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Designing and Evaluating a Scientific Training Program and Virtual Learning Materials

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Abstract

The University of Hawaii's John A. Burns School of Medicine developed a professional development program and virtual learning materials to assist high school science teachers become familiar with laboratory techniques prior to engaging in authentic molecular biology research. The purpose of this paper is to provide an evaluative overview of the program with emphasis on the virtual materials that were designed to employ a blended learning approach to augment offline classroom learning. The virtual learning materials provide a unique sphere for scientific learning in which skills can be reproduced in an offline environment. Twelve high school science teachers participated in the training program and were given full access to the online materials. After participation in the program, teachers filled out a final survey and completed a final written reflective statement as a form of evaluating the program and online materials. Thematic analysis was used to code participants' responses. Results showed that teachers recounted meeting the scientists as a valuable experience, teachers were grateful to learn real-world application of current research, and teachers described the importance of learning skills to prepare students to succeed in higher education. Additionally, results showed teacher's intent to use the virtual learning materials as homework tools and in classroom lessons.

Keywords

Blended Learning; Professional Development; Science Teacher Training

Introduction

“If students see the passion and excitement from their teacher, the hope is that they too become excited.”

—Participant 4, final written reflective statement.

One route to instilling student commitment to the STEM (science, technology, engineering, math) pipeline is by renewing teacher's excitement and vigor for the material. Especially in Hawaii, high school science teachers have scant access to professional laboratories to update their skills and knowledge in science. If teachers are not up-to-date with current scientific research and lab techniques, subsequently, students will also lack the necessary current skills and material comprehension to become competitive in the science field. To address this, the John A. Burns School of Medicine (JABSOM) at the University of Hawaii at Manoa developed a professional development program for high school science teachers to update their laboratory skills and understanding of current molecular biology research. In addition to the teacher-training program, virtual learning materials were created to facilitate offline learning.

A core goal of the training program was to provide teachers with a familiarity for laboratory protocols and skills prior to conducting research and consequently assist their students in these skills (Boulay, Parisky and Leong 2012). The virtual learning materials were developed to provide participants in the training program access to protocols and professionally packaged molecular biology material to increase comprehension critical to effectively participate in a professional research laboratory (Boulay, Parisky and Leong).

Literature Review

As technology develops, so do scientific research protocols and techniques. Alongside science developments, it is necessary for all science professionals to keep current with evolving techniques and skills. To best prepare students for success in a scientific field, teachers first need to be able to understand current scientific techniques and research. A popular method of learning that is being incorporated in many classrooms is the blended learning approach.

Blended learning combines traditional in-class learning strategies with online learning (Hoic-Bozic, Mornar and Boticki 2009). This type of education creates an environment where learning may transcend time and distance, learners can study at their own rate, and learning materials can be tailored to an audience's needs. Blended learning is crucial to science learning as access to labs and costly science equipment can be limited. Previous research has investigated the success of virtual learning materials on student lab learning. For example, Climent-Bellido et al. (2003) found that introducing a simulation program to a group of individuals prior to engaging in laboratory experiments increased comprehension of scientific techniques and basic concepts as opposed to those who did not have access to the computer simulations. Various other studies have also found blended learning to help learners (Collis, & Bruijstens, Kees der van Veen, 2003; Garrison & Kanuka 2004; Smelser, 2002). Particularly useful for teachers and students in Hawaii where access to labs and science equipment is scarce, blended learning can prepare learners prior to their hands-on lab work.

In addition to online learning, having hands-on experience with advanced technology and equipment will undoubtedly instill teachers with a strong understanding of current research and techniques. Learning style theorists posit different learning styles are effective for different learners (Keefe 1987). Important for educators who teach students how to perform science experiments, teachers first need to learn how to use science equipment themselves. Engaging in hands-on lab work is likely to instill teachers with confidence to include newly learned practices into their own classroom. Moreover, by providing a change in teachers' repetitive routines, teachers' can renew their vigor for the material by participating in science experiments.

By renewing teacher's excitement, students too will benefit. The theory of emotional contagion predicts that people automatically synchronize and mimic others behaviors and as a result converge emotionally from the activation and/or feedback from such mimicry (Hatfield, Cacioppo and Rapson 1992). Observing teacher excitement in a classroom may influence student's commitment and enthusiasm for the subject. A study by Mottet and Beebe (2000) found emotional contagion to be very prevalent between teachers and students. This study found that instructor pleasure (broadly defined as how well one is doing) and student pleasure were positively and significantly correlated such that the more pleasure instructors reported feeling during class the more pleasure students reported feeling during class (Mottet and Beebe 2000). Understanding how teachers influence students will aid future instructors by helping them in multiple facets. Teachers will be able to shape social interactions, teachers will learn how to engender positive emotions to the classroom,

and teachers will learn how to avoid “catching” negative emotions from student which may influence teaching styles and classroom rapport (Mottet and Beebe 2000).

Teacher burnout has also been researched to be contagious between teachers (Bakker and Schaufeli 2000), which can influence teacher behavior in a classroom setting. Indeed, research has found that teachers' emotions influence students and classroom dynamics. A study by Bakker (2005) found that teacher flow, defined as “a short-term peak experience that is characterized by absorption, work enjoyment, and intrinsic work motivation” (p. 37), was positively related to student flow such that the higher feeling of flow for teachers, the more flow students experienced.

As teachers' emotions can influence student learning and behavior, it is important to investigate how participating in professional development programs influences teachers' emotions. Therefore, the current study investigates the type of positive emotions teachers experienced while participating in the teacher-training program. Equally important to teacher emotions, the effectiveness of virtual learning materials can provide insight to the increasingly popular blended learning approach. Thus, this study also explores teacher's evaluative reports of the virtual learning materials developed alongside the program.

Method

Program Development

The professional development program is a long-term initiative with the first program being held in 2010 (see Boulay, Parisky and Fulford 2010). The focus of this paper is the data collected from the 2011 professional development program. The 2011 program consisted of a two-week program split up into 10 laboratory-training days. Teachers' engaged in hands-on lab-work every day of the program and attended lectures by scientists. Several molecular biology techniques were performed and practiced by teachers. For example, teachers practiced centrifugation, DNA electrophoresis, DNA/plasmid purification, DNA ligation, restriction enzyme digestion, western blotting, polymerase chain reaction, using a spectrophotometer, immunostaining, cell culture, tissue sectioning, microscopy, and pipetting.

The online materials were developed alongside the program to supplement offline learning. The Center for Cardiovascular Research (CCR) within The John A. Burns School of Medicine (JABSOM) collaborated with the Distance Course Design and Consulting (DCDC) in efforts to develop a virtual learning initiative (Boulay, in press; Boulay et al. 2009). The online materials included unlimited access to four core modules, each consisting of multiple sub-topics. The four core modules were: introduction to molecular biology, nucleic acid techniques, protein techniques, and cell culture techniques. Each sub-topic within a core module contained objectives, specific content materials, animations, and activities to help facilitate learning.

With the goal of initiating a blended learning approach, professional developers set out to create a website that incorporated a blend of content, video segments, two-dimensional and three-dimensional guided animations, laboratory protocols, interactive tutorials and problem sets, and virtual laboratory investigations. Introductory videos were created to begin each sub-topic and explain techniques in specific content areas. The video segments in particular provided teachers with specific preparation in using the research equipment at JABSOM. For example, videos provided step-by-step instruction on Centrifugation, Western Blotting, and Tissue Sectioning.

Multiple professionals reviewed the website and the scientific content on the website originated from a well-developed in-person training and well-known and highly regarded online resources such as those of Howard Hughes Medical Institute (see Boulay, in press and Boulay et al., 2009 for an in-depth description of the development for the online materials). Teachers were given access to the website prior to engaging in the program to provide teachers time to review techniques and protocols before entering the lab.

Participants

In 2011, participants were selected from a pool of biology teachers at the secondary level from the State of Hawaii, including the islands of Maui, Oahu, and the Big Island. A total of $N=12$ high school science teachers were invited and participated in the professional development program in June of 2011. The participants ranged from 0-15 years of experience teaching high school biology ($M = 6.3$, $SD = 5.3$). In addition to teaching General Biology, the participants reported teaching other various biology classes, for example, Honors, Anatomy/Physiology, and College Prep. Often a taught the highest level of science offered at his or her school and took on extra roles within the school. A few examples of the additional roles teachers were responsible for are Class Advisor, Website Administrator, and Current Health Pathway Teacher. All teachers were provided with a stipend and those teachers living geographically distant received additional airfare and housing for the duration of the program. Teachers were also provided with an additional stipend to spend laboratory equipment to take back to their classroom.

Data Sources

The summer program asked for multiple sources of information from the participants (i.e., pre-survey, post-survey, resumes, and final written reflective statements). Of the measures, only the post-survey and final written reflective statements are included in this study as these sources included the most appropriate information. The post-survey asked teachers about their definition of molecular biology, their overall program experience, their views of the scientist presentations, their development of molecular biology techniques, and their experiences with the virtual learning materials. The post-survey was given to all of the teachers at the end of the program before they left. All teachers responded to the survey resulting in a 100% completion rate.

Teachers were also asked to write a 1-2 page reflective response after participation in the program. Voluntary prompts were provided to teachers as a suggestion for guiding their narrative. The prompts included questions asking after areas such as their career goals, the knowledge and/or skills gained from the program, and how they may include the learned material in their own classroom. Teachers were emailed with instructions to complete the final written reflective statement and were asked to type and email their response to the head researcher. Eleven out of the 12 teachers completed their final statement resulting in a 92% completion rate.

Data Analysis

A foundational method for qualitative analysis is the inductive thematic approach. Through this approach, the current study seeks to gain insight of the recurring themes present in the teachers' post-surveys and final statements (Boyatzis 1998). While thematic analysis has been labeled with poor clarity in the analysis process (Attride-Stirling 2001), this study will provide an explicit explanation for the ways the themes were identified in the data set (Braun and Clarke 2006).

In the summer of 2010 the first professional development program was conducted. At that time two researchers coded the teachers' responses of the final surveys and final reflective

written statements separately utilizing an inductive thematic approach (Braun and Clarke 2006). This approach allowed themes to naturally arise without any a priori themes or hypotheses in mind. Although researchers cannot “free themselves of their theoretical and epistemological commitments” (Braun and Clark 2006, 12), codes were data-driven in that the codes were strongly linked to the data themselves and were not fit into a pre-existing coding frame. Collaboration between the two researchers lead to a list of 24 agreed upon codes.

In 2012, a new researcher was introduced to the data. Adopting a triangulation approach to coding, multiple researchers evaluated the data sources and codes to corroborate consistent themes and patterns in the data set (Quinn Patton 2002). Taking steps towards coding validity, if each researcher independently found comparable themes in the dataset, those themes (or codes) were considered significant to the data. In the thematic analysis nature, codes were designated as important if they were recurring (same thread of meaning), repeated (repetition of key words or phrases), and forceful (stressed phrases or words) (Owen 1984).

Collaborating again, the new researcher and an original researcher agreed upon 23 total master codes and developed a thorough matrix that included the shorthand symbol, term, and description for each code. Of the 23 codes, only positive affect (“PA”) and reference to any web material (“W”) will be analyzed for this study. PA and W were chosen to be included in this study as they were the third and fourth highest code recurring in the data set, respectively. In addition, previous studies of the same data set have already explored teachers' increased knowledge from the program, their intent to use the learned material in their own classrooms, and confidence to teach molecular biology techniques (Boulay & van Raalte, in press; van Raalte & Boulay, 2012). These papers also provide a more detailed description of the information teachers learned from the training program. “PA” was described as any reference to positive experience, feeling, or emotion and any positive evaluation of the program. “W” was described as any reference to the website. These codes were assumed to be the most relevant to relate to emotional contagion and use of blended learning in this training program.

Results

Positive Affect

Analysis of the post-surveys and finals statements revealed a vast positive response to the professional development program. Of the 23 codes, the instances of “PA” occurred the third highest of all the codes at 90 total instances. Overall, participants reported on the organization and success of the professional development program. Teacher excerpts are split into post-survey and final written reflective statements. As there are vast instances for this code, only five excerpts from the post-surveys and four excerpts from the final written reflective statement are included as illustrations. Moreover, each excerpt is sourced from a different teacher across both data sources.

Post-Survey Excerpts

“I think it was a fantastic workshop due to the unique combination of the hands-on experience and meet-a-scientist.”

-Participant 1

“I think this program is very innovative in blending teachers and researchers and using the labs to give teachers a chance to do labs.”

-Participant 3

“This program is a fabulous opportunity to see basic textbook knowledge/protocols taken to real world application, and very organized.”

-Participant 4

“The workshop succeeded in inspiring teachers to think about bringing biotechnology into their classrooms and how to integrate it into an already full curriculum.”

-Participant 10

“This is the type of professional development that is most needed/necessary (in Hawaii).”

-Participant 11

Final Written Reflective Statement Excerpts

“This experience was a great opportunity to inform educators about what skills are needed for incoming college students. So many of the students in Hawaii are not properly prepared to entire higher education.”

-Participant 2

“...providing the guest scientists to present their studies was a great asset to learning.

It provided the balance between the skills to learn in the lab in comparison to the bigger picture to why we learn the skills in the lab.”

-Participant 5

“The summer research program was truly an enlightening experience.”

-Participant 6.

“...I just want to say that this experience has been one of the most practical and fun program that I have participated in.”

-Participant 9.

“The program delivered more than I expected. I would rate it at the high end of the workshops I have attended.”

-Participant 12.

Website

Reference to the virtual learning materials resulted in the fourth highest found code at 74 counts. All of the references to the website included a positive overtone. Consistently, participants reported on the effectiveness of the virtual learning materials and how the online material will be adapted into their own classroom. Teacher excerpts of the “W” code are split into post-survey and final written reflective statements. As there are many instances for this code, three excerpts are included in the post-survey excerpts and four excerpts are included from the final written reflective statements as examples. Each excerpt is sourced from a different teacher across both data sources.

Post-Survey Excerpts

“Modules that prep for labs and using videos to see what to expect (supported my learning experience)”

-Participant 11

“It (the website) was very helpful in familiarizing me with terms (vocab) and how/ why we were going to do things.”

-Participant 12

“I think the online content was perfect and sufficient.”

-Participant 6

Final Written Reflective Statement Excerpts

“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.”

-Participant 3

“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.”

-Participant 10

“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.”

-Participant 9

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

-Participant 4

Discussion

The aim of this study was to explore 12 high school science teachers' experiences in the two-week long professional development program. To achieve this, two codes were investigated in this study: Positive Affect (“PA”) and Website (“W”). Undoubtedly, teachers evaluated the program highly and commended the organization and effectiveness of such a program being offered in Hawaii. Additionally, the virtual learning materials were praised and reported as informative and useful for preparing for lab-work and future curricula development.

The results of the “PA” code were split up into post-survey and final written reflective statements. In the “PA” excerpts from the post-surveys, teachers reflected their attitudes towards the effective organization of the program, the success of the program, and how meeting the professional scientists were worthwhile. In the “PA” excerpts in the final written reflective statements, teachers reported on the real-world application of the learned material and commented on the importance of learning the skills needed to prepare students to succeed in higher education.

Similarly, the results of the “W” code were split up into post-survey and final written reflective statements. In the “W” excerpts from the post-surveys, teachers found the

vocabulary words useful to prepare for laboratory work and found the videos on the website helpful. In the “W” excerpts from the final written reflective statements, teachers discussed their future use of the virtual learning materials as homework for their students, how they will use the resources from the website in their own classrooms, and what not to do in laboratories.

Implications

Several implications resulted from this study. First, it is apparent that high school science teachers need and appreciate professional development programs. Often, the geographical distance of Hawaii to the mainland U.S. excludes teachers from participating in valuable professional development programs. Participants in the current study evaluated the program to be useful for their own knowledge and future classroom application. It is hoped that the success of the training program will encourage training programs for teachers to be initiated.

Second, teachers frequently reported their use of the learned material in their own curricula. Important to the students of Hawaii, success in a scientific field must be instigated with current skills and techniques early on in education. Then, high schools students' knowledge of current research and laboratory techniques would reflect in a higher education course. By exposing high school science teachers to professional scientists and current research, the information will be transmitted to high school students.

Third, the virtual learning materials proved to be successful in engaging teachers in blended learning. Teachers responded positively to the virtual learning materials and frequently reported using the online material (videos, vocabulary words, links) in their own classrooms. By providing teachers with access to the professionally developed website before engaging in hands-on lab-work, teachers were able to spend time reviewing techniques and lab protocols before entering the lab and, in turn, could spend more professional development time practicing the techniques in hands-on ways. This approach leads to a combined learning effort that reinforced laboratory protocols and techniques prior to engaging in hands-on lab-work.

Limitations and Directions for Future Research

Although there are several implications to the current study, there are some limitations that should be addressed. First, although teachers reported using the learned information and virtual learning materials in their own classroom, specific descriptions of how this would be done is unclear. In the future, it may be beneficial to the program coordinators to know exactly what type of information will be included into a high school classroom so this type of information is reinforced throughout the program. As previous research reinforces, teachers desire practical classroom strategies to be included in professional development programs (Leask and Younie, 2010). Structuring the training program to meet the needs of high school science teachers' mandatory lessons will advance the program further.

Second, the theory of emotional contagion was developed as a potential outcome of the teacher-training program; yet, this study did not investigate if teachers' positive emotions were translated to the classroom. If teachers did experience a boost in their excitement for science, we would expect to see this inspiration translated to student excitement. Future studies may want to investigate how professional development influences participants' emotions and subsequently influence student emotions.

Last, it is unknown how this professional development program specifically compares to other professional development programs. Teachers were not required to compare their experiences in this program to other professional development programs they have attended (if any). However, teachers were asked in the post-survey what they would like to work on

next if they were to continue in the program. Teachers responded with suggestions such as including information on how to implement the protocols in a high school classroom, designing lesson plans together, and investigating research questions. In addition to meeting teachers' suggestions for the development of the program, future researchers may obtain data that could compare the effectiveness of professional development programs.

Conclusion

In summary, the professional development program succeeded in providing high school science teachers with professional packaged useful online and offline resources. Teachers excerpts were split into two categories: positive affect and website. In the positive affect code, teachers' post-survey excerpts revealed their appreciation of the hands-on lab-work experience, teachers' excitement at meeting professional scientists, and teachers' reported boost in their inspiration for science. Moreover, teachers' final written reflective statements revealed an appreciation for learning current skills that are applicable to their graduating students who will be incoming freshman students at college, and teachers touched on the real-world application of current research.

In discussing the online materials, teachers' post-survey excerpts reported on the usefulness of the website in preparing for doing techniques in the lab, and how the website would be worthwhile to include in curricula activities. Additionally, teachers' final written reflective statements reinforced teachers' intention of using the website for their own classrooms in the future. As technology develops, it is evident that virtual learning materials will be incorporated into scientific learning. As it relates to laboratory experiences, combining both offline and online learning will encourage successful habits and techniques in a professional laboratory.

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Dr. Rachel Boulay: Rachel Boulay is the Director of Education for the Center for Cardiovascular Research. She is committed to building the bridges between science teachers and scientists to collaboratively spark students' interest in science. She recently launched a statewide initiative to upgrade the content knowledge of biology teachers teaching in public high schools throughout the Hawaiian Islands and the Pacific. She has a broad background in research and evaluation as well as in curriculum development, technology integration and organizational change in education. Research areas include the development and structure of online open access content for teaching science, professional development for K-12 teachers

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