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To cite this article: Thomas M. Onorato (2014) Connecting Students and Microbiology Through the Lived Experience, Community College Journal of Research and Practice, 38:7, 625-637, DOI: [10.1080/10668926.2012.710123](https://doi.org/10.1080/10668926.2012.710123)

To link to this article: <http://dx.doi.org/10.1080/10668926.2012.710123>



Published online: 03 Mar 2014.



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# Connecting Students and Microbiology Through the Lived Experience

Thomas M. Onorato

*Department of Natural Sciences, LaGuardia Community College/CUNY,  
Long Island City, New York, USA*

A disconnect exists between students and biology that is often propagated by information-dense lectures that provide little opportunity for integrative learning and reflection. The author's professional development activities have allowed him to build upon his pedagogical creativity and develop a structured reflective ePortfolio-based microbiology assignment. The assignment incorporates integrative learning by connecting students to the subject content through their lived experiences. Students had to write about, research, and reflect on a disease caused by a microorganism that somehow had impacted their lives. The assignment was staged in four parts: (a) write a detailed description of the disease-related event, (b) research the biology behind the disease, (c) reflect on the original event with a new understanding of the biology behind it, and (d) identify common themes among their classmates' work and reflect on how microbiology relates to other courses and their future careers. The key facets that made the assignment successful are a reflective element, the connections it fostered (i.e., between the students, their pasts, microbiology, and their classmates), and electronic Portfolio. Aspects of integrative learning were greatly rooted in the assignment: life-long and lifewide learning, folio thinking, and networked self. Collectively, student work, qualitative feedback, and quantitative feedback confirm that the assignment fostered integrative learning through connecting students to microbiology through the lived experience.

Students often learn biology primarily by memorization. One of the greatest challenges encountered is moving students beyond the memorization of seemingly disconnected scientific facts to pass an exam. Part of the responsibility for overcoming this challenge lies with the professor. Therefore, how do science professors break away from the crutch of information-heavy lectures and better connect students with biology? One approach is to adapt their pedagogy for the interdisciplinary 21st century classroom and move beyond just teaching the details to engaging students as intentional learners (Lord, 2007). Intentional learners are able to connect disjointed learning experiences (Huber & Hutchings, 2005).

Weaving the real-world into the biological concepts being taught will lessen student perception that biology is a collection of disconnected facts that are unrelated to society (Chamany, Allen, & Tanner, 2008). Chamany et al. make an interesting observation that "students model their instructors'

behavior and follow their lead” (p. 267). Therefore, science professors must infuse a social context into what they teach to facilitate a connection between the student, subject matter, and lived experience (i.e. real world) that would beget a more comprehensive understanding of biology.

One means to do so is through integrative learning. The Association of American Colleges and Universities (AAC&U) and The Carnegie Foundation for the Advancement of Teaching’s (2004) statement regarding integrative learning states the following:

Integrative learning comes in many varieties: connecting skills and knowledge from multiple sources and experiences; applying theory to practice in various settings...Significant knowledge within individual disciplines serves as the foundation, but integrative learning goes beyond academic boundaries. Indeed, integrative experiences often occur as learners address real-world problems. (para. 2)

Integrative learning can have two faces, the network and the symphonic selves. The network self represents values such as student engagement, analysis, and folio thinking, and it emphasizes activities such as connection, revision, embeddedness in day-to-day life, and reflection-in-action (Cambridge, 2009). Science educators need to infuse the network self of integrative learning into the assignments they develop for their courses. Therefore, emerging pedagogical tools that foster integrative learning experiences must be utilized.

Portfolios are one way in which institutions of higher education are creating opportunities for integrative learning (Chen, 2009; Huber & Hutchings, 2005). Electronic portfolios (ePortfolios) are media for promoting integrative learning (Arcario, Eynon, & Clark, 2005; Eynon, 2009) due to their inherent characteristics: collect, select, reflect, and connect. Students can connect their lived experience and the subject content through the connectivity and reflection afforded by ePortfolios, thus emphasizing integrative learning and rooting their newly acquired knowledge of biology in personal and cultural experiences (Chamany et al., 2008).

## PURPOSE

Recognizing the need to add integrative learning into the community college science curriculum, this paper describes the author’s use of integrated learning in a general microbiology course at a large urban community college in the northeast United States. In this practitioner’s paper, the incorporation of an integrative learning experience in a general microbiology course through a structured reflective ePortfolio-based assignment is presented. This assignment is a product of the author’s participation in a faculty development seminar on connected learning at his institution, which was part of the AAC&U and Carnegie Foundation’s Integrative Learning Project (Arcario et al., 2005).

The objectives of this assignment are to enhance student understanding of microbiology, to increase student awareness to the importance of understanding science in society, and to integrate the lived experience through connecting students to their past, classmates, and microbiology. Student feedback supporting the efficacy of this assignment in achieving its objectives is presented. The primary purpose of data collected is solely assessment of the assignment’s efficacy in achieving its purpose to provide an integrative learning experience through enabling students to make connections between microbiology and their lived experience. This approach to assessment through student evaluation is not unprecedented (Eason, 2006). Eason assessed the role of reflection in a science course for nonscience majors using a Diagnostic Learning Log

(DLL) consisting of four short-answer questions and a questionnaire comprised of four questions using a Likert scale. Additionally, the applicability of this assignment to be adapted for use in other science courses and the limitations of this paper are discussed.

## ASSIGNMENT STRUCTURE

The overarching objective of this assignment was for students to choose a disease caused by a microorganism that somehow personally affected them. Setting this basic premise for the assignment allowed the author to immediately connect microbiology to the students' lived experiences. The primary connections the assignment prompted students to make were to their past, classmates, and microbiology. The incorporation of a reflective element would be crucial for integrating the lived experience to more deeply connect students to microbiology.

The major inspiration for this assignment's reflective element came from Rodgers (2002). The assignment was staged into four parts that incorporated aspects of Rodgers' reflective cycle. Intrigued by how Rodgers slows down the reflective process by separating reflection and description, the author wanted students to provide a detailed description of the event they chose that was void of emotion and reflective hindsight before exploring the emotional aspects of the event. After students had increased awareness of the details of the event and the emotional aspects of it, they were asked to reflect on the event. Students were asked to be present in and describe a past experience, incorporating the first and second phases of Rodgers' reflective cycle.

Part 1 of the assignment set the groundwork for integrating the students' lived experiences into their understanding microbiology and connected them to their past. Building upon this, the next phase of the assignment asked students to research the biology behind the disease-related event they described and reflected on. This aspect of the assignment attempted to incorporate Part 3 of Rodgers' reflective cycle (Rodgers, 2002) by having students take intelligent action through researching and understanding the biology, notably microbiology, behind the disease relevant to their lives. This armed the students with a new knowledge of microbiology and biology in general that would prepare them for the next phase of the assignment.

Students next had to reflect on the disease-related event they wrote about in the first part of the assignment in light of the new understanding of the biology behind the disease. The objective was to have students analyze their personal event from another perspective and to form explanations that were not apparent when they originally reflected on the event in the absence of the biology behind the disease. This "analysis of experience" constitutes the third part of Rodgers' reflective cycle (Rodgers, 2002, p. 235). Additionally this part of the assignment also incorporated the fourth part of the cycle, experimentation.

The last phase of the assignment not only blended Parts 3 and 4 of her reflective cycle (Rodgers, 2002), but it also brought it full circle by asking students to once again be present in their experience and learn to see. Students were prompted to connect what they had written in their ePortfolio and what their classmates had written by identifying themes common to their event and those events described by five classmates. Central to Part 4 of the assignment was that students had to read everyone's ePortfolios and choose the five that they felt most connected to and/or had impacted them the most. This ensured maximum connectivity and integration of the lived experience. It also shifted the central teacher-student paradigm by making class work a community, peer-based activity.

## PARTICIPANTS

The assignment was given for five consecutive semesters of general microbiology from fall 2009 to fall 2010. Participants were students registered for the course in accordance with standard institutional registration processes. Students were unaware of which professor was teaching their section until right before the semester started, and they were provided the details of the assignment on the first day of class. The total sample size ( $N$ ) of all sections combined was 73 students: fall 2009 session I,  $n=21$ ; fall 2009 session II,  $n=13$ ; spring 2010 session I,  $n=12$ ; fall 2010 session I,  $n=16$ ; and fall 2010 session II,  $n=11$ .

## EVALUATION OF THE ASSIGNMENT

### Student Feedback

Student feedback was collected at the end of each semester and used to determine whether the objectives of the assignment were met. Students anonymously completed a feedback survey based on a five-point rating scale (1=*least*, 3=*average*, 5=*best*). Responses with a value of 1 or 2 were grouped as below average (<AVG); responses with a value of 3 are taken as average (AVG); and responses with a value of 4 or 5 were combined as above average (>AVG). The scale also included not applicable (NA) as a choice. In addition, students also provided qualitative feedback on the effectiveness of the assignment.

### Statistical Analysis

The primary reason for performing statistical analysis was to authenticate that the percentage of above average responses significantly differed from that of below average responses. Because the efficacy of this assignment was validated by the percent of above average responses, it was vital to certify that the difference in above average responses was not due to random variation of student responses across semesters.

One-way Analysis of Variance (ANOVA) with Tukey post-hoc comparison was carried out. The  $p$  values for ANOVA are indicated in the legends of each figure. The  $p$  values determined by Tukey post-hoc comparison are as follows:  $*=p < .05$ ;  $**=p < .01$ ;  $***=p < .001$ ; they represent significant differences with respect to <AVG responses. Error bars represent the standard error of mean ( $SEM$ ).

## RESULTS

### Student Evaluation of the Assignment

The primary purpose of having students evaluate this assignment was to assess the assignment's efficacy in fulfilling its objectives: to enhance student understanding of microbiology, to increase student awareness to the importance of understanding science in society, and to integrate the lived experience through connecting students to their past, classmates, and microbiology.

In order to gain insight into student perception of this structured, reflective ePortfolio-based assignment, students were asked to rate their experiences: overall, in creating the ePortfolio, and in doing the written aspect of the assignment. Over 50% of the students rated their overall experience as above average. This significantly differed from the percentage of below average responses (see Figure 1). While about 40% of the students enjoyed creating their ePortfolio, no significant differences were observed among responses (see Figure 1). Approximately 45% of the students rated their experience in doing the written aspect of the assignment as above average; this significantly differed from the below average responses (see Figure 1).

It is interesting that student opinion regarding creating ePortfolios was lower than expected (see Figure 1). This may stem from the lack of student experience with ePortfolio and the limited use of ePortfolios in science classes. Approximately 79% of my students responded that they had never used ePortfolio in a science course.

Incorporation of pedagogies, which superficially can be viewed as irrelevant, into science courses can be met with opposition, especially from students. For example, Prud'homme Généreux and Thompson (2008) tried to incorporate reflection into their science classes through journal entries and writing assignments but encountered student resistance. Their students did not see the relevance of doing those writing assignments in their biology class. This offers one explanation to why no significant difference was observed in above average responses to creating the ePortfolio (see Figure 1).

Combining reflection and integrative learning that ePortfolios foster enhanced a classical writing assignment that resulted in an above average student response (see Figure 1). Although the students may have felt apprehensive about the assignment at first, they eventually saw the benefit of the assignment as evidenced by this one student's comment: "Even though I did not really accept the idea that I had to create an ePortfolio as part of my coursework, in the end I really appreciated the assignment." In fact, when asked if they would recommend this

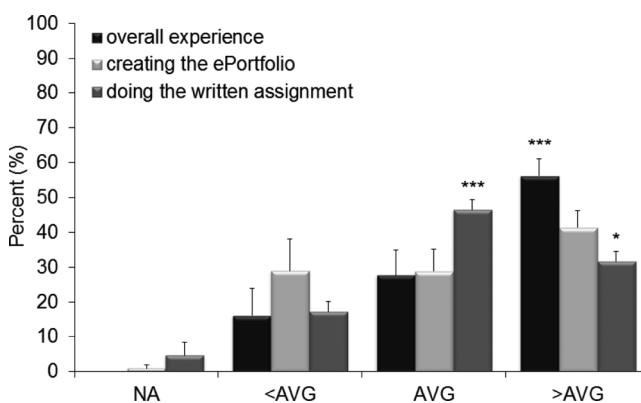


FIGURE 1 Students' perception of the ePortfolio assignment: overall experience, creating the ePortfolio, and doing the written assignment. The  $p$  values for ANOVA are  $< .0001$ ,  $< .0022$ , and  $< .0001$  for overall experience, creating the ePortfolio, and doing the written assignment, respectively. Asterisks indicate a significant difference from  $< \text{AVG}$  by Tukey post-hoc analysis.

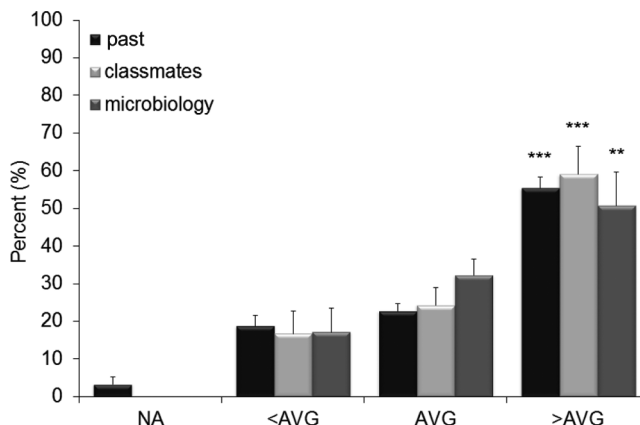


FIGURE 2 The ePortfolio assignment connected students with their past, classmates, and microbiology. The  $p$  values for ANOVA are  $< .0001$  for all categories. Asterisks indicate a significant difference from  $< \text{AVG}$  by Tukey post-hoc analysis.

ePortfolio-based assignment to future students, 57% of responses were above average and only 19% were below average; the above average response significantly differed from the below average response.

The three main connections the assignment attempted to establish were to the student's past, to the student's classmates, and to microbiology. The assignment was extremely effective in establishing these connections (see Figure 2). Over 50% of the students considered the assignment to have done an above average job in fostering connections to their pasts. Approximately 60% of the students indicated that the assignment was above average in connecting them to their classmates. Approximately 50% of the students provided an above average response that the assignment connected them to microbiology. Regardless of the specific connection, all above average responses significantly differed in comparison to the below average responses (see Figure 2).

Assessment of this assignment also included qualitative feedback from students in addition to the five-point-scale survey questions. One student wrote with regard to the connection to the past:

This assignment has helped me learn new things. I probably would have never looked up the type of bacteria that caused Wet Tail in hamsters or looked up its treatment because it was so long ago. I actually forgot about the incident until I had to really think of a disease that had an impact on me.

This statement captures the essence of the multiple facets of integrative learning. This student unknowingly resonates what Lord (2007) mentions, "educational theorists tell us that discovering the meaning of something by utilizing what one already knows builds new insights and, therefore, new knowledge" (p. 71).

Introducing a social pedagogy into an information-dense class, such as microbiology, is not without challenge. It could be a hit or miss with regards to learning outcomes. The following collection of student responses testifies to the richness of leveraging peer interaction with integrative learning:

Through the use of ePortfolio I was able to acquire a lot of information regarding my classmate's experiences with loved ones who are actually diagnosed with HIV. This gives a great picture of the disease.

I found creating a profile so that we could all see what we were writing about was very creative and helpful. It allowed me to learn more about the different bacteria that affected my classmates.

The ePortfolio project has allowed me to connect with my classmates in such a way that I never experienced before. In reading everyone's project, I was able to see how microbiology plays out in the "real world," that is something you can't get by reading a textbook.

One strength of this assignment is that we had to read our classmate's work and reflect on it. It actually made me look into some of the things they were talking about and therefore expanding my knowledge.

My classmates told stories about how a microorganism impacted their life and this created a lasting image. This image will help me retain the information in their reports well after this class has ended.

The following student quotes affirm the power of integrative learning:

Doing the ePortfolio assignment did help me learn a lot about microbiology. It forced me to do additional research on my own which lead me away from just the material in the textbook and out into the wealth of information in other texts and on the Internet. I found myself originally looking for information on *S. pneumoniae* and slowly but surely wandering off topic to pursue other interests pertaining to micro. When I got a piece of information on one thing, it would lead me to yet another question and I would go ahead and research that because I simply needed to know and so I gained a lot of knowledge on microbiology thanks to this assignment!

The ePortfolio assignment was helpful because it allowed me to integrate my freshly learned knowledge of microbiology with a life experience, and to test my previously held theories and knowledge about microbiology. We do not understand the complexities of microbial mechanisms, thus we misuse and abuse technology in our ignorance. This ePortfolio assignment caused me to question what exactly do I really know about antibiotics and anti-parasiticial medications.

Many professors, including the author, desire for students to go beyond the minimum requirements set forth in course syllabi and take on the role of intentional learners. It is understandable why frustration can set in when students fail to do so. As Chamany et al. (2008) mention, "students model their instructors' behavior and follow their lead" (p. 267). The above student quotations regarding their connection to microbiology are in collaboration with that statement. Because the author developed an assignment that intentionally incorporated integrative learning and required his students to become intentional learners, they were able to use microbiology to seek out other information and begin the process of seeing the connectedness, even between scientific disciplines.

Finally, the assignment aimed to increase student understanding of microbiology and reinforce the belief that understanding science is important in society. Over 45% of the student felt the assignment increased their understanding of microbiology, while over 65% percent of the students felt that the assignment strengthened their belief that understanding science is important in society (see Figure 3).

### Examples of Student Work

Overall, the assignment aimed to incorporate the student's lived experience into microbiology in order to foster connections between the student and the student's past, classmates, and subject



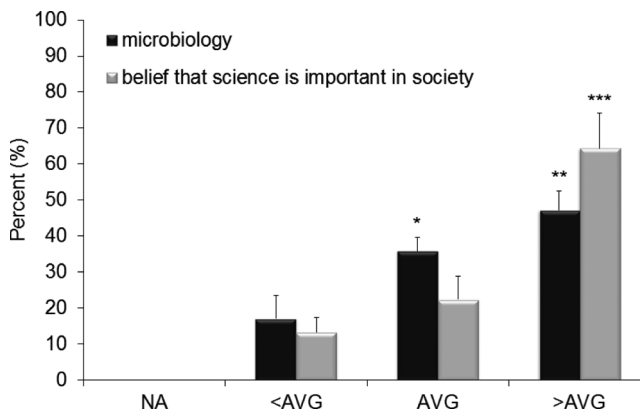


FIGURE 3 The assignment increased student understanding of microbiology and the belief that understanding science is important in society. The  $p$  values for ANOVA are  $< .0001$  for both categories. Asterisks indicate a significant difference from  $< AVG$  by Tukey post-hoc analysis.

content. The connections students synthesized would hopefully provide them with an integrative learning experience that shifts emphasis from the memorization of disconnected facts to a deeper understanding of microbiology-rooted society.

A majority of the student work produced was remarkably rich in lived experience; the plethora of connections the students made between microbiology and society surpassed the expectations the author had during the development of the assignment. One student wrote about HIV and an uncle who died of AIDS when the student was younger and living in Africa. The student described how it was thought that the uncle's HIV infection was a curse from God. Upon completion of Parts 2 and 3 of the assignment, that student realized that the uncle's disease was not a punishment but the work of a deadly virus.

While there is a wealth of exemplary student work that illustrates integrative learning through structured reflection, the author chose to showcase a complete example (minus Part 2 and only excerpts from Part 4 due to space limitations) of an assignment about one student's experience with cholera. It is worth noting that any identifiers that would breach the anonymity of the student and persons mentioned in the assignment were removed. Such identifiers include names, dates, and specific locations.

To recall, in Part 1 of the assignment students had to separately describe the event, write about the emotion behind the event, and reflect on it. Below is the example of what the student wrote for Part 1:

**Description.** In \_\_ I was working as a public health nurse in a small health care center on the Thailand/Burma border. In \_\_ fighting broke out between the Burmese Army and a Burmese opposition group. The fighting was concentrated around the border region and resulted in a flood of thousands of Burmese refugees crossing into the town of \_\_, Thailand where my health center was located. It was decided that local schools and Temples would be used as temporary shelters for the refugees. These shelters quickly became overcrowded and the existing sanitary facilities were not adequate. Within several weeks parents began bringing children into my health care center with severe diarrhea and vomiting symptoms. Also, senior citizens began appearing with the same set of symptoms. On the first night 2 children and one elderly woman died at the health center. At this point, I realized that the health and poor sanitary conditions at the refugee camps was very serious.

I immediately notified the State Health Department officials and requested help. We needed doctors, nurses, and a variety of medical supplies. The emergency personnel arrived about 2 days later and began taking stool samples to be analyzed at a lab facility. The test results took several more days and came back positive for *Vibrio cholerae* bacteria. We requested extra I.V. fluids along with antibiotic medications and began treating patients. Those not experiencing vomiting symptoms were treated with oral fluids, a solution of boiled water, salt and sugar. They were also given tetracycline antibiotic in capsule form. The very sick patients were given I.V. fluids along with antibiotics. It took 2 weeks to bring this situation under control. The well water supply was treated with chlorine, all refugees were given doses of tetracycline, and temporary sewer and toilet facilities were constructed to improve the sanitary conditions. These actions soon brought the cholera outbreak under manageable control, but unfortunately resulted in 18 fatalities mainly of young children and the elderly.

**Emotion.** My experience with this cholera outbreak was scary, exhausting and emotionally draining. I could hear gunfire from the fighting across the border. At times I felt helpless to save some of the very ill patients. There was simply not enough help to treat all the sick patients effectively. Watching a young child dying before my eyes and being unable to save him/her was a very sad experience. I worked almost around the clock with little sleep for weeks. Being so tired added to the anxiety of the situation. I think many of the other doctors and nurses involved shared my sadness in the unnecessary suffering and loss of life. This was a political war where innocent village people just became caught in the middle of the fighting. We were all feeling angry at the brutality of the Burmese government and army against its own people.

**Reflection.** In reflecting back to the event in \_\_\_\_, I think that my town government could have had a better emergency plan in place. We could have had a location ready with all the necessary housing, sanitary and medical supplies already in place, or at least ready for quick delivery. Emergency personnel such as doctors and nurses could have a written plan telling them what to do in such an emergency. A lot of valuable time could have been saved instead of waiting for lab tests and supplies to arrive. This would have prevented many of the fatalities from occurring to begin with. This tragic cholera outbreak taught me the importance of being prepared in advance for quick action in an emergency. I believe that I could have been better trained and informed in the steps to take in an emergency situation and to quickly recognize the symptoms of a cholera outbreak.

Not only is the student beginning to more deeply connect to this aspect of microbiology but the professor is seeing cholera in a new light through this integration of the lived experience. This detailed description of the event cannot be captured in a textbook.

Part 3 of the assignment required this student to reflect on the event described in Part 1 after researching for Part 2 the microbiology behind that event:

My advice to anyone finding themselves faced with a wave of very ill patients is to act immediately to treat patients without waiting for lab test results. Contact state health officials for assistance right away.

When I think back to the cholera outbreak I experienced as a young nurse in Thailand, I am sure that I would have felt differently about the situation if I had a fuller understanding of the biological nature of *Vibrio cholerae*. I experienced a lot of anxiety, at the time, because I did not comprehend why so many people were getting violently ill so rapidly. I did not know what immediate steps to take to effectively deal with the situation. If I had a better sense of control over the worsening situation, my emotions would have been calmer resulting in better decision-making.

I could probably have saved some lives and definitely alleviated much suffering, if I more fully understood how to make a quick cholera diagnosis. Oral rehydration therapy would have been started sooner, and I would have notified the state health officials immediately at the first sign of cholera symptoms. Precious time would have been saved resulting in fewer lives lost.

It is of critical importance for nurses to understand the biological science behind an infection like *Vibrio cholerae*. With a good scientific understanding, we can take the appropriate actions immediately to minimize the spread of the infection and help save lives of those already sick.

Reflecting back on the event in Part 1 and performing the research on the disease in Part 2 allowed the student to connect to microbiology on a more personal level through the incorporation of the lived experience. In Part 3, the student makes an important realization that his/her anxiety stemmed from a lack of understanding of the biology behind the outbreak. As the student is reflecting on this experience with a new understanding of the biology of cholera, the student begins to move away from just memorizing facts and gains a confidence that allows the student to begin to offer advice to others.

For Part 4 of the assignment students read their classmates' ePortfolios and chose five that they felt most connected to and identified a common theme. The following is an excerpt from what the same student wrote for Part 4:

I felt most connected and interested in the projects by Students V, W, X, Y and Z. I found two recurring themes in all of their work. First, is that microorganisms, whether bacterial, viral, or fungal, have the capacity to inflict both physical and emotional suffering on humans and animals alike. Second, is that a lack of scientific understanding of these microorganisms contributes to strong feelings of worry, fear and anxiety.

I believe my new understanding of microbiology will help in both my college career and after by giving me the desire to investigate the causes and effects of things more completely. I won't be lazy in researching the true nature of something. Knowledge will give me an increased confidence that will be helpful in my chosen career of nursing and all areas of my life.

## DISCUSSION

Connecting biology to a meaningful event that occurred in the student's life serves as a powerful tool for students to become more proactive about understanding the subject and not passively focus on memorizing disconnected and fragmented facts. Having students bring a personalized view of a generic topic also enriched the author's experience as a biology professor. Reviewing various desk copies of microbiology does not provide him with the same insight on cholera as he obtained from reading his student's lived experience with it. One student stated, "Believe it or not, I actually rather enjoyed doing this assignment and I didn't dread when parts of the assignment were due, but rather looked forward to it." As the professor, the author can understand this because he looked forward to seeing what they wrote because of the incorporation of their rich lived experiences. This assignment never became stale over the five semesters it was implemented because the author learned something new and unique regarding a microbial-based disease from his students' lived experiences. Even when several students in the class chose to write about the same disease, each student integrated a different lived experience.

### Pedagogical Relevance

The utilization of reflection in science, although not mainstream, has been attempted (McDonald & Dominguez, 2009). While McDonald and Dominguez incorporated a reflective element to enrich student learning in the lab, here the author took the approach of using reflection

to frame a semester-long lecture assignment that aimed to incorporate integrative learning into his microbiology class. The goal was to use reflection to weave the lived experience into microbiology and to have students synthesize connections. A key facet of the assignment that made it successful was the structured reflection modeled after Rodgers's (2002) reflective cycle. This reflective element in conjunction with ePortfolio, for its inherent characteristics of reflection and connection, established an exceptional integrative learning experience for students, as the following student comments corroborate:

It helped me understand microbiology better because I was able to put a face to the science, so to speak.

I appreciated being able to express my own personal experiences and sentiments regarding HIV/AIDS in the "Emotions" and "Reflections" portions of this project.

We reflected on the research, which is something that a person rarely gets to do in a science course.

As evidenced in this paper, aspects of integrative learning were greatly rooted in this assignment. Taken together, the student work and feedback presented in this paper confirms that the assignment connected several students to microbiology through the lived experience (i.e., connecting them with their past and classmates).

Establishing the connection between the lived experience and microbiology allowed students to experience lifelong and lifewide learning, underlying features of integrative learning. As Chen (2009) mentions, lifelong learning occurs over various stages of life, while lifewide learning deals with the type of education—formal (in the classroom), nonformal (outside the classroom in a formal setting), and informal (outside any formal setting). This basic premise of the assignment allowed students to experience lifelong learning by relating the topics of microbiology they were learning in a formal education setting to the lived experience that spanned time back to the student's past. Part 4 of the assignment allowed students to begin to realize the impact of what they were learning in microbiology on their future, both while continuing their education at the community college and beyond.

ePortfolio played a powerful role in embedding a lifewide element of education into the assignment. Grounding the assignment in ePortfolio allowed the author to integrate elements of the formal, nonformal, and informal components of lifewide learning. ePortfolio provided an organized learning environment outside the classroom (i.e., nonformal component) where students can connect what they were learning in their class (i.e., formal setting) to the lived experience comprised of their past events and those of their fellow classmates (i.e., informal learning). Utilizing ePortfolio for this assignment allowed for maximizing student learning while adding a personal element that would lead to student understanding of the material and not the memorization of easily forgettable disconnected scientific facts.

Chen (2009) describes folio thinking as "a learner-centered pedagogy focused on providing structured opportunities for students to create learning portfolios for the purpose of fostering coherence and making meaning" (p. 31). Having reflection, integrative learning, and ePortfolio reinforce each other throughout this assignment instilled a folio-thinking mentality in the students—resulting in them envisioning learning as lifelong. The best exemplar of this is the following statement from one of the students:

I definitely think the assignment has increased my learning of biology. In previous classes I felt as though I was learning definitions and how to take tests. With this assignment it has forced me to

work independently and interpret and learn biology in a way that is much more effective. I have noticed since after finishing this assignment that I am much more interested in really understanding how diseases and organisms work. Prior to this I would have never thought like that.

The statement from this student speaks volumes to the much needed transformation in science education that incorporates reflection and integrative learning to produce students who understand the biology as proactive integrative learners, not as isolated memorizers of facts.

## IMPLICATIONS FOR PRACTITIONERS AND RESEARCHERS

This ePortfolio-based assignment documented in this paper aims to serve as a springboard for other science educators to see the potential of integrative learning, in conjunction with such pedagogical tools as structured reflection and ePortfolio, and to develop assignments and activities that utilize the lived experience to connect students to biology. As integrative learning starts being more commonly incorporated into undergraduate science education, science educators can shift the emphasis from memorizing disconnected facts to allow the student to skillfully apply and take ownership of the subject content, resulting in a more long-lasting retention of information.

Based on the preliminary results obtained, the next phase in the development of this assignment for a more global scale would be to seek Institutional Review Board approval for a controlled study assessing the impact of this assignment on student grades and retention. Other microbiology instructors could give this assignment and sections could be randomly divided into control (no assignment) and experimental (assignment) groups.

An immediate impact of the work presented here is adaptability of this assignment for other science courses. For example, a professor teaching immunology could use this assignment by just rewording the overarching premise to “choose an immunological disorder.” A cell biology, genetics, or even a general biology professor can adapt this assignment and incorporate the lived experience to connect students to the subject matter and provide an integrative learning experience. This assignment will work for both science major and nonscience major courses: The author first piloted this assignment in his nonscience major Principles of Biology course.

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