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Of Butterflies and Silences: Exploring Teachers' and Students' Experiences in High School Biology Classrooms

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Abstract

This paper is a hermeneutic inquiry into how students and teachers experience the biology classroom and how they navigate between expectations from external factors leading to classrooms that are focused on memorizing facts and the desire to engage students deeply in the discipline of biology. From data collected from semi-structured interviews with teachers and students, and an open-ended questionnaire, the paper explores the experiences and assumptions about teaching biology that is prevalent in the classroom. The inability of teachers or students to be able to point to memorable experiences within the classroom leads to a discussion of students' experience of biology as a passive transmission of facts that are often considered irrelevant and boring. The paper explores the teachers' sense of conflict between wanting to instill a love for biology in their students and their perceived role in preparing students to memorize information for tests and prepare students for post-secondary school.

Keywords

Hermeneutics, classroom education, biology, science, teaching, memorization

Of Butterflies and Classrooms

The work our students do is memorisable . . .
but it is rarely especially memorable. (Jardine et al, 2003)

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Figure 1**.** Photo of an owl butterfly

About a year before I began my current research, an event occurred that still haunts me. After a family vacation in Costa Rica, I posted some photographs to Facebook. One particular picture was from a conservatory housing hundreds of butterflies of different endangered species. One of the workers had carefully picked up an owl butterfly (*Caligo eurilochus*) and gently spread its wings so that we could see the coloration (Figure 1). The butterfly's markings looked just like the face of an owl. He then carefully turned it sideways, with the wings together, so that the coloration revealed a clear impression of the head of a snake. Next to the picture I posted, "Biology 30 lesson . . . owl butterfly—great example of mimicry. Hold it another way, and it looks like the head of a snake! See! Biology is fun everywhere!" Some former students whom I had taught 15 years earlier responded. One wrote, "*How come you never had anything that fun in our class . . . lol*?" to which I replied, "*every day was a fun day in my bio class*," which led another student to declare, "*15 pages of notes per day on photosynthesis is not my idea of fun*" and "*my left wrist still cramps up from time to time.*" Although I knew they were joking, I was shocked. I had been told by these same students many times biology had been one of their favorite courses, yet their primary recollection was one of mundane note-taking of topics they cared nothing about.

I think back to those classes and now realize what they said is true. I remember the room as darkly lit, the overhead the only source of light. I stood with my binder full of pre-made overhead sheets, passing on predetermined knowledge. I also used diagrams, stories, puns, and analogies, but it was all about giving students information, hoping that they would remember it long enough for the test. Even now, I see myself standing there, waiting for students to be finished copying the notes . . . the moments of silence broken only by the humming of the projector, the scratching of pencils, and the rustling of their loose leaf paper. Often I felt overcome by impatience, wanting to move on, but knowing I had to follow all the correct teaching methods I had been taught: walking along the desk rows, checking to see how far along the students were and asking, "Can we move on now?" in anticipation of the next section of the overhead sheets. During those long note-taking days, I, too, had been bored, waiting for them to write the notes so I could move on to more notes. Palmer (1998) has described this experience: "[sometimes] the classroom is so lifeless . . . and I am so powerless to do anything about it—that my claim to be a teacher seems a transparent sham" (p. 1). Like Palmer, I felt like a fraud with a few moments of authenticity. In fact, the irony of the above Facebook conversation was that I did take that particular class on a two-day trip to a Northern Alberta lake where they worked with biologists in the field to study the different biotic and abiotic factors of the lake. This included field work in boats and lab work in a university laboratory; however, rather than recalling that special field trip, their first thoughts were of the daily grind of notes and textbook questions. In later years, I thought I would be innovative and hand out fill-in-the-blank notes to decrease student writing, but that change still maintained my role as the disseminator of knowledge and the students as passive vessels. Even during “fun” events like labs or videos, it was still a one-way procession of information, and questions were answered quickly so I could move on. No wonder students’ recollections were of notes; I rarely offered them an opportunity to journey into the discipline of biology, to ask questions, to do something memorable.

A Hermeneutic Study

The Draw to Hermeneutics

The data for this research (Pelech, 2015) were based on an interpretive inquiry into how students and teachers understand the question, “what does it mean to teach biology well?” The focus was to explore the participants’ experience of the biology classroom and how they navigate between the expectations of external factors, such as diploma[1] examinations, post-secondary requirements, and the expectations laid out in the *Alberta Education Program of Studies*’ for teaching through an inquiry-based focus. As indicated in the experience described above, these were tensions I had experienced throughout my own teaching career in high school biology and I wanted to explore how other teachers and students navigated through their own experiences.

Following from Gadamer’s work in *Truth and Method* (1960/2006), the application of hermeneutics attends to questions of meaning and understanding—questions that are complex and nuanced and provide few easy answers (Smits, 1997). Davey (2006) has argued that “philosophical hermeneutics is not interested in the acquisition of facts and information but in what happens as a consequence of embarking upon such a quest for knowledge” (p. 38). My draw towards exploring this topic hermeneutically emerged from an extensive examination of the literature that coalesced when I came across the following quotation: “Science teaching has suffered because science has been so frequently presented just as so much ready-made knowledge, so much subject-matter of fact and law, rather than as the effective method of inquiry into any subject-matter” (Dewey, 1910, p. 122). In spite of a plethora of research that has identified the “issues” and recommended “solutions” to increase student interest in the hundred years since Dewey, it is evident that little has changed. What is missing from the literature are the lived experiences of students and teachers of the practice of teaching and learning biology. I wanted to create the conditions where Gadamer's *fusion of horizons* (2006) could emerge from my dialogue with teachers, students, the literature, and my own experiences.

Data Gathering and Analysis

The data were gathered through semi-structured interviews with six students and seven teachers as well as an open-ended questionnaire completed by 81 students enrolled in grade 12 Biology in

[1] Diploma examinations in Alberta are provincially mandated standardized tests that students complete within their final grade in high school in English, French, Social Studies, Mathematics, and all of the Sciences. The weighting for the exam at the time of writing this article was 50% of the student's overall mark but changed to 30% of their mark in 2015.

the province of Alberta. The teachers' experience ranged from 5 years to over 20 years. Moules, McCaffrey, Field, and Laing (2015) have described studying a topic hermeneutically as occurring through a process of reflexivity, dialogue, and interpretation. I cycled multiple times between reading the interview transcripts, listening to the tapes, analyzing the open-ended questionnaires, and reading deeper into the literature on science education.

The intent of the analysis was not to find universal themes, but rather, as Gadamer stressed, to "understand the phenomenon itself in its unique and historical concreteness . . . to understand how this man [sic], this people or this state is what it has become, more generally how it happened that it is so" (Gadamer, 1960/2006, p. 4). I started with questions that were tied directly to the teachers' and students' experiences in the biology classroom, asking for specific examples, which I hoped would begin a deep discussion into what it means to teach biology well. Exploring the uniqueness of the particular and "bring(ing) it to presence, not essence" (Moules, 2002, p. 6) was intended to help the particular not to just stand out as an individual experience, but to allow the particular to "stand with its history, legacies, and relationships . . ." (p. 6). My intent was to allow the teachers and students to be able to share their experiences and, subsequently, open up the conversation of teaching biology and how we came to understand it as it is lived in the classroom.

My first few interviews both confirmed my expectations of student and teacher experiences, but also provided some surprises. Gadamer (2006) observed that the first necessary condition of hermeneutics occurs when someone or something addresses us. Gadamer (2006) stated that "a question … 'arises' or 'presents itself' more than that we raise it or present it" (p. 360). The following explores this experience where, through dialogue, the unexpected emerged from the interviews with the students and teachers.

Of Silences and Surprises

The first interview was with Student NH, who was in a first-year university biology class. She had attended a school from a Separate (Catholic) Board in Alberta with a class size of 30-35 students, and most of the assessment had come from tests and unit exams. To explore what had engaged her in biology, I asked the following:

> [Interviewer]: . . . what I'd like you to do is think back to a biology lesson that you felt was good . . . that really helped you understand biology. So, if you could describe what that would have been like?
> [Student NH]: OK, so basically what my teacher did is she gave very comprehensive notes for us to copy down off of an overhead. With that she kind of talked to us and then she actually gave a personal example. . . She was talking about . . . hypothyroidism, she actually had it herself. So, she was relating all these things about her own personal experiences about that. I found that it helped me remember that concept and actually grasp that concept a lot easier than if there was, you know, no story behind it.
> [Interviewer]: So, it was the storytelling that impacted you.
> [Student NH]: To an extent, yeah.

When Student NH first described taking notes as a good biology lesson, I was taken aback. I did not think a student would describe taking notes as a lesson that had gone well. When I looked at how I asked the question, I realize that I had stated, "that really helped you understand biology." It would make sense that within a framework of a course that was assessed primarily on tests and a diploma examination that Student NH would consider a "good" class as taking comprehensive notes. During the interview, my interest in teaching practice that involved alternatives to taking notes made me pay attention to the storytelling she mentioned her teacher had used to help contextualize the topic. To bring out this piece, I pursued this line of questioning:

> [Interviewer]: Was that the only incident that you can think of where there was a story that helped you remember?
> [Student NH]: . . . I can't really think of too many. She kept talking about all her family members . . . But I can't think of any other specific incidences. She also gave a lot of diagrams, a lot of notes. She was very comprehensive. She was actually a very good teacher.

Even though Student NH described how storytelling helped her understand the topic, she could not come up with any specifics. I had assumed that a student would take this opportunity to bring up any interesting, engaging opportunities that had occurred in the class; was this because there had not been any?

The second student interview was with Jill, also a student in her first year at university taking a science degree in biology. After hearing that most class time in her Biology 30 had been spent taking notes and doing activities described as "textbook stuff, worksheets, exams," I asked:

> [Interviewer]: So, when you think back to your Biology 30 class, think about a class that was really interesting, what you would consider a good class, a good lesson and . . . describe it for me. What would that have looked like?
> [Student Jill]: What I liked was we would go in and first of all, we would get homework check right away . . . then what we would do is we would do a fill in the blank notes . . . Then after that we'd get questions and then the time that we had to work in class we'd get like a significant amount time . . . We would always go over the homework from the previous night.
> [Interviewer]: So, within those, the kind of daily structure, can you think of a particular lesson that really stuck out for you or something you learned in Bio 30 that really stuck out for you, that you really enjoyed doing?
> [Student Jill]: My favorite unit was genetics. That's what I remember . . . I don't remember like a specific day that was really exciting but I definitely liked the actual learning process of that. . . I don't enjoy labs as much . . . I like to take notes and learn it as opposed to do it in lab.

When Student Jill stated that she had enjoyed genetics, I thought we would discuss an activity or event that she had experienced that had allowed her to pick genetics as her favorite topic; however, she could not remember anything specific and, in fact, preferred to take notes as opposed to doing lab work. My assumption that students would much rather do hands-on activities was challenged. These two students believed that being given comprehensive notes, homework checks, and textbook work to be examples of an interesting biology lesson.

My next interview was with Vicki, a teacher with five years of experience teaching at a large urban high school in Alberta. She explained how her desire to teach biology arose from her fascination with the topics she had studied in high school. She stated that she wanted to inspire students to learn about biology and hoped to hear them say, "Wow, our human bodies are amazing! Ecosystems are amazing!" Teacher Vicki described thinking constantly about ways to incorporate interesting examples of biology whenever she traveled during her vacation breaks. In keeping with that conversation, I asked Teacher Vicki the following:

> [Interviewer]: So, if we go to your classroom, can you describe for me, if you're thinking about instilling that passion for your students, can you describe for me a lesson or something that you have done that would demonstrate that?
> After the two previous interviewees replied by discussing note-taking and homework checks, I was certain that my rewording of this question would lead to the discussion of an engaging lesson.
> [Teacher Vicki]: I think it's just the way that you present it. You have to sell the lesson to them, you have to link it to things that they already know. This is not new information for either one of us. But, for example, (4 second pause)

At the point of coming up with an example, Teacher Vicki paused for four seconds. It seemed like a long time on the tape considering the rest of the time she responded to questions quickly and animatedly. After the four second pause, she began "I" and then paused again, then continued:

> I (pause)—at the beginning of every semester I make a batch of Play-Doh. Three or four batches of Play-Doh and they're colour coordinated and things like that . . . I just reuse it all the time because it's tactile and the kids can make brains, or they can make the eyeball . . . These are fun and successful lessons because they're hands-on and they actually get to see what they can't really see because it's just movement of molecules . . . But for the most part I have PowerPoint lessons, I just click through and I talk to them, they write it down, then we do examples . . .

Throughout the interviews, I sensed that the students and teachers were not able to give me specific examples of when a lesson had gone well. I suddenly realized that the *absence* of specific examples was what demanded my attention. I reconsidered the 4-second silence that occurred during Teacher Vicki's interview. That quiet pause was reminiscent of when I was a biology teacher desperately trying to engage students with exciting lessons. However, the perceived constraints of the course structure, the expectations of the students, parents, and administration, and the need to "prepare" students for the diploma exam all hung within that silence. I know if our roles were reversed and I was asked that question, I would have responded in the same way, with silence, because my teaching practice was identical: giving comprehensive notes, having students fill in the blank note sheets, even using Play-Doh to make certain difficult topics interesting. Within that silence, I felt a common bond in having a sense that the "every-day-ness" of teaching biology was missing something significant. Greene (1995) argued that as teachers, it is "simply not enough for us to reproduce the way things are" (p. 1), which is what happens if teachers become "clerks or functionaries" as opposed to allowing students to ask questions creatively and explore topics through dialogue “among people who have come together to solve problems that seem worth solving to all of them . . .” (p. 5). Through this process of vigorous inquiry, Greene suggested, students become active in the discipline and are able to explore “what might be” (p. 5).

In the epigraph at the beginning of this article Jardine, Clifford, and Friesen (2003) have stated that when the topics we teach are structured “under ‘basics-as-breakdown,’ the work our children do might be memorisable (a version of control, prediction, and manipulation) but it is rarely especially memorable” (p. 87). Memorization is passive and does not allow students the creative freedom of curiosity to become involved with the topic; whereas, being memorable requires the student to become a dynamic part of the event, as opposed to remaining a submissive figure. The students and teachers whom I interviewed spoke about comprehensive notes and homework checks, which all point to memorizing. Nothing in their teaching and learning experiences seemed memorable. For experiences to be memorable, the disciplines need

> to become things that students undergo, not just objects that they “have,” things that enchant, possess, and capture their imaginations, their passions and not just things they “possess” and can then exchange in the market economy of knowledge-as-commodity, for marks. (Jardine et al., 2003, p. 87)

For something to be memorable, the students must have a vivid experience, which means they need to undergo an event or a journey, to venture into something where they could be “changed by its lessons” (p. 87). In the interviewee’s descriptions of the biology classroom, there had been no opportunities presented in the classroom for journeying, which would have allowed students to experience the discipline of biology as it lives in the world. The transmission of fragmented facts did not appear to allow this space to be created for students to venture into, which is likely why students were not able to describe moments when they were engaged in science. Sadly, this phenomenon was not something unique to these teachers and students; rather, it remains common practice.

Common Experiences of Science Education

Three common views of science education by students emerged from a study conducted by Lyons (2006) through a comparative analysis of three research projects conducted in England, Sweden, and Australia. Students held the view that: (a) science education is simply a passive transmission of facts; (b) the science content is irrelevant and boring; and (c) science is a difficult subject due to the nature of how it seemed irrelevant and learning was about memorization (Lyons, 2006). These experiences were echoed by the student respondents in my research. The interesting phenomenon that I noticed in the interviews with both teachers and students, no matter whether they were from public, separate, or private schools, in urban or rural settings, was the similarity of their experiences with those described in the research below.

Science Education as Passive Transmission of Facts

Lyons’ (2006) first theme, that the passive transmission of facts from teachers or textbooks to students was a common characteristic of science education, was evident among all of the students I interviewed. In the interviews, for example, Student Rick described his biology class as rote learning: “90 percent of the classes would be, you know, open your textbook read three to four pages. Do the exercise at the back, and then either, you’d ask your questions as you were going along, you would work with someone nearby.” Similarly, Student Martin stated that “In a typical class session we were usually taking notes for maybe half an hour to 45 minutes. We didn’t take notes every class . . . the rest of the time we would spend maybe doing like an assignment or worksheet.”

As well, all of the 81 students that responded to the questionnaire indicated that taking biology was inherently a passive transmission of facts. Although a few students on the survey stated that they wished biology class was otherwise, many thought that the best way to teach biology was simply by improving the way science was passively transmitted. In one response on the questionnaire, a student described this experience in a wonderfully graphic way:

> I find when we do a lot of shovel-and-puke work it gets very old and boring… Working entirely out of the textbook is really boring and I find myself losing more information than I am gaining. Bio [sic] has too much memorization and not enough hands on work.

“Shovel-and-puke” was a telling description of what happens in many biology classrooms, including mine. For that particular student, biology class meant that information was being “shovelled” into the students, and then he was asked to “puke it out” on a test. How the student described learning was also significant, where his statement “I find myself losing more information than I am gaining” becomes a useful critique for the fragmented view of learning. As a biology teacher, I was comfortable with the idea that there is a body of knowledge (curriculum) that I must do my best to transmitting information to my students’ so that they could understand biology. I based my assumption on the idea that education is the “acquisition of learning ‘objects’—facts and procedural rules that can be understood as facts” (St. Julien, 2000, p. 255). I wonder now how anything in that process could be memorable.

Only a few students seemed to think that biology could be taught differently from note taking and test making. One student asked for teachers to “show us the real thing” by bringing in “research papers and articles that are interesting and relevant to the area currently being covered in biology” and using “examples from our real life.” Another asked teachers to “make it less about memorization and more about understanding, with more real life applications through experiments or field trips.” In particular, Student Rick described how it is important to raise ethical and controversial issues in the classroom. Although he felt that much of the course content was not controversial because its predetermined facts were “core to the topic,” he believed there were still controversial issues when new understandings emerged in the scientific field.

The experiences described by the students in my study mirror the findings in the secondary analyses made by the Programme for International Student Assessment (PISA) in 2006 that compared student engagement in science across Organization for Economic Co-operation and Development (OECD) members (OECD, 2007). PISA gathered data of student interest in science from student questionnaires as well as embedded contextualised questions about student attitudes towards science within the actual test units (Woods-McConney, Oliver, McConney, Schibeci, &

Maor, 2013). The report indicated that in Canada the types of teaching strategies that created the most engagement and interest in science were those least experienced by students. These included students being allowed to design their own experiments, to choose their own questions, and to test out their ideas (Woods-McConney et al., 2013). As a result, their experience of science was as Lyons (2006) described, through passive transmission of facts.

The Nature of Science Education: Irrelevant and Boring

In Lyons (2006), students overwhelmingly expressed the common viewpoint that science content is irrelevant and boring. This criticism of science classes has been repeated often throughout the history of research on science education, and appears to remain relevant to today's classrooms as well (Aikenhead, 2005; Osborne & Collins, 2001; Schussler, 2009; Turner & Peck, 2009; Willms et al., 2009). Turner and Peck (2009) observed that students leave high school believing that "school science is confusing, trivial, depersonalized, irrelevant and decidedly uncool" (p. 55). Schussler (2009) described a study by Yazzie-Mintz in 2006 that asked over 80,000 students why they are bored in science class. Seventy-five percent responded that it was due to lack of interest, and 39 percent said the material was not relevant. As far back as 1902, Dewey had described how irrelevant content disengages students when science is presented as facts without any connection to students' lives:

> It condemns the fact to be a hieroglyph . . . the most scientific matter loses this quality when presented in external ready-made fashion—those things that are most significant to the scientific man, logic of actual inquiry . . . drop out. (p. 202)

Lyons (2006) reported that students' views of science being irrelevant to their lives led to a sense that the topics were boring as well. The boredom described by Lyons (2006) would often deter students from pursuing careers in science, even when they initially expressed a desire to continue into a scientific field upon graduation. Students repeatedly take notes, but often they are seldom told why they need to learn particular content (Lyons, 2006).

Aikenhead (2003) reported that one of the fundamental concerns regarding traditional science teaching is the "dishonest and mythical images about science and scientists it conveys" (p. 12). McComas (1998) had previously noted that scientists were often presented as being objective and scientific methods as being capable of providing absolute proof. What is often lost with this portrayal is the tentativeness and creativity which are both key components of the process of scientific investigation (Aikenhead, 2003; Blades, 2001; McComas, 1998). One of the main sources of this myth is the way laboratories and the scientific method are presented in science classes (McComas, 1998). In most science textbooks, a linear, lock-step approach to the scientific method is provided, implying that all scientists follow a common series of steps to do research. Many students, in fact, are disappointed when they learn that scientists do not have a framed copy of "the scientific method" posted above their workbench (McComas, 1998). "The scientific method" is presented in classrooms as a predetermined, tidy, linear activity that students must follow, then write up to hand in for assessment. There is no imagination, creativity, or opportunities for discovering new ways of understanding a concept. If course work is presented in this way, students acquire an understanding of science that does not bear any relation to the lived world of science (Blades, 2001).

According to Eger (1989), students could see applications and creativity in other subjects, such as language arts, but they felt that science courses were "presented as a singular, unifunctional [course] with no different interests" (p. 81). When I asked Student Noel, "Has biology given you anything in your everyday life," she responded,

> Um, not really. It was just something that I did in school, and that's what I want to do in university . . . I wouldn't say it affected my daily life . . . I enjoyed the stuff we learned, but it didn't change the way I thought about things as opposed to if you took Social [Studies] or something.

As well, Student Rick stated that taking biology did not offer any "life shifting, earth shattering conclusions" for his life. Neither of these students were able to connect classroom biology to their own lives, yet most of my respondents could voice how they applied the knowledge that they learned to their own lives, especially when it came to understanding their own health and watching television shows that were medically based. There seemed to be a disconnect between what the students perceived as science in the classroom and the science encountered in their everyday lives, as if these were two separate, unrelated entities.

The interesting twist in the research occurred when many of the students who described science classrooms as irrelevant and boring were able to see science as it lives in the world as being interesting and relevant. This contradiction confirms the findings of Turner and Peck (2009) in the University of Oslo's project *ROSE: The Relevance of Science Education*, in which students differentiated between their experience with school science and with science in general. A similar finding is illustrated in Lyons (2006) by the student comment that:

> I like to read scientific books and magazines and watch such programs on TV. All I know I have learned that way, and I really like science. But I don't like that sort of science we have to learn in school. (p. 601)

Eger (1989) also pointed to the contradiction that, while research showed a decreased interest in school science, the general public's increasing interest in real-world science had led to the proliferation of books and publications by outstanding scientists. Lindahl (2003, cited in Lyons, 2006) concluded that it was not the content itself that students found irrelevant and boring, but rather how it was presented in school. Most of the students I interviewed described how biology allowed them to see and appreciate the world in different ways. For example, when I asked a student whether biology had impacted his life in general outside of school, he responded by stating that studying biology had allowed him to appreciate the complexity of life:

> [Student Martin]: I think [science] enhances the beauty of something because you can look at a piece of grass . . . one of the things we learned [is] how complicated photosynthesis really is. So, you can look at a piece of grass and just be like "wow, that's pretty incredible.

The distinction between biology in the classroom and biology in the world was clear when one student answering the question on advice for teachers pleaded, "Don't make students write out all their notes—there are way too many in biology!" yet also said that biology had impacted her life because "now I know conditions and symptoms of diseases/disorders when learning about the human body . . . I find biology very interesting because it is a relatable course–unlike math/physics." The ability for students to see ways that the knowledge could be used in their lives helped them appreciate studying biology, in spite of having described the class as involving too much note-taking and memorization.

Science is Difficult

The third vision of science education which students commonly hold, is that science is a difficult subject. Although the students Lyons (2006) interviewed found science intellectually stimulating, they complained about the overwhelming terminology and, more importantly, that difficulty arose primarily from passive learning, memorization of facts, and the irrelevance of the content. Any discussion of difficulty by the students in this research came from the massive amount of information presented and how fast teachers plowed through it. In the questionnaire, students asked teachers to slow down, not give as many notes, and provide lots of examples for them to help memorize the mountain of information. One student in my research pleaded for teachers "to take things slow. Giving tons of information in one class makes me panic and start to freak out and feel overwhelmed." How well can students truly understand a concept in biology if they are not given the time to slow down and explore the topic?

Based on focus groups across 144 students, Osborne and Collins (2001) found that one of the most often articulated concerns students had was how rushed the curriculum seemed to be in science classrooms. They found that when a biology course is focused primarily on content and the teachers' need to cover a curriculum that is overloaded, then students are "frog-marched across the scientific landscape, from one feature to another, with no time to stand and stare, and absorb what it was that they had just learned" (p. 450).

Many of the students who responded to the questionnaire in my study shared this concern. For example, one of the students suggested, "students should be given 10-15 minutes or so at the end of class to review, ponder and ask any questions they may have about the material." It is telling that a student has to ask for 10-15 minutes of time to contemplate the topics they learned. Out of a 90-minute class, they do not have 10-15 minutes to slow down and think about all of the pieces of curriculum that have been thrown at them. If they do not have time to ponder, to ask questions, to wonder, then how can they be engaged in the topic? How can they have any sense of biology as a discipline?

Because the curriculum is perceived as content-heavy, Osborne and Collins (2001) reported that science was delivered primarily through transmissive modes of teaching, so students did not have time to dwell on a topic. In fact, some teachers respond to questions from students by asking the student to just take what they are teaching at face value, that they did not have time to go into what they are asking (Osborne & Collins, 2001). As a result of this rushed curricula, it seems that students skip along on the surface like a rock, never breaking the surface so that they can explore what is underneath. As long as biology teachers see their role as giving one piece of information after another, without feeling they can slow down to help students understand how biology really lives in the world, it makes sense that students would find biology difficult. Greene (1995) argued, for example, that the detrimental effect of this disconnect has lasting negative effects. When knowledge is presented as disconnected pieces of information, it does not need care from us. In fact, she asserted, that since disconnected knowledge has been removed from the living field in which it belongs, it rejects the possibility of caring. As a result, Lyons (2006) pointed out that most of the difficulty that students expressed was not in the topics themselves but "with passive learning, memorization, or the irrelevance of the content, rather than from any intellectual challenge" (p. 603). However, most science classes in the countries studied in Lyons research presented a pedagogical framework of content-focused classes that teachers and students had to get through in order for students to pass tests.

Breaking the Silences: Butterflies and Mimicry in the Classroom

From the conversations with the teachers, there was an overwhelming sense of feeling conflicted over how they teach biology because they want to instill passion in their students and have them leave the class with a love of biology. The teachers all talked about not caring if the students remembered specific content, yet when they are in the classroom, the content remains their main focus. Looming over them are the all of the specifically mandated content and outcomes, the ominous shadow of the diploma exams, the marks required to compete for post-secondary admission, parental expectations, and student demands to "just tell us what we need to know." Thus, although teachers' immediate attention was on getting the "material across" to prepare students for the diploma examinations through memorization and note-taking, their long-term goals included having students develop an appreciation for biology and acquire skills that would be useful in their lives. Turner and Peck (2009) identified these "two incompatible goals" as one of the key reasons of disengagement by students. They described how teachers are caught between preparing students for more advanced courses—mainly "feeding the metaphorical 'pipeline' of students who will go on to pursue post-secondary study in science-related fields" (p. 55)—while, at the same time, trying to serve the majority of the student population, who will not pursue careers in science (Turner & Peck, 2009).

As a result, endless pages of notes are being taken, as opposed to stopping to look at the uniqueness of a butterfly's wing and appreciating how beautiful and complex our world is that this butterfly could seem to be an owl, a snake, and a butterfly all at the same time. This is not an example of mimicry—*it is* mimicry as it lives in the world. The butterfly is not there for us to be able to understand the word "mimicry," but rather, being part of that world where we live with that butterfly, we can begin to understand why mimicry is part of our ontology. Memorizing the word and looking for an example is counter to what science and knowing should be. We should be looking at the world and understanding the world with the word. Yet we teach concepts and words, emphasizing definitions and quizzes, and we then point to the butterfly only to help make the word more memorizable.

Cartesian thinking would tell us that a butterfly is a butterfly; whereas, science would name it *Caligo eurilochus*; but in nature, it is also seen as an owl and a snake. How it lives its life is multifarious, not black and white as many science classrooms would have us assume. In the classroom, teachers seek opportunities to make connections through telling stories or connecting to moments, but these moments are often an aside, a tool used in an attempt to help students "cover" the material. The stories and connections are often a means to an end to help the students memorize the concepts. The students are not asked to share their stories or even to participate in storytelling, because their questions and wonderment are often seen as slowing down the primary focus of covering the curriculum (Blades, 2001; Macpherson, 2009; Osborne & Collins, 2001). The stories become merely the icing on the dense structure of content and testing, and are quickly set aside when time is rushed.

The conflict between covering the content and making connections is like a dance that goes unacknowledged, and when teachers tried to discuss it in the interviews, we were confronted with moments of silence and vagueness. Instead, what emerges are discussions of note-taking, Play-Doh making, homework checking—all elements of my own teaching. So, when I think back to my darkened classroom with the single source of light on the overhead screen projecting predetermined notes, the students in rows facing forward, quietly writing down, suffering the physical and mental cramping that this experience could only offer, I am embarrassed. Why did I teach that way? I spent 17 years not knowing that this method could be something else. How else could it be? This is a question that teachers do not have many opportunities to explore within their frenetically paced lives in schools, but one that hopefully will begin to emerge more and more.

The specific learning outcome in Biology 30 related to mimicry reads, "students will: [30–D2.2k] explain the role of defence mechanisms in predation and competition; e.g., *mimicry, protective coloration, toxins, behaviour*" (Alberta Education, 2014, p. 77, original italics). This specific learning outcome is only one of over 70 outcomes narrowly focused on knowledge and STS connections. Within these outcomes are sub bulleted outcomes that bring the count to over one hundred, not including the outcomes for initiating and planning, communication, and teamwork. How can teachers find time to make the class anything but memorisable when they are required to cover all of these specific outcomes? Before every Knowledge, STS, Skills outcome in the *Alberta Education Program of Studies* it states, "Students will." For example, "*Students will* explain the role of defence mechanisms in predation and competition; e.g., *mimicry, protective coloration, toxins, behavior,*" (p. 77). At the bottom of every page in the *Alberta Education Biology 20/30 Program of Studies* there is a disclaimer: "**Note:** Some of the outcomes are supported by examples. The examples are written in italics and **do not form part of the required program** but are provided as an illustration of how the outcomes might be developed" (Alberta Education, 2014, original bold).

The purpose of the italicized examples is to give teachers options how they can present the different topics. The intent is to allow flexibility in different classrooms, which then allows teachers to choose to take up topics in different ways. In the face of the 70 bulleted objectives the students are expected to reach (meaning, then, the teachers must teach), the reality is that anything italicized is often seen as an add-on, an extra, something that will not show up on the diploma examination. If it is assumed the italicized examples are simply an add-on to the real (that is not italicized) content, then how the content is connected in the world is lost. Aikenhead (2005) has described the tension teachers experience between "educational soundness and political reality" (p. 385). Teachers are often caught between what the research demonstrates as strong pedagogical decisions to increase student engagement, but politics such as "historical precedence, pressure from universities, directives from professional interest groups . . ." (p. 385) all contribute to how teachers decide to teach.

This makes me wonder, is this way of teaching a form of mimicry? In biology, mimicry is when one organism pretends to be something else in order to survive by looking or behaving like something it is not. The owl butterfly has two large marks on its wings to look like the eyes of an owl in an attempt to scare away its predators. Maybe that is what teachers are doing. To protect ourselves, we say we are trying to teach using stories to engage the students, but in reality, we are still focused on the content, because that is how we survive. What if I had turned the light on in the classroom and allowed students to look around, to look at the world and each other and ask questions? What if we had ventured into the world where a butterfly could be an owl and a snake and ask how did it come to be and why is it important to know? The difficulty for me as a teacher is what if I turn the light on my vulnerability of what I know about biology, what I do not know becomes exposed as well? I may have to abandon the role of disseminator of knowledge and become a person that also needs to journey into the world in ways that are unfamiliar to me. What if I had shifted the focus from *students will* to *students' will*? The Merriam-Webster online dictionary defines the term "will" as "used to express a command, exhortation, or injunction: you will do as I say at once." If teaching and learning are going to be the journeying that Jardine (2003) addressed, for it to be memorable, then the *students' will* needs to be part of the journeying. By shifting the "will" from commanding to inviting, "used to express desire, choice, willingness, consent," then students could choose to journey into the complex discipline of science and explore the world where they live with the butterfly and understand why mimicry is important in the world. However, when we look at the research of science classes in Canada, Europe, USA, and Australia, the most striking element of the results is how universal student disengagement with classroom science is spread throughout the Western world. If students are invited into this world of butterflies that are owls and snakes, then their own stories and questions could emerge, potentially leading to moving beyond memorizing and creating space for memorable moments.

Conclusion: Moving away from Mimicry

From exploring the literature and my research of student and teacher experiences, it would seem that many attempts to change how biology is taught have been made with little success. In light of the research that suggests students experience biology as a form of mimicry, the question remains: how can we find ways for students to experience biology as it lives in the world?

Jardine (2012) began his book, *Pedagogy Left in Peace,* with a quote from a speech by Gadamer (1992) called, "The Idea of the University–Yesterday, Today, Tomorrow." I found this quote compelling when contemplating how to move forward with this research.

> We should have no illusion. Bureaucratized teaching and learning systems dominate the scene, but nevertheless it is everyone's task to find his free space. The task of our human life in general is to find free spaces and learn to move therein. In research this means finding the question, the genuine question. (p. 59)

Jardine (2012) further argued that we need to free classrooms from the ingrained "circumstances that make schools, teachers, and administrators retract from any such suggestions of free spaces and the work needed to live therein" (p. 9). From my research, those circumstances include the pressure of too much content, the sense of never getting past preparing for the next test, and prescribed learning outcomes that already dictate where the topic will take us (Derby, 2015). I would argue that it does not mean forgetting about those factors but recognizing that they can be taken up differently, where the topic becomes alive in context of the world in which it belongs. I am drawn to the concepts of creating a free space, where teaching and learning is a living universe, a place where something happens to us; in other words, something memorable. What would it be like for the classroom to be a living, contemplative place of being, where free space is opened for students to have opportunities to delve in depth into the field of biology? A place to ponder, to wonder, and to ask questions?

This is where hermeneutics can speak profoundly to science, by helping to find ways to root the scientific concepts back to the habitat of which they are part; into what Heidegger would call "being in the world" (as cited in Kozoll & Osborne, 2004, p. 158). Finding ways to bring these concepts back into the world in a way that includes their ancestry, the memories that they evoke, and the truths they say about the world is essential to understanding the complexity behind why students seem disengaged in science. Allowing students to have opportunities to be part of the conversation already in play would move the content in the biology classroom away from what Jardine (2013) described as an "ever-accelerating succession of 'nows'" (p. 8). Students would then be able to recognize that science is not a static book of facts, but a living discipline that has a history, which impacts the present and the future.

Being immersed in the discipline of biology means that problems can be understood more deeply, allowing a spontaneous and yet informed response to questions. Knowledge can then be used to answer a question in a new and unanticipated way, moving away from the passive transmission of facts. By exploring in-depth the many questions that emerge from events in the world that demand a biological understanding, students would then able to see why biology is an important and valued body of knowledge. Biology instruction would no longer be about disconnected facts, but a part of living in the world along with the butterflies, owls, and snakes. Biology classrooms can then go through a process of metamorphosis from being an example of mimicry to being experienced as a "transformative capacity [through] the process of engaging with a subject matter" (Davey, 2006, p. 39); or put differently, how biology actually lives in the world.

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