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Delivery and Impact of Virtual Teacher Professional Development Workshops

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Abstract

Over the past few years, education at all levels has been greatly disrupted by the COVID pandemic. For many schools, face-to-face interactions were reduced or restricted to only those activities that have been determined to be essential for student instruction. The pandemic has also had a great impact on teacher professional development programming, which traditionally has been delivered largely in face-to-face settings. This paper examines the implementation of a series of energy technology teacher professional development workshops that were delivered virtually using online meeting apps. The results of the workshops are presented including participant measures of learning gains, and feedback describing how faculty participants used the information gained to modify their curriculum and instruction. The discussion includes observations and recommended practices to promote the effective incorporation of tools and equipment for remotely delivered workshops.

Introduction

The COVID pandemic resulted in an unprecedented disruption to education at all levels ranging from kindergarten through college and university classrooms. School closures, masking and social distancing requirements, contact tracing, and quarantines have changed how educators interact with students and have placed a new emphasis on remote learning and virtual instruction. The pandemic has also had a great impact on teacher professional development programming, which was also forced to shift to virtual delivery. The research data on the impacts of COVID pandemic induced changes is limited, particularly in the areas of energy technology and teacher preparation. A recent pandemic study of academic programs in engineering and teacher education profiled an interdisciplinary project engaging university and middle school students in wind energy technology [1]. Student reflection papers described significant challenges to skill development and negative socioemotional consequences that resulted from the pandemic disruption and change of delivery format to remote learning. While this was one of the first publications to document the adverse impacts of the pandemic on student learning and teacher preparation, the results are not entirely unexpected, and the findings are probably not unique to this particular situation.

The pandemic forced many programs that were developed for face-to-face delivery to change course mid-stream in the spring of 2020 with little or no time to prepare. The result was an uneven delivery of education, as instructors scrambled to patch virtual lessons together in the face of widespread school closures. The same can be said for teacher professional development and continuing education programs that were disrupted in the first half of 2020. In the months that followed, the education community rallied and instructors in almost every discipline and grade level became familiar with new technology for distance learning. This paper reports on the shift to virtual instruction for a series of renewable energy professional development workshops targeting STEM faculty, and summarizes some of the lessons learned from the experience.

Background on the two collaborating organizations

For many years, the CREATE Energy Center (CreateEnergy.org) and KidWind (www.KidWind.org) have delivered faculty professional development programs in solar photovoltaics and wind energy to teachers from both higher education and K-12 institutions with

STEM programs that incorporate energy technology. In response to COVID, these organizations pivoted to develop new faculty development workshops using online video conferencing platforms.

Funded by the National Science Foundation Advanced Technological Education Program, the CREATE Energy Center was originally founded in 2002 by College of the Canyons, and is now led by Madison Area Technical College. The goal of the CREATE Center is to advance the field of renewable energy by supporting two-year college programs while serving as a source of mentoring, industry networking, faculty professional development, and educational materials [2]. CREATE has produced renewable energy program profiles, faculty and alumni interview spotlights, an ongoing newsletter, blog, and a robust collection of hands-on laboratory instructional materials. The CREATE community of practice includes over 900 energy educators representing all fifty U.S. states and three U.S. territories. The CREATE Center delivers hands-on Renewable Energy Institutes for educators [3], provides guidance in the development of energy infrastructure and instructional campus laboratories [4], and has conducted a number of international faculty programs related to renewable energy [5-8]. With an emphasis on fostering connections between high school and technical/community college educators, CREATE promotes career pathways in the energy sector, and seeks to grow the nation's skilled technical workforce.

Since 2004 KidWind has empowered K-12 students and educators to become innovative renewable energy leaders of tomorrow by providing hands-on activities, lab material kits, educator professional development, and engineering design challenges. The KidWind Challenge flagship program has trained more than 10,000 teachers worldwide, who impact more than 500,000 students a year [9, 10]. This competition has since expanded to include solar and hydropower and marine energy challenges. More recently KidWind has been focused on developing educational materials around the power grid and is working with a variety of partners to launch a Clean Energy Educators Association to better support teachers seeking to educate their students about clean energy

CREATE and KidWind have worked together since 2010 to expand teacher training and faculty development in the field of energy education available to both community college, high school and middle school teachers throughout the United States. Through collaboration, the two organizations have sought to improve teachers' knowledge and skills, and to strengthen the connections between middle schools, high schools, and technical colleges. By bolstering teachers' understanding of energy technology, CREATE and KidWind seek to educate the next generation of STEM professionals for the energy sector

Virtual Instruction - Responding to Pandemic Challenges

KidWind's major goal is to build the capacity of educators to bring clean energy concepts into their own classrooms and communities. Prior to COVID, KidWind's network of instructors would hold more than 50 teacher professional development workshops and presentations nationwide each year. These workshops typically include a rich assortment of hands-on activities, along with guest speakers and tours of energy installations. Unfortunately, the COVID pandemic made the face to face activities impossible, necessitating a switch to virtual professional development programming.

At the same time in 2020, teachers across the country were also forced into virtual instruction as public schools worked through various periods of lockdowns and quarantines. It was apparent that many teachers were seeking good models of online instruction, and were interested in finding new resources that they might be able to use for remote education with their own students. It became clear to the leaders at CREATE and KidWind that it might be possible to deliver some critically needed resources and assistance, if we could quickly deploy a high-quality professional development program that could be implemented virtually.

Workshop Development

In the summer of 2020 KidWind invested around $10,000 in audio-visual equipment and launched a three day virtual academy with 35 teachers in attendance. This led to a series of six hour virtual workshops delivered over the following year, on the topics of wind, solar and the power grid. Short descriptions for each of the workshops are provided here, and more detailed information is available on the KidWind website.

Solar Energy: Educators dive into the science and technology of solar energy while exploring solar photovoltaics, power measurement, and how to construct creative solar devices.

Wind Energy: Educators engage with the science and technology of wind power while exploring blade design, power measurement, and operation of wind turbines.

Energy & the Power Grid: Educators bring the power grid alive in the classroom while exploring circuits, power measurement, and simulations.

A week before each workshop, KidWind shipped out a package of hands-on tools and materials that were to be used as part of the instruction. Teachers were also given a pre-test to better understand their baseline knowledge and preconceptions. After the workshop teachers were given a post-test, evaluation, and a detailed list of resources to further help them implement lessons in the classroom.

Recruitment of Teacher Participants

KidWind sent the workshop announcements out multiple times to their master email list with over 9500 recipients. First announcements were sent in November 2020. Open rates for these announcements were between 14.7% -16.8%; higher than typical rates of 9-11%. CREATE also sent the announcement to its email list of over 900 educators. The open rate for the CREATE MailChimp campaigns were 27.3% for administrators, and a 22.6% open rate for faculty. The higher open rate for the CREATE list, is likely a reflection that this is a more narrowly defined disciplinary community of energy educators. In addition, the virtual workshops were posted on both the KidWind and CREATE websites.

The cost for participant registration was partially offset by grant funding provided by CREATE, such that the cost to the individual teacher was reduced to only $10. Teacher participants who completed three of the workshops also received $200 in additional lab materials provided by KidWind. Demand for the workshops was rather strong, with each workshop filling within a couple weeks of its announcement and call for applications.

Results

A total of 136 individuals enrolled in the workshops, with 70 teachers completing one course, 18 teachers completing two courses, and 47 teachers completing a series of three courses and earning the additional lab materials provided by KidWind. 70% of the participants identified as female, 18% as male, and the remainder did not indicate a gender. Additional participant demographics are provided below.

Tables 1a and 1b. Demographic information describing the racial identity and age of the teacher participants.

White	73.5%
Black	3.7%
Hispanic	3.7%
Asian	3.6%
Native American	1.5%
Native Hawaiian	0.7%
Chose not to identify	13.2%

Age of teacher participants	
under 20	2.8%
20-29	5.0%
30-39	18.3%
40-49	23.5%
50-59	29.4%
60-69	8.8%
70+	1.4%
Chose not to provide	11.0%

Tables 2a and 2b. Demographic information describing the courses/subjects and grade levels taught by participants. *Note that most teachers taught more than one subject and more than one grade level, so the course totals exceed the # of respondents.*

Courses/Subjects Taught	# of responses	%
Engineering/ Technology	75	22.7%
Earth Science	46	13.9%
Physics	42	12.7%
Biology	41	12.4%
Chemistry	37	11.2%
Math	33	10.0%
Other	56	17.0%
Total Courses Taught	330	

Courses/Grades Taught	# of responses	%
12th	51	13.6%
11th	51	13.6%
10th	45	12.0%
9th	43	11.5%
8th	49	13.1%
7th	49	13.1%
6th	53	14.1%
5th	34	9.1%
Other	56	14.9%
Total Courses Taught	431	

Immediately following the virtual workshops teachers were asked the following questions based on a scale of 1-strongly disagree to 5-strongly agree:

- The training improved my knowledge of the subject matter = 4.77
- I plan to integrate these new materials into my classroom = 4.87

Pre- and post-tests documented increases in teacher knowledge for all three workshop topics, with Wind = 26% increase, Solar = 15% increase, and Power Grid = 15% increase.

In February of 2022 a follow up survey was sent to measure the impact of the workshops on changes to teaching practice. The survey elicited 54 responses (a 40% response rate).

The following data show clear evidence of the implementation of the workshop content into existing curriculum and instruction.

Figure 1. Teacher participant responses to the question, *"Have you used the information gained at the virtual workshop(s) to do any of the following? (mark all that apply)*

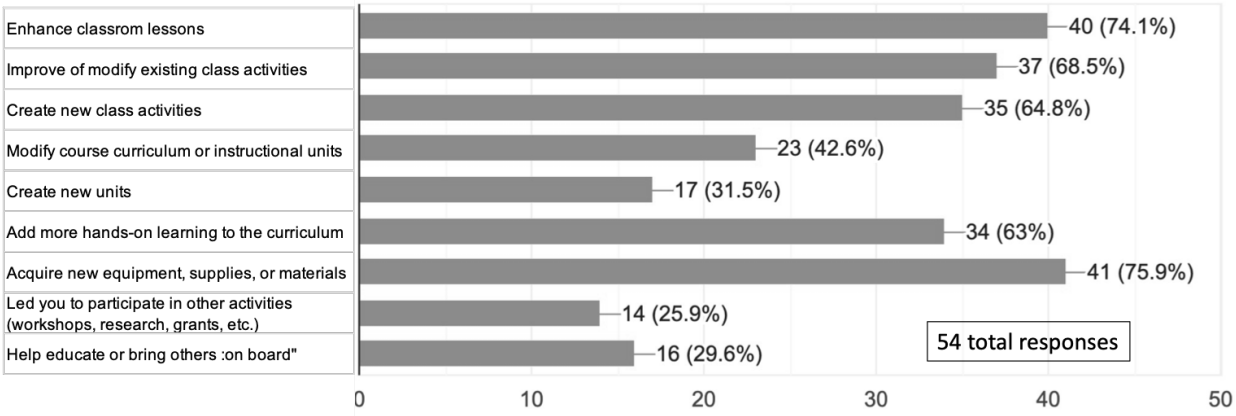
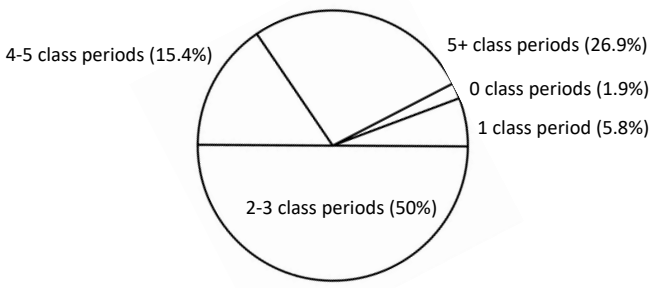


Figure 2. Teacher participant responses to the question, *"If you increased the amount of time you covered renewable energy in your classroom, how much more time did you spend? (one class period = approximately 45 minutes)".*



Next Steps for KidWind

KidWind had expected to move back to in-person training in the fall of 2021, however, the omicron variant compromised in-person training. In January 2022 KidWind launched a new round of virtual workshops with funding provided by CREATE. Registration for the 2022 workshops lagged the pace of the year prior, and reached a somewhat smaller number of participants (115). There are several possible explanations for the slightly dampened interest:

- We have saturated our contacts list of educators and need to do wider outreach.
- Many teachers are back to in person teaching and do not have the time or inclination to complete virtual training.
- Teachers are burned out from two years of COVID impacted education and are not currently interested in additional professional development.
- Teachers are mostly interested in a return to in-person training.

In addition to the courses previously offered by KidWind, a new workshop in marine and hydro power has been launched. In the next year the goal is to develop new faculty professional development workshops in energy storage, microcontrollers, electric vehicles and transportation.

KidWind plans to reintroduce in-person training in summer 2022. However, some version of online professional development will likely still remain in the program lineup. KidWind is also currently exploring the concept of a self-paced virtual professional development program. Teachers have also expressed interest in learning more about geothermal and nuclear energy.

Next Steps for CREATE

In past years, CREATE has offered a three day in person Solar Institute faculty professional development workshop using the solar photovoltaic tools, equipment, and instructional laboratory at Madison Area Technical College [3]. The institute provided an opportunity for teachers to get their hands on solar equipment, explore how it works, and experience building a working residential scale solar PV system as they develop a plan to incorporate solar PV concepts, equipment and lab activities into their classes. After being forced to cancel plans for the 2020 in person institute, and based on the success of the KidWind online workshops, CREATE and Madison College decided to pilot a virtual solar institute in the summer of 2021.

Early in the planning process, it became clear that many of the face-to-face activities would be impossible to duplicate online. Thus, the virtual workshop would not be a replacement, but rather would serve as a complement to the face-to-face Solar Institute. The virtual workshop extended over a week, meeting on Zoom three times for presentations and twice for optional discussions. Between online meetings, the participants completed hands-on activities based on CREATE solar PV lesson plans. Participants also developed a plan for how they would incorporate one of the CREATE solar lessons into one of the existing courses that they teach.

Participants were shipped a "CREATE solar kit" with the tools and equipment they would need to carry out the lab activities planned for the Institute, with the intention of participants keeping the materials to use in their classrooms. The equipment provided to participants included: digital multimeter capable of measuring DC voltage, clamp-on digital multimeter capable of measuring DC current, a 12 Volt, 25 Watt solar photovoltaic module, a handheld solar power meter (pyranometer), and an infrared temperature sensor.

Participants took a pre-test and post-test to determine the knowledge gains from the training. The average score on the pre-test was 9 out of 25 possible points. The median score was also 9. On the post-test, the average score was 18 and the median was 20. The participants demonstrated clear, significant gains in knowledge.

Evaluations taken at the end of the Solar Institute indicated participants recognized their knowledge gains and were much more likely to include renewable energy concepts and activities in their classes. All of the participants said they are now more interested in additional CREATE workshops. Many of the evaluations contained some version of “I cannot wait to take a CREATE class in person!” Based on the success of this pilot effort, CREATE plans to continue offering the virtual solar institute in the future in tandem with the traditional face to face solar institute.

Discussion and Recommendations for Others

As a result of the pandemic, most educational programming has had to make some sort of adaptation to incorporate online instruction and distance learning. Educators were forced to make these changes on the fly, with little preparation, and in most cases without readily available scholarly research to guide their programmatic and instructional changes. In an effort to share the CREATE/KidWind experience, and to help others in the creation of future web-based faculty professional development programs, we have assembled a list of some key observations and recommended practices.

1. Choose Content Carefully.

When planning a workshop agenda for online faculty professional development, it is highly unlikely that everything that could be done in a face-to-face format would translate readily to distance learning. Foremost concerns should be given to safety – risks that might have been acceptable with participants working under face-to-face supervision of instructors (e.g. working with 120V electricity), may not be reasonable for people working in a self-directed environment. In the case of the KidWind and CREATE workshops, participants worked with bench scale electrical apparatus that produced electric potentials of less than 20 Volts, and currents in the milliamp range. The lab activities that were included in the workshops were also selected to include only lessons that had previously been well vetted, and that we were confident that teachers could complete using only the written instructions provided and with minimal additional instruction from the workshop facilitators.

2. Thoughtfully Select the Tools, Instruments and Materials to Include.

When participants are working from home, you cannot assume that they will have the same tools and associated lab supplies that they might have available at their school. For example, in addition to the wind and solar equipment, the KidWind and CREATE lab kits also included digital multimeters, wire strippers, and lever lock wire connectors to facilitate construction of electrical circuits. The lab kits also included an assortment of electrical wires, so that we could be sure that every participant had the materials available to assemble electric circuits, that they were all using the same wire size/gauge, and that they had the same wire colors available as the instructors. Thus, participants were able to assemble circuits that exactly replicated those demonstrated by the instructors on camera.

Likewise, there may be special considerations to make in the choice of specific tools and materials to supply if participants are working remotely. For example, although we knew that many teachers participating in the wind and solar would have access to digital multimeters, it also would have been extremely challenging to teach a group of participants if everyone had different instruments that operated in different ways. For this reason, both KidWind and CREATE included electrical meters in the lab kits that were sent to participants. For the CREATE solar workshops we acquired somewhat more expensive electrical meters with auto-ranging functionality to simplify the operation of the meters, and avoid confusion with participants having meters set to an incorrect range setting. CREATE also sent two different style meters – a conventional multimeter for measuring electric potential (in Volts) and a clamp meter to be used for measuring electric current (in Amps). Having two distinctly different looking meters helped to clarify the functionality of each for the participants, and eliminated a potential source of confusion in the lab procedures. While many of our participants would have

been fine without this special consideration, inclusion of the meters in the lab kits helped to ensure that less experienced and novice learners were not confused or left behind. Selecting tools or instruments for lab kits that are simpler and/or have fewer features can help to mitigate differences in participants' prior knowledge, can help prevent errors, and in some cases might also reduce costs.

3. Adopt More Flexible Scheduling for Online Instruction.
It is common practice for face-to-face professional development workshops to be delivered as single day long sessions, and this is typically done to minimize participant travel requirements. However, this condensed and intensive format is not necessary for an online workshop, since participants are working from home. Conversely, when planning a virtual workshop, it is important to be cognizant of the duration of time that participants are asked to spend in any individual online session. We observed in early pilots that online participant engagement started to wane after more than 90 minutes of continuous instruction. For this reason, the KidWind and CREATE workshops were broken up into smaller segments that provided participants with down time in between the online instruction, so that they could work with their lab tools and materials and engage in self-instruction and discovery. When participants returned for the next online session, time was always allowed to answer questions that the participants had before proceeding to the introduction of any new content.

In the case of the CREATE solar workshops, scheduling of additional office hour/discussion sessions in between the main lesson activities provided a platform to solicit and answer participant questions, and led to a more detailed discussion of how the workshop activities might be implemented with students. The discussion sections were especially valuable to less experienced participants, since it offered a forum to get questions answered in a less formal instructional setting. In this way, the agenda for the online professional development activities more closely mirrored that of a teacher education academic course, rather than the condensed and intensive formats that are typical of conventional face-to-face professional development workshop programming.

4. Embrace Webcasting Technology and Sharpen Instructor Tech Skills.
Delivery of online workshops can be greatly enhanced if the instructors spend some time mastering the various types of equipment used to deliver the online workshop. Use of computers and web conferencing software with screen sharing functionality is essential. Audio quality is greatly improved with the integration of dedicated headsets and microphones, rather than relying on audio equipment that may be built into a computer. The deployment of a variety of camera types can also enhance instructional delivery. Presenters for example may wish to switch between a stationary document camera used for viewing of hardcopy print materials, a mounted web camera to view lab materials arranged on a bench, and a handheld camera or smart phone device that allows the instructor to film video footage as the camera is moved to capture different perspectives or used to zoom and focus in on various components that form a larger lab apparatus. Cameras mounted on a headband can also allow an instructor to record video footage from his or her point of view, while leaving both hands free to manipulate tools and equipment in real time. Regardless of the types of cameras used, instructors are encouraged to rehearse with the video equipment prior to going "live" with their workshop sessions. It takes some practice to get familiar with the operation of any individual camera, and it will probably take a few attempts

to become proficient at streaming video while also keeping the imaged item(s) of interest in focus and in the field of view. CREATE recently produced a series of webinars that may be helpful to educators seeking to learn more about AV technology and techniques for teaching online [11].

5. Leverage the Numerous Benefits of Online Recordings.
The KidWind and CREATE online sessions were all recorded, archived, and made available to participants for streamed viewing. This was quite beneficial for participants who missed an online session (the likelihood of which are elevated during a pandemic when participants or their family members might fall ill at short notice). The recordings were also beneficial for less experienced and novice participants who needed to review sections of the presentation to reinforce important concepts. The recordings were used by several participants while they were executing lab activities. They were able to perform the lab procedures, while viewing their screen at the same time to replay and observe the instructors demonstrating the same lab tasks. Importantly, the recordings have also proved quite valuable for the workshop instructors. Instructors were able to review and identify weaknesses in the instruction, and devise strategies for improvement. It also helped to quantify the amount of time spent on various parts of the workshop agenda, and facilitated revisions to improve the allocation of time for future workshops.

6. Employ Online Professional Development to Broaden Participation.
One of the benefits of online workshops is that they can bring people together from all over the country. Teachers who may find it hard to carve out several days away from home for our traditional in person Solar Institute, may find it easier to sign up for a virtual workshop. This may especially be true for teachers who are also parents and may have young children at home. KidWind received more than enough applications to fill up each of the workshops, with participants from 35 different states. CREATE overfilled its workshop and had several people participating in the virtual solar institute even though we were unable to send them a set of tools and equipment, including one participant from Canada and another from Belize. Establishing these geographically diverse learning communities is one positive aspect of virtual instruction that is not otherwise easily accomplished in a face-to-face format.

Some novice participants in the KidWind and CREATE workshops commented that they had considered attending prior face-to-face professional development events, but were apprehensive about their abilities or perceived shortcomings of pre-requisite knowledge. Some of these individuals indicated that they were less intimidated by the online platform, and following the virtual workshop(s) they expressed newly gained confidence in their ability to participate in a future face-to-face solar workshop. Based on these findings, it is reasonable to conclude that online faculty development might be especially well suited to reach younger teachers with limited teaching experience and/or content expertise, but who (by virtue of their age) are likely to be more comfortable with computer technology and web based communications than their older peers.

Conclusions
Despite the COVID pandemic, we found that educators were still very hungry for professional development opportunities in energy education, and they readily adapted to the delivery of

teacher education programming in an online format. Pre- and post-testing clearly showed that teachers were able to learn from virtual instruction, and follow up surveys indicate that the teachers have changed their instructional practices based on the content and knowledge gained from virtual workshops. Furthermore, online professional development programs have shown the ability to reach a much broader audience of educators than conventional face-to-face workshops. This is especially true for individuals that might come from schools that lack the funds necessary to support faculty travel to attend in-person events.

Nevertheless, online instruction should not be viewed as a replacement for face-to-face faculty professional development. Especially in the science, engineering, and technical fields, there are many types of hands-on instructional experiences that do not translate well into a virtual platform, or involve risks to participants that are better managed in a face-to-face setting. Despite their successful online experience, the faculty participants in this study also expressed a strong preference for face-to-face learning. Going forward, a mix of delivery methods is probably best to meet the continuing education needs of the largest number of teachers. Thus, the new challenge for educators will be to find the resources necessary to support programming for both online and face-to-face faculty professional development.

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