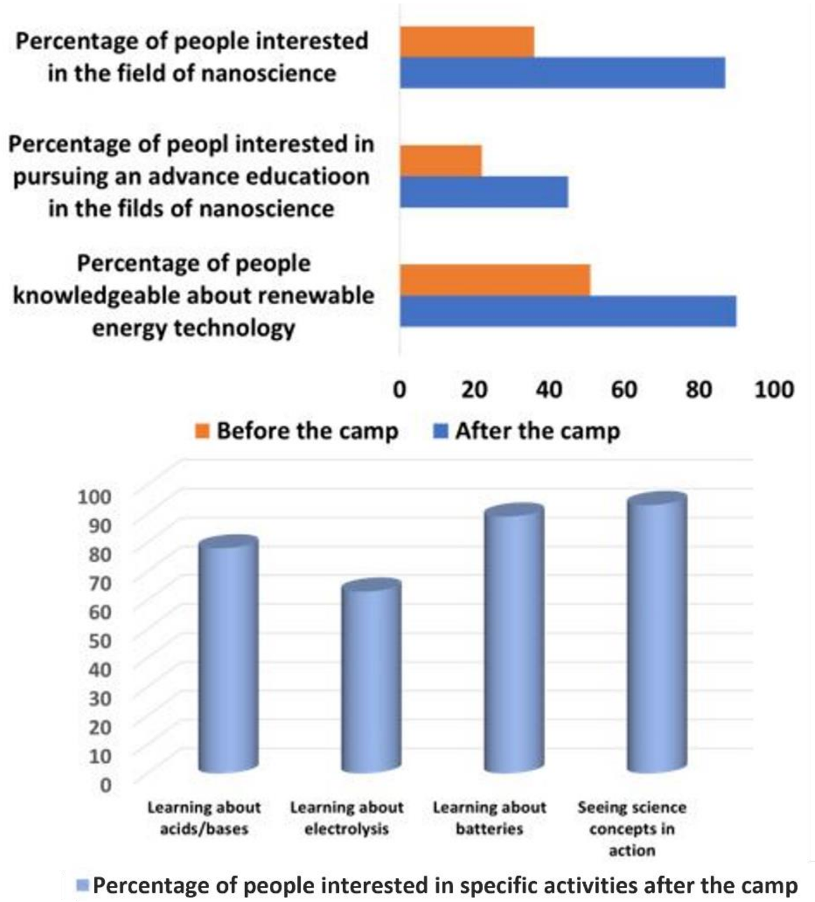

Figure 3. Student responses before and after the 2022 in-person STEM camp session

Key strategies to successfully implement a virtual camp

1. Choosing an interactive online platform: Choosing a user-friendly and reliable online platform enables real-time interaction between the students and their instructors. We utilized the Zoom platform because it offered advantages such as video conferencing, virtual whiteboard tools and breakout rooms. A sound and interactive online platform created a virtual camp environment that encouraged active participation, engagement, and collaborative learning between participants and the instructors.
2. Designing hands-on experiments and projects: We designed appropriate and safe experiments for the students to conduct from their respective homes using readily available materials. For example, for the pH indicator experiment which demonstrated the identification of acids and base mixtures, purple cabbage powder (anthocyanin powder) purchased from Amazon was measured (25 milligrams (about the weight of a grain of rice) each) and put into four different sealed graduated centrifuge tubes. To make an anthocyanin solution, the students simply had to mix the powder with tap water. 50 mL solutions each of orange juice, lemon juice, sparkling water, and vinegar were put

into appropriately sealed and labeled centrifuge tubes. These solutions with different pH served as our solution of interest while the anthocyanin solution acted as our pH indicator. All liquids were safely sealed and labeled before they were shipped out to the participants. During the actual experimentation, the students were only required to add each of the pH solutions into each of the indicator solutions, observe/record the visible color changes and quantify the pH of each solution using a pH paper.

3. Planning a well-balanced schedule with breaks to avoid fatigue: Planning a well-balanced schedule for a virtual camp is crucial to avoid fatigue and ensure an enjoyable and productive experience for participants. We ensured checking this box by clearly defining the camp objectives and divided the camp session into manageable time blocks with each experiment allocated 40 minutes to an hour. We took periodic breaks after every two to three sessions and avoided scheduling long, continuous sessions that could lead to fatigue and decreased engagement from the participants.
4. Virtual lab tours: We organized a virtual tour of our research lab and the research facilities at the Nebraska Center for Materials and Nanoscience (NCMN). This provided the students with a glimpse into the exciting world of STEM, fostering curiosity and the motivation to explore further.
5. Organize virtual team-building activities to foster a sense of community and collaboration: Virtual team-building activities are an excellent way to foster a sense of community and collaboration among participants in a virtual camp. It also promotes an inclusive environment for all participants. We started each camp session with icebreaker questions which allowed the students to share a little bit about themselves and/or their experiences. We realized that this helped ease them into the business of the day and encouraged their full participation.
6. Offer technical support to address issues that may arise.
7. Establish a feedback system to gather inputs from participants: We prepared anonymous surveys to gather structured feedback from the participants. The survey was designed to be straightforward with a mix of multiple-choice questions, rating scales, and open-ended questions.

Empowering the future: A proposed hybrid STEM camp for middle- and high school students

In the wake of the pandemic, there is widespread belief that the future of STEM education will adopt a "hybrid" approach, combining remote and traditional in-person learning [5]–[9]. As part of this innovative and dynamic shift, a hybrid STEM camp catering to middle and high school students emerges as a program aimed at inspiring young minds and equipping them with essential skills for success in STEM fields. In a recent work, Lane et al. [10], in a hybrid summer camp, conducted research on how digital game-based learning experiences can stimulate interest in STEM subjects using Minecraft as a game of choice. The researchers' findings indicated that remote camp settings could be as effective as in-person ones.

The primary objective of a hybrid camp is to create a nurturing and stimulating environment where students can explore and engage with like-minded peers in various STEM-related disciplines. By incorporating both virtual and in-person elements, a hybrid camp offers a flexible and engaging experience for participants. This innovative setup blends engaging virtual learning with expert-led online sessions and in-person (or virtual) collaborative group activities to ignite the passion for STEM among middle- and high schoolers (Figure 4).

In-person workshops enriched with immersive experiments and hands-on projects solidify theoretical knowledge and connect it to real-world applications, inspiring participants to envision exciting STEM career opportunities. To ensure equal access to resources, each student will receive a customized STEM kit.

The advantages of a hybrid STEM camp are manifold. For one, it bridges the gap between virtual and in-person participants, fostering collaboration and networking among students from different geographical locations, including those from various countries and regions, thereby enriching the camp's cultural and social diversity. Moreover, this format allows for more flexibility in attendance, scheduling, and participation, accommodating the diverse needs and circumstances of the participants. The inclusion of virtual components makes the camp accessible to a broader audience, including individuals with disabilities or health conditions that may hinder their ability to attend traditional in-person camps [11].

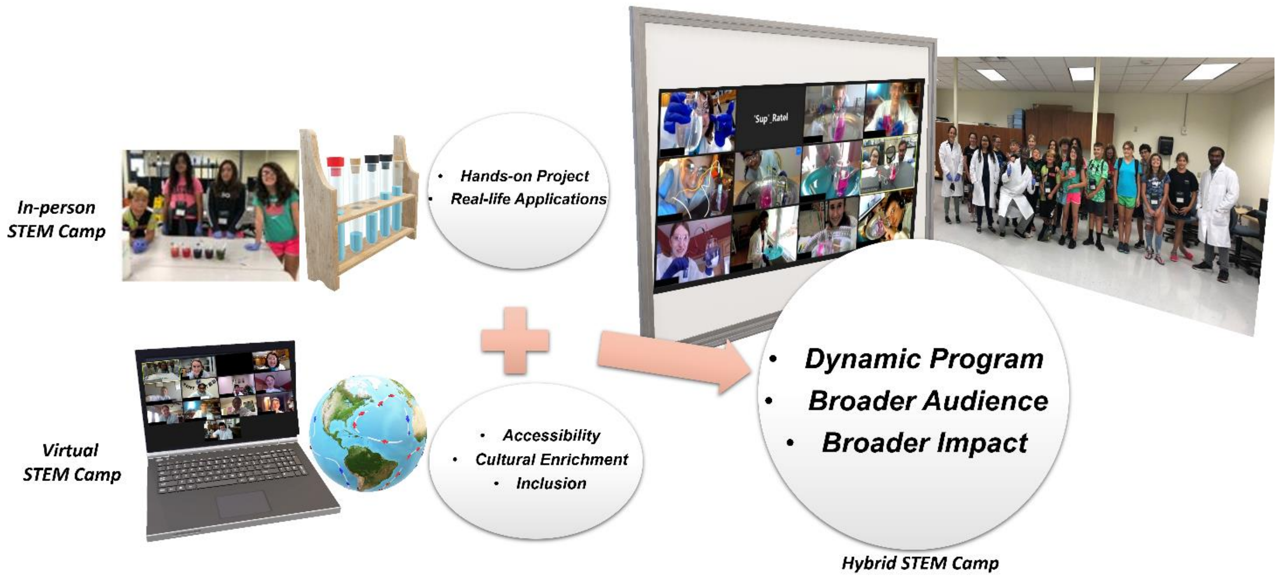

Figure 4. Nanomaterials groups' proposed Hybrid STEM camp, combining various elements from both in-person and virtual STEM camps.

Furthermore, the cost-effectiveness of hybrid camps and their reduced carbon footprint, resulting from minimized resource consumption and decreased travel requirements, make them environmentally friendly while remaining budget-friendly for participants [12]. As the education landscape evolves, hybrid STEM camps hold immense potential in shaping the future of STEM education for young minds.

Key strategies to successfully implement a hybrid STEM camp

Implementing a successful hybrid STEM camp will require careful planning, organization, and consideration of a range of factors. Here are some key strategies to ensure a smooth transition and effective implementation:

1. Define clear goals and objectives: Begin by establishing clear and measurable goals for the camp. As organizers, you should establish specific learning objectives for the camp, outlining what skills and knowledge you want the participants to gain. Then, align these objectives with the respective age and grade level of the students to ensure appropriateness.
2. Engaging curriculum: Developing an engaging and well-structured curriculum that incorporates hands-on activities, interactive experiments, team projects and real-world applications is also key to a successful hybrid STEM camp. Organizers should ensure that the content is challenging yet accessible to both middle and high schoolers.
3. Hybrid format: Balance in-person and virtual experiences to cater to both local and remote participants. Offer on-site (i.e., in-lab) activities for local students and provide remote participants with online sessions, virtual lab experiments, and interactive discussion. Utilize technology for remote collaboration.
4. Technology readiness: Ensure that all technology platforms and tools required for the camp are tested and reliable beforehand. Participants should have access to necessary devices and a stable internet connection.
5. Experienced instructors and mentors: Get qualified and experienced instructors who are passionate about STEM education and skilled in working with middle and high school students. You should also provide them with the necessary resources and training to ensure effective teaching.
6. Collaboration and teamwork: Design activities that encourage collaboration and teamwork among the participants. Working in groups enhances problem-solving and communication skills, major skills much needed in STEM.
7. Personalized learning: Recognize the diverse interests and abilities of the students and offer opportunities for personalized learning paths. Pre-assessments to gauge the students' knowledge should be considered and then, the curriculum can be tailored accordingly.
8. Safety protocols: For in-person or virtual hands-on activities and experiments, prioritize the safety and well-being of the participants. Extra care should be given to ensure that all participants understand and follow all relevant health and safety guidelines. Organizers should also plan to implement protocols that mitigate accidents during in-person or virtual hands-on activities and experiments.
9. Inclusivity and diversity: Ensure the camp is inclusive and welcoming to all students, regardless of their background, gender, or ethnicity. Organizers should strive to foster an environment that promotes diversity and values different perspectives.
10. Evaluation and feedback: Regularly assess participants' progress and gather feedback from the students and their parents/guardians. Use this feedback to make necessary improvements and enhance the overall experience.
11. Marketing and communication: Organizers should aim to develop a comprehensive marketing plan to reach the target audience effectively. Social media platforms, school partnerships and local community outreaches can be used to promote the camp.

By carefully implementing these strategies, one can create a rewarding and enriching hybrid STEM camp experience for middle and high school students. One should remember that it is especially important to continuously review and refine the approaches taken based on the feedback and lessons learned from each camp session.

Conclusion

The implementation of a virtual STEM camp demonstrated its value and advantages through increased engagement and interest among middle and high school students during the pandemic. By drawing on past in-person experiences, the virtual camp effectively addressed challenges related to lab access, enabling students to conduct experiments from home and sparking a huge interest in STEM fields, particularly in nanoscience and renewable energy technology. Leveraging the expertise gained from in-person STEM camps is vital when designing the virtual components in a hybrid STEM camp, allowing for a seamless transition, and maximizing the camp's impact on students' career aspirations and passion for STEM.

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