Development of a company-sponsored optics educational outreach program

Cory Boone, Rebecca Emerich, Andrew Fisher
Edmund Optics, 101 E Gloucester Pike, Barrington, NJ 08007

ABSTRACT

Public optics outreach is critical for fostering a passion for optics building the workforce that will solve the photonics challenges of tomorrow. This paper will cover the strategies and hands-on demonstrations that Edmund Optics used to build and scale a company-sponsored optics educational outreach program that now teaches over 2,000 students every year through over 60 events. The students reached through these events range from third grade to high school students. Internal promotion of the program has led to over 45 employees participating every year at local schools, museums, and local events. A system for on-site school visits allows students to take field trips to Edmund Optics' headquarters, and established shadow programs allow high school students to experience different careers in the optics industry. The program is now scaling to a global level, and best practices and strategies for scaling up a company-sponsored educational outreach program will be discussed.

Keywords: Outreach, optics, educational, education, optical, industry, company, science

1. INTRODUCTION

Optical sciences and engineering impact nearly all areas of modern life including health, energy, transportation, and the manufacturing of all the innovations that improve our quality of life. However, the majority of the population has little to no exposure to this field and may have no association with the term "optics" besides eyeglasses. An influx of new engineers, scientists, and technicians knowledgeable in optics is critical for the continued advancement of technology. Creating a company-sponsored optics educational outreach program spreads awareness of the importance of optics to not only young students reached through the program, but their families, teachers, and their surrounding communities. It sparks the passion for science that will build the workforce required for solving future photonics challenges. In addition, company-sponsored optics outreach programs have secondary benefits including improving employee communication skills, fostering a positive company culture, and spreading brand awareness.

2. DEVELOPING A LOCAL IN-PERSON OUTREACH PROGRAM

The optics educational outreach program at Edmund Optics started off as grassroots events organized by employees in their spare time. They reached out to local schools to set up visits where they could teach students about optics, but the frequency of events was inconsistent. Many organizations may find themselves in a similar situation with employees desiring to participate in outreach but no true organization or strategy. The following steps outline how a consistent, growing, company-sponsored outreach program was developed.

2.1 Dedicated outreach ownership and leadership

The first, and arguably most essential, step towards creating a company-sponsored outreach program is to establish dedicated ownership and leadership of the program. This could be one individual or a small committee of individuals. The optimal solution is to have outreach leadership built directly into an individual's job description. Edmund Optics leadership fortunately provided the resources to bring on Rebecca Emerich, a part time employee whose sole responsibility was the management of the outreach program. Rebecca was a middle school science teacher before taking on this new role. Getting executive buy-in for these resources will be discussed in Subsection 2.2. Volunteer outreach leadership can also be effective as long as responsibilities are clearly defined for the individual or small leadership committee.

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2.2 Getting executive buy-in

Securing company resources to dedicate to any non-volunteer outreach leadership and activities might appear difficult if the push for expanding the outreach program is not coming directly from executive leadership. The exact key "selling points" for securing executive buy-in for a given organization are dependent on the company culture and executives, but potential benefits to emphasize to company leadership beyond simply giving back to the surrounding community include:

1. *Long term investing in your company's future workforce* – Creating a passion for optics and science in the young people directly reached by the outreach program may very well become future employees, especially if they live locally to one of your locations.
2. *Spread brand awareness* – Outreach does not just make an impression on the students directly reached, it impacts their families, teachers, and surrounding community. This extended group may include potential customers and employees.
3. *Improve brand image* – Customers are more likely to purchase from a company they feel is making a positive impact through educational outreach or other means.
4. *Improve employee communication skills* – The ability to explain optical concepts at a simple level to young students strengthens employees' communication skills and knowledge of core optics concepts, which will be beneficial for their on-the-job performance.
5. *Improve employee performance* – A 2014 study published in *Management Science* found that employees engaging with corporate social responsibility policies have a 13% rise in productivity on average.[1]
6. *Build inter-departmental relationships* – Employees who may never otherwise work together can form close relationships through outreach activities.

2.3 First steps

With Rebecca as a dedicated outreach leader, Edmund Optics began laying the groundwork to grow the outreach program. The first step was establishing relationships with local schools ranging from elementary to high schools. Rebecca found contact information for local principals, teachers, museum directors, and educational non-profit leaders through Twitter and the organizations' webpages and emailed them to see if they were interested in a complimentary outreach visit to teach optics concepts through hands on demonstrations. Only approximately 2% of recipients responded. Rebecca also reached out to Edmund Optics employees with children to see if their teachers were interested.

The small initial group of teachers and museum staff who partnered with the Edmund Optics outreach program grew organically through word-of-mouth. Example demonstrations and best practices for outreach events themselves will be covered in Subsections 2.6 and 2.7. There are many available resources with demonstration ideas and other materials useful for starting an outreach program including Optics4Kids.com[2], the 100 Educational Activities About Light and Photonics Quick Reference Guide by Leiden University[3], and EdmundScientific.com, the online home of Edmund Optics' outreach program[4]. The development of the Edmund Scientific digital presence will be covered in Subsections 3.1 and 3.2.

2.4 Growing local in-person outreach program

The Edmund Optics educational outreach program grew organically after establishing the initial relationships described in Subsection 2.3. Hosting an event for one teacher spread the word that complimentary educational visits from Edmund Optics were possible to other teachers in the same grade, school, and district. Establishing the first relationship was the most important step.

Rebecca then fostered these relationships by keeping conversations going with teachers a few times a semester. Best practices discovered by Edmund Optics include reaching out to teachers every September. Many schools, especially 5th grade classes, tend to teach students about light in the Spring, at least in the state of New Jersey, USA. Touching base in September reminded teachers that Edmund Optics' outreach visits were available as they planned the year's curriculum

When touching base with teachers, Rebecca shared new educational videos and other educational resources. Creating a digital presence for outreach programs is described in Subsections 3.1 and 3.2. Photos from outreach events were shared on Edmund Optics social media channels, spreading awareness to other local schools and institutions.

Internal promotion of the program is critical for building a volunteer base of employees for participating in outreach events. Any internal communications such as newsletters, company-wide emails, and company-wide events are excellent ways to

highlight the work of existing outreach participants and make it clear to others that they can also get involved. It is not necessary for employees to be engineers themselves in order to understand optical concepts to the level required to participate in educational optics outreach. The number of Edmund Optics employees participating in outreach events has grown to 45 as a result of internal promotions and word of mouth.

2.5 Types of in-person outreach events

Edmund Optics participates in a variety of in-person outreach events for local young people including:

1. *School visits* – Visit local classrooms of students ranging from elementary school to high school to introduce them to optics and take them through hands-on demonstrations to teach them optical concepts such as total internal reflection, refraction, and polarization (see Subsection 2.7).
2. *Field trips/tours* – Local classes visit Edmund Optics' headquarters in Barrington, New Jersey for a short presentation about optics and how it impacts so many areas of our lives, hands-on demonstrations, and a tour of the building including our NJ optical manufacturing facility.
3. *Shadow programs* – A small group of high school students comes to the headquarters to "shadow" a department. A representative or group of representatives from the department give them a short presentation on what careers in that department look like and let the students see the department in action. For example, when shadowing manufacturing, employees can walk through the process of how a particular manufacturing challenge was solved with the students in the actual production environment, and when shadowing marketing, students can join a photo or video shoot.
4. *Community events* – Reaching out to local museums and non-profit organizations can open the door to participating in educational community events. For example, Edmund Optics participates in community nights at the Franklin Institute, a local science museum, where families come to see science demonstrations from a wide range of organizations and companies.

2.6 Best practices for hosting in-person outreach events

Over the years, Edmund Optics has discovered best practices for keeping students engaged during outreach events and maximizing participation. The language used by employees is critical for retaining the audience's attention and understanding. Technical vocabulary should be avoided and while optical concepts, such as polarization and total internal reflection, are being taught, they should be described in simple terms that are familiar to students.

To keep the audience engaged, any presentations should be as interactive as possible. While tools like PowerPoint can be helpful for framing a conversation, attention will be quickly lost if employees are simply talking to students from a slide deck for an extended period of time. Ask students lots of questions and tie concepts into things that excite them or relatable technologies that they interact with often in their lives. Ask if they have used virtual reality or augmented reality and explain that augmented reality is used in smartphone applications they are familiar with such as "filters" on social media that add virtual elements to the real images captured through their phone.

When describing optical concepts and components, explain how they connect to virtual and augmented reality, 3D movies, autonomous vehicles, and other interesting applications. Point out objects in the room containing optics or where optics were involved in manufacturing them, such as projectors, screens, and electronics like their cell phones.

The majority of Edmund Optics outreach events begin with a short presentation about optics and optical engineering and then stations of several demonstrations. Running multiple demonstrations at once with one employee per demonstration allows for the use of less materials, helps the presenter better control and engage with the students, and enables students to feel more comfortable asking questions since they are in a smaller, more intimate group.

2.7 Hands-on optics demonstration ideas

The resources shared in Subsection 2.3 including Optics4Kids.com[2], the 100 Educational Activities About Light and Photonics Quick Reference Guide by Leiden University[3], and EdmundScientific.com, the online home of Edmund Optics' outreach program[4], are great sources of hands-on demonstration ideas. When creating demonstrations, the Edmund Optics outreach program has several guiding principles. They should be hands-on and keep students active to increase engagement. The more physical the better. Demonstrations should involve scientific exploration and problem solving while also being scalable.

Scalable demonstrations can be performed both in a single classroom or a festival or other community event where there may be hundreds of participants. This can be achieved by utilizing materials that can be re-used or by leading demonstrations where disposable materials are small and inexpensive.

Four of the demonstrations proven to be most successful during Edmund Optics outreach events are:

1. **Laser maze**
    - Capacity: ~6 students
    - Time frame: 8-15 minutes
    - Summary: Introduce students to the concept of reflection.
    - Objective: Students will explore reflection through exploration. They will use mirrors to reflect laser light to navigate through a maze (Figure 1).
    - Materials:
        - 6 Lasers – 1 per student
        - 36 Mirrors – 6 per student
        - 6 Mazes – 1 per student
        - Index Cards – 1 per student
    - Laser Safety: Discuss with students the importance of laser safety. Emphasize that the lasers should only be used on their maze and not directed towards any person's face.
    - Up-front question: Ask students if they know what mirrors do.
    - Activity:
        - Give each student or pair of students 6 mirrors, a laser, maze and an index card.
        - Have students attempt to navigate the laser light through the maze by positioning the mirrors in the correct way. Have them use the index card to see where the beam of light is. See Figure 1 for the proper way to hold the laser and the correct arrangement of mirrors.
        - As students are working through the maze you can ask the following questions:
            - What is happening to the light? (It is reflecting off the mirrors).
            - Why can mirrors reflect light so well? (They feature smooth metallic layers, and for advanced students explain that the metallic layers are electrically conductive, causing the electromagnetic field of light to change directions and reflect).
        - Challenge early finishers to get through the maze using only 4 mirrors.

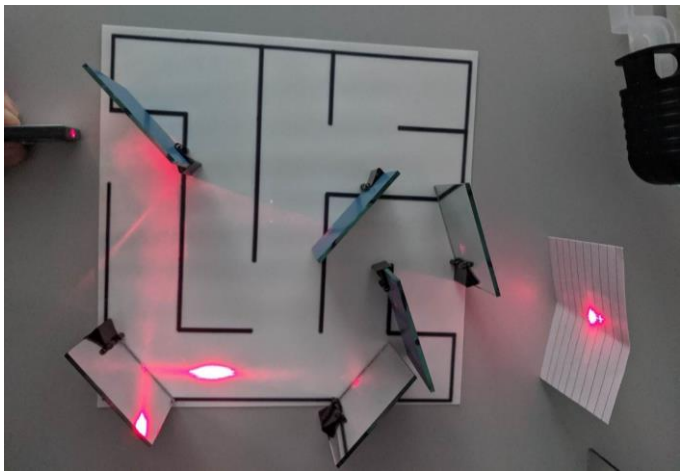

Figure 1. The laser maze demonstration is simple but drives home the law of reflection for students.

2. **Polarization**
    - Capacity: ~6 students
    - Time frame: 8-15 minutes
    - Summary: Introduce the concept of polarization.

- Objective: Students will explore polarization and polarimetry, ending by creating a "stained-glass" mosaic to further explore polarization.
- Materials
    - Laptop or other LCD screen – at least 1
    - 12 Polarizers – 2 per student
    - Slinky – only 1 needed
    - Oven rack, comb, or any other object featuring vertical lines with space between them, such as a comb – 2 needed
    - Piece of paper – only 1 needed
    - Transparent plastic objects (such as utensils, CD case, plastic wrap) - ~4 total pieces recommended
    - Plastic Sheets – ~4 recommended
    - Cellophane film tape
- Up-front question: Ask students if they have heard of polarized sunglasses. Explain that they are about to learn what makes them "polarized".
- Activity
    - Introduce the concept of polarization
        - Use slinky to demonstrate that light is a wave.
        - Use oven racks and slinky to show how linear polarizers work.
            - Explain that linear polarizers are made of materials all pointing in one direction, like the oven rack, and that they can only let light waves in a particular orientation pass through.
            - Turn the oven rack 90° so that it is now perpendicular to the orientation of the slinky and ask the students if the light will be able to pass through. It will not.
            - Now put the second oven rack in front of the first one but have its orientation be perpendicular to the first one. Ask the students what would happen to light going through if the light (slinky) was oscillating in different orientations. In all cases, it will be blocked.
        - Give each student 2 polarizers each so that they can see this for themselves.
            - Have them look through one polarizer at their surroundings.
            - Then have them place the second polarizer in front of the first one and rotate it, observing how they cannot see through it when the polarizers are "crossed".
            - Explain that polarized sunglasses block horizontally-polarized light, preventing glare.
        - Investigate the polarization of LCD screens.
            - Place a polarizer in front of a computer screen and rotate it, revealing that in certain orientations no light is let through.
            - Ask students what this tells them about the screen. It shows that the screen is polarized, and they can observe this with most LCD screens.
        - Use the computer screen and 1 polarizer to create a polarimeter.
            - Place transparent plastic objects between the computer screen and a polarizer to reveal a rainbow of colors.
            - Explain that this is showing the stress inside transparent materials. The change in density from this stress changes how fast light can move through the object.
            - Have students look at multiple objects through their homemade polarimeter.
            - Have students make a "stained glass window" by putting overlapping pieces of cellophane film tape on a sheet of plastic and looking at it in the polarimeter.

3. Morse code

- Capacity: ~6 students
- Time frame: 8-15 minutes
- Summary: Introduce students to the concept of total internal reflection (TIR).
- Objective: Students will understand the concept of TIR and how optical fibers are used for communication. Students will use a laser and fiber optics to send Morse code messages to their partner through a fiber.
- Materials:
    - Printed Figure 2
    - Lasers – 1 per 2 students
    - Optical fibers – 1 per 2 students
    - Morse code sheets – 1 per student
    - Pens – 1 per student
    - Pieces of paper – 1 per student
    - Optional materials
        - Fish tank
        - Creamer
        - Stirrer
- Laser Safety: Discuss with students the importance of laser safety. Emphasize that the lasers should only be used with their fiber and not directed towards any person's face.
- Up-front question: Ask students if they have heard of Verizon Fios. Explain that "Fios" stands for "Fiber Optic Service".
- Activity:
    - If you have the fish tank, creamer and stirrer, use them to demonstrate TIR.
        - Fill the fish tank about 2/3 full of water.
        - Add a pinch of powdered creamer and stir.
        - Shine the laser light through the fish tank at an angle so that TIR takes place.
        - Explain TIR in simple terms.
    - If you do not have the fish tank, creamer and stirrer, instead show them a printed image of Figure 2 and explain TIR in simple terms.

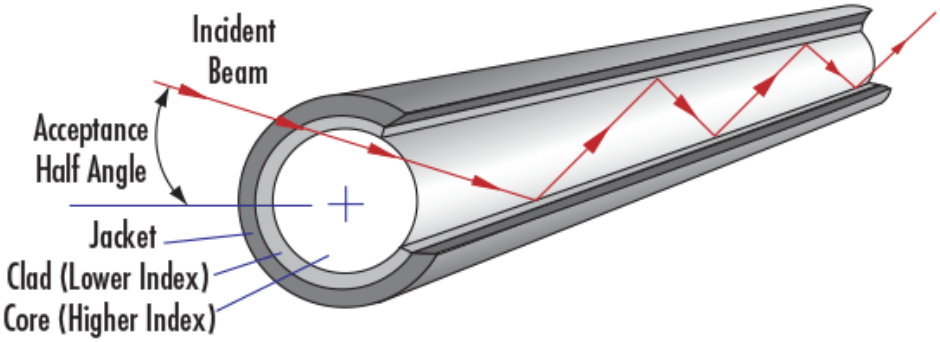

Figure 2: This depiction of total internal reflection (TIR) inside of an optical fiber can be used to introduce the concept to students if a fish tank is not available.

    - Next, shine a laser into one end of an optical fiber and show the students the laser coming back out the other end, even when the fiber is bent.
    - Explain the importance of fiber optic communications for high-speed internet in simple terms.
    - Have students send Morse code messages to each other through a fiber.
        - Break the students into groups of 2, with a group of 3 if there are an odd number of students.
        - Give each group 1 laser, 1 optical fiber, and as many Morse code sheets, pens, and pieces of paper as there are students in the group. Figure 3 is an example Morse code sheet from the Radio Society of Great Britain[5].

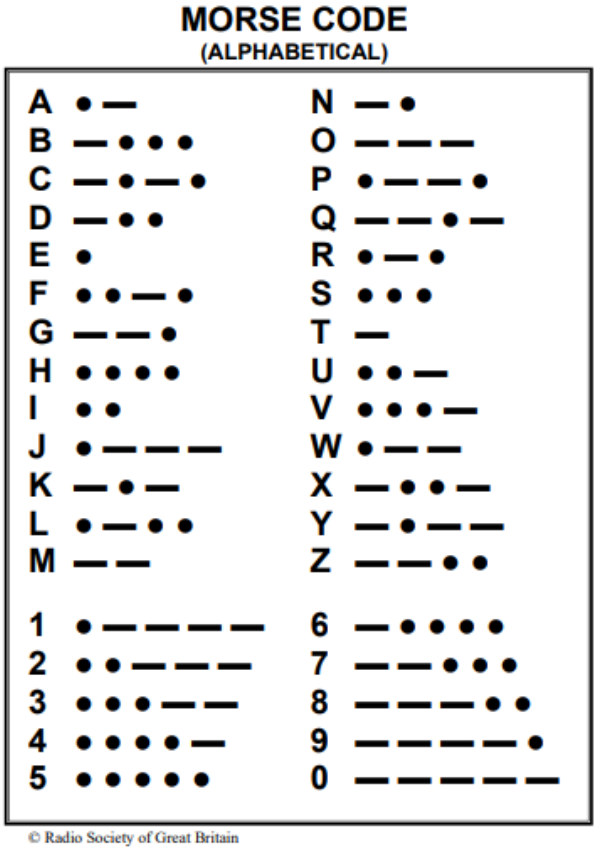

Figure 3: Morse code sheet from the Radio Society of Great Britain[5]

- Explain that the dots are a short pulse of laser light and the dashes are a longer laser pulse.
- Have 1 student in the group hold one end of the fiber and send a message through it using the laser and Morse code.
- The other student(s) will hold the other end of the fiber and decode the message, using a pen to write the message down on their paper.
- Once the message is decoded, have the students switch so that they all get to both send and receive messages.

4. Fun with filters

- Capacity: ~6 students
- Time frame: 8-15 minutes
- Summary: Introduce students to white light, diffraction gratings, and optical filters.
- Objective: Students will observe all the colors of the visible spectrum through a diffraction grating and see the effects of optical filters on white light.
- Materials:
  - Diffraction gratings – 1 per student
  - Slinky – only 1 needed
  - Filter sets – 1 per student
    - Set of absorptive filters in violet, blue, green, yellow, orange, and red
  - Flash lights – 1 per student
  - Pieces of white paper – 1 per student
- Up-front question: Ask students if they know what colors white light is made of.

- Activity:
    - Have students look through their diffraction gratings at light sources around them and explain what they see. They will see rainbows as the grating breaks the broadband light sources around them into their component wavelengths.
    - Explain that white light is made of all visible colors and describe how rainbows are formed in simple terms.
    - Use the slinky to demonstrate that light is a wave and describe how color is determined by wavelength.
    - Introduce students to optical filters.
        - Have them look through individual filters and shine their flashlight through them.
        - Ask them to explain what is happening to the white light. All wavelengths except those matching the color of the filter are being absorbed, while those select wavelengths are transmitting.
        - Ask them to try and make certain colors without using that color filter.
            - "Create yellow light without using the yellow filter," which is done with red and green filters.
            - "Create magenta light without using the magenta filter," which is done with blue and red filters.
            - "Create green without using the green filter," which is done with blue and yellow filters.
        - Ask students what will happen if they put all of the filters together. No light will be transmitted since all wavelengths will be absorbed.

3. SCALING UP PROGRAM FOR GLOBAL REACH

Building an in-person program is a great way to educate those in your local community, but finding ways to make your outreach program digital will allow for it to be efficiently scaled up. Also, in times where in-person outreach is not possible, such as the COVID-19 pandemic, digital outreach may be the only way to continue optics education.

3.1 Creating outreach videos

Videos explaining optical concepts in simple terms can be conveniently incorporated into teacher's lesson plans, introducing optical concepts without the resource commitment of an in-person outreach visit. Edmund Optics was fortunate enough to have an in-house video production team, but even simple videos captured using a cell phone can now be more than sufficient quality.

Edmund Optics created several different types of videos to expand the audience reached through our outreach program. Our higher-production value videos include an introduction to optics and a series of others featuring Rebecca Emerich that introduce the concepts of refraction, reflection, lasers, and absorption[4]. These videos are shared through Edmund Optics' outreach website and YouTube channel.

Edmund Optics also created a series of new, lower production quality videos to address the closure of schools due to the COVID-19 pandemic. Employees recorded themselves explaining an optical phenomenon such as why the sky looks blue and how cameras work. These videos were uploaded to a website called Flipgrid and shared with our outreach contacts and others in Edmund Optics' database[6].

Creating similar videos and a webpage to act as a home for your outreach program will help build a digital presence that expands your reachable audience.

3.2 Hosting virtual outreach events

The COVID-19 pandemic led to Edmund Optics developing completely virtual outreach events, as all in-person events were cancelled. Events were set up in Zoom Video Communications so that students could join a call with several Edmund Optics employees and a group of other students from their homes. First, students were shown the same PowerPoint presentation used during in-person events to introduce them to optics.

Next, the students were walked through hands-on demonstrations. Edmund Optics mailed kits of optical components and materials for demonstrations to all students that registered, but virtual outreach events can also be effective without dedicating the resources to ship supplies to students. Many activity ideas from the sources described in Subsection 2.7 can be performed with common household objects. Instructions can be sent to parents before the event so that the required materials can be gathered.

The demonstrations in the Edmund Optics virtual outreach events included the Fun with Filters demonstration described in Subsection 2.7, creating a rainbow by placing a mirror at an angle in a tin of water and shining a flashlight on it, and using a flashlight to observe transmission, reflection, and absorption in common materials. While not a direct substitute for in-person events, virtual outreach events allow you to expand your outreach audience beyond those geographically close to you. They also future proof your program from situations which make in-person visits impossible.

3.3 Spreading in-person outreach program across a global organization

Edmund Optics' outreach program mainly stemmed from the Barrington, NJ headquarters. Several steps were followed to further scale up to a global outreach program which coordinated efforts across multiple locations across the globe. If you are creating a company-sponsored outreach program for a global organization, these steps will help greatly expand your outreach audience.

1. *Create a template for outreach events* – Creating a shared format used for outreach events put on by different global locations ensures that best practices are shared among all locations. This also makes it simpler to add to and refine the structure of all global outreach events.
2. *Send outreach kits to each location* – Kits containing optical components and materials for several hands-on demonstrations can be sent to locations across the globe to ensure they have everything required for outreach events.
3. *Social media promotion* – Sharing pictures and information about global outreach events hosted by your company spreads awareness and can lead to more teachers, parents, and others in your local communities wishing to participate.

Following these steps has helped Edmund Optics transform their local outreach program to a global one that reaches students in the Americas, Asia, and Europe.

4. CONCLUSION

Introducing young students to optical sciences through public optics outreach plants the seeds that could grow into the future passionate and skilled photonics workforce. Developing a company-sponsored optics educational outreach program accomplishes this while offering employees a fulfilling way to give back to their communities and enhance their own skills. The steps followed by Edmund Optics outlined here provide a possible template for creating and building such a program. While the structure and culture of every company differs, this blueprint aims to provide tools that could be beneficial to any company wishing to develop an outreach program. A wider spread of company-sponsored programs across the industry will educate young people across the globe at a scale beyond the reach of any company on its own.

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