Quantum education and pathways - an open-source modifiable presentation to high school and college students

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ABSTRACT

This paper describes and provides examples of a presentation, 'Quantum for High School & College Students' created to give to high school and college students to encourage them to consider using quantum science and technologies in their studies and careers. Some thoughts on critical thinking about abstract subjects and mentoring capture the attention of the student audience, which is followed by the main topics. The presentation includes an introduction to quantum science (including a laser diffraction demonstration), quantum computers and cybersecurity, many more quantum science and technology applications, education and career pathways that use quantum science and on-line resources. There is a very brief history of quantum science, an outline and nine examples of the many fields of study and endeavor, and a couple (optional) references to how governments are supporting these efforts. Some specific on-line references are provided to company and university websites where substantial information can be found for students seeking to learn more about all thing's quantum with some focus on quantum computing.

The modifiable Power Point presentation can be downloaded from the author's website, complete with lecture notes and hotlinks to all the references. A specific webpage has been created and organized so that it can be accessed by potential presenters and students seeking to learn more about the topics. The presentation can be given by other volunteers including quantum graduate students, professors, and high school teachers. The presentation and on-line resources may be very useful to SPIE members and SPIE Student Chapters seeking to recruit students to their companies and universities. Other related professional societies, such as the American Institute for Physics and their Society of Physics Students may also find this useful.

Keywords: Quantum education, career pathways, outreach, high school, college, students, Kahoot, laser

1. INTRODUCTION AND MOTIVATION

In a previous paper[1] presented by the author and his colleagues at this conference in 2018, an introduction and history were reviewed of the Laser Electro-Optics program at Irvine Valley College. After about 25 years, that program was transferred to Pasadena City College[2], near the Jet Propulsion Laboratory, where the principal instructor, Dr. Brian Monacelli, works as a Senior Optical Engineer. Throughout the years of formal and informal optics and laser education, it has been clear that there were many more job openings than there were skilled and educated people to fill them. This remains true and is even more so for those additionally educated with quantum science and technology as described in a recent paper[3] published by the author and his colleagues regarding a new program, EdQuantum, being developed as an extension to the laser technology program lead by Laser-Tec[4]. In this EdQuantum paper, some future work is described to help build a pipeline of students from high schools and early college years to education and careers in the quantum world. Specifically referenced in this paper is the alignment with the National Science Board (NSB) Vision 2030 Roadmap[5], "To help fill the quantum education pipeline for future years, the EdQuantum project will use educational tools and recruiting networks for K-12 so EdQuantum students, teachers, and professional industry volunteers can work with K-12 educators in their local regions to prepare K-12 students for college and university programs that include quantum technologies." And "Future EdQuantum efforts may involve reaching out and cooperating with professional societies such as SPIE and Optica as well as with photonics clubs at colleges and universities in Central America, South America, and the Caribbean to share our curriculum and materials for teaching quantum science." Note that while the author wrote these sections into the EdQuantum paper, the current efforts are the individual contributions by the author and are being implemented in Southern California. The next phase of this effort will be in cooperation with the Optical Society of Southern California and affiliated companies, schools, and non-profit organizations.

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2. MODIFIABLE PRESENTATION CONTENT

The Power Point slides of the presentation, "Quantum for High School & College Students", are available to download from the author's website so that they can be modified to fit the presenters' biographical details and perspective on quantum science and technology. The main goal is to provide presenters with a substantial starting point so presenters do not have to start from scratch to create a new presentation; but can use the slides and resources provided. The hope is that presenters will use this presentation to jump start their educational recruiting process and be able to get in front of prospective quantum students that may join their college and university programs and then get jobs in the quantum workforce. The main slides that need to be modified are the title page (figure 1) and introduction page (figure 2). The mentors page (figure 3) also needs to be modified to show and describe mentors of the presenter. There is also a slide about Pasadena City College's Laser Tech program in Southern California that is specific to the author and others that are in Southern California. This can be replaced with information about a college or university local to the presenter. All the other slides may be used 'as is' or modified to meet the presenter's perspective to reach the students in their audiences. The slide on critical thinking is, in the author's opinion, important to convey to students because it describes familiar abstract words and concepts that can then be used to discuss quantum concepts that are unfamiliar and abstract. This can help get the students in the audience be prepared to receive an introduction to quantum concepts and how they are related to more familiar concepts like computers, chemistry, biology, energy, finance, manufacturing and many more.

The last two sections of the presentation; 'Pathways for High School and College Students' and 'On-Line and In-Person Resources' are the 'call to action' to provide the students specific action they can take to get involved in the quantum world. These will be reviewed in section 5 of this paper and these slides can also be modified with the presenter's contact information and opportunities for live in-person follow on instructions, in addition to the on-line resources that students in any geographic location can access, typically at no cost to the students.

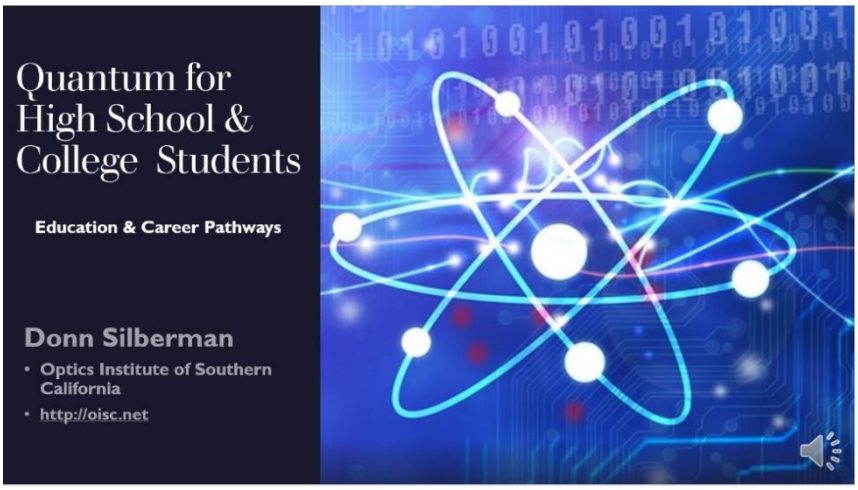

Figure 1. Title slide to be modified by new presenters

Figure 2. Introduction slide to be modified by new presenters

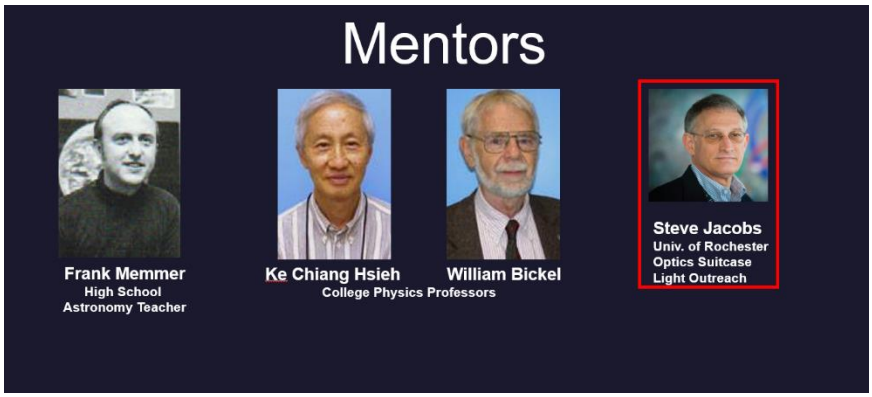

Figure 3. Mentors slide to be modified by new presenters

3. LASER DIFFRACTION DEMONSTRATION – A QUANTUM DEVICE

As part of "What is Quantum?" and "Why should you care?" There are a few slides, a short video and a live (or recorded) laser diffraction demonstration about the historic development of quantum physics. The laser is used to articulate and demonstrate, as shown in Figure 4, some differences between Newtonian and quantum physics and capture the students' attention and keep them excited about learning more.

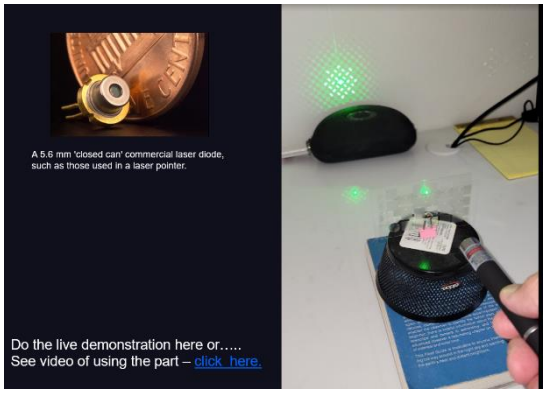

Figure 4. Laser Diffraction Demonstration

4. USING 'KAHOOT! FOR SCHOOLS' - REALTIME QUIZZES

An on-line educational tool, 'Kahoot! For Schools'[6], was introduced to the author by the local high school engineering instructor[7] who has allowed the author into his classrooms to give the first versions of this presentation. Together, the author and instructor created two Kahoot quizzes for this presentation. Six questions and one definition are provided in the first Kahoot, mid-way through the presentation and six questions and one information slide are in the second Kahoot near the end of the presentation. Figures 5 & 6 show examples of Kahoot screen shots from the presentation. Figure 5 is a screen shot of a quiz question and Figure 6 is of a definition.

The main idea for using Kahoot is to engage the students more deeply during the presentation so that they can integrate the topics and concepts into their daily thinking and be ready to "take action" down the path that includes some quantum education and career opportunities. Using the two prepared Quantum World Kahoot quizzes during the presentation is as simple as clicking on the URL links on the slides and then clicking through the prompts as a guest or the presenter can log into Kahoot if they have previously signed up with an appropriate username and password. The images that appear on the presentation screen prompt the students to scan an on-screen QR code with their cell phones and then provide the current Kahoot game number and their nickname. Then their nickname will appear on the screen with all their fellow students who have signed in. There are extensive instructions on how use public Kahoot quizzes in reference [6] and a pdf file on the author's website with some specific examples.[8]

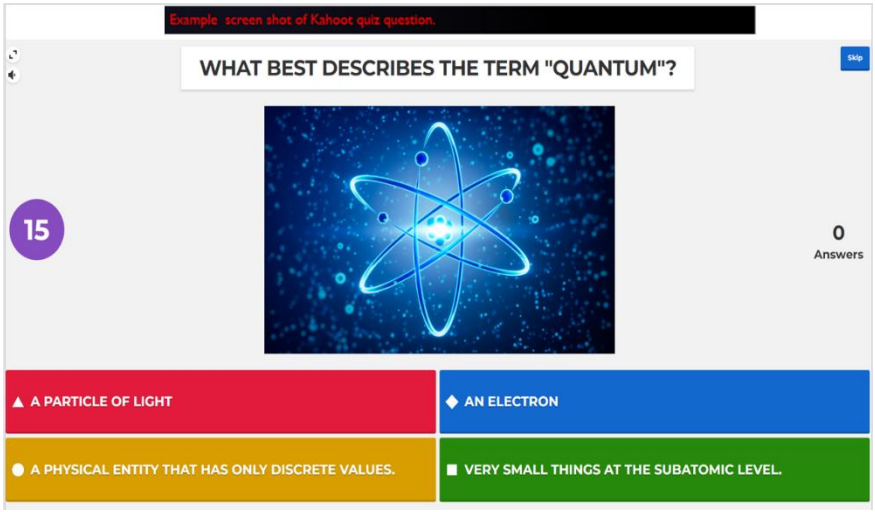

Figure 5. Example screen shot of Kahoot quiz question.

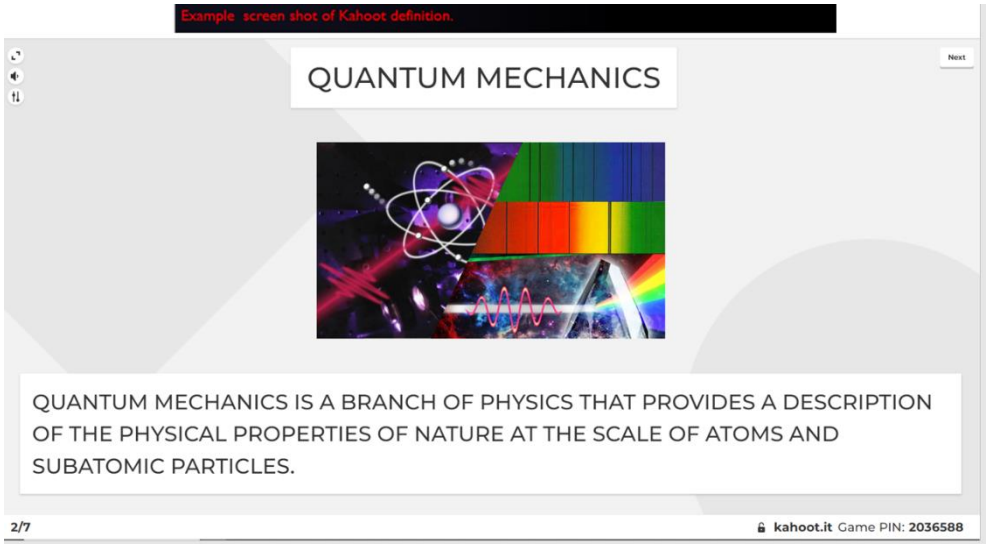

Figure 6. Example screen shot of Kahoot definition.

5. MANY MORE QUANTUM COMPUTING APPLICATIONS

There is a section in the presentation to the students that briefly reviews seven quantum computing applications and mentions nine more, as shown in Figure 7. Links to all of these are available on the author's website. These are provided to give the students a flavor of the many applications where quantum computers are being explored.

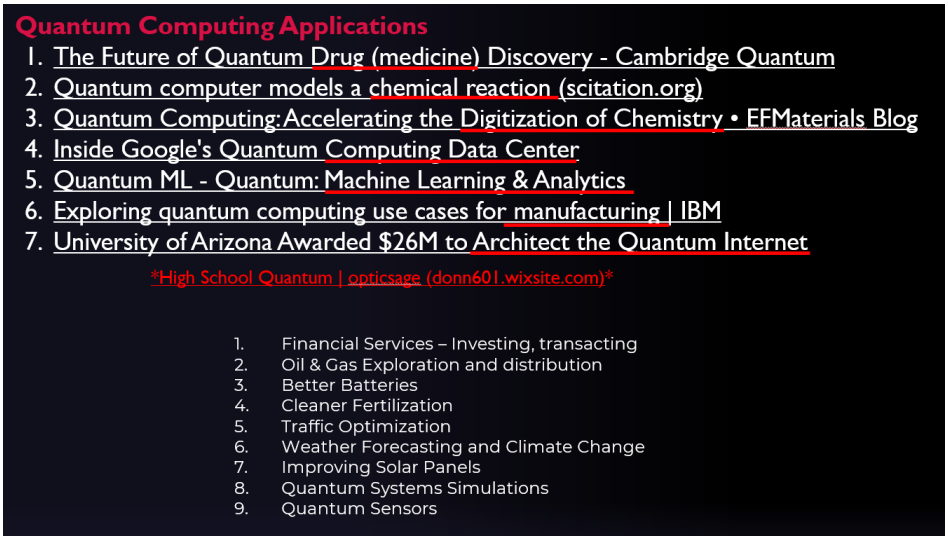

Figure 7. Quantum computing applications that are reviewed in the student presentation and more that are referenced on the author's website.

6. ADDITIONAL RESOURCES FOR PRESENTERS, TEACHERS, AND STUDENTS

As mentioned earlier in this paper, the last two sections of the presentation; 'Pathways for High School and College Students' and 'On-Line and In-Person Resources' are the 'call to action' to provide the students specific action they can take to get involved in the quantum world. Some of these slides should be modified with the presenter's contact

information and opportunities for live in-person follow on instructions, in addition to the on-line resources that students in any geographic location can access, typically at no cost to the students. Other slides can be used as is, such as the Quantum Educational Resources, shown in Figure 8, Big Tech Websites and Quantum Computing Quantum Companies, (not shown) and Quantum On-Line Resources, shown in Figure 9.

Figure 8. Quantum Educational Resources

Figure 9. Quantum On-line Resources

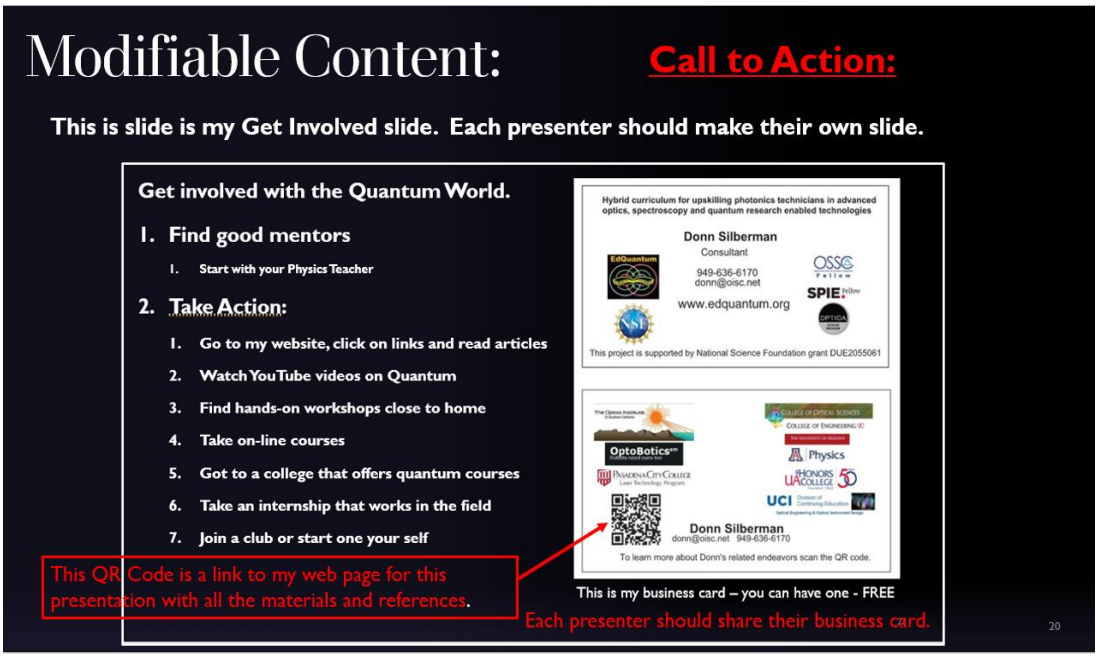

Figure 10. Get involved with the Quantum World

The final slides that need to be modified are "Get involved with the Quantum World" shown in Figure 10, Follow the Digital White Rabbit, shown in Figure 11 and the Summary / Thank You slide, (not shown.)

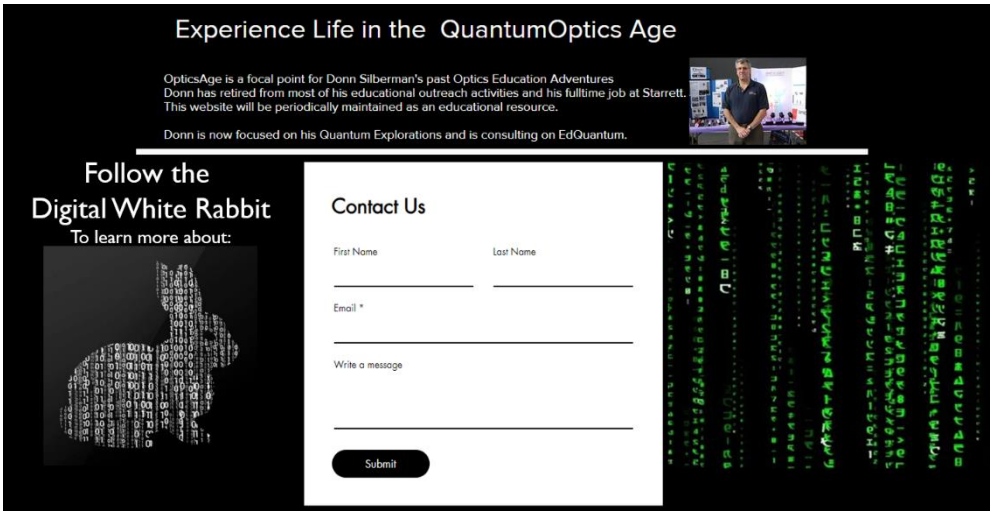

Figure 11. Contact Us. Submission page to the author's website.

7. LOGISTICS

The logistics for obtaining the PowerPoint slides, lecture notes and support for the presentation "Quantum for High School and College Students is straightforward. Go to the author's web page "Contact Us", fill in your name and email address and a message requesting the PowerPoint slides and a brief note on how you plan to use them; and the author will send you a direct link to download the slides. All the other information is available on the author's webpage as open access.

8. RESULTS SO FAR

As mentioned in section 4, the author gave the first presentations at a local high school[9], just prior to the end of the academic year at the Samueli Academy, and the survey results from Samueli Academy students (3rd yr. students[10], 4th yr. students[11]) are available on the author's website. In general, the presentation was very well received. During the presentation, as mentioned previously, a 'call to action' was provided to the students and the list of things they can do includes, 'join or start a club'. Directly after the presentation, two 3rd year students contacted the author to request assistance in starting a quantum school club. This sparked a new thread to a discussion the author has been having with a professor[12] at a local university who is the Co-Director of their Institute for Quantum Studies. Subsequently, the author, the professor, a colleague, and the two students all met to discuss plans for the summer and the coming academic year. Next, a revised version of the presentation, including the Kahoot quizzes, was given to another class of students at a summer program[13] also at the Samueli Academy. These students wrote the author letters of appreciation[14] which provided an indication that they learned much and may follow up to learn more about quantum science and technology. Also, some of the letters were from fellow students who did not attend and would like to have an opportunity to learn about quantum; this was a surprising and welcome result.

9. CONCLUSIONS & FUTURE PROJECTS

The author has spent many years developing and giving presentations to students of all ages and backgrounds in Southern California, where there is a great diversity in the student population, which may be representative of student populations in other parts of the country and other countries in the western hemisphere. The presentation, "Quantum for High School & College Students", has been and will continue to be improved and shared with others who may give it to students in locations globally through professional societies like SPIE. To begin, SPIE will share this with SPIE Student Chapters directly after this paper is published as this paper serves as a guide to using the presentation.

Two future and related projects are described briefly in an informal paper[15], "Quantum Education and Workforce Development" available on the author's website. One proposed project is with the Discovery Science Center, where the author had, in years past, hosted Optricks Days and Laser Extravaganza Days. Now, in cooperation with the Optical Society of Southern California, some Quantum based projects will be considered. The second proposed project is with a local educational outreach non-profit, Vital Link, where again, the author has had successful projects in the past (pre-COVID) and has now reached out to upgrade their "What is Light?" career exploration hands-on exhibit with new quantum-based information and a diffractive optics laser demonstration like the one in this presentation. The author hopes to tie these projects into the "Quantum for High School & College Students" presentation and will share the results of these two projects in future conferences.

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