Published in final edited form as:

Int J Technol Knowl Soc. 2014 ; 9(4): 13–24.

Impacting the Science Community through Teacher Development: Utilizing Virtual Learning

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Abstract

Commitment to the STEM (science, technology, engineering, math) pipeline is slowly declining despite the need for professionals in the medical field. Addressing this, the John A. Burns School of Medicine developed a summer teacher-training program with a supplemental technology-learning component to improve science teachers' knowledge and skills of Molecular Biology. Subsequently, students' skills, techniques, and application of molecular biology are impacted. Science teachers require training that will prepare them for educating future professionals and foster interest in the medical field. After participation in the program and full access to the virtual material, twelve high school science teachers completed a final written reflective statement to evaluate their experiences. Using thematic analysis, knowledge and classroom application were investigated in this study. Results were two-fold: teachers identified difference areas of gained knowledge from the teacher-training program and teachers' reporting various benefits in relation to curricula development after participating in the program. It is concluded that participation in the program and access to the virtual material will impact the science community by updating teacher knowledge and positively influencing students' experience with science.

Keywords

Virtual Learning; Teacher Training; High School Science

The need for science and math professionals is increasing despite the decline of students committed to rigorous college careers in science, technology, engineering, or math (STEM). In response to this, national professional development programs have been set forth such as the National Math and Science Initiative (NMSI). As of February 19, 2011, the Phys.org website noted that important figureheads such as Barack Obama support professional development programs in STEM fields (Phys.org 2011). An important aspect of professional development programs is to solidify or ignite student excitement and commitment to STEM careers.

Previous research has examined and grouped particular elements that contribute to the success of pre-collegiate STEM programs (Broody 2006). For example, Broody suggests exposure to strong content knowledge, hands-on demonstration, appreciation for the application of STEM research, role models, and raising interest to be influential in confirming students' commitment to a STEM related career. Other studies have evaluated the factors that impact commitment to the STEM pipeline and they suggest high school to be a core influence to students' impressions of scientific careers (Subotnik et al. 2009, 11-12).

Additionally, previous studies suggest early exposure to science may influence commitment and interest into a scientific career, though no causal relationship has been found (Tai et al. 2006, 1143-1144).

With this in mind, the John A. Burns School of Medicine developed a professional development program for high school science teachers. This teacher-training program was scheduled to run over the summer month periods when teachers are less time constrained. A goal of the initiative was to “assist teachers as they help their students develop a familiarity for laboratory techniques prior to conducting molecular biology research in an authentic laboratory setting” (Boulay, Parisky and Leong, forthcoming). Additionally, the program was developed in hopes to achieve quality teacher development training to “foster interest in medical research and strengthen the qualifications of the pool of future medical practitioners in Hawaii” (Boulay, Parisky and Fulford 2010, 2). By improving teachers’ knowledge and skills as it relates to molecular biology, students can benefit in their learning.

An innovative development of the program combined both authentic laboratory experiences with technological learning. Online materials were developed to augment the offline professional development learning. Virtual learning is fast becoming an acceptable and meaningful instructional aid in the educational technology realm (Garrison and Kanuka 2004). The term for combining online and offline learning is called blended learning and it allows learners to educate themselves outside of a classroom setting, learn new theories, concepts, protocols before entering the classroom, and allows learners to transcend geographical distances. Blended learning is currently a popular concept in education research. For example, multiple studies have found a beneficial aspect to using virtual learning materials in an educational setting including but not limited to group processing, decision-making, and community enhancement (Garrison and Kanuka 2004, Johnson et al. 2002, Roval and Jordan 2004).

Past studies have investigated teachers’ understanding, confidence to teach, website experiences, and scholarly challenges (Boulay and van Raalte 2012; van Raalte and Boulay 2012) after participating in the teacher-training program. However, research has yet to identify teachers’ knowledge expansion and classroom application of learned materials from the program. Therefore, this study seeks to investigate in what ways teachers’ knowledge of molecular biology is influenced and whether teachers intend to include learned material into their own classrooms after participating in the teacher-training program.

Research Question

How does participation in the summer teacher-training program and access to the online learning materials influence teachers’ knowledge of molecular biology and classroom integration?

Method

Participants

The participants were selected from a pool of biology teachers at the secondary level (teaching students from ages 14-18) from the State of Hawaii, including the islands of Maui, Oahu, and the Big Island. A total of 12 high school science teachers participated in the professional development program in June of 2011. A difficulty for the instructors in the program was the diverse group of teachers that participated in the program. The teachers ranged from 0-15 years of experience teaching high school biology ($M = 6.3$, $SD = 5.3$) and taught a diverse range of biology classes such as Honors, Advanced Placement, Anatomy/Physiology, College Prep, Biotechnology, Marine Biology, and Environmental Science. Teachers were selected to participate in the program as they were teaching one of the highest levels of science offered at their schools.

Program Development

The teacher-training program is a long-term initiative evolving from 2010 (see Boulay, Parisky and Fulford 2010). The program being investigated in this study was conducted in June of 2011. The teacher training consisted of a two-week program, split up into ten laboratory-training days. A typical day in the teacher-training program consisted of a morning lecture, hands-on lab-work, a lecture by a professional scientist on his/her current research, lunch, and another hands-on lab-work session. The molecular biology techniques that were practiced in the lab were, but not limited to, centrifugation, DNA electrophoresis, DNA/plasmid purification, DNA ligation, restriction enzyme digestion, western blotting, polymerase chain reaction, spectrophotometer use, immunostaining, cell culture, tissue sectioning/staining, microscopy, and pipetting. The program was conducted at The John A. Burns School of Medicine in Honolulu, Hawaii. Five teachers from outer islands (Hawaii and Maui) were compensated for travel expenses.

To supplement the teacher-training program, an online resource was also developed alongside the program (for the development, designing team, and process of the online materials see Boulay, forthcoming; Boulay, Parisky and Leong, forthcoming). The website utilized highly regarded and well-known sources such as materials developed by the Cold Spring Harbor Laboratory and Howard Hughes Medical Institute. In collaboration with Dr. Hutchins at the University of Calgary, the online materials were developed to provide users with an easy interface to increase knowledge on molecular biology techniques. The website included four main modules (introduction to molecular biology, nucleic acid techniques, protein techniques, and cell culture techniques) with multiple topics within each module. Activities, animations, and content tutorials can be found for each topic within a module. As the teacher-training program was conducted over a two-week program, it was essential for teachers to become familiar with lab techniques prior to engaging in hands-on lab-work in a professional medical lab. By learning lab protocols and watching video demonstrations of the techniques prior to entering the lab, teachers were able to spend more time performing the techniques during the program. Teachers were given full access to the online materials the as soon as they confirmed their attendance for the program (see Figure 1).

Data Sources

The data sources for this study were the teachers' final written reflective statements. Teachers were emailed within one week after participating in the program and were asked to type a 1-2 page reflective response on their experience. Optionally, teachers were given various prompts in five general areas to which they could respond. These prompts included the participants initial goals, knowledge/skills acquired, impact on career goals, impact on teaching, and how the experience impacted their short-term and long-term employment goals. Eleven out of the 12 teachers completed their final written reflective statement resulting in a 92% completion rate.

Data Analysis

Without any *a priori* hypotheses or themes, inductive thematic analysis (Braun and Clarke 2006, 6-9; Patton 2002, 453-454) was conducted on the original data collected after the first professional development program held in 2010. Repetitive exploration was conducted each year on the data that was collected from the professional development program. Multiple coders were used across the years to repeat the process. In 2010, two original coders sought themes and patterns in the data and collaborated on a list of agreed upon codes. A new coder was educated on the agreed upon codes in 2010 and repeated the coding process for the 2011 data. Similarly, two coders (an original coder and the new coder) met several times and agreed upon a set of 23 total codes for 2011. Of the 23 codes, only *knowledge* and *classroom application* are being investigated in this study to answer the research question. The description of the two codes in the current study are a collaborative effort, however, only one set of coders themes are presented.

Results

Knowledge

Researchers defined *knowledge* ("K") as a code that described any reference to their knowledge base or when a teachers' perspective had changed because of the program's content influence. When calculating the number of hits "K" received in the coding of final written reflective statements, "K" was the fourth highest frequent code out of 23 total codes with 22 references. Eight of the 11 teachers referenced "K" in their final written reflective statements indicating a common theme among the teachers. A goal of the professional development program was to develop teachers' skills and knowledge base to aid their instruction with students; the responses of teachers in their final written reflective statements reflected just that. The following excerpts from the teachers in the "K" code are divided in sub-categories; knowledge and skills, confidence to teach, and marketable skills. Each of these sub-categories became apparent as an independent theme within the "K" code.

Knowledge and Skills—Within the "K" code, teachers described a general reference to their increased knowledge and skills within molecular biology. For example:

"I significantly enhanced my scientific knowledge and skills throughout this program."

“Not only did my knowledge prosper as a result of this program, my laboratory skills were perfected as well.”

“The summer research program was truly an enlightening experience. I was looking forward to the knowledge and skills that each day presented. From meeting scientific researchers to performing the latest molecular biology laboratory techniques, everyday was a plethora of information that I had not known before.”

Confidence to Teach—Within the “K” code, teachers also described their goal of increasing their knowledge of molecular biology and laboratory techniques. Most often, it was made clear that teachers looked to boost their confidence to teach classes at school by acquiring more substantial knowledge of molecular biology. For example:

“I feel that this experience provided me with additional confidence in my ability to handle any biology class that is given to me. I will now apply for biology positions as well as just general science positions. It also strengthened my resume and provided me with valuable knowledge and skills to offer to my future students.”

“My initial goals were to refresh my knowledge on the content and practice new lab skills so that I could become more comfortable and teach these skills to my students. I also wanted to get ideas for incorporating these labs into my Plants and Animals in Hawaii classes for next year.”

“My initial goals prior to entering the summer program were to obtain knowledge and skills that would help me become a better teacher.”

“Prior to entering this program I hoped to learn new skills in the field of biology. Majoring in marine science for my undergraduate, I was only required to take basic biology and marine biology courses. I wanted to expand my knowledge of molecular biology lab techniques in case I teach an advanced biology class in the future.”

“My ultimate goal whenever I attend workshops or programs like this one, is always to acquire the knowledge and skills that will make me a more effective educator for my students.”

Marketable Skills—Another sub-category of the “K” code is marketable skills. Similar to confidence to teach, teachers reported using the knowledge they learned in the professional development program to help boost their students’ marketable skills. For example:

“This summer research program will have a significant impact on my teaching pedagogy. I was able to gain skills, knowledge, and techniques that I can pass on to my students that I know will be necessary for them to have in order to be a step ahead in their future college endeavors.”

“I was fortunate to find out that my high school has a lot of the equipment that we were able to work with and now that I have a better understanding of the process, I am able to conduct these high-level experiments with my students, enriching their IB biology experience and knowledge as well as giving them the same experiences to compete with students from prestigious high schools around the world.”

Classroom Application

Although no component of the program was set aside to educate teachers how to incorporate the information learned in the program to a high school level classroom, the skills and techniques that were learned during the program were reported as material that will be utilized in teachers' future curriculum. *Classroom application* ("CA") was a code that described any reference to how learned information will be incorporated into a classroom. When calculating the number of hits "CA" received in the coding of final written reflective statements, "CA" was the second highest frequent code out of 23 total codes receiving 40 references. All participants in the program referenced "CA" in their final written reflective statements indicating a strong theme among the teachers. Similarly, the subsequent excerpts from the teachers in the "CA" code are divided in sub-categories; molecular biology techniques, website, and networking. Each of these sub-categories became apparent as an independent theme within the "CA" code. One teacher excerpt in particular highlights multiple themes within in the "CA" code. Before the sub-categories within the CA are explored, this particular excerpt deserved to be highlighted on its own.

"I feel incredibly fortunate to have had this experience with CCR (Center for Cardiovascular Research). I must emphatically say that this was, without a doubt, the best professional development experience I have ever had in teaching. It enhanced my knowledge and skills. It reignited my passion for science. It provided me with a network of colleagues. And, most importantly, it will benefit my students by enabling me to implement cutting-edge curriculum in my classroom."

This excerpt highlights themes such as increasing knowledge base for molecular biology, inspiring enthusiasm for science, and connecting high school science teachers together. Notably, in his perspective, this particular teacher described the most important aspect of the program was learning content from the program to incorporate in a classroom setting. This excerpt acceptably prefaces the following sub-categories for the "CA" code.

Molecular Biology Techniques—Every day of the program teachers engaged in hands-on lab work. In these labs, instructors taught and supervised teachers on their techniques. These techniques were reinforced each day and became a predominant valuable learning experience for all teachers. Many of the high school science teachers do not get to practice their lab skills as their school does not provide the necessary equipment, or they do not have access to a laboratory. This program provided teachers with daily hands-on lab work, which encouraged teachers to incorporate more technique learning in their own classroom. Additionally, teachers were provided with a modest grant to buy classroom materials they believe would help their teaching in class. A constant challenge for high school science teachers in Hawaii is finding enough funding or materials to be able to include important lessons in their classrooms. In the following few examples, teachers report on the importance of practicing lab skills and how they will be using these specific lab techniques in their own classrooms. For example:

"I have started lesson planning for my classes next year and I plan to use the money from the program budget to purchase pGLO kits from Bio Rad as well as a micro-centrifuge and a few pipettes."

“I am looking forward to considering the possibility of adding invite cell culture as a lab activity in an advanced placement biology course.”

“As a direct result of this program, I hope to add the appropriate equipment necessary to add protein electrophoresis to the AP Biology curriculum.”

“I also want to try to incorporate DNA fingerprinting which uses DNA electrophoresis into my classroom.”

“Our first experiment was a bacterial transformation. I had not grown anything on an agar plate since microbiology class in college. I really enjoyed this basic procedure and have ordered a “transduction of antibiotic resistant gene kit” and incubator for my students to start doing these kinds of labs in Biology. I think performing a procedure that allows the students to actually see the end result of plasmid insertion will help them to better understand the role of DNA in determining the traits of organisms.”

Website—Within the “CA” code, there were several references to the website that deserved its own sub-category. All references to the website were positive. Evidently, the website was evaluated to be a good source for teachers before entering the program and also for students that can use the website to improve their comprehension of scientific material and laboratory protocols prior to entering a lab. The following are teachers’ comments relating the website to their classroom. It is clear from the teacher excerpts below that the website was found to be informative and useful to both new and veteran teachers and high school students.

“The online materials organized by CCR (Center for Cardiovascular Research) will make a direct and immediate impact on my AP and Honors level biology courses. I plan to reference them and require parts as pre-lab homework. I hope that the students will not only come to laboratories more prepared but also continue to reference the materials as necessary when they study for assessments. Some of the students are likely to use the resources when they leave for college and continue their studies in science”

“I really enjoyed the Lab Wars video on what not to do in the lab. It made the strongest impact on lab safety and it would be great to show to my students to have them note what things you are not supposed to do in the lab.”

“The online tutorials and handouts of protocols were an added bonus to the experience which could be used to enhance classroom lesson plans.”

“Before the program started I was sent a link to a resource website that was full of background information, lab technique videos, interactive links and animations to help me prepare for the program. I bookmarked many of the resources for future use with my students, I had come across some of them before but there were so many new, useful ones too.”

Networking—High school teachers in Hawaii have limited resources to contact and network with fellow educators. Another sub-category that arose in the “CA” code was

networking. The participants were excited to communicate with other science teachers to discuss classroom procedures and exchange curriculum ideas. It is uncommon for high school science teachers in Hawaii to meet and communicate with one another on a frequent basis because of geographical distances and heavy workload burdens. This program brought a small group of high school science teachers together which the participants found extremely valuable as they could exchange teaching philosophies and course ideas. For example:

“I made connections with teachers in other school districts – teachers with whom I can share lesson plans and collaborate on curriculum development. For me, this is especially useful because I teach the Health Services Pathway courses. I am one of only two such teachers in my school.”

“To network with researchers and people who have a current career in science in order to improve the relevance of lessons on technology in my biology courses.”

“My initial goals for education were to learn about biotechnology laboratory skills and protocols that I could use in my own classroom and to network with other science teachers and scientists to expand my resources for the classroom.”

“...The thought of getting together with some other science teachers in a lab for a couple of weeks was kind of exciting. I also thought it would be a good opportunity to beef up the unit I teach on DNA and heredity.”

Discussion

It is clear from the teachers' final written reflective statements that the material learned in the program increased teachers' knowledge on molecular biology, updated their skills within a laboratory setting, and the information learned in the program is intended to be incorporated into their future classrooms. The two codes that were investigated in this study were labeled *knowledge* and *classroom application*. The first code *knowledge* referred to an increase or an influence on the participant's knowledge base relating to molecular biology and techniques. It is clear from teachers' responses that their knowledge of molecular biology was positively influenced after participating in the program. Within this code, the following three sub-categories were found: knowledge and skills (teachers felt a general increase in their knowledge base and skills for molecular biology), confidence to teach (the knowledge gained from the program positively influence teachers' confidence to teach molecular biology), and marketable skills (teachers felt an increase in their knowledge base would help their students become more marketable in a science career).

The second code *classroom application* recorded any reference to incorporating the learned material from the program in a classroom setting. It is clear from the teachers' responses that a lot of the information learned in the program is applicable and will be incorporated into the classroom. This code also had several sub-categories. These sub-categories were classroom application in general (one teacher excerpt revealed multiple core themes that resulted from participation in the program), molecular biology techniques (teachers reported on many laboratory skills that will be incorporated in their classrooms), website (the online materials were noted as a source to use for teachers' classroom material), and networking (teachers'

reported meeting other teachers as an opportunity to discuss class lesson plans and protocols).

Of particular interest, teachers' indicated an intent to engage in blended learning at a high school level by incorporating the online materials in their own classrooms. While many studies are incorporating blended learning at a tertiary level (Johnson et al. 2002, Roval and Jordan 2004), this study is one of the first to show the intent of using online materials to augment classroom learning for science teachers in Hawaii. As reported, teachers conveyed an interest in using the website or other online materials to help their students study protocols and using online materials for homework assignments. This may influence and boost the way high school students in Hawaii compare in learning abilities to the mainland U.S. As blended learning is becoming supported as an educational concept, there is little doubt it will integrate to high school curricula in Hawaii.

Implications

There are multiple implications to the current study. First, the two codes that were investigated, *knowledge* and *classroom application*, exemplify the successfulness of the summer professional development program. Teachers reported on their expanded or newfound knowledge for molecular biology and often reported on their likelihood of integrating the learned material into their own classrooms. The latter especially demonstrates how teachers are concerned for the welfare and success of students in a scientific career. Most often, teachers reported a desire to include information into their classrooms to benefit student learning and success.

Second, the written reflective statements revealed the networking opportunities that resulted from the program. Teachers reported on their excitement to meet other high school science teachers that faced the same challenges in school such as a lack of laboratory equipment or maintaining student commitment to a science field. Teachers viewed the networking opportunity as a rare and important time at which teachers can communicate and exchange contact information for future endeavors. Connecting high school science teachers is especially important in Hawaii as the schools do face multiple challenges (such as a lack of resources); these challenges may be very common to other schools outside of Hawaii as well.

Third, this study provides grounds for future research regarding the usefulness of professional development for high school science teachers. As teachers frequently reported using the learned material from the program in their own classrooms, it would be useful to investigate exactly how teachers intend to do this. By collecting responses from teachers in this regard, it provides ideas for future professional development programs to potentially include a section about classroom integration. Teachers may find this useful and it may be another step toward helping students commit to a career science.

Fourth, the online materials were an excellent way for teachers to learn protocols and refresh technique strategies before engaging in the hands-on lab-work. As the professional development program was conducted over two-weeks and a variety of lab techniques were practiced, it was essential for science teachers to review their knowledge of techniques prior

to engaging in the lab sessions for optimal learning. As reported by the teachers, the online materials enriched their learning by providing a different arena that could be utilized in their own time before engaging in the hands-on labs.

Limitations and Directions for Future Research

There are several limitations to the current study. First, it is unknown whether teachers actually increased their knowledge of molecular biology after participation in the program versus self-reporting their learning. Future studies looking to investigate the effectiveness of a professional development program may benefit by testing participants on subject material before and after participating in the program to test whether knowledge increases and combining or supplementing self-reported learning by participants. Further, another test could be provided to teachers one month after participation in the program to test the retention of learned material in the program.

A second limitation to the current study is the application of learned material into classrooms. As shown above, teachers frequently reported that they wanted to use the material learned in the professional development program in their own classrooms. However, without further investigation, it is unknown whether teachers indeed used the material in their curriculum. Comparing teachers' classroom practices before and after participating in the program would provide more sufficient evidence as to how teachers use the learned material (or online materials) in their own classrooms. Without a test-retest, it is unclear exactly how teachers' practice changed from before they took the course.

One of the goals of this program was to solidify student commitment to science. However, without a before and after test, it is unknown if teachers enthusiasm is transferred to students and in turn students become more committed to a science career. Future studies may use a longitudinal study to assess how students are affected when their teacher participates in a professional development program. This approach was beyond the scope of the current study.

Conclusion

In conclusion, the summer professional development program designed for high school science teachers was beneficial for the 12 participants. Two common themes that were investigated in this study were *knowledge* and *classroom application*. After participating in the program teachers reported an increase in their knowledge of molecular biology. When teachers describe their knowledge increasing, these statements fall into three general subcategories. First, teachers described their increased knowledge in relation to scientific techniques and lab skills. Second, teachers describe their increased knowledge in terms relating to an increase in their confidence to teach. Finally, teachers discuss their increased knowledge in relation to marketable skills they can foster in their students. As one may conclude from the results of this study, teachers themselves identify different areas of knowledge at it relates to the learned information from a professional development program. Considering different types of knowledge applications may be significant to future professional development program designs.

In addition to the increased knowledge of molecular biology, teachers reported including material from the teacher-training program in their own classrooms. When describing how learned information could be incorporated into teachers' own classrooms, these statements fall into three general subcategories. First, teachers described how the lab techniques could be incorporated into their own labs with students. Second, teachers described their intentions of using the online materials with their students to increase students' comprehension of scientific material and lab protocols prior to entering a lab. Last, teachers discussed valuable networking opportunities with other science teachers as a means to exchange teaching philosophies and course ideas. As one may interpret, teachers find many benefits in relation to their curriculum development when participating in a professional development program. While teachers attend a professional development program to better themselves, they are unfailingly considerate of improving their curricula. Hence, future professional development programs inviting teachers may improve their program design by including more thorough explanation on how information can be translated to a classroom setting.

Acknowledgments

Funding for this research was provided through the following grants: US National Institutes of Health Grant No. P20 RR016453, UH1 HL073449, P30 HL107251, P30 GM103341 and US Department of Education Grant No. P336C050047. The funding for the program was provided by ARRA stimulus award 3P30RR16453-07S1.

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Figure 1.
Screen Shot of the Online Materials Homepage
Source: <http://www.ccrhawaii.org>