

INSTRUCTOR FORMATIVE ASSESSMENT PRACTICES IN  
VIRTUAL LEARNING ENVIRONMENTS:  
A POSTHUMANIST SOCIOMATERIAL PERSPECTIVE

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In Partial Fulfillment  
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Doctor of Philosophy

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INSTRUCTOR FORMATIVE ASSESSMENT PRACTICES IN VIRTUAL LEARNING  
ENVIRONMENTS:

A POSTHUMANIST SOCIOMATERIAL PERSPECTIVE

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## **DEDICATION**

To my children, Alyssa, Hailey, and Abby, always go after what you want in life and surround yourselves with people that will help make that happen. To my husband Chris, thank you for believing in me and trusting in our ability together to always find a way through whatever life brings us. To my mom, Debra Edwards, thank you for believing in me and helping in more ways than I can count.

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## ABSTRACT

The importance of undergraduate science learning for the workforce and scientific literacy is consistently emphasized by prominent organizations and influential publications such as the American Association for the Advancement of Science (AAAS) (1993, 2013), the National Research Council (NRC) (2010, 2011, 2012a, 2012b, 2013) and the Coalition for Reform of Undergraduate Science, Technology, Engineering, and Math (STEM) Education (CRUSE) (2014). Moreover, important undergraduate and K-12 reform policy documents including the National Research Council (NRC) (2012) and the Next Generation Science Standards (NGSS) (Achieve Inc., 2013) set lofty goals aimed at improving science education. At the same time, science curricula content and assessment are shifting to virtual formats (Smetana & Bell, 2012), and enabling learning and assessment to be depicted in more dynamic and interactive ways. Furthermore, assessment scholarship offers opportunities to make instructional decisions with the aim to aid student learning (e.g. Bell, 2007; Black & Wiliam, 1998, NRC, 2012; Shepard, 2000). Nonetheless, harnessing the full potential of virtual formats to reach these goals for science learning and assessment has proven challenging. Therefore, in this research study, I explored how the technology in one online undergraduate biological science course can impact how an instructor can aid student learning.

Specifically, I focus on one asynchronous online Nutrition science course for undergraduate non-majors at a large research institution. My interest was on the role materials have on the instructor's online formative assessment practices. How student learning was assessed was examined from the instructor's perspective. The instructor was

an experienced online instructor that had experience working in a biological science lab as well as training as a science educator. The student purpose for taking this course was to meet a general education requirement toward undergraduate education. This study focuses on one course across two semesters and considers the features of the assignments from three different angles. First, is a case study that considers how the assessments are influenced by the instructor. In Chapter 2, I use the Assessment Literacy Framework's (Abell & Siegel, 2011) section *assessment interpretation and action taking* to present evidence that suggests it is important to consider the role of the materials in virtual learning environments on instructor formative assessment. I suggest instructor formative assessment practices can be supported through *communication* and *customization* to aid student learning. I also introduce the concept of Stacked quizzes to scaffold instruction.

In the chapters that follow, I begin to consider how materials can act and move in a virtual environment to impact an instructor's formative assessment practices. I use the agential realism framework (Barad, 2007) to "peek" inside and describe how the technology embedded assessments impact the instructor's practice related to formative assessment. In Chapter 3, I explore the concept of assemblages considering how assessments embedded in technology can influence instructor formative assessment practices (Barad, 2007). In Chapter 4, I explore sociomaterial assemblages from a more global perspective regarding the instructional design of the course and instructor formative assessment practices (Barad, 2007).

This post-humanist framework enabled me to think beyond artificial boundaries, consider the actions of the assemblages, and how it can affect practice by focusing on identifying the differences and the effects those differences cause. I describe

assemblages' agency and how that agency can drive formative assessment discourse in the course. I describe the agency of assemblages created specific to formative assessment to aid student learning from a sociomateriality perspective. I suggest assessments can encourage or constrain an instructors' ability to support student learning in online classes. The agency can act on an instructor's ability to interpret student needs and take action based on informed instructional decisions. Furthermore, I describe how the linear structure of a course could impact instructor formative assessment practices. Overall, these studies suggest that the assessment features in virtual environments can both aid and hinder instructor practices. Additionally, I suggest that assessments in virtual environments include: 1) the content (e.g. the science), 2) the style (e.g. worksheet, writing assignment, quiz etc.), and 3) the technology tools.

The findings have implications for instruction and research and suggest that learning communities may want to consider that student centered learning theories and student-centered course design for online education could be incomplete. The primary implication includes ways to support formative assessment practices for science instructors in virtual environments by looping instructor formative assessment opportunities throughout a course. Finally, these findings can help others develop assessments that fully support student learning by including the instructor's assessment needs and abilities. The conclusions I present cannot be considered a solution to all courses. However, I encourage other researchers to consider alternative explanation(s) by thinking with theory.

## CHAPTER ONE

### Introduction

This introduction serves to provide the background information the reader needs to fully understand this dissertation. I begin by sharing a biography that discusses my relevant experiences for this research. I discuss my laboratory research experiences, my background in teaching and course design, and the type of students I teach.

I follow this biography with sections intended to provide the foundational information needed to understand my dissertation research. I provide with a brief overview of the literature on each of the constructs: 1) assessment, 2) educational technology, and 3) materiality that ground my three manuscripts. Then, I discuss how research is done in the social sciences with a focus on how conventional qualitative and post-qualitative research differs. These sections provide an opportunity for me to define the terminology, and introduce important concepts, such as the role of data, bias, and manuscript format. I also take this opportunity to explicitly explain when and why one would use a post-qualitative research approach and what it contributes to the literature. I conclude with a justification for this approach and explain why I was drawn to it.

Due to the differences in post-qualitative studies and conventional qualitative research I provide an explanation of the “post” theory, Agential Realism (Barad, 2007). Agential Realism informs the manuscripts in Chapters 3 and 4 of my dissertation. This allows the reader to be introduced to the ideas and terminology in context before reading the actual manuscript. I explain how this theory informed my study including the research question I asked, what I considered data, how I analyzed data, and how I wrote the manuscripts. Finally, I provide a brief overview of each manuscript situating the reader in the context of the study.

## **Biography**

**Science.** I feel as if I have always found science interesting. I spent 11 years working in academic research labs. For 5 of those years, I was in charge of a molecular biology lab. In high school, I took science classes and I did well. This was in the mid to late '90s when the internet was in its infancy, and I had to read a book and ask people when I wanted to know something. There was no Google. I asked many questions and I learned that the more specific the question I asked the more likely I would receive a satisfying answer. Then one day in class my questions began to address scientific topics that had not yet been discovered. I was asking about viruses. AIDS was a recent topic in school and I was curious about how the virus worked. There was very little known at the time about HIV. I realized that day that science was not just a collection of facts, and that we did not know everything. More importantly, I learned there are scientists actually doing research. At that point I knew I wanted to be a part of asking questions that lead to discovering new and exciting things.

I majored in Biology as an undergraduate student. I qualified for Pell Grants as well as “work study,” which meant that I was guaranteed a job on campus as a form of financial aid. The first week of class as a freshman undergraduate, I walked up to who I thought was the head of the Biology department and said “I want to do research”. He kind of chuckled, said “ok,” and then I was dismissed. Half way down the hall I turned around and went back to his office and I said, “I mean, can I do research now? I have work study, I need a job and I want to work in a lab.” He took a minute to register what I was asking and then said “ok, I think we can find something for you.” That began my years working in research labs. I got involved in doing laboratory science research

projects immediately. As an undergraduate, I worked in a microscopy research lab where I helped to characterize the calcification process of the juvenile Blue Crab dorsal carapace. I learned many microscopy skills including preparing samples for Transmission Electron Microscopy (TEM) and Scanning Electron Microscopy (SEM), as well as different techniques to cut and stain samples for light microscopy. I discovered central channels that were highly calcified going through the center of mounds evenly dispersed throughout the dorsal carapace. I got to present my research findings at a conference. I loved being in the lab.

I decided I wanted to earn a Master of Science (MS) degree in Cell and Molecular Biology, and chose a MS granting institution. I loved the academic atmosphere and more importantly, I learned that **research is the practice of observation, formulating a hypothesis, designing experimentation, data interpretation and reflection.** My research focused on using the technique RNA interference (RNAi) to identify the Collagen IV cell surface receptor in the model organism *Caenorhabditis elegans*. I found the topic interesting. I found the techniques that included things like Polymerase Chain Reaction (PCR), cell culture, transformation and transfection, microinjection and microscopy fascinating.

I began working in a research lab at the University of Missouri immediately after I graduated with my MS degree. I ran the entire Molecular Biology Lab, where I had the opportunity to contribute to and collaborate on fascinating scientific research. Our research focused on gene expression of GABA receptor subunits as it relates to the Central Nervous System (CNS) control of blood pressure in pregnancy. It was during this employment that I developed an appreciation for the importance of statistical significance



and a large well-designed research study. Additionally, I loved the laboratory techniques I used. I was doing laser-capture microscopy where I would capture 1-10 neurons, isolate the RNA, and then use reverse transcription to create DNA. This was used as a template for real-time PCR. As a molecular biologist, I became good at these techniques because I understood the actions of the reactants, how the instrument relates to the other items in the reaction, and my influence in the process. I saw how each piece of my reaction worked together and influenced what I was able to amplify and learn about something I could not see directly.

I loved learning how the techniques worked. How the different parts worked together and resulted in something new and exciting. I shared this one day with a professor, Ed, over lunch. Ed was mostly retired and came in a few days a week to “tinker in his lab.” He shared with me one mistake new researchers often make is that they learn one method and then design all their research questions around this method. Ed suggested that instead they should decide the topic of their research and then over the years expand on the methods they use to explore their topic. He explained you can always learn new methods.

**Teaching.** I began teaching in 2003, 16 years ago. I have been teaching science courses online for 10 years, and designing online science courses for 6 years. Additionally, I worked for two years at ET@Mo, the educational technology department at the University of Missouri. I helped faculty with educational technology needs.

In addition to online, I have taught biology courses that incorporated online instruction with face-to-face science labs, also known as, hybrid courses. Furthermore, I have taught traditional face-to-face undergraduate biological science courses in both

small and large lecture settings. Over the past 10 years, I have been teaching a variety of online courses consistently. These courses have included Introduction to Biology for majors, non-majors, and pre-nursing students, as well as Physiology for pre-nursing students, Anatomy for pre-nursing students, and Biotechnology and Society for non-majors. I have also taught Environmental Science and Ethics of Eating both available to all undergraduate majors. These online courses were taught for a variety of institutions including a land grant research institution, a community college, and a for-profit college.

My teaching experiences began at Missouri State University while earning my MS degree in Cell and Molecular Biology. I taught an Introduction to Biology lab class and, a bit to my surprise, I quickly became known in the department as a good teacher. I was good at telling the students what they were supposed to learn and new graduate students would sit in on my class to learn what to teach. I learned that a “good teacher” would tell students what they needed to know. I also found it helped that I am a native English speaker. I also took note when students struggled with content. I began to explain what they need to learn *and* how to learn it. Furthermore, I began to think there was more to being a good teacher than giving a well-articulated presentation in English. I taught for 6 semesters, up to three sections of the Introduction to Biology lab course per semester. I also taught up to two sections of Physiology lab classes for three semesters. I held weekly meetings with other graduate students to discuss how lab content aligned with lecture content and how to help our students learn the information in both. I found that noticing when students had trouble and then helping them learn the material was important. This experience shaped my view that as a teacher I should help my students learn.

My online teaching experiences began more out of necessity. In 2009, I had a new baby at home and my husband's job was eliminated due to the 2008 economic crash. We needed the money. I thought I might supplement our income by teaching online. I found a course to teach.

Teaching online was different than face-to-face. The course told students what to learn, I graded. I became concerned when I noticed my students were often very suspicious of foundational science concepts. Yet, it seemed almost impossible to address these issues. In my online course I was micro-managed to ensure I was doing the things "good teachers" do. I was encouraged to grade quickly and respond to emails in 24 hours. I realized the focus on adherence to policies was not helping students develop an interest in science as a process of investigation and a conceptual understanding of science concepts. I suspected there was much more to teaching online than what was being emphasized. I began to pay attention to how I could help students and try new ways to help them learn. I came across the department of Science Education after teaching online a few semesters. I thought I would try taking a course, and that maybe learning about teaching and learning would help me teach my students. I enrolled in the course College Science Teaching with Sandra Abell. She encouraged me to apply to the Science Education PhD program, which I met with skepticism. I asked her "What *kind* of research do you do in science education?" While I did not have a complete understanding of what kind of research science education focused on I began this program knowing the field of science education is not Science and the research is very different.

**Course Design.** I have 6 years of experience in the design of online science courses. I also have helped with the design of an online high school Biology course for

Mizzou online. Additionally, I created and currently teach an Ethics of Eating course for the department of Nutrition and Exercise Physiology at the University of Missouri. I also co-created a course that focuses on Science as presented through the Media. Most recently, I completed the creation of a course on Careers in Biotechnology. My current work is on a course that explains “Why Science Says.” The focus is on specific topics important in science by teaching students the reasons science emphasizes specific concepts and the real consequences of ignoring the science.

My experiences teaching and designing online courses came together with my lab research experiences to let me think about that the material elements in my online courses. I began to consider if these material elements influenced how or if I could aid student learning. While teaching, I thought of the components of my class like the components of a PCR reaction. I would try to change one variable at a time and see how it would *influence my ability to help* students learn important science topics. This is how my science brain worked, but this is not how research in science education works.

I explored avenues such as media literacy and assessment research. I learned everything I could about teaching and learning with technology and I read as many research articles as I could find. I got very frustrated with the research literature in science education. I felt it was asking the wrong questions, ignored data, and focused on the wrong variables. Therefore, discussing how these studies added to a body of knowledge about teaching and learning was at the least uninteresting and at the worst a waste of my time. I then came across the idea of materiality and felt this focus on the material elements was what was missing in the research studies I had been reading.

**Undergraduate non-science majors.** My interest is in teaching undergraduate non-science major students. I have taught both science majors and non-science majors. I found non-science majors the most challenging, rewarding, and important to teach. Many of my students are rural Missouri students. These are a subgroup of people I know and understand pretty well. As an adult, I lived in rural Missouri for 8 years. I would informally address science issues in conversations. I became good at offering explanations about science topics, at times unsolicited, to rural non-science people. I became a resource and an informal teacher about a wide range of science topics.

I also noticed a nationwide conversation about science topics, such as stem cell research and climate change. I observed people being influenced by special interest groups who used resources such as the media to take advantage of their lack of knowledge of science topics. I am interested primarily in teaching and designing courses for non-major science students because these are the students that I think need this information. I have had the opportunity to hone my ability to communicate science topics, and the real consequences associated with not understanding basic science concepts to non-science individuals.

I decided that one place where my areas of expertise converge is the teaching of science content online in a Midwestern university. This was what I wanted to focus my dissertation on. I wanted to explore how an instructor could aid student learning in a virtual environment while taking into consideration variables that other literature seemed to ignore, the material elements. How to address the material elements was the challenge. I wanted to focus on how the assessments supported the instructor's ability to formatively assess science. I had no idea that what I was suggesting was very different than what

other science education researchers were discussing. Next, I explain the concepts assessment, educational technology, and materiality to begin situating the reader in the constructs used in this dissertation.

## **Assessment**

The National Research Council (NRC) (1996) defined what assessment should include. First, assessment should assess rich, well-structured knowledge, assess understanding and reasoning, it should be used to learn what students do understand *and* what they do not understand. Assessment should be used to measure achievement and as a learning opportunity. It should be used as part of a process to engage in ongoing assessment of work often accomplished through multiple discrete assessment opportunities. Additionally, educational research suggests that assessment should support learning (Black & Wiliam, 1998; Black, Harrison, Osborne, & Duschl, 2004), include system-based knowledge and practices (NRC, 2012), focus on epistemologies (Dixon-Román & Gergen, 2012), provide opportunities for metacognition (Achieve, Inc., 2013), consider ways to address identity (e.g. Calabrese & Tan, 2010; Tan, Calabrese-Barton, Kang, & O-Neil 2013), and be **used as a tool for** the student (Moseley, Baumfield, Elliott, Gregson, Higgins, Miller & Newton, 2005) **and the teacher** (Abell & Siegel, 2011; Willis, 2011). I am interested in the use of assessment as a tool for the teacher.

Table 1 illustrates the three purposes for assessment, Diagnostic, Formative and Summative and the purposes for each. While diagnostic assessment enables one to determine prior ideas and summative assessment focuses on what students know at one discrete moment in time (Ehrmann, 1995; Shepard, 2000), formative assessment can be

used for multiple purposes (Abell & Siegel, 2011; Bell, 2007; Black & Wiliam, 1998; Ehrmann, 1995; Shepard, 2000). Specifically, formative assessment can be used to inform students about what they know and do not know to improve self-learning, help teachers to gauge students' progress, provide data for teachers to base instructional decisions, increase students' motivation to apply knowledge and practice skill (Bell, 2007; Black & Wiliam, 1998; Ehrmann, 1995; Shepard, 2000). When assessment is used as a tool for the teacher to enhance student learning it is referred to as formative assessment.

Table 1. Types of assessment and their purposes (Abell & Siegel, 2011).

<b>Types of Assessment</b>	<b>Purpose of Assessment</b>
<b>Diagnostic</b>	Elicit students' prior knowledge
<b>Formative</b>	Inform students about what they know and do not know to improve self-learning
	Help teachers to gauge students' progress
	Provide data for teachers to base instructional decisions
	Increase students' motivation to apply knowledge and practice skill
<b>Summative</b>	Provide evidence of students' learning for the purpose of grading

**Formative Assessment.** Formative assessment is defined as assessments that enhance student learning and enable the instructor to address conceptual difficulties (Bell, 2007; Black & Wiliam, 1998; Ehrmann, 1995; Shepard, 2000). These goals are enabled by formative assessments that support the needs of the instructor to change instruction based on data provided by the formative assessments (Abell, 2007; Hattie & Jaeger, 1998; Hattie & Timperley, 2007). I am interested in formative assessments that provide

data for instructors to base instructional decisions and help instructors gauge students' progress.

In classroom settings, formative assessment can be done informally with the instructor making intuitive or qualitative interpretations based on student cues or through intentional classroom assessment techniques (CATs) (Angelo & Cross, 1993; Black & William, 1998; NRC, 2001). Formative assessment depends on multiple forms of student data to drive instructional decisions (NRC, 2001).

Additionally, in recent years there has been a shift of the content and assessment of science curricula to virtual formats (Smetana & Bell, 2012). These virtual formats use educational technology to create learning and assessment opportunities. This has enabled science to be depicted in more dynamic and interactive ways. As previously stated, this study is focused on a subset of formative assessments that provide data for instructors to base instructional decisions and help instructors gauge students' progress through the use of web-based educational technology.

### **Educational Technology**

Educational technology, also referred to as instructional technology, provides numerous tools to support student learning. A few notable examples include Inquiry Learning Environments (ILE) such as WISE, E-Portfolios, WebQuest, and Diagnoser (Howland, Jonassen, & Marra, 2012). Assessments that use educational technology can be designed to support student learning, and the instructor's ability to aid student learning and understanding. Currently, technology is used in assessment to encourage problem-solving, provide real-time feedback to students and teachers, and for logistical and cost effective reasons (Pellegrino, 2013). Technology can assist with creating new



assessments to meet the needs of assessment for learning (NRC, 2001). Nonetheless, with all the promising ways technology is being used to support learning, technology is rarely integrated formatively in a way that utilizes modern assessment practices (NRC, 2001).

Howland et al. (2012) explain the need for a significant paradigm shift in how we view technology to achieve meaningful learning *with* technology. Meaningful learning *with* technology includes students using technology tools to construct knowledge, participate in conversation, articulate ideas, collaborate, and reflect on their learning (Howland et al., 2012). The emphasis of meaningful learning *with* technology is contrasted by the more common case where students are expected to learn *from* technology. A classic example of students learning *from* technology includes educational television programming; e.g. Sesame Street. In these cases technology is evaluated on how well it can replace existing functions. While we know students can learn *from* technology, technology can be much more powerful when students learn *with* technology; where the technology is “used as engagers and facilitators of thinking” (Howland et al., 2012, p.7). The development of tools that support learning *with* technology also include online environments that support embedded assessments, a couple notable tools include the West Ed SimScientists program (Quellmalz, Timms, & Buckley, 2012) and DIAGNOSER (Thissen-Roe, Hunt, & Minstrell, 2004; Howland et al., 2012; NRC, 2001).

The development of specific formative assessment tools for specific lessons illustrates how formative assessment can be enabled by the use of learning *with* technology, yet to rely on individual programs as the primary means of incorporating formative assessment in instructional technology seems daunting and unnecessary. Rather

than developing a new tool for each course, lesson, or content area one could utilize the tools available in a formative way. To achieve this the developed assessments need to support student understanding (NRC, 2000) and the instructor's ability to aid instruction by helping teachers gauge student progress and make instructional decisions (e.g., Bell, 2007; Black & Wiliam, 1998). However, technology research literature currently and historically evaluates technology on the ability to increase student access to content while reducing costs and focuses on how effective the subsequent strategies are compared to more traditional (not educational technology) strategies (Howland et al., 2012; Johri, 2011).

A line of research and policy documents call for a focus on *what* teachers need to know to incorporate technology into their teaching, often in a face-to-face context (e.g. Mishra & Koehler, 2006; International Society for Technology in Education, 2000; U.S. Congress Office of Technology Assessment, 1995). Yet, Mishra and Koehler (2006) point out the focus should be on *how* teachers use technology and the teacher's contribution. Furthermore, Bolldén (2015) uniquely focuses on teacher practices with technology from a sociomaterial perspective enabling a focus on the network of intra-actions that occur. Next, I explain what sociomaterial is and how that point of view can move the research in this field forward.

## **Materiality**

Materiality is defined as the study of material objects (Baird, 2004). In this study the material object is defined as the assessments and educational technology in the course. Research on Materiality focuses on the material object, the properties of artifacts associated with the material object and how those artifacts are used by people (Leonardi, 2012). More specifically, the focus is on the features of an artifact that do not change across time or location. Materiality “identifies those constituent features of a technology that are (in theory) available to all users in the same way” (Leonardi, 2012, p.7).

The use of materiality in education studies enables a focus on the use of technology-in-practice (Barad, 2007; Leonardi, 2012; Orlikowski & Scott, 2008) where practice is defined as socially shaped in a community where the activities are negotiated (Leonardi, 2012). I chose to use this perspective because it enables me to focus on “how does it work” and to consider how the materials support learning *and* how different groups of people, in this case teachers, use the technological tools that are intended to support learning (Barad, 2007; Law, 2004; St. Pierre, 2015; Taguchi, 2012). For example, Bolldén (2015) described online teaching practices that focus on both social and material perspectives. She investigated how online pedagogy works and concluded that online pedagogy can be considered a multifaceted concept, rather than a series of best practices, because the characteristics of materiality are qualitatively different depending on the technology platform (Bolldén, 2015). This means that the technology platform can drive the need for different pedagogy. These results align with the broader claims that practice is affected by a network of social and material interactions.

Waltz (2006) explains that in education the use of materiality can help us understand how material educational tools affect social practices; for example, textbooks can drive pedagogical activities, align curricula, limit instructor academic freedom, and cost affects students' ability to purchase a textbook. Furthermore, Fenwick, Edwards, and Sawchuk (2015) and Fenwick and Landri (2012) explain that material things act together and with other things, such as the social interactions. These interactions result in a network of interactions that can appear as larger issues including policy, gender identity, expertise and even social structures such as racism. This focus on the network of interactions, termed assemblages, suggests that even these larger issues are a system of interactions are held together by often precarious interactions between the social and the material that can be identified and changed, rather than an all-powerful hierarchal system.

**Sociomateriality.** Sociomateriality aligns with materiality. The term sociomateriality is considered redundant by some scholars because materiality does not exclude the social (Norman, 2013). However, other scholars point out that the use of the term sociomateriality emphasizes the merging of the material and social elements, and includes how those technological tools are used within a specific social context and focuses on the practice in which the technology is embedded (Leonardi, 2012; Orlikowski & Scott, 2008). Fenwick and Landri (2012) chose to use the term sociomaterial related to assemblages to emphasize the social nature of human *and* nonhuman materials in this network of interactions. I see this as slightly analogous to a PCR reaction, the reagents (materials) work together to create a reaction (assemblage). Latour (2004) explains that assemblages are a new entity with agency, meaning that when this network forms it creates a new "thing," an assemblage, and like a reaction

assemblages have the ability to do something (Latour, 2004). Furthermore, sociomaterial studies are able to shift the conversation to focus on assemblages and describe *how and why*, “how they move, and how they produce what may appear to be distinct objects, subjects, and events. How and why do certain combinations of things come together to exert particular effects?” (Fenwick & Landri, 2012, p.3).

Sociomaterial studies view an investigation of materials in one of two directions 1). how materials are shaped *by people* and 2) how *materials encourage* certain actions (Law, 2010) When research studies focus on how the materials are shaped *by people* the focus is on the people, a humanist focus. If, however, one focuses on how the *materials encourage* certain actions then the focus is on the material, a post-humanist focus.

This sociomaterial perspective aligns with an emerging literature base that emphasizes understanding the practices of how materials (e.g. technology) actively play a role in learning (Bolldén, 2015; Latour, 2005; Orlikowski, 2002, 2010; Orlikowski and Scott, 2008; Suchman, 2007; Johri, 2011). Specifically, this lens leads the research in a direction that aligns with practices as it relates to learning *with* technology (Bolldén, 2015; Howland et al., 2012) and “can assist in research and design of learning technology by providing a pertinent lens to examine emergent socially and materially intertwined learning practices” (Johri, 2011, p. 208). Yet, Sorenson (2009) and Waltz (2006) have claimed that a humanist approach has prevented us from seeing how the materials are shaping practice.

Next, I define conventional qualitative research and post-qualitative research. I discuss the assumptions made and the methods involved. The role researchers and theorists such as Deleuze and Guattari (1987), Latour (2004), Fenwick and Landri

(2012), Orlikowski and Scott (2008), and Barad (2003, 2007) offer to a post-humanist study and I connect that to a post-qualitative research method. I focus this section only on qualitative and post-qualitative research. Additionally, while I would welcome a discussion on scientific research and quantitative research methods it is beyond the scope of this dissertation.

### **Research in Social Science**

Qualitative research is often defined by the methods employed, such as ethnography and case study (Hatch, 2002; Lincoln & Guba, 1985, St. Pierre, 2015). For the purpose of this discussion I refer to this type of research as conventional qualitative research. These methods are at times mixed with quantitative analysis in studies referred to as “mixed methods” (Denzin & Lincoln, 2007). For example, in a mixed methods study one might do statistical analysis on how students perform on a pre-posttest. Then a case study can describe the students that show up as outliers.

The “Post” research genre is as different from conventional qualitative research as a descriptive case study is to statistical analysis. Authors often refer to “The Posts” when discussing “Post” research because there are many types of research considered “Post.” A few examples of “Post” research genres include Post-Structural, Post-Humanist, Post-modern, Post-Feminist, and Post-Colonial. In the literature, authors tend to lump these very different “Post” genres together and may refer to them all as Post-Structural or as just “Post.” Aghasaleh and St.Pierre (2014) explain to discuss the methodological differences among all “Post” genres and conventional qualitative research they use the term post-qualitative. Aghasaleh and St.Pierre (2014) explain the differences between what they define as conventional qualitative research and post-qualitative research as

depicted in Table 2. It is important to note what one views as knowledge and is worthy of research is defined differently in post-qualitative research. Following, this table I also present the purposes of research in each version as well as provide an explanation regarding how the basic assumptions differ.

Table 2. Comparison of post-qualitative research with conventional qualitative research (Aghasaleh & St.Pierre, 2014).

	<b>Conventional Qualitative Research</b>	<b>Post-qualitative Research</b>
<b>Paradigm</b>	Humanism	Post-humanism
<b>Ontology</b>	Hierarchical knower (agentive human)/ language (transparent representation)/ known (passive reality)	Flattened knower, language, and the known are all agentive and materially and discursively constructed
<b>Goal</b>	Understand (interpretivist, naturalistic, etc.) Emancipate (critical, Neomarxism, Praxis, etc.)	Deconstruct (persistent critique of something you cannot not want.)
<b>Subject</b>	<i>Human voice</i>	The <i>structure</i> in which this voice is produced and reproduced.
<b>Beginning</b>	Method (ethnomethodology, phenomenology, etc.)	Theory (genealogy, deconstruction, archaeology, marginality, performativity) or concept (assemblage, intra-action)
<b>Data Collection</b>	Interview, Participant Observation	Intra-action with texts, human, non-human, etc.
<b>Analysis</b>	Coding	Thinking and Writing
<b>Contributions to the Literature</b>	Accumulation of knowledge	N/A
<b>Limitations</b>	Generalizability, Validity, Subjectivity	N/A



**Paradigm and Ontology.** Aghasaleh and St. Pierre (2014) explain that to understand the differences in conventional qualitative and post-qualitative inquiry one needs to begin with paradigm. They define paradigm as “models or frameworks that are derived from a worldview or belief system about the nature of knowledge and existence” (Aghasaleh & St. Pierre, 2014, p.2). For the purposes of this dissertation, I offer an oversimplified yet useful definition of paradigm as a view that constitutes reality. B. Baker (personal communication, April 17, 2019) compares a paradigm to a religion in that it changes about as frequently and tends to be as deeply held of a conviction. Multiple authors (e.g. Denzin & Lincoln, 2018; Guba & Lincoln, 1994; Hatch, 2002; Morgan, 2014) have defined and characterized paradigms. While an in-depth discussion of every paradigm is beyond the scope of this dissertation, there are five commonly discussed paradigms (Guba & Lincoln, 1994; Hatch, 2002) that I briefly describe in relation to this work. 1) Post-structural assumes that reality is complex, and can be illogical. Furthermore, identifying the nuances is important. This dissertation fits within a post-structural paradigm. 2) Positivism is a paradigm that is highly criticized in post-qualitative work; it assumes that there is one reality that we can know through the use of systematic methods. 3) Postpositivism is more similar to positivism than post-structural. It assumes there is one expansive reality that we can investigate within limitations. 4) Constructivism is often used in education and assumes reality is constructed and centered on the human experience. Finally, 5) a critical paradigm focuses on power and changing the power structure.

Aghasaleh and St. Pierre (2014) categorized paradigms as humanist or post-humanist. Humanist paradigms view the person as the most important subject of

qualitative research and everything else matters only as it pertains to the person, e.g. constructivist. In contrast, post-humanist paradigms do not hold this hierarchical view and instead are said to have a flattened ontology (Deleuze & Guattari, 1987/1980). A flattened ontology considers objects, language, and the human are all important to consider, e.g. post-structural (Deleuze & Guattari, 1987/1980). In conventional qualitative research, ontology is referred to as what exists as defined by your paradigm (Hatch, 2002). Epistemology is the knowledge produced by these assumptions (Hatch, 2002). While post-qualitative research views this distinction as arbitrary (St. Pierre, 2015).

**Subject.** Subject is what we focus our research on. The subject can be human or non-human. Subject influences the types of research questions you ask and the underlying assumptions you make (Aghasaleh & St. Pierre, 2014, Denzin & Lincoln, 2007; Guba & Lincoln, 1994; Hatch, 2002). In humanist studies the subject is the person and consider objects/things as they relate to people. In Post-humanist studies, the subject is never the person, *the subject is a structure* composed of lots of pieces (Aghasaleh & St. Pierre, 2014). Foucault (1966/1970) explains that it is the conditions the structures make that are interesting. So rather than explore *what* people say we should consider the *conditions* that enable what can be said or what cannot be said (Foucault, 1966/1970). Spivak (1993) and St. Pierre (2011) explain that because of the nature of language, what people say typically echoes normalized humanist discourse. When we see people as the most important aspect then our speech reflects that. Furthermore, what people say does not consider how the material influences the normalized discourse itself. I learned this statement is exceptionally accurate as I read many research studies that I found

frustrating and irrelevant. I saw these studies as ignoring data (non-human things) and asking the wrong questions.

**Overarching goal.** With so much ambiguity regarding what constitutes reality and what to ask research questions about in social science, it becomes challenging to figure out the point and the overall goals of research. Therefore, I offer my understanding of the goals of conventional humanist research and post-qualitative research. In conventional qualitative research the goal is to describe as well as possible a particular context with the aim to ultimately understand a human experience (Aghasaleh & St. Pierre, 2014; Hatch, 2002). Some critical theorists in humanist research take it a step further and try to also change the world based on their understanding of those human experiences. In post-qualitative research the general goal is deconstruction (Aghasaleh & St. Pierre, 2014). Deconstruction means that the focus of the research is to examine a structure, consider how taking that structure for granted can have unwanted problematic effects, and rethinking how the structure can be altered to ameliorate those effects (Derrida, 1997/1967). This is done by reading the data, where “Derrida is a way of reading” (Aghasaleh and St. Pierre, 2014, p.2). This reading of the data is your analysis and is always in the context of your research.

Furthermore, the structures that post-qualitative research focuses on are in place because they serve (usually) a positive purpose, such as to support student learning. Therefore, it can be challenging to identify what negative affects result from these structures. I suggest an example outside of education and science as a way to consider the differences of conventional and post-qualitative research. The military is a well-known organization with a defined structure. If you want to describe and understand the

experiences of a marine or soldier then you would want to use conventional qualitative methods. If you are interested in why and how (or if) the rank structure supports a strong effective military and identify the possible unintended (possibly negative) consequences of the rank structure, then you would want to use post-qualitative research methods.

**Adding to the Literature Base.** Conventional humanist qualitative research seeks to describe and add to our understanding of the world. This often assumes that we can add to the literature base through incrementalism (Kuhn, 1970). Incrementalism assumes that we can through small incremental steps build on previous knowledge. This is how science refers to knowledge (Aghasaleh and St. Pierre, 2014; Kuhn, 1970). However, post-qualitative research does not assume that we can incrementally add to the knowledge base because of the types of questions addressed, it acknowledges that this type of research is not science, and does not try to be. Instead, post-qualitative research suggests incrementalism only works within one paradigm, not across paradigms, so incrementalism is not a useful aim (Aghasaleh and St. Pierre, 2014). Instead, the goal is only to create new knowledge, through the process of deconstruction. If you deconstruct the rank structure of the military through your reading of the data, then your findings are the creation of new knowledge.

**Data and Analysis.** In this section, I first describe conventional qualitative research data and analysis in order to help explain post-qualitative data and analysis. I briefly discuss method and theory because Post-qualitative data and analysis requires one to start with theory and method. In this section, I also provide a list of my data for the study and explain why I should not provide that very list in a post-qualitative publication.

I also provide a specific example from my own published research to help explain the ideas put forth.

Conventional qualitative research data is to be collected and analyzed using a well-designed study. The study aligns with a specific research paradigm that precedes the research question and purpose for the study (Hatch, 2002). The study needs to begin with a provisional hypothesis based on provisional patterns and use purposeful sampling to collect data. A theoretical or conceptual framework guides the study that follows one of several traditions. A few examples of a tradition include case study, ethnography, grounded theory, or action research (Hatch, 2002).

In-depth data collection involves multiple sources of information rich in context which is used with a detailed description of the context to enable an analysis of the data collected and development of themes (Hatch, 2002). Themes are developed through a process of data analysis called coding which can be done inductively or deductively.

Hatch (2002) suggests that inductive data analysis can be used across all paradigms. I think Hatch (2002) describes post-structuralism from a humanist postpositivist point of view. The Polyvocal methods he suggests for post-structural research center the human as the subject, not the structure (Table 2). For example, he suggests to Post-structural researchers “Wherever possible, take the stories back to those who contributed them so that they can clarify, refine, or change their stories” (Hatch, 2002, p.202). It is only possible to allow a human to clarify their story in this way, not a structure. This also suggests there is a correct way to read the data and that it aligns with the original author’s intent. Aghasaleh and St. Pierre (2014) and Law (2004) claim that post-qualitative research should not try to borrow methods of data analysis from

conventional qualitative research for this very reason. Moreover, Law (2004) explains that in conventional qualitative research the need for methodological rules with defined methods is an assumption. These methods are used to address humanist studies and help one gather and analyze data on a human subject. If one wants to consider data to address a non-human subject these conventional research methods fall short (Law, 2004).

The methods used to accomplish post-qualitative research reflect “a sustained critique of and is highly suspicious of the idea of ‘method’” (Aghasaleh & St. Pierre, 2014, p. 1). Instead, post-qualitative research suggests that if theory drives your research then the method will follow (St. Pierre, 2015). Furthermore, post-qualitative inquiry has taken a stand to *never* offer a specific methodology because it is inadequate to assume a pre-designed method can guarantee research quality (St. Pierre, 2015). Explaining, when one starts with method then the study fails to adequately incorporate theory. In critique of this statement, I suggest she may not be fully considering conventional qualitative researchers’ use of a good theoretical framework. Regardless, in Post-qualitative research **theory determines *what* you consider data, *how* you analyze your data, and *how* you write up your results.**

In **post-qualitative research the use of data** is just as important as conventional qualitative research but there should never be a list in your manuscript of data you collected and analyzed. The subject of the research is on structures with multiples pieces (Table 2). The researcher is automatically one of those pieces so data cannot be “collected,” it is never separate from the researcher (Aghasaleh and St. Pierre, 2014; Law, 2004). Essentially, you are submerged in the data. I think at this point it is helpful to provide a **list of my data and an explanation of why this list should not be created.**

The data available in this undergraduate biological science course offered for two semesters included assessments, the educational technology tools and the instructor's practices. Assessments included 8 papers, 6 worksheets, 2 concept maps, 2 exams, 16 quizzes, and 64 videos. Videos are not usually considered an assessment but this instructor used videos as assessments. The educational technology is defined as the tools and features of the canvas LMS. The features considered in this study included the platforms the content assessments were embedded, announcement features, quiz tools, content editor with the ability to embed videos, comments tools, email, course copy import/export ability, dashboard and navigation, gradebook, and organization modules. Instructor comments related to the course, such as email and announcements were the third. This included 38 emails, and 18 announcements. I did not include student data and it is possible that student data could reveal additional information; but this is not considered a limitation of this study from a post-perspective. The separation of all the data like I have listed above puts the focus on the individual pieces of the structure, not the structure that they create. The structure is the subject and what I am really observing, therefore the structure is what I describe and report.

In the first draft of Burcks, Siegel, Murakami and Marra (2019)- our first attempt at post research- as first author I described all the data like in the previous paragraph. We thought this was how we should describe the structure. We then created a framework regarding how the data related to one another to describe the way the pieces of the structure work together. This first draft was sent back with an email and comments stating that this is *exactly* what we are *not* supposed to do. One editor's comment to our proposed framework was "I am wondering how this image is appropriate if you are

working from a sociomaterial perspective? Isn't what you have here what Latour rails against – separating the social and the material and then putting them together? ? Shouldn't the practice emerge from the sociomaterial?" We completely reworked the publication to reflect "Post" research by taking the editor's and Latour's (2005) advice. We focused on the practice that *emerged* from the sociomaterial regarding instructional design to support science learning. We did this by describing the actions happening in the course. We then explained those actions as a result of the structure. Listing all the data and then putting it back together takes the focus off the structure, which is the subject of the research. Instead it puts the focus on all the variables all at once, which is not effective and does not offer any new knowledge.

This example of what we initially did incorrectly from Burcks et. al. (2019) is why St. Pierre (2015) issues a "warning" of sorts that if your study tries to use defined conventional qualitative methods with a "Post" paradigm it will result in a confused mixed up study that cannot produce anything new. In addition, because results are openly acknowledged to be interpretations of how you read the data it becomes unthinkable to show your interpretations are based on how you triangulated data that you did not "collect." I do think the strong stance taken by members in the field regarding data can be prohibitive of sharing your findings with a broader audience and this is something I might want to further explore in the future. Essentially, post-qualitative researchers explain often it is the methods that prevent you from addressing the research question because the methods are providing data on the wrong subject. If this is the case then it is fine to adjust the methods (St. Pierre, 2015). I return to the idea of data and explain my data for



this study in more concrete terms in this introduction in the Agential Realism subsection below.

**Trustworthiness.** Conventional qualitative research emphasizes a defined methodology to ensure reliable results (Lincoln & Guba, 1985). Specifically, Table 3 illustrates trustworthiness, and emphasizes the use of the corresponding criteria, concerns, and methods as derived from Lincoln and Guba (1985) (Baker, 1995). Next, I briefly explain the information presented in Table 3 so I can explain how it relates to Post-qualitative research.

To address concerns regarding credibility the methods employed should enable the researcher to learn the culture, test for misinformation, build trust, identify salient elements, identify crucial atypical events, report researcher bias and be aware of human instrument frailty (Lincoln & Guba, 1985). According to Lincoln and Guba (1985) this can be accomplished by engaging in a prolonged period of participant observation, triangulate sources and methods, introduce expert debriefing, perform a negative case analysis and member checks. While constant comparative analysis should look for emergent themes and estimate obtrusiveness of data collection.

Transferability can be addressed by providing the reader with thick descriptions for a contextual reference (Lincoln & Guba, 1985). Dependability concerns such as methodological shifts, redundancy, the Pygmalion effect and the Hawthorn effect as well as inquirer sophistication should be addressed by ensuring overlap in data collection methods, systematicity of observations and data collection obtrusiveness, thick descriptions and an analysis of the role of the researcher. Expert and peer debriefing assist in data analysis.

Confirmability is considered to be addressed by ensuring data is grounded in theory, with logical inferences and clear reasoning for identified categories provided in the manuscript (Lincoln & Guba, 1985). These are considered to be addressed by providing an audit trail, triangulating data, and expert debriefing. It is considered important to include systematicity of observations and data collections, member checks, inter-rater reliability and to accommodate negative evidence.

Table 3. Trustworthiness: Corresponding Criteria, Concerns, and Methods (Baker, 1995).

Criteria	Concerns	Methods
Credibility	<ul style="list-style-type: none"> <li>• Learn the Culture</li> <li>• Test for misinformation</li> <li>• Build trust</li> <li>• Identify salient elements</li> <li>• Identify crucial atypical events</li> <li>• Researcher bias</li> <li>• Human instrument frailty</li> </ul>	<ul style="list-style-type: none"> <li>• Prolonged period of participant observation</li> <li>• Triangulation of sources and methods</li> <li>• Peer debriefing</li> <li>• Negative case analysis</li> <li>• Member check</li> <li>• Constant comparative method</li> <li>• Estimations of data collection obtrusiveness</li> </ul>
Transferability	<ul style="list-style-type: none"> <li>• Provide reader with contextual reference</li> </ul>	<ul style="list-style-type: none"> <li>• Thick descriptions</li> </ul>
Dependability	<ul style="list-style-type: none"> <li>• Methodological shifts</li> <li>• Establish redundancy</li> <li>• Pygmalion effect</li> <li>• Hawthorn effect</li> <li>• Inquirer sophistication</li> </ul>	<ul style="list-style-type: none"> <li>• Overlap of data collection methods</li> <li>• Systematicity of observations and data collection obtrusiveness</li> <li>• Thick descriptions</li> <li>• Analysis of researcher's role</li> <li>• Expert debriefing</li> </ul>
Conformability	<ul style="list-style-type: none"> <li>• Theory grounded in data</li> <li>• Logical inferences</li> <li>• Clear reasoning for category identification</li> <li>• Accommodate negative evidence</li> </ul>	<ul style="list-style-type: none"> <li>• Audit trail</li> <li>• Triangulation</li> <li>• Peer debriefing</li> <li>• Expert debriefing</li> <li>• Systematicity of observations and data collections</li> <li>• Member check</li> <li>• Inter-rater reliability</li> </ul>

In post-qualitative research the term trustworthiness is not used. All the previously mentioned concerns are addressed by looking for alignment of theory with the rest of the study. Specifically, the reader should look to see if: 1) theory informed the research question, 2) theory guided methods, and 3) theory informed the write up of the paper. The reader should ask if the study's theory aligns with the paradigm, and the reader should make sure the author is not mixing ontologies (St. Pierre, 2015). A publication that provides listing of data analyzed and especially if there are developed themes through coding data suggests a lack of understanding of the theory and brings into question the results. This is the mistake we made and later corrected in Burcks et. al. (2019). Post-qualitative research is not "anything goes." I explain next a similar interpretation on the ideas of limitations and bias.

### **Limitations, Bias, and Contradictions**

Acknowledging limitations to your research is important to consider in conventional qualitative research, but in post-qualitative research limitations are a logical fallacy. Furthermore, these researchers do not use the term, "since post-qualitative research is thinking, the *limitation of thinking* is unthinkable" (Aghasaleh & St. Pierre, 2014, p. 2). Alternative explanations may align with the use of a different theory or a different paradigm. Alternative explanations are just as valid as the ones I present and do not take anything away from my interpretations. In fact, an alternative explanation can be another publication.

Bias is treated in a similar manner. Rather than addressing your bias as a negative aspect to your research, in post-qualitative research it is instead considered important to situate yourself in your research by providing an in-depth biography. This biography

provides the necessary information for the reader to understand how you are able to make specific interpretations through your reading of the data with a specific theory (Burman, 2011). In essence, your bias becomes part of the research and your reader can decide if it helps or hinders your claims. This is why I provided an extended biography previously in this introduction section.

In both veins of research it is important to consider contradictions to ideas within a research study. However, post-qualitative research considers contradictions to be a normal part of reality, reality itself can seem contradictory and illogical (Barad, 2003; Guba & Lincoln, 1994; Hatch, 2002). There may be issues to grapple with, but one needs to consider as Barad (2003) explains, “what often appears as separate entities (and separate sets of concerns) with sharp edges does not actually entail a relation of absolute exteriority at all” (Barad, 2003, p.803). She means that apparent contradictions may just be at the small piece of reality you are considering at the moment and if you take into consideration a more global view the contradiction may fall away.

### **The Manuscript**

In conventional qualitative research the manuscript of the research study follows a predictable pattern that grounds the research in the literature (Hatch, 2002). Hatch (2002) provides a check list (Hatch, 2002, p. 258) which I used in the writing of Chapter 2 of this dissertation because I first used conventional qualitative methods to look at my topic from a humanist perspective. The study should present the methodology, consider all the data and clearly ground the findings in the data. This is followed by a discussion of the research findings within the context of relevant literature. The goals include for the reader to be able to clearly understand the study and determine if the conclusions are reasonable

using trustworthiness. In contrast, post-qualitative research manuscripts break all the rules.

The primary importance in post-qualitative research is to honestly represent your research, while keeping in mind that thought is never linear (Aghasaleh & St. Pierre, 2014; St. Pierre, 2015). If thinking is the process of your research and thought is not linear then you should not provide a stepwise description of your thought process. A stepwise description is not honestly representing your research. The goal of the manuscript is more than to just pass on information to the reader instead the goal of the manuscript is to get the reader to interact (or possibly intra-act (Barad, 2007)) with the manuscript. The reader is expected to play a role in interpreting the manuscript, which may or may not be aligned with how the author wrote it and may change with each reading. These ambiguities are accepted and encouraged. One main difference that needs to be emphasized is that because data is read rather than collected and analysis is considered thinking with theory, one should never write a data and analysis section, nor should you provide a list of data or step wise account of analysis in your manuscript (Aghasaleh & St. Pierre, 2014; St. Pierre, 2015). Your manuscript should first include who you are and why you can make these interpretations. It should say what theory you are using, though it does not need to provide an in-depth explanation of that theory. From there the format should follow your theory. For example, it makes sense to offer a diagrammed assemblage if you are using the concept of assemblages, which I provide in Chapter 4.

## **Making sense of Different ways Research is Done**

In this section I provide a justification for this approach and explain why I was drawn to it. My view of reality is informed by my work doing science. As a molecular biologist I would manipulate something I could not see directly; indirect methods enabled me to learn about my research topic (e.g. DNA). The idea of assemblages makes sense to me as I will elaborate on in this section. For example, in my lab work I considered how each part of my reaction did something and influenced how the other “things” worked. If my primers were long that influenced the machine annealing times and so on.

I found myself agreeing with St. Pierre’s (2015) critique of conventional qualitative methods, that the defined methods of conventional qualitative research try to make something seem systematic and offer positivist assurances. She suggests that the goal of interpretative research is to interpret. I considered her suggestions that it might be odd to try to convince others of the credibility of my interpretations of subjective content done systematically.

Moreover, I agreed mostly with what St. Pierre (2015) argues, that social science is interpretive, that following a prescribed method cannot guarantee validity, and results are interpretations built on other interpretations. However, I question that claim because it seems to suggest that there is no validity or value to social science research. I would argue that interpretations by someone who has wrestled with the ideas and is more knowledgeable than others on that topic are valuable to consider. I found, somewhat surprisingly, that much of this interpretative research is interesting and can provide valuable insights even if it did not address what I wanted to study.

Before becoming aware of differences in the way research is done in the social sciences, conventional qualitative versus post-qualitative, I found the ideas offered by Barad (2007). Barad has a PhD in Physics and is a tenured faculty member in a social science department at the University of California at Santa Cruz. She has wrestled with the ideas of how to negotiate her understanding of the world as a scientist and her work in social science research extensively over the past 20 years. Barad (2007) explains a way to view the world that takes into account a scientific world-view while at the same time acknowledges that social science research is not scientific research, and values both. Her theory aligns with Post-humanist methods. Next, I explain Agential Realism (Barad, 2007). I explain how it helped me to align my experiences in science and explore my research interest on material elements through a post-qualitative approach.

### **Agential Realism**

Barad (2007) presents Agential Realism as an ethico-onto-epistemology. In essence this means that Agential Realism provides its own way to view the world and is underpinned by her work as a physicist. Agential Realism claims that the social and material combine to create phenomena. Fenwick et al. (2015) describe phenomena as “hybrid assemblages of materials, ideas, symbols, desires, bodies, natural forces, etc.” (Fenwick & Landri, 2012, p.3). It is the effects the phenomena produces that are interesting and reported in a publication. This utilizes the notion that objects are equally as important for research as humans and so aligns with a flattened ontology (Barad, 2007; Deleuze & Guattari, 1987; Latour, 2004). Next, I further explain how the use of Barad’s post-humanist framework enabled me to align post-structural paradigm, ontology, theory, and research methods, (e.g., agential realist theoretical framework, agential cuts,



diffractive analysis, and manuscript format) in a way to describe the agency of assemblages without privileging the people over the materials.

Agential Realism enabled me to focus on assemblages created by both material and human elements. Agential Realism claims that the term interaction is not accurate when discussing sociomateriality; instead Barad (2007) created the term *intra-actions* as a way to represent a conceptual shift from interaction. While interaction focuses on humans as the social element and objects as the material in the concept sociomaterial intra-action specifically includes the objects as *both* social and material. This change in view is significant as one asks what assemblages do, the knowledge produced by assemblages (Fenwick & Landri, 2012), and how assemblages drive discourse including not just what is said but what *can* be said (Barad, 2007). This focus also drives a discussion regarding how oppressive assemblages can be interrupted and weakened (Fenwick & Landri, 2012). Rather than continue with a theoretical discussion of Agential Realism I now walk the reader through Agential Realism as it relates to this dissertation research to provide a better understanding of both the theory and how that theory informed my research.

**Situating my Research in Methodology.** Agential Realism (Barad, 2007) first enabled me to view the material objects, (assessments, educational technology etc.) in an online undergraduate biology course as both social *and* material in nature. This also introduced the concept of intra-acting agencies that form assemblages. This is in contrast to theories such as actor network theory used by other sociomaterial researchers such as Orlikowski & Scott (2008) and Müller (2015) that separate the social and the material.

Next, I explicitly explain these concepts and how they informed my post-qualitative research study.

First, Agential Realism (Barad, 2007) informed my research question which focused on the actions of the assemblages. This undergraduate biological science course was offered for two consecutive semesters, the Spring and Summer of 2017 with 15 and 94 students, respectively. For this research study I asked, “What is the nature of assemblages that affect the instructor’s formative assessment practices in an online asynchronous undergraduate non-majors biological science course?” This research question enabled me to consider how assemblages *can* affect an instructor’s formative assessment practices.

In addition, Barad (2007) offers the concept of **agential cuts** as a way to define the boundaries of a sociomaterial assemblage and “peek” inside a phenomenon to observe the agency. The agential cut in Chapter 3 defines the boundaries of the sociomaterial assemblage as the educational technology tools and the instructor’s formative assessment practices. Therefore, I essentially “bounded” the agential cut to look at how the educational technology tools and the instructor’s formative assessment practices intra-act.

I began with the educational technology tools in the canvas LMS. I looked at how the tools were supporting formative assessment opportunities. I considered the announcement feature, quiz tool, content editor, comments tool, discussion tool, email, and gradebook. I noticed in this class the educational technology tools that provided formative assessment opportunities plugged into a second data set, the Assessments which included 8 papers, 6 worksheets, 2 concept maps, 2 exams, 16 quizzes, and 64 videos. Therefore, in Chapter 3 my assemblage became three intra-acting sociomaterial

elements: 1) the content (e.g. the science), 2) the style (e.g. worksheet, writing assignment, quiz etc.) and 3) the technology tools (and any words those tools could facilitate). In these intra-acting sociomaterial assemblages I looked for formative assessment opportunities or the lack of formative assessment opportunities using diffractive data analysis.

Agential Realism offers a specific way to “read” the data through a process called **diffractive data analysis**. This enabled me to consider how those tools are driving the instructor’s practice and entangling the instructor. This is done by considering what the assemblages “plug into.” In this way I was able to describe assemblages’ **agency**.

**Diffractive data analysis** asks: 1) What knowledge is produced? I did this by looking for “Does it showcase student learning?”; 2) What force the sociomaterial assemblages wield? I did this by asking “How can the teacher help the student, what opportunities are available?”; and 3) How these assemblages can be oppressive (to the instructor’s formative assessment practices)? I did this by considering “Are there times the teacher is does not help the student?”

Specifically, I asked how does the assemblage of the three intra-acting sociomaterial elements: 1) the content (e.g. the science), 2) the style (e.g. worksheet, writing assignment, quiz etc.) and 3) the technology tools (and any words those tools could facilitate) showcase student learning? How *can* the teacher help the student when these three elements intra-act? What opportunities are available because of these intra-actions and are there times the teacher is does not help the student?

I found there are assemblages whose agency impact formative assessment. In Chapter 3 I described how that agency drives formative assessment practices. I also

described the structures that determine what *can* be said regarding formative assessment opportunities within each defined assemblage.

In contrast, I took the same approach in Chapter 4 but from a more global view. The agential cut in Chapter 4 defines the boundaries of the sociomaterial assemblage as the course design (instructional design) and the instructor's formative assessment practices. This cut also determined my data, to begin I considered the platform, the content embedded in assessments, the organization of the assessments within modules, the organization of the assessments across modules, the dashboard and navigation. I looked at how these features in this particular organization were supporting formative assessment opportunities. This means I considered the announcements in sequence, and how the assessments relate across and within modules. This included the style, the content and the sequence of each of the 8 papers, 6 worksheets, 2 concept maps, 2 exams, 16 quizzes, and 64 videos.

I found the assemblages now in this agential cut engulfed multiple assessments. While the individual assessments still consisted of three intra-acting sociomaterial elements, I saw that these assessments were also intra-acting. I also saw that the role of the technology tools could cross multiple assessments. In these intra-acting sociomaterial assemblages I was still looking for formative assessment opportunities or the lack of formative assessment opportunities as the assemblages' **agency**.

I found there are assemblages that “do something” shift, move, change, impact in some way, formative assessment across the course. I saw that individual assessment level entanglements that can exert oppressive forces may at times be overcome at the instructional design level of the course through these intra-actions. I describe in Chapter 4

the agency of these assemblages and how they can overcome oppressive forces described in Chapter 3. Therefore, it is the agential cut that makes Chapter 3 and Chapter 4 very different studies which considered different data sets, assemblages, and gave different results.

### **Overview of Research Study**

I conclude this introduction with an overview of my dissertation to help the reader to understand the following chapters. I produced three manuscripts; each are grounded in the literature on modern assessment practices, educational technology, and sociomateriality. The common themes that unite my research are 1) **formative assessment** to enhance learning, 2) **educational technology**, and 3) **sociomateriality**. For this study, I focused on how educational technology-based assessments have agency and therefore are assumed to “be doing something” that influences the instructor’s formative assessment practices.

**Overview of Manuscripts.** Chapter 2 addressed the nature of formative assessments integrated into the course used to support student learning. This first study’s sociomaterial focus on formative assessment practices considers how the formative assessment materials are shaped *by the instructor* and assumes the materials have agency, the materials “push back” in some way (Law, 2008). In this study I began to explore sociomateriality first from a humanist perspective as described by Law (2008). This enabled me to explore these concepts following the methods of conventional qualitative research, it was during this process that I began to experience and understand the limitations a humanist approach has on our ability to see how the materials are shaping practice (St. Pierre, 2015; Law, 2008; Sorenson, 2009; Waltz, 2006). My data and

analysis explored how the instructor was shaping the materials. It did not consider how the materials shaped her practices.

I also wanted to be able to share the findings of this study with science educators in their own journal format. I realize many scholars highly value the conventional qualitative methods previously described therefore I followed a conventional humanist qualitative research approach by using a case study (Hatch, 2002). Working in this pragmatic way I chose a sociocultural and constructivist view for this study. I inform my methods and results with the assumption that knowledge is constructed through a process of co-construction and a mutually agreed upon construct of reality (Hatch, 2002).

I addressed the research question “How do the assessments provide information about student learning and opportunities to take action?” using the Assessment Literacy conceptual model (Abell & Siegel, 2011). I focus on the subsection Interpretation and Action Taking to analyze the data. The primary data included: 1) field notes of instructor observations regarding the assessments and the instructor’s communication in and about the course, 2) educational technology tools, and 3) assessments. Additionally, interview questions focused on assessment features that aided interpretation and action taking. The goal of this research question was to *describe* features in the technology-based assessments that were influenced by the instructor’s formative assessment practices. I plan to publish this study in a teacher-oriented science education journal so I tailored the writing, data I present, and my discussion toward this audience. I am targeting a journal such as the Journal of Science Education and Technology. Finally, I placed the study that reflects the write up of the norms of conventional qualitative research first. This is so that this manuscript can serve as a way for the reader to become acquainted with my research

setting and the types of data used throughout this dissertation. This is to the scaffold the research as the reader moves forward.

Chapter 3 consists of the first post-humanist manuscript and addresses the sociomateriality of individual **assessments** within the instructor's formative assessment practice. I use Barad's (2007) Agential Realism to guide my study as I previously described in my explanation of Agential Realism. The context is the same online asynchronous undergraduate non-majors biological science course described in detail in Chapter 2. My analysis is on *how the materials affect* the instructor's use of technology based assessments to formatively assess student learning. The research question "What is the nature of assemblages that affect the instructor's formative assessment practices in an online asynchronous undergraduate non-majors biological science course?" enabled me to explore the agency of the assemblages defined by the agential cut at the educational technology tools and the instructor's formative assessment practices.

Per post-qualitative standards this manuscript explains what I found by thinking with theory and the implications of how this framework enabled me to think beyond artificial boundaries. As Barad (2007) emphasizes my manuscript focuses on discussing the differences and, more importantly, the effects those differences cause that I identified (Barad, 2007). Therefore, what I describe are assemblages' agency and how that agency drives formative assessment discourse in the course. I plan to publish this study in a journal such as the journal *Pedagogy, Culture and Society* which publishes research papers that align with a post-qualitative research format.

Chapter 4 consists of the final manuscript; the study also draws on Agential Realism (Barad, 2007) with an agential cut that consists of the **course design**, also

referred to as instructional design, and formative assessment practices. This study's focus on the instructional design of the course enabled me to explore how the organization of assessments within the course and corresponding educational technology influence the instructor's ability to aid student learning. The research question reflects the theory by again asking, "What is the nature of sociomaterial assemblages created by an online non-majors biological science course?" The goal is to take a more global view of the course compared to Chapter 3. There is a focus on how the technology encourages and constrains certain practices across and throughout the course. I aim to publish this manuscript in a research journal, such as *Pedagogy, Culture and Society*.



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## CHAPTER TWO

### **How can Instructors Help Students Learn Online?: Harnessing and Circumnavigating Educational Technology Assessment Tools**

#### **Introduction**

**Learning Science.** The need to help undergraduate students learn science for both the workforce and public literacy has been well established (e.g. American Association for the Advancement of Science (AAAS), 1993, 2013; National Research Council (NRC), 2010, 2011, 2012a, 2012b, 2013; The Coalition for Reform of Undergraduate STEM Education (CRUSE), 2014; Kober, 2015). Historically, the physical location undergraduate students learned science occurred in a variety of face-to-face classroom formats where a range of teaching methods were employed. More recently there has been a shift underway moving the content and assessment of science curricula to virtual formats (Smetana & Bell, 2012). This move to virtual formats is enabling science to be depicted in a manner that permits more dynamic and interactive opportunities for learning and assessment. This shift is also creating opportunities which have great promise to assist in meeting the goals set forth by influential undergraduate and K-12 reform policy documents such as the National Research Council (NRC) (2012) and the Next Generation Science Standards (NGSS) (Achieve Inc., 2013).

Yet, reaching these lofty goals for learning and assessment has proven challenging, particularly in virtual formats. As a means to work toward supporting student learning we can look to assessment scholarship which has consistently emphasized the use of assessment to make instructional decisions that aid student learning (e.g. Bell, 2007; Black & Wiliam, 1998, Gottheiner & Siegel, 2012; NRC, 2012;

Ruiz-Primo & Furtak, 2006; Shepard, 2000). Additionally, assessment is known to be a powerful tool to assist student learning through supporting instructor practices, where practice is defined as socially shaped in a community where activities are negotiated (Leonardi, 2012). More specifically, research has emphasized formative assessment as a way for the instructor to find out what students know and then use that information to adjust instruction (Bell, 2007; Black & Wiliam, 1998; NRC, 2012; Ruiz-Primo & Li, 2013; Shepard, 2000; Willis & Klenowski, 2018). This use of formative assessment in the instructor's practices has shown that it leads to students reaching the desired learning goals. Additionally, it is unsurprising then that the importance of the instructor's role in aiding student learning is also recognized by scholars (Bell, 2007; Black & Wiliam, 1998).

### **Assessment and Instructor Practices.**

Unlike conventional assessments that evaluate learning at one point in time and are referred to as assessment of learning, formative assessment enhances student learning (Ehrmann, 1995; Shepard, 2000). In a course that consists of limited face-to-face communication, assessments are the primary means an instructor can facilitate student learning. Moreover, a disconnect in assessment methods and instruction is known to possibly inhibit student learning (NRC, 2001b) and it is unknown how assessments and instruction in virtual learning environments support formative assessment practices.

This research is grounded in the literature on assessment practices. Where assessment practices emphasize that assessments should cognitively challenge students to think critically (Abell & Siegel, 2011; NRC, 1996; Siegel, 2007), support students' learning (Black & Wiliam, 1998; Siegel, 2007), reduce potential biases (NRC, 2001a;

Siegel, 2007; Siegel, 2013; Solano-Flores & Trumbull, 2003), and motivate students to learn and engage in the learning process (Achieve, Inc., 2013; Clark, 2012; Cowie, Jones & Otrrel-Cass, 2011; Fusco & Barton, 2001). Furthermore, assessment practices should provide opportunities for metacognition, allow students to apply and transfer their knowledge, elicit prior ideas, develop understanding, and enable students to express their thinking (e.g., Abell & Siegel, 2011; Edwards, 2013; Siegel, 2007). Additionally, scaffolding is a key feature in assessments that assist in student learning. When an authentic context is part of an assessment, students begin to develop into independent thinkers and problem solvers (e.g., NRC, 2001a). These key features support effective assessments that support student learning.

Formative assessment enhances student learning because teachers are able to help students address conceptual difficulties through instructor feedback (Hattie & Jaeger, 1998; Hattie & Timperley, 2007). Additionally, formative assessment can be used to inform students about what they know with the goal of improving self-learning, can help teachers gauge students' progress, provide data for teachers to base instruction, and increase students' motivation to apply knowledge and practice skill (Abell & Siegel, 2011). In a face-to-face classroom an instructor is able to change instruction based on data from formative assessments (Abell, 2007) and can be done informally with the teacher making intuitive or qualitative interpretations based on student cues such as student questions, body language and facial expressions (NRC, 2001b). This study is interested in the subset of formative assessments that provide data for teachers to base instructional decisions (Table 1).

Educational research on formative assessment in virtual environments has focused on providing instant feedback to students to assist themselves in learning (e.g. Buchanan, 2000; Henly, 2003). This however focuses on factual learning and has limited use for assessments that focus on higher order thinking skills. While other research in virtual formats focus on one of two lines of research. First, much research focuses on comparing technology-based assessments to conventional assessments' ability to support student learning (Annetta & Shymansky, 2006; Bernard, Abrami, Borokhovski, Wade, Tamim, Surkes & Bethel, 2009; Frailich, Kesner & Hofstein 2009; Kyza, 2011; Ryoo & Linn, 2012). Second, is the Technological Pedagogical Content Knowledge (TPCK and TPACK) research line based on Mishra and Koehler's (2006) introduction of the TPCK framework for teacher knowledge. TPCK focuses on what instructors know about how to use the technology to support student learning. While a 2013 review of the TPCK literature by Chai, Koh and Tsai suggested a modification of the TPCK framework to parallel the same concepts with a focus on student learning with technology.

Educational research on effective ways to support student learning in virtual environments have been distilled into "best practices" that are implemented by online programs (Lewis & Abdul-Hamid, 2006). These best practices include specific global recommendations including quick teacher response times, teacher interaction with students in discussion boards, and extensive teacher feedback on assignments within one week of student completion. Additionally, while online educators understand the value of assessments designed to promote student learning, enable students to learn by interaction with the assessment, each other and the instructor (Shepard, 2000; NRC, 2001b) the instructor's needs to support learning have not been addressed.

Therefore, the purpose of this case is to describe how the assessments provide the teacher opportunities to interpret student learning and to take action to support student learning. This was addressed by both typological analysis utilizing the subsection Instructor Interpretation and Action Taking of the Assessment Literacy conceptual model (Abell and Siegel, 2011 ) (Figure 1) and emergent themes grounded in the data.

I suggest this case study is unique in that it takes a different perspective with a focus on instructor formative assessment practices in a virtual format with an instructor who uses assessment to enhance student learning. To further explain how this case is unique consider if a similar vein of research surrounded the use of the telephone. Research would focus on 1) comparing communication with the telephone to face-to-face communication, is it as effective? and 2) what people know about using a telephone, what more do they need to know to use a phone in different situations? Yet this seems ridiculous because it does not represent how people actually use the telephone in practice. Furthermore, these lines of research would ask these same questions regarding all the tools one could choose to use to communicate (e.g. land line, cell phone, Facetime, Zoom, text messages, email etc.). Rather than focus on comparing the quality of communication in each setting or on an individual's knowledge of a telephone, a more authentic way to consider the use of the telephone would be to look at the telephone itself as it can be used in practice. When you decide to use a telephone or another means of communication you begin with a need to communicate with someone and choose which communication tool to use based on many factors in how you plan to use it. Do you want to see the person as you talk? Do you need to speak in real time? Do you want the person to be able to refer back to your message? I suggest that this case study enabled me to

explore educational technology tools to support learning from the perspective of how the assessments enable how an instructor can actually use them.

Additionally, it is imperative to consider if assessments in virtual formats can influence instructors' formative assessment practices. In this study, I consider how these assessments may influence the informed instructional decisions instructors can make by encouraging particular ways of interacting with students. In this way, this study attempts to reshape how we think about technology-based assessments, science teaching, and instructor practices to place a greater emphasis on the use of assessment to make instructional decisions that aid student learning.

## **Conceptual Framework**

### **Assessment Literacy Framework**

In this study, I chose to consider how aspects of the course assessments influenced an instructor's practices that support student learning of science content in an online undergraduate introductory non-majors nutrition course. I used the Assessment Literacy conceptual model (Abell & Siegel, 2011) with a specific focus on Interpretation and Action Taking to analyze the data. The Assessment Literacy Framework (Abell & Siegel, 2011) consists of five dimensions: 1) *assessment values and principles*, 2) *what to assess*, 3) *assessment purposes*, 4) *assessment strategies*, and 5) *assessment interpretation and action taking* (Abell & Siegel, 2011; Gottheiner & Siegel, 2012). Within this framework, I focused on how assessments provided opportunities for the instructor to interpret student learning and ways to take action to aid student learning based on that interpretation. Figure 1 illustrates how this component, *Assessment Interpretation and Action Taking*, relates to the other components in the Assessment

Literacy Model. Specifically, instructor interpretation of assessment data and the actions they take following assessment activities is directly related to the instructor's values and principles and their knowledge of assessment practices. For example, an instructor that uses assessment for formative purposes may support learning by using assessments to interpret student difficulty and take actions to support learning based on those beliefs. I specifically focus on assessments which enabled us to understand the nature of formative assessments in this context. For example, an assessment may provide the instructor a clear picture of student learning but limited opportunities for action taking, in practice an instructor with a sophisticated knowledge of assessment may be able to work around this limitation in the assessment. Likewise, an assessment that provides opportunities for interpretation and action taking may not be incorporated into an instructor's practice if the instructor is only beginning to develop their assessment literacy. In this study, I was not interested in characterizing the instructor's knowledge or beliefs nor do I measure student learning; rather I focus on the opportunities to aid learning available for the instructor that are presented by the assessments. I do suggest that future research could use these findings to influence the interpretation of studies that focus on aspects of instructor knowledge or student learning.

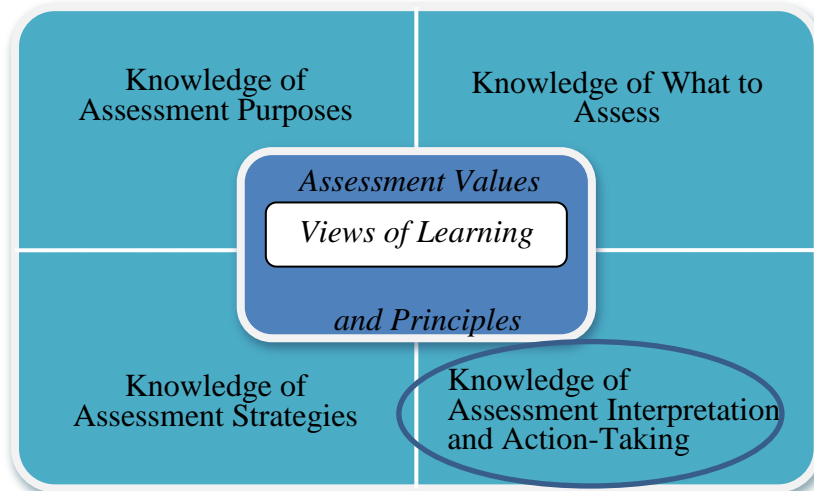


Figure 1. A model for science teacher *assessment literacy* (from Abell and Siegel, p.212 2011).

In the findings, I describe how features in course assessments provide the instructor opportunities for Interpretation and Action Taking in this context. I demonstrated how online assessments may provide opportunities for the instructor to aid student learning. It is also possible that features can unintentionally constrict instructor practices which support learning. Furthermore, I address ways to interrupt and weaken negative effects.

## Methods

A case study method was chosen to understand how the assessments support an instructor's interpretation and action taking practices (Hatch, 2002). I used the case study approach described by Stake (2000). This approach was chosen in order to offer an opportunity to explain how the assessments provide information about student learning and opportunities to take action. This is a single case study using purposeful sampling of an experienced online instructor. She has worked as a scientist and has science education training. This instructor and her biological science course were selected for several reasons. This course was chosen based on the focus of basic science content in a virtual environment with all course work and instructor interaction take place using educational



technology. This instructor's science experiences and teaching expertise support her ability to teach in an online environment. This course is an established course in the Nutrition and Exercise Physiology department with 14 students in the Spring semester and 94 students in the Summer semester. This instructor was also selected because she is able to interpret assessments and take action based on that interpretation in her course.

The case studied was the formative assessment opportunities in the online course. This is a within-site study and multiple sources of information included: field notes with my observations of the instructor's actions in the course. This included observations such as decisions she made to modify and change assessments, what and where she chose to communicate with students regarding student concerns, and grading throughout the course. The Educational Technology and Assessment documents, such as assignments and quizzes, emails and course announcements also offered a rich source of data. Interview data, was also included as a secondary data source. This bounded system included the place as one online course, offered two semesters, and included the documented assessments, the educational technology, and the instructor's formative assessment practices during the online course (Creswell, 1998). The system is bounded in time by the start of the spring 2017 semester and the end of the summer 2017 semester. This enabled in-depth data collection involving multiple sources of information rich in context. The context of the case is situated within the online community. Data collection enabled me to do a detailed description of the case and analysis of themes to report the "lessons learned" from the case (Lincoln and Guba, 1985). This research is grounded in the literature on assessment practices that emphasize assessment should cognitively challenge students to think critically (Abell & Siegel, 2011; NRC, 1996; Siegel, 2007),

support students' learning (Black & Wiliam, 1998; Siegel, 2007 ); reduce potential biases (NRC, 2001a; Siegel, 2007; Siegel, 2013; Solano-Flores & Trumbull, 2003), and motivate students to learn and engage in the learning process (Achieve, Inc., 2013; Clark, 2012; Cowie, Jones & Otrell-Cass, 2011; Fusco & Barton, 2001).

**Assumptions and Bias.** My assumptions and bias for this study include that assessment can be used to enhance learning rather than just evaluate learning. Online education can support learning and assessments provide a framework for instructors to teach in a manner that can enhance student learning. While the instructor plays an integral role in assisting student learning there are key features in assessments that enable the instructor to best meet the needs of the student. These features may be the same for both virtual and face-to-face classrooms. However, I am assuming that it is possible that the characteristics of assessments that support learning in face-to-face courses hold true for virtual learning environments. I think the interaction between the instructor and the assessment that facilitates student learning is altered in a virtual environment, therefore I am bias toward addressing the characteristics of the assessment that enable the instructor to interact with the assessment and therefore facilitate student learning. An assessment is any activity that supports student learning and it may use one or more teaching strategies. In an online course the teaching strategies can also be tools unique to the virtual environment. These include items embedded in the learning management software (LMS) such as threaded discussions, short answer questions, essays, worksheets, email, announcements and quizzes. I am interested in the educational technology tools and how they support formative assessment practices; I am also interested in the nature of the assessments that enable and utilize these strategies. Moreover, I believe that there are

features of the assessments that enable the instructor to interact with the assessment empowering the instructor to better support learning. I do not suggest that this can provide a cause-effect explanation for all courses; however, the principles from other singular cases can be considered for application to remote contexts (Stake, 2005; Yin, 2009).

**Context.** This study took place in an online undergraduate biological science course for non-majors in the Nutrition and Exercise Physiology department at a large Midwestern University. The students in this course were undergraduate non-major pursuing a bachelor's degree students in a nutritional science class. . The type of students in the course, undergraduate non-majors, is reflected in the content of the course assessments.

The instructor Tracy (pseudonym) taught biology courses and had previous experience working as scientist. The same instructor taught both semesters the course was offered. This course is offered completely online using a LMS, no face-to-face communication occurred outside of the course. LMS. The course consisted of eight two week units in the spring semester and 4 two week units in the summer semester, with 15 students and 94 students respectively. The course was a 3 credit hour course and students were expected to spend a minimum of 6 hours on course activities per week. During each two week unit students completed a series of assessments by watching videos, reading the course textbook and completing assigned course activities. Each unit began with a series of quizzes that are embedded with science content videos ranging in length from 2 to 5 minutes and focused on specific science content aligned with the unit's course goals. The instructor used these quizzes embedded with videos as an instructional tool to support

students' science content learning. The multiple choice quizzes consisted of 3 to 5 questions with automated grading and focused on video content from a multinational education company. This activity was followed by one or two assessments that met specific course learning goals. These assessments included worksheets, written papers, and concept maps. They provided students the opportunity to explore and synthesize ideas from the unit in a personally relevant context. The unit ended with a multiple choice reading quiz over any assigned reading based on the course textbook. The instructor communicated with her students through email, assessments, and course announcements.

Tracy used the assessments to address the learning goals of the course. The learning goals for the course were stated in the syllabus as:

1. Recognize the general role of nutrition in health and disease states.
2. Design a healthful diet.
3. Read and understand food labels.
4. Recognize the roles of micronutrients in the body.
5. Recognize the role of macronutrients (carbohydrates, fats, and proteins) in the body.
6. Recognize the collaboration of nutrition and exercise as keys to good health.
7. Recognize the importance of food safety and technology.
8. Recognize the importance and changes of nutrition through the life cycle.

**Approaches assessments used to meet learning goals.** The instructor used assessments to meet learning goals with 4 primary approaches: 1) written papers, 2) worksheets, 3) concept maps, and 4) videos. These types of assessments utilized different educational technology tools as teaching strategies such as quiz tools, word document

displays, announcement tools, email, and comment bubbles. Assessments may meet one or more learning goals. I provide 4 examples of assessments, one from each approach, and the learning goals they each addressed. The Food Safety Assignment was a written paper approach and met the learning goals laid out in the course syllabus by asking students to, “Recognize the importance of food safety and technology” (Figure 2). Figure 3 displays the Food Label/Calorie Calculation Assignment, a worksheet, and asks students to complete the worksheet by reading and understanding a food label to address the learning goal, “Read and understand food labels.” Figure 4 is the Obesity Assignment, assessment asking students to create a concept map regarding obesity. This assessment addresses the learning goal, “Recognize the collaboration of nutrition and exercise as keys to good health.” Finally, Figure 5 is the Movie Assignment and is an example of an assessment that asks students to watch a video; this assessment also utilizes a second approach because students should write a paper about the movie. This assessment addressed the learning goals “Recognize the general role of nutrition in health and disease states” and “Design a healthful diet.”

# Food Safety Assignment

## Food Safety Assignment

2 points per question/10 points total

1. The use of genetically modified organisms (GMOs) is one of the most controversial issues in food science today. List and discuss three advantages and three disadvantages of using GMOs in food.
2. Discuss the four basic rules of safe food handling.
3. Discuss the new Organic Standards that have been established for the labeling of all organic products.
4. Describe how the human body defends itself after contracting a food-borne illness.
5. Discuss what steps you might take to reduce your exposure to pesticides in food.

[Food Safety Assignment - Student Version.docx](#)

65

Figure 2. Food Safety Assignment

The Food Safety Assignment (Figure 2) content requires students to answer questions about basic science information in the context of safe food handling. This assignment is completed as a worksheet format of multiple short answer questions. The assignment is submitted online as a Word document using a word document display tool (Figure 7).

**Food Label/Calorie Calculation Assignment (20pts)**

*Please use the Picture of the Label Below to Answer the Questions*

Credit will not be given if work is not shown – even if your answer is correct!

Are the Fiber One bars shown in the picture high, low far, or within the suggested guidelines for fat? How would you make this determination? Please describe and show your calculation. (3 pts)

1. Are the Fiber One bars shown in the picture high, low far, or within the suggested guidelines for fat? How would you make this determination? Please describe and show your calculation. (3 pts)
2. How many total grams of Fiber One bars are there in the box of bars? (2 pts)
3. What is the Statement of Identify for this item? (1 pt)
4. Who was the food manufacturer? (1 pt)
5. How many bars would you have to consumer to meet or exceed the Percent Daily Value of fiber? (2 pts)
6. How many Calories are generated from the total carbohydrates in a Fiber One bar? (2 pts)
7. How many Calories are generated from the saturated fat in a Fiber One bar? (2 pts)
8. Given there are 29 grams of total carbohydrate in a Fiber One bar, 9 grams of dietary fiber and 10 grams of sugars, what might account for the remaining 10 grams of total carbohydrate? (2 pts)
9. Name three allergens that might be present in Fiber One bars? (3 pts)
10. Are Fiber One bars a significant source of Vitamin A? (1 pt)
11. What is the most prevalent ingredient by weight in Fiber One bars? (1 pt)

Figure 3. Food Label/Calorie Calculation Assignment Except.

The Food Label/Calorie Calculation Assignment asks students to complete a worksheet style assessment with short answer questions. See Appendix B for an enlarged view and complete assessment content. The assignment is submitted online as a Word document using a word document display tool (Figure 7).

## Obesity Assignment

This assignment is a departure from previous assignments. The purpose of this assignment is to get you to learn and integrate some new ideas about obesity and to create your own visual map in the process. Attached is a paper on concept mapping. It is written for a middle school teacher audience, but I think it does a good job of simply explaining what a concept map is and how to make one. If you are familiar with concept maps you are not required to read it - it is simply for your benefit. You may create your concept map by hand (and just take a photo or scan it) or you can use a computer program to help. You can find ideas for some free concept mapping software at <http://eduwithechn.wordpress.com/2007/04/14/some-free-concept-mapping-programs/> . From an initial look, the gliffy program allows five free maps and looks more intuitive.

For this assignment you will individually create a concept map around the idea of obesity. I would like for you to use at least two references, but you may cite your references at the end of your written portion of the assignment. I would also like to see a minimum of 10 ideas related to obesity, but there is no limit to the number of ideas you can present. You should include connecting words between the ideas. This is a good opportunity for you to explore your ideas about obesity and to literally put them all on paper in front of you so that you can \*see\* the connections.

I would also like you to write a short reflection (min of half page - no more than 2 pages) about the process of creating the concept map and how you view the interrelationship between the ideas and the core concept (obesity) and between the ideas themselves. You will earn 10 points for creating a concept map that meets the criteria above (10 ideas around obesity with connecting words/relationships) and 10 points for your reflection (regardless of length).

### Attachments

- [Vanides Concept Maps.pdf](#)

Figure 4. Obesity Assignment.

The Obesity Assignment (Figure 4) asks students to complete a concept map connecting a minimum of ten ideas related to obesity, connecting words are required between concepts. Software for the completion of the concept map is offered through a link but the software is not required. Alternatively, students can complete the assignment by and upload a picture to the LMS submission page.



### Movie Assignment

This assignment stems from my observations about the importance of media or film portrayal of nutrition or food related ideas. For this assignment I would like for you to view one of the movies listed below (you may read the book if you prefer) and write a 2-3 page paper (length can be longer if you feel you need it, but I am not requiring it). All of these films have their own particular point of view and you should understand what it is and how it relates to what you have learned and what your personal ideas or stances might be. I am assigning 30 points for this paper because of the time commitment, but I do not expect you to actually write much more than you have for previous paper related assignments.

Acceptable Movies (you will need approval for a movie not on this list):

- Fast Food Nation (1:53)
- The Future of Food (1:28)
- Fresh the Movie (1:12)
- Food Inc. (1:34)
- Killer at Large

Particulars of the Assignment:

- Roughly three pages, double spaced, 12 pt. font. Your name should be in the header in the top right.
- Proper grammar, spelling, and generally good writing.
- Paper should include a 1 – 2 page summary of the movie including an introduction and any concluding ideas.
- Paper should also include a reflection where you apply your own ideas to the content of the film and discuss where you agree or disagree with the point of the film.
- References are not required for this assignment, but you must clearly identify the movie you chose to discuss.

[Movie Assignment.docx](#) 

Figure 5. Movie Assignment

The Movie Assignment (Figure 5) requires students to choose one of the listed movies to watch and then complete a 2-3 page paper discussing the movie's point of view, how that point of view relates to what students have learned in class, and their personal ideas. This assessment is also completed in a Word document and submitted in the LMS using a word document display tool (Figure 7).

## **Participants**

**Teacher.** The participant in this study included the course instructor, Tracy. Pseudonyms are used for all participants; Tracy is an experienced biology instructor who has taken graduate level courses in science education and has a Master of Science degree in a biological science. Tracy is also a scientist in the Nutrition and Exercise Physiology department. She designed and teaches two other courses for this department both online. Tracy has the ability to incorporate her beliefs and knowledge of student learning into the online classroom. She taught the online biological science course Spring and Summer 2017 semesters, at which time data collection took place.

Tracy has a view of learning aligned with a social constructivist view of learning (Hatch, 2002). She believes that one should build on students' prior knowledge and that learning is a social endeavor where knowledge is co-created (Hatch, 2002). This is evidenced by her explanation during an interview that a teacher should scaffold the course to support student learning. Specifically, Tracy stated "this entire course is scaffolded." She further explained that the scaffolding was implemented to help students learn. This scaffolding is also evident by the way assessments were organized within and across units as demonstrated in the course syllabus (Appendix B). This study focuses on the nature of assessments that enable Tracy to observe and interpret student learning and what actions she takes in order to address students' needs. This leads to the interaction between the assessments and the instructor, and this enables the instructor to support student learning.

**Delimitations.** This study focuses on the assessments embedded in those tools therefore this study is not about instructor knowledge, or the instructor's assessment

literacy. The activities of the instructor are considered as they relate to formative assessment practices. This study considers how the instructor uses the tools and teaching strategies available in an online course while considering the possibility that the instructor is making those choices based on limitations of the assessments rather than a lack of her knowledge. This study is not about students' use of assessments nor is it about the students' learning. Student data was not considered for this study. While this study was rich in data the absence of student data is a possible limitation of this study. This study's focus is on the *characteristics of the assessments* that support the instructor's ability to interpret student learning and take action on those interpretations.

#### **Data Collection and Analysis.**

At the start of class in January 2017, I requested instructor consent to use their context in a research study. I provided an informed consent letter by email. In this letter I explained the purpose of the research, the proceedings, and confidentiality. I also explained that no additional work is required, the benefit/significance of the study and that there is minimal risk. The instructor replied to this email agreeing to participate in the study. I began collecting data during the first week of class.

I gained **access and entry** to the course by email agreement from the course instructor and IRB approval beginning January 2017 to April 2019. The instructor added me to her LMS site. I had access to the electronic course as an instructor during the spring semester of 2017 and as long as needed thereafter. I began to develop rapport with the instructor through email communication and continued to build rapport and structuring interview questions during the course of the study.

At this point I negotiated my role as an observer; I had no contact with the students and only contacted the instructor through email. I became familiar with the setting by logging into the online canvas site approximately three times a week. I read the course schedules and received course emails and announcements. This enabled me to understand the schedules, interactions and the norms of the setting. During this time I defined my data collection unit around each individual assessment. My field notes included the assessment, any instructor comments regarding the assessment, and the educational technology tools the assessments are embedded in. I also considered any emails the instructor sent about the assessments. I considered my obtrusiveness to be minimal because my presence in the online course was not detectable by the students or the instructor. I refined my data collection methods by defining my data collection unit. I formed a provisional hypothesis based on provisional patterns in the assessments. I adjusted this provisional hypothesis based on the patterns I am coding in the data. I began to triangulate my data as the instructor began supporting student learning.

**Data.** Collection of data occurred during spring and summer 2017 semesters, where I visited the online course approximately 3 times a week for 2 hours each time. Primary data sources consisted of observations of: 1) **field notes**, 2) **educational technology**, and 3) **course assessments**.

**Field notes** consisted of my observations of instructor practices regarding to the online course assessments. I focused on observing the instructors actions including changes she made to assessments. I also examined all course communication she provided including announcements, and comments made on assessments. My focus was on what the instructor did within the LMS. I considered how the online assessments

embedded in the educational technology supported the instructor's formative assessment practices through opportunities for interpretation and action taking. Interpretation included the ability to see student needs and action taking includes the actions the instructor took to meet the needs she interpreted. My field notes of instructor observations and the interview provided additional insight regarding how this instructor was able to navigate the assessments and educational technology for interpretation and action taking.

**Educational technology** in this study was embedded in the LMS platform. The education technology tools I included were the tools the instructor used in this course. These tools included the content editor with the ability to embed science content and videos, the comment tools associated with the gradebook, email features featured within the LMS, an announcement feature, a course copy import/export ability, and standardized formatting for modules organization. The announcement tool had specific features such as the ability to delay posting and encourage students to like or respond to the post. Quiz tools provided two screens, one where the instructor could provide instruction or embed addition features. The second screen enabled the instructor to create quiz questions that could be multiple choice, short answer, True/False, or essay. The content editor was a blank screen that provided the instructor the ability to embed worksheets, concept maps, essays and videos. The comments tool was embedded in the gradebook feature and enabled the instructor an option to provide place comments to refer to anywhere within a submitted assignment. Email correspondence was from the course instructor to students. I looked at this course across two semesters; therefore, I considered the use of course copy import/export ability to move the course content from one semester to the next, and

modules provided a process for linear organization of each unit. For this course there were 38 emails and 18 announcements.

**Course Assessments** were considered across both semesters and included 8 papers, 6 worksheets, 2 concept maps, 2 exams, 16 quizzes, and 64 videos. The papers were graded assessments that asked students to explain and apply basic nutrition science concepts, such as the GMO and the Organic food assessments. The worksheets were graded assessments that focused on basic science content knowledge and application of that knowledge, such as the Food Label/Calorie Calculation Assignment. One concept map was offered each semester, and was used, for example, as a way for the students to understand obesity in a broader context and provided an opportunity for reflection. The quizzes were embedded with videos and used as a way to provide students science content.

Additionally, a 1 hour **instructor interview** provided a secondary source of data. This semi-structured **instructor interview** was conducted after observations and course completion as a secondary data source to further understand instructor interpretation of course assessments and observations. This interview was conducted after the course was completed and recorded using a digital audio recorder. I took additional manual notes. Transcribed interview data with corresponding inference notes was used in coding of the data. Pertinent information was transcribed word-for-word.

Student ideas were not a data source for this study. My focus is not about the students' interpretations on whether the assessment tools helped them understand the science information, nor the students' ability to apply their knowledge. I focus on the instructor's needs to aid student learning. These data sources enabled me to triangulate

the data. It is possible that student data could reveal additional information; this is a possible limitation of this study. I analyzed the data until I achieved redundancy.

### **Data Analysis Procedures**

Analysis of data occurred concurrently with data collection and regular review of field notes. This informed further collection of data in an iterative manner. This iterative process enabled me to increase the depth and focus on themes of interest. I was able to develop a high degree of coherence across data sources.

Data analysis proceeded in two steps. First, deductive analysis was used to look for evidence that aligned with Interpretation and Action Taking (Abell & Siegel, 2011). Then, I inductively analyzed for emergent themes across the data (Hatch, 2002). My findings reveal the “lessons learned” from the case with detailed descriptions (Lincoln & Guba, 1985) that illustrate the emergent themes. I introduced expert debriefing of my observations in how the assessments supported Tracy’s formative assessment practices (Lincoln & Guba, 1985; Yin, 2009). Typological patterns of Interpretation and Action Taking opportunities were identified and provisional themes were collected and described in analysis notes which drove further analysis, I took care to consider appropriate descriptions. Trustworthiness guidelines for method and strategies regarding credibility, transferability, dependability, and confirmability within the context of the study were addressed following the guidelines of Lincoln and Guba (1985).

Typological pattern and provisional themes were informed by the section Instructor Interpretation and Action Taking in the Assessment literacy framework (Abell & Siegel, 2011). These themes were developed by analyzing 1) field notes of instructor observations, 2) educational technology tools, and 3) assessments. Specifically, instructor

observation considered how the instructor used the assessments and educational technology tools for interpretation of student learning and how she addressed student needs. Furthermore, interview data helped inform the instructor's interpretations of the assessments, educational technology tools and student learning. This data helped me to identify surface level codes. These codes included: 1) email, 2) comment tool, and 3) announcements. These categories were then decontextualized to include features such as procedural, conceptual, and science content. Themes across these categories were developed. One code was identified inductively, Stacked quizzes. Two major themes emerged from the data *communication* and *customization*.

Data analysis was conducted reflexively from January 2017-April 2019. To address concerns regarding credibility the methods I employed enabled me to learn the culture of the classroom through observations of the course in progress and after completion. I tested for misinformation by looking for contradictory evidence, I built trust by ensuring the instructor that I was interested in the assessments and how they supported her practices rather than classifying her knowledge. I identified salient elements in the data as well as identifying crucial atypical events, such as when Tracy did not assist students. I reported researcher bias and am aware of human instrument frailty (Lincoln & Guba, 1985). These methods as outlined in Table 1 were addressed by engaging in a prolonged period of participant observation over the course of two years beginning in the Spring 2017 semester, triangulation of sources and methods. I introduced expert debriefing, I performed a negative case analysis and member checks. In addition, I did constant comparative analysis looking for emergent themes and estimated obtrusiveness of my data collection.



Transferability was addressed by providing the reader with thick descriptions for a contextual reference (Lincoln & Guba, 1985). Dependability concerns such as methodological shifts, redundancy, the Pygmalion effect and the Hawthorn effect as well as inquirer sophistication were addressed by ensuring overlap in data collection methods. I also ensured systematicity of observations and data collection obtrusiveness, thick descriptions and an analysis of my role as the researcher. Finally, expert debriefing assisted with my limited experience as a qualitative researcher.

Confirmability was addressed by ensuring my data is grounded in theory, I have logical inferences and clear reasoning for categories that are identified (Lincoln & Guba, 1985). I did this by trying to provide an audit trail, triangulating my data, and I did expert debriefing. I had systematicity of observations and data collections, member checks with more experienced researcher. I achieved inter-rater reliability by independently reviewing and agreeing on data interpretations. I accommodated negative evidence by identifying negative cases in my data and explaining those, such as when it appeared that Tracy told a student she could not rework and resubmit an assignment. It was found that this case was explained in the following communication by Tracy when she stated “I simply read your email wrong.” Tracy, instead was addressing a procedural course policy issue rather than student learning.

## **Findings**

I found this undergraduate biological science course was a rich source of data. Tracy’s science background, teaching abilities and the course’s focus of basic science content provided an interesting place to observe and provided the ability to answer my research question:

How do the assessments provide information about student learning and opportunities to take action?

In the following, I first describe a general orientation to the course, and then report in two sections on the themes 1) *communication* and 2) *customization* that defined the formative assessments and supported the instructor's formative assessment practices in this online course. I then discuss one emergent theme found through inductive analysis, Stacked quizzes.

The course curriculum was presented in a linear trajectory and outlined in the syllabus. Students completed a series of assessments in one unit that included videos that address the science content, short quizzes aligned with videos, worksheets, papers, or assessment activity that aligned the unit's science content learning goals, and a reading quiz. There were 8 units and students could complete these units on or before a scheduled due date.

This research question is addressed first by how the assessments in this course align with the section Instructor Interpretation and Action Taking in the Assessment literacy framework (Abell & Siegel, 2011). What the instructor does after the interpretation of students' work enables the assessment to be used formatively. The use of educational technology tools and assessments for *communication* and *customization* enable formative assessment emerged from the data. Through inductive analysis Stacked quizzes also emerged as a theme.

This case resulted in the emergent themes 1) *Communication* and 2) *Customization* represent opportunities that occurred when assessments embedded in the instructional technology were able to meet the instructor's needs. Specifically, I found

that assessments that met the instructor's needs for interpretation and action taking included the features 1) opportunities for the instructor to communicate multiple times and 2) enabled the instructor to modify instruction through the assessment.

### **Communication.**

*Communication* was a finding that emerged through deductive analysis in this case. In the *communication* theme I had the sub themes Email, Comment tool, and Announcements. These were an emergent theme based on typological analysis using the interpretation and action taking subsection of the assessment literacy framework (Abell & Siegel, 2011). One key of formative assessment is the ability to support student learning and I found that when LMS supported opportunities to communicate to students it provided a way for the instructor to deliver additional instruction and take action to support learning. I now explain how Tracy's case helped us understand how *communication* is supported in this online course.

**Email.** In the online classroom the instructor used email to communicate with students to support learning. When the technological tools provided a way to communicate with students the assessment was able to enhance student learning. For example, while there were emails that focused on procedural questions, email also provided an opportunity for the instructor to communicate with students and support formative assessments. Tracey explained in an email to a student "I just checked your assignment myself. You are very lucky that I did. You did not do the assignment properly and would not get very many points (if any) the way you completed it." She then provided the student with additional guidance and the opportunity to rework and resubmit the assignment. In my field notes, I also noticed that Tracy would use email to

initiate conversations with individual students regarding course content. Tracy would contact students and inform them if they had not completed a specific assessment and offer additional advice regarding the assessment. In this way Tracey's practices regarding formative assessment from the perspective of instructor interpretation and action taking were supported by the technological tool, Email, because students were provided the opportunity to incorporate new instruction. This Email also demonstrates that email supports the ability of the instructors to communicate outside the assessment creating a new place for interaction regarding this assessment.

**Comment Tool.** Assessments that had the comment tool feature provided a way for the instructor to address student work. Assessments, such as written assignments, were embedded in a tool that provided the opportunity to leave comments (Figure 7). Specifically, Figure 6, displays the assessment Disorders Related to Specific Foods Assignment. In this assessment students explain a food disorder that relates to their own life. Students would complete this assessment in a word document and submit it to the gradebook. In my field notes I noticed that the instructor was able to interpret student learning based on the completion of these assessments and how those assessments aligned with the "Particulars of the Assignment" outlined in the assessment. The comment tool provided the instructor an opportunity to communicate with the student to offer additional instruction. An overview of the tool is provided in Figure 7. This figure provides a visual of the comment tool and how it can be expanded and placed throughout the assessment. Furthermore, an enlarged view of comments from the course instructor is in Figure 8. Figure 8 demonstrates the types of comments, and the frequency of the comments provided to students. Based on my field notes, the types of comments for this

assessment focused on drawing the student's attention to the "Particulars of the Assignment Section." However, the ability to rework assignments and address instructor feedback was not built into these assessments. Yet, because the format of the written assignments was the same across the course this did provide students the ability to incorporate the feedback from the instructor across assessments. In this way students could learn from mistakes and complete a task. Then the instructor can review the work on that task and communicate with the students about the instructor's interpretation of her observations. Additionally, this provided the opportunity to adjust instruction from assessment to assessment.

### Disorders Related to Specific Foods Assignment (20 pts)

This assignment stems from the In Depth section of Chapter 3 in our main text. This section talks very broadly about food intolerances, food allergies, and a genetic disorder (Celiac Disease). For this assignment you will choose one intolerance, allergy, or Celiac's disease and relate it to your own life experience. This can mean discussing your personal experience, the experience of someone in your life or even an imagined perspective.

#### Particulars of the Assignment:

- Roughly two pages, double spaced, Times Roman 12 point font. Your name should be in the header in the top right. Proper grammar, spelling, and generally good writing.
- Sections should include:
  - an introductory section about what intolerance, etc. you will discuss. This should be based on at a minimum of two acceptable reference (see below - if you are not sure about your references, ask me) and should include both a definition and a description.
  - how this has impacted your life (or your friends or people you don't know) on a daily, weekly, annual, lifelong basis.
  - an example of how this condition is portrayed in the media (popular magazines and blogs are acceptable here but must be cited in the References section).
  - what sorts of accommodations or alternatives are there to traditional food preparations for this condition. Are there products on the market specifically for this condition?
  - a concluding paragraph about the impact of this condition on the nutritional needs of the affected person with suggestions to improve the nutritional health of the individual.
- References can be cited using APA or MLA and should include:
  - Reputable magazine or newspaper that routinely covers nutrition and health related information (NY Times, SELF Magazine, Prevention, Men's Health, Women's Health, etc.).
  - Scientific or clinical journal (Journal of Nutrition, JAMA, etc.)
  - Textbook – other than used in our course.
- Notes...
  - You will do well to use section headings to outline your paper and clarify your thoughts.
  - The minimum number of references is truly a minimum – to truly get an understanding it helps to read multiple sources.

Figure 6. Disorders Related to Specific Foods Assignment (excerpt)

The Disorders Related to Specific Foods Assignment is a paper and asks students to apply the concepts to their lives.

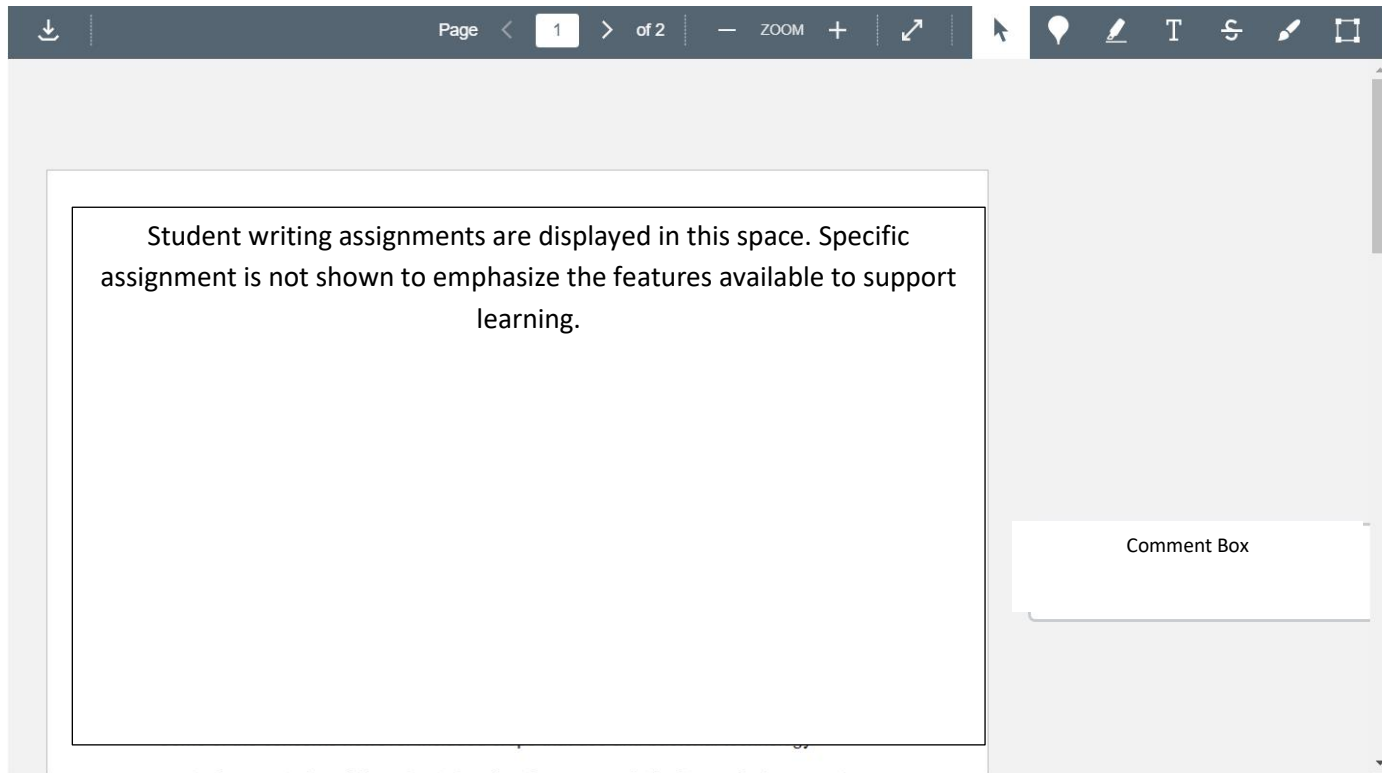


Figure 7. Word Document Display Tool

The comment box is embedded in the Word Document Display Tool, and used across assessments.

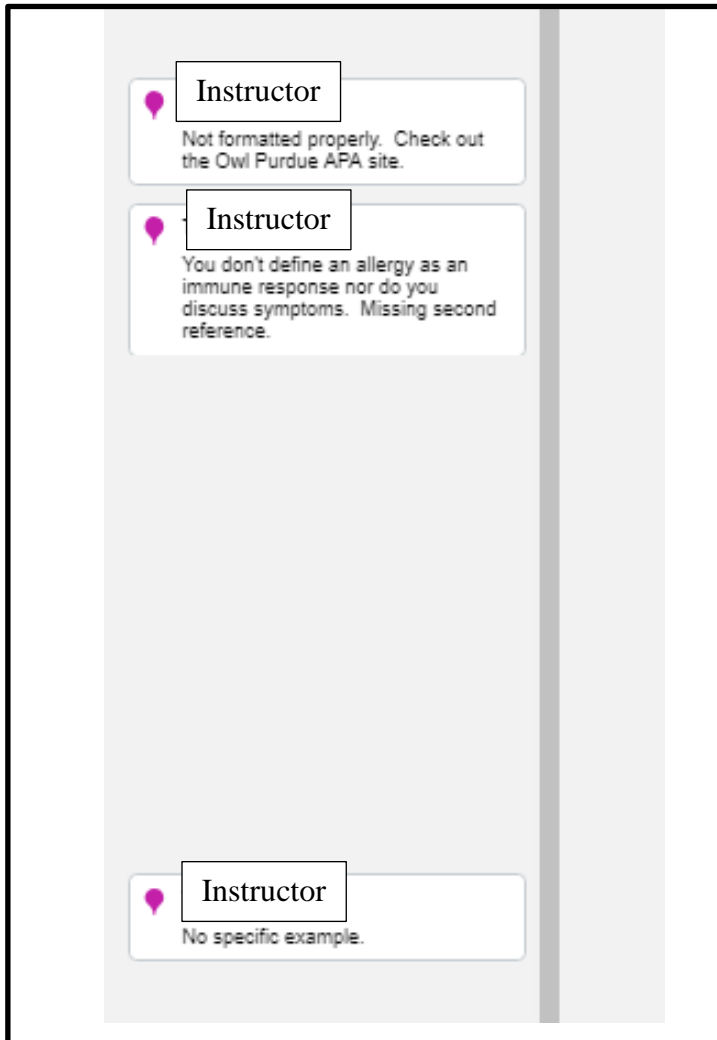


Figure 8. Instructor Comments in Comment Tool

My field notes provided a rich source of data that revealed the Comment Tool was the feature in each writing assessment that provided the instructor the opportunity for *communication*. This tool encouraged action taking by providing students with additional scaffolding and instructional support. Furthermore, our instructor, Tracey, explained that “written assignments are great.... so many ways to communicate with students.” She explained that she leaves many comments for students to consider and in this way her “time is better served by making them [students] think about more complex things.”



When students addressed this feedback, the formative assessment supported the instructor's needs for interpretation and action taking.

**Announcements.** Announcements were located at the top of the LMS web page. Students were able to view Announcements immediately after logging into the LMS course. The Announcements provides an additional way for the instructor to communicate with students. Figure 9 illustrates one of the announcements she shared with her class. Based on my field notes I was able to tell that this announcement was provided while students were working on their next paper. Therefore, it was used in a formative way to take action to support student learning. This Announcement tool supported the instructor's formative assessment practices by enabling the instructor to provide additional feedback to students about a specific assessment. In this way the announcement tool supported the instructor's interpretation and action taking practices through a means for communication. Additionally, I noted in my field notes that while this instructor did not utilize the opportunity, the announcement tool offers a setting that enables students to "like" the announcement and a setting that enables students to reply to the announcement. If the instructor had chosen to use these features then it is possible that the announcement feature could have provided additional formative opportunities. A limitation of this study is that this instructor did not make full use of the features of this tool to support her formative assessment practices.

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

Edit

⋮

 Indent for paragraphs, please Mar 5, 2017 at 12:36pm

[All Sections](#)

I have found that more than a few of you are not indenting at the beginning of your paragraphs. This is not MLA or APA and I find it *\*very\** distracting. I have not taken off any points, but please do indent on future writing assignments.

Search entries or author Unread   

← Reply

Figure 9. Announcement.

My field notes revealed this Announcement was used to by the instructor to take action and support student work in a formative way.

This Announcement was sent out while students were working on the next writing assignment.

In addition to providing instruction the instructor also used the announcement tool to remind students to complete assignments on time. While this may not provide additional instruction, sending reminders to complete assessments could be understood as interpreting student needs and taking action to support those needs.

One issue was that Tracey found it difficult to determine if students accessed the feedback she provided. She stated “I don’t know if they read the comments” and “I can’t make them check email.” Explaining that she may communicate to a student an opportunity to rework an assignment yet the student doesn’t realize this opportunity is available until several weeks later or not at all. Tracy explained in the interview that the ability to *communicate* with students in multiple ways (e.g. comments, announcements, and email) is essential. Specifically, Tracy explained that “email in canvas goes straight to your inbox but if they [students] post a comment [using the comment tool] you have to go into the course site and select comments specifically. So, I’ve missed a few conversations students have tried to start with me because of this.” This feature suggests that the technology could be improved to further support instructor practices.

### **Customization.**

This bounded system revealed *customization* as a theme. I also had Email, Comment tool, and Announcements as subcategories. In addition, I had a fourth theme, Stacked quizzes, which emerged through inductive analysis and aligned with *customization* but not *communication*. Stacked quizzes are an emergent theme based on typological analysis. Aligning with the key feature of formative assessment to take action to support learning, I found *customization* was one way the instructor was able to

accomplish this. In this theme, I explain how Tracy's case revealed *customization* is supported in this online course.

**Email.** Tracy is also able to use email to send students *customized* instruction. Worksheet assessments including the Food Safety Assignment (Figure 2) represented an example of a missed opportunity to meet the needs of the instructor and one obstacle for formative assessment. Specifically, this assessment asked conceptual questions, such as “List and Discuss three advantages and three disadvantages of using GMOs in food” that require students to demonstrate their understanding yet provide limited opportunity to modify instruction to address student difficulties. Interestingly, this instructor chose to use email to mitigate this limitation. For example, Tracy sent an email to one student that asked the student “to reformat and resubmit with more detail. It looks like you have a good general understanding of the assignment and additional detail will also help improve your score.” In this way, Tracy was able to support student learning using *customized* instruction with email. In my field notes I also observed that Tracy was able to use email to *customize* assistance regarding the Stacked quizzes.

**Comment Tool.** Unexpectedly, assessments that utilized the comment tool showed a higher degree of *customization* both in providing customized feedback to students and with customization to the assessment content based on instructor's expertise. For example, the GMO (Figure 10) and an Organic Foods Paper (Figure 11) writing assessment were added the summer semester and replaced the Sports Beverage assessment from the spring semester. Furthermore, the Obesity Assignment (Figure 4) asks students to complete a concept map connecting a minimum of ten ideas related to obesity. Specifically, Tracy explained in the interview that she *customized* these

assessments to align with her science knowledge and knowledge of the students. In my Field notes I noted that she was able to use these assessments to support instructor interpretation and action taking through *customization* because they enabled her science expertise to support instructional decisions. In addition, Tracy also incorporated a new position paper in the summer semester. In the interview Tracy explained this allowed her to “address important science topics and what students find interesting.” Tracy may have also updated assessments throughout from semester to semester as a way to renew course content. For example, in the summer semester Tracy replaced the granola bar assessment (Figure 3, Appendix A) with a new pizza assessment.

Specifically, the instructor *customized* assessments supported her ability to take action to support learning based on her interpretation of how her students usually view the topic through prior course assessment. Tracy explained that with the GMO assignment (Figure 10) students typically have trouble identifying reliable sources and tend to glean information from biased sources. In my field, notes I noted she was able to use this assignment as an opportunity to allow students to learn how to identify reliable sources, using the comment tool. Specially, the Genetically Modified Organism (GMO) writing assessment (Figure 10) provided an opportunity for the instructor to identify student understanding and provide written feedback using comments which aligned with the previous code *communication* and the content was *customized* to align with the instructor’s expertise.

## GMO Paper

[GMO Assignment-SS17.docx](#) 

### GMO Assignment

This assignment stems from the current debate surrounding genetically modified organisms (GMO). What are GMOs? For this assignment, I would like for you to write a position paper with an assigned position (pro/con) about the use of GMOs. If your last name begins with A-L you will write a position paper in support of GMOs. If your last name begins with M-Z you will write a position paper that is against use of GMOs. Every paper needs to develop an argument using factual information using reliable scientific references. Please follow the outline provided below to understand what each section of your position paper needs to include. In your conclusion paragraph, I would also like you to weigh in with your personal thoughts about whether you agree or disagree with your assigned argument, if you would recommend GMOs, and why/why not. *For this paper, I ask that you use appropriate references to reinforce your writing and support claims you might make.*

#### Particulars of the Assignment:

- Roughly two pages, double spaced, 10 or 12 point font (Times New Roman) and no more than 1 inch margins. References should be cited in APA. Your name should be in the header in the top right.
- Proper grammar, spelling, and generally good writing.
- Sections should include:
  - **Introduction:** An introductory section that defines a GMO (including how and why they were created) and introduces both positions considered in this paper (pro/con), while clearly identifying your assigned position. This should be based on at a minimum of two acceptable reference (see below - if you are not sure about your references, ask me).

Figure 10. GMO Paper, excerpt.

This GMO Assignment paper addressed student understanding of the science and the need to consider reliable sources.

## Organic Foods Assignment

This assignment stems from the current cultural fascination with organic foods. Today you can go to any grocery store and you have a choice between two items that look identical but one is labeled organic - *but what does organic actually mean?* For this assignment, I would like for you to write a paper that defines and discusses organic foods and the related farming techniques. You will also need to consider potential positive and negative effects of organic foods. Finally, and only in your conclusion, I would like you to weigh in with your personal thoughts about whether you would recommend organic food and why/why not. *For this paper, I ask that you use appropriate references to reinforce your writing and support claims you might make.*

### Particulars of the Assignment:

- Roughly two pages, double spaced, 10 or 12 point font (Times New Roman) and no more than 1 inch margins. You should use APA formatting for your references. Your name should be in the header in the top right.
- Proper grammar, spelling, and generally good writing.
- Sections should include:
  - **Introduction:** An introductory section about organic foods. Be sure to define the terms, Organic, USDA Certified Organic, All Natural, Organic farming practices, and modern farming practices. This should be based on at a minimum of two acceptable references (see below - if you are not sure about your references, ask me).
  - **Potential advantages:** What positive effects may result from growing and consuming organic food on human health and the environment in both the short and long term? On a practical note, how does this affect things like cost, safety and availability.
  - **Potential disadvantages:** What negative or adverse effects may result from growing and consuming organic foods on human health and the environment in both the short and long term? Can they be overcome? On a practical note, how does this affect things like cost, safety and availability.
  - **Conclusion:** A concluding paragraph about whether you would recommend organic foods and why/why not?
- References should be cited in APA and should include:
  - Reputable magazine or newspaper that routinely covers nutrition and health related information (NY Times, SELF Magazine, Prevention, Men's Health, Women's Health, etc.).
  - Scientific or clinical journal (Journal of Nutrition, JAMA, etc.) **\*MUST USE AT LEAST 1\***
  - Textbook – other than used in our course.
- Notes...
  - I do not use a formal rubric as I like the flexibility of looking at a paper in its entirety.
  - You will do well to use section headings to outline your paper and clarify your thoughts.
  - The minimum number of references is truly a minimum – to truly get an understanding it helps to read multiple sources.

Figure 11. Organic Foods Assignment

The Organic Foods Assignment is a writing assessment that was *customized* to meet the instructor's science content knowledge and her knowledge of the students.

Course worksheets such as the Food Label assessment (Figure 3, Appendix A), were able to support instructor interpretation but provided limited opportunities, beyond the comment tool, within the assessment for the instructor to take action to support student difficulties. Students were asked to complete 11 questions demonstrating their knowledge of how to read food labels. The instructor was able to determine that students had difficulty grasping specific content by interpreting student responses, such as the meaning of percent values presented on food labels. Additionally, I noted in my field notes that the instructor was able to provide feedback about questions students had difficulty with using the comment feature described in Figure 7 and Figure 8. However, these assessments Tracy *customized* missed the opportunity for students to address the feedback because, unlike in writing assignments and quizzes, worksheets did not include multiple drafts. Therefore, these assessments only partially met the needs of the instructor to aid student learning.

### **Announcements**

The announcement tool (Figure 12) enabled the ability to *customize* messages for a class. For example, videos played an important role in this course and when Tracy received several emails about videos not working she provided an announcement to the entire class Titled “Videos not playing...” that stated “I have had a few emails so I just sat down to check it out. In my case, I had to allow flash to run to be able to view them (I was using Microsoft Edge - I find that the Chrome doesn't always work best for me.” The announcement tool enabled Tracy to send a customized message for a specific issue students were dealing with, she then offered a solution to the issue.



Announcements have features that enable students to reply or to “like” a message. As previously noted, however, I recorded in my field notes that Tracy did not utilize these features. These features could help the instructor know if students read the Announcement. I also noted in my field notes that what is unique about the announcement feature is the ability to *customize* communication. This enabled the instructor to easily *communicate* with the entire class at a single time, as often as necessary, and can be delayed if desired.

The screenshot displays the Canvas LMS interface for the 'Announcements' tool. On the left is a dark sidebar with navigation icons for Account, Dashboard, Courses, Calendar, Inbox, Commons, Help, and a back arrow. The main content area is titled 'SP2017' and includes a search bar with a dropdown menu set to 'All'. Below the search bar is a list of five announcements, each with a checkbox, the text 'Announcement shows up here', and a 'Posted on:' timestamp. A blue '+ Announcement' button is located in the top right corner. The interface is clean and modern, with a white background and blue accents.

Announcement Title	Posted on:
<input type="checkbox"/> Announcement shows up here	'17 at 3:02pm
<input type="checkbox"/> Announcement shows up here	'17 at 3:25pm
<input type="checkbox"/> Announcement shows up here	17 at 7:24pm
<input type="checkbox"/> Announcement shows up here	' at 12:36pm
<input type="checkbox"/> Announcement shows up here	' at 11:54am

Figure 12. Announcement Tool

This Announcement Tool provides the instructor to *customize* communication with the entire course, as frequently as desired, and can schedule the release in advance.

Stacked quizzes. Stacked quizzes were an interesting emergent theme that arose from the data through inductive analysis. Assessments which supported instructor interpretation and action taking also needed to be *customized* to address instructor constraints. For example, I noted in my field notes that Tracy made time for grading and giving individualized feedback on other assessments by using stacked quizzes in a formative way. These stacked quizzes were a form of *customization*. This instructor was able to specifically address time as a limitation by using videos embedded in a series of multiple choice quizzes, automatically graded.

Interestingly, traditional quizzes are often not used formatively; however, some quizzes were stacked so that they provided students with scaffolding for more complex concepts. The concepts in the order they are scaffolded are presented in Figure 13 as To Watch and To Do items. For instance, one series of videos and a following quiz included information about healthy meal choices. The stacking of the quizzes are depicted graphically in Figure 14. The first video engaged students with a story about a group of people who live longer and are healthier than many people. This was followed by a short three question quiz regarding what the featured group ate. The second video and quiz in the series taught students about portion sizes of foods they ate. The third video and quiz connected the ideas of portion sizes to food labels. This was followed by a fourth video explaining Daily Required Intake (DRI) of calories. Fifth and sixth videos and quizzes that helped students apply their knowledge to their daily lives by calculating their own DRI. This series of stacked quizzes represents one assessment that enabled the instructor to reduce her time grading while also providing opportunities for formative assessment. Students were able to complete each quiz multiple times until they could provide the

correct answers and the instructor could check to see if students found a particular portion of the series of assessment difficult, such as the calculations for DRI. However, any need for additional instruction had to be provided through alternative communication such as individual emails to students or a class announcement. Additionally, quizzes could be customized to add in more scaffolding as needed. Tracy explained that she scaffolds her entire course. She also explained that in “reading quizzes I allow all students to take the quizzes twice.” Tracy stated she does this because she feels she is helping students learn and students are then “motivated to go find that correct answer.” In this way, Tracy explains that the technology supported her practices to find out what students know and then provide customized support.

Lesson 1 - due by 5 pm on Friday, June 9th

- Lesson 1 To Watch: “The Blue Zones”: Sardinian Diet
- Lesson 1 To Watch: How Many Servings Are You Eating?
- Lesson 1 To Watch: Crackdown on Food Labels: Many Not as “Healthy” as Claimed?
- Lesson 1 To Do: DRI Determination (5 pts)
- Lesson 1 To Do: Reading Labels (5 pts)
- Lesson 1 To Do: Math Video Activity: Estimated Energy Requirement (EER) (5 pts)
- Lesson 1 Reading Quiz (15 pts)
- ***Food Label/Calorie Calculation Assignment (20 pts)***

Figure 13. Lesson 1 Scaffolded topics used in the stacked quizzes.

In addition to scaffolding the science, these stacked quizzes (Figure 14) can work by first engaging students. This is followed by a second quiz that addresses the science content and a third quiz may explain the application of that information. While, a final quiz(zes) can aid students in their ability to apply that knowledge.

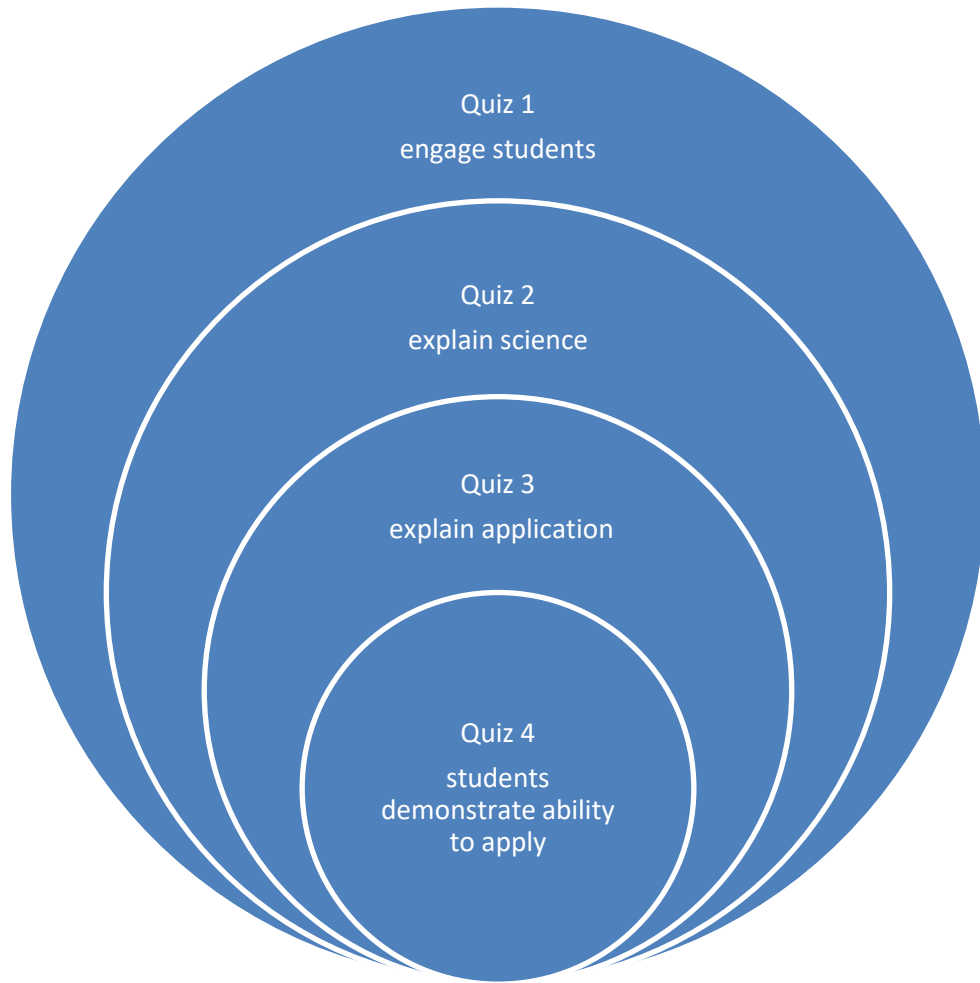


Figure 14. Stacked quizzes where each quiz builds on the previous quiz.

## Discussion

This case's unique findings support previous findings that assessments should support students' learning, that scaffolding can be used to support learning (Siegel, 2007) and cognitively challenge students to think critically (Abell & Siegel, 2011). This study also adds to the literature that *communication* and *customization* enables the instructor to support student learning.

It has been previously defined that Assessments that are able to meet these four criteria for assessment practices provide metacognition opportunities enabling students to

self-regulate their learning, and apply and transfer their knowledge (e.g., Abell & Siegel, 2011). In addition, assessments should elicit students' prior ideas and understanding and provide opportunities for learners to express their thinking (Siegel, 2007). Scaffolding within assessments and within the course help to mediate students' learning (Siegel, 2007, Abell & Siegel 2011). This study suggests that in addition to these criteria, in an online course, assessments and the educational technology tools should provide opportunities for the instructor to *communicate* with students and provide *customization* opportunities. This was achieved in this study by utilizing educational technology tools in innovative ways to support instructor formative assessment practices.

Instructors often have difficulty constructing and using effective assessments in their classrooms (Abell & Siegel, 2011). This difficulty is enhanced in the online classroom. Additionally, this suggests that while one tool per assessment, such as a comment tool may not be sufficient one should consider the use of multiple tools to support learning. I suggest that we should consider that not all assessments need to be restricted to one specific technology tool. In fact, we could consider the worksheet assessment as beginning with conceptual questions. First, the student demonstrates to the instructor their understanding of a topic, and then the comments feature provided by the LMS (Figure 2) is one way for the instructor to give *customized* feedback. Next, email could be considered a second tool that can be *customized* and incorporated into the assessment on an as needed basis for the instructor to *communicate* with the student and provide additional *customized* feedback online focuses on providing students with the right answer so that students can improve self-learning (Costa, Mullan, Kothe, & Butow, 2010). This may also increase students' motivation to practice. However, online

formative assessment does little to help teachers gauge students' progress nor does it provide opportunities for teachers to make instructional decisions based on student assessment data. This study adds to the current literature by suggesting that online formative assessment can utilize assessments embedded in educational technology that enable communication opportunities and customization. This can provide opportunities for teachers to make instructional decision based on student assessment data.

Yet, "most assessments in current use are based on outmoded conceptions of cognition and learning and on impoverished observation and interpretation methods, as compared with what could be the case given modern scientific knowledge of cognition and measurement." (NRC, 2001b, p. 4). Assessments that are designed to promote student learning through formative assessment rather than assess student learning enable students learn by interaction with the assessment, each other and with the instructor (Shepard, 2000; NRC, 2001b). The assessments in this study utilized modern understandings of cognition. The instructor utilized her sophisticated understanding of assessment to make observations and interpretations that are more aligned with modern learning. In addition, this study found that *communication* and *customization* is essential to move an assessment from assessment of learning to assessment for learning, formative assessment (Black & Wiliam, 1998). Assessment for learning supports student learning, rather than measuring student knowledge at a single moment.

In this study, I placed a greater emphasis on technology-based assessments and how those assessments relate to instructional decisions that aid student learning. This unique perspective begins to help reshape how we think about science teaching, and instructor practices by considering how the content assessments are embedded in the

technology and how those combined features support or prevent an instructor's formative assessment practices. We suggest that this research study implies that no individual assessment or tool is ideal for all instructional decisions. Similarly, the land line is not always superior to the cell phone, email or Facetime. Rather, we suggest that the assessments in virtual environments that support instructor formative assessment practices include two features which enable the instructor to support learning: 1) *customization* and 2) *communication*.

These findings provide implications for instructor practice, course design and best practices for teaching and learning in virtual environments. First, we suggest that the assessment in virtual learning environments is more than just the content (e.g. the science) and the style (e.g. worksheet, writing assignment, quiz etc.). Just as importantly, the assessment also includes the technology tools embedded within the assessment, for example:

- comment tools
- announcement features
- email options
- videos
- settings that allow for students to rework problems
- resubmission notifications for the instructor

When considered all together these features impact instructor practice. We assert that our findings suggest features in assessments can aid or hinder an instructor's practices regarding Interpretation and Action Taking to aid student learning. For example, online writing assignments with multiple drafts provided our instructor opportunities to interpret student understanding and take action to address those needs. Furthermore, worksheets represented missed opportunities because there were limited



opportunities for action taking. Yet, we suggest instructors and course designers should also consider that more than one of the technology tool can be implemented in a single assessment. For example, one assessment could include a discussion thread to find out what students know through student generated test questions and then a quiz could implement those test questions, possibly in a stacked series as a means for the instructor to aid student learning.

In addition, Siegel (2013) illustrated that instructors can hold a broad knowledge of assessment yet demonstrate a different sophistication of assessment literacy. While, this study did not address what the instructor knows about assessment, a possible limitation to this study, it does suggest that when instructors have the academic freedom to develop and customize quality course assessments then what they are able to assess and how they can use that information to aid student learning can also be influenced by the technological features embedded in course assessments. I believe this builds on the observations by Willis and Klenowski (2018) that “teachers resist or react to material properties that may constrain quality learning.” (p.30). I suggest this may be because the teachers are resisting the constraints to their practices that support learning. In addition, I found that there are ways to navigate limitations imposed on assessments by the technology, for example an instructor could take action by extending assessments using alternate routes outside the original assessment to aid student learning (e.g. email).

Furthermore, most assessments do not help students develop conceptual understanding and the ability to participate in public discussions of related science issues (Beatty & Schweingruber, 2016; NRC, 2001b), an increasing need to create a scientifically literate public. In online courses, the issue is more dire. Formative

assessment in online courses often focuses only on providing students with automated quick feedback (Pellegrino, 2013) rather than focusing on conceptual understanding and developing scientific literacy skills. Moreover, the instructor's needs to provide support to students in the development of these skills are not a focus; in fact one tension discussed in a review of the literature by Donnelly, Linn, and Ludvigsen (2014) was that instructors wanted the ability to customize the curricula for their students; however, researchers that designed technology-based Inquiry Learning Environments (ILEs) were primarily concerned with maintaining the integrity of the ILE. Littenberg-Tobias, Beheshti, and Staudt (2016) found that when instructors used educational technology in face-to-face classrooms, students had greater learning gains in science content understanding when the instructor customized the assessment activities to provide students opportunities "to revisit their predictions, engage students in different learning modalities, and make deeper connections between scientific Concepts" (Littenberg-Tobias et al., 2016, p. 365). Donnelly et al. (2014) also found a line of literature that supports the idea that the contribution of the instructor influenced student success in ILE in K-12 education (e.g. Furberg, Kluge, & Ludvigsen, 2013; Gerard, Spitulnick, & Linn, 2010).

Tracy's *customization* of assessments that utilized the comment bubble features aligns with findings discussed by Mishra and Koehler (2006) that suggests it is important to consider what the teacher knows about teaching with technology within the context of her other specialized teaching knowledge, TPACK. This finding does align with calls from this line of research that suggests it is important for teachers to know how to incorporate technology into their teaching practices. While, Tan (2019) also supports the notion that

what teachers know influences student learning by suggesting that, “What is needed is a form of improvisational instructional competence that is able to react and respond with appropriate pedagogical expertise to the teacher-student dance of learning” (p.86). We suggest that while knowledgeable experienced teachers are capable of using technology to support learning how that technology can be used is also influenced by the technology itself.

This research study begins to explore how the assessments can support an instructor’s practices. Furthermore, while studies with a technology focus including Annetta and Shymansky (2006); Bernard, et al. (2009); Frailich, Kesner and Hofstein (2009); Kyza (2011); and Ryoo and Linn, (2012) each compare face-to-face learning with technology. We suggest that the underlying assumption, that direct comparisons of two assessments can and should be done, ignores how the assessments may be influencing instructor practices and fails to provide useful ideas to move the field forward and support student learning.

This study demonstrated that in online education, it is possible that assessments may be able to meet the needs of the instructor. Specifically, assessments may be able to provide the instructor opportunities for interpretation and action taking by including opportunities for the instructor to provide additional instruction and for students to revisit areas of conceptual difficulty. Tracy *customized* additional instruction, and occasionally encouraged students to rework some errors, yet limitations were still an issue. It is possible that a high-level of assessment literacy (Abell & Siegel, 2011) can enable an instructor to overcome some assessment limitations, yet technology features can aid the

instructor in supporting student learning such as the integrated features in the LMS enabled Tracy to *communicate* with students and leave specific *customized* comments.

Additionally, these findings have implications for research and practice. Our findings can be used to help develop assessments that fully support the instructor's assessment needs and abilities both in online and face-to-face courses. Given our findings, we agree with DeLuca, LaPointe-McEwan, and Luhanga's (2016) conclusion that there is a need to enhance assessment literacy because it has been shown to improve assessment practices and student outcomes. Yet, we suggest that while experienced and knowledgeable instructors can have meaningful experiences with students which aid learning and may be able to find ways to work outside an assessment when needed (e.g. email) that course assessments need to provide opportunities for instructors to interpret and take action to meet student needs through opportunities for *Customization* and *Communication*. Furthermore, as Selwyn (2015) pointed out in an editorial regarding the language of educational technology that "the possibility of technology not leading to learning and/or other educational gains is rarely a matter for consideration" (p.2-3). We suggest that there is also a possibility the technology may not supporting teachers' practices.

This work aligns closely with previous work on social and material interactions that identified affordances material objects have (Fenwick et al., 2015). According to Fenwick et al. (2015), Norman (1999, 2002), and Dickey (2003) affordances are features in an artifact influenced by the intention it was built for and includes the "perceived and actual properties of the thing, primarily those fundamental properties that determine just how the thing could possibly be used" (Norman, 2002, p.9). Thus, certain actions are made

easier than others based on affordances and perceived affordances. However, affordances are typically specific features in a technological tool, such as the ability of a threaded discussion tool to encourage student to student interactions, rather in this study I identified common traits, the ability to *communicate* and *customize*, amongst what these authors may refer to as affordances. We suggest these traits may be helpful to consider when building in affordances.

### **Practical Implications**

We suggest that practical implications of this study include considering how to implement assessments that provide opportunities for *Customization* and *Communication* using the tools available in technology-based assessments to implement previously established formative assessment practices. For example, Classroom Assessment Techniques (CATs) (Angelo & Cross, 1993) could be implemented in online courses using tools such as discussion questions and email. This would provide the instructor with information regarding student understanding and a chance to build in action taking opportunities. Semester long projects that use worksheets and build over the course of the semester could be incorporated into courses to provide both the instructor and students the benefits of worksheets while also meeting the needs to re-address areas of conceptual difficulty.

This study introduced the idea of using stacked quizzes as an additional way to build on conceptual ideas. The focus for this study was on the assessment tools shaped by the instructor's practices. Student ideas were beyond the scope of this study and therefore not used as a data, however future studies could address this topic from the students' perspective and consider students' interpretations on whether the assessment tools helped

them understand the science information or apply their knowledge. Additionally, while we agree with others that online instructors could benefit from more training in online assessment and well-designed assessments are needed; this study also suggest that features in assessments can aid or hinder instructor's practices regarding Interpretation and Action Taking to aid student learning. There is great educational promise for science curricula in virtual formats to meet current goals for learning and assessment (Achieve, 2013; NRC, 2012; Smetana & Bell, 2012). In our study we illustrate how assessments can encourage or constrain instructor s' ability to support student learning in online classes by impacting their ability to interpret student needs and take action on informed instructional decisions. When we support instructors' assessment literacy and use assessments that provide the opportunity to customize assessments through multiple opportunities to interact with students then instructors can better interpret student needs and take action to support student learning.

### **Additional Limitations**

This study can be considered to have many limitations and I have discussed those limitations throughout this paper. In addition to those limitations I have already discussed, other potential limitations include the fact that I am a new researcher and this study is part of my dissertation research. As discussed previously, my paradigmatic view does not align with conventional qualitative research and the tenets put forth by Lincoln and Guba (1985). Therefore, I collected and analyzed data in a systematic way and the methodological notes I kept were thorough I admit I find this approach does not align with paradigmatic view. This may be considered a limitation.

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## Appendix A: Food label Assignment

### Food Label/Calorie Calculation Assignment (20pts)

*Please use the Picture of the Label Below to Answer the Questions*

Credit will not be given if work is not shown – even if your answer is correct!

1. Are the Fiber One bars shown in the picture high, low fat, or within the suggested guidelines for fat? How would you make this determination? Please describe and show your calculation. (3 pts)
2. How many total grams of Fiber One bars are there in the box of bars? (2 pts)
3. What is the Statement of Identify for this item? (1 pt)
4. Who was the food manufacturer? (1 pt)
5. How many bars would you have to consumer to meet or exceed the Percent Daily Value of fiber? (2 pts)
6. How many Calories are generated from the total carbohydrates in a Fiber One bar? (2 pts)
7. How many Calories are generated from the saturated fat in a Fiber One bar? (2 pts)
8. Given there are 29 grams of total carbohydrate in a Fiber One bar, 9 grams of dietary fiber and 10 grams of sugars, what might account for the remaining 10 grams of total carbohydrate? (2 pts)



- 9: Name three allergens that might be present in Fiber One bars? (3 pts)
10. Are Fiber One bars a significant source of Vitamin A? (1 pt)
11. What is the most prevalent ingredient by weight in Fiber One bars? (1 pt)

**General Mills** oats & chocolate  
NATURALLY FLAVORED

**FIBER ONE** CHEWY BARS

**35% Daily Value of Fiber**  
Contains 4g of total fat per serving.

5 - 1.4 OZ (40g) BARS  
NET WT 7 OZ (200g)

**Ingredients:** Chicory Root Extract, Semisweet Chocolate Chips (sugar, chocolate liquor, cocoa butter, soy lecithin, natural flavor), Whole Grain Oats, High Maltose Corn Syrup, Rice Flour, Barley Flakes, Sugar, Canola Oil, Glycerin, Maltodextrin, Honey, Tricalcium Phosphate, Palm Kernel Oil, Soy Lecithin, Salt, Nonfat Milk, Fructose, Malt Extract, Cocoa Processed with Alkali, Baking Soda, Caramel Color, Natural Flavor. Mixed Tocopherols Added to Retain Freshness.

**CONTAINS SOY, MILK; MAY CONTAIN PEANUT, ALMOND, SUNFLOWER AND WHEAT INGREDIENTS.**

**Nutrition Facts**  
Serving Size 1 bar (40g)  
Servings Per Container 5

Amount Per Serving	
<b>Calories</b>	140
Calories from Fat	35
<b>% Daily Value*</b>	
<b>Total Fat</b> 4g	<b>6%</b>
Saturated Fat 1.5g	<b>9%</b>
Trans Fat 0g	
<b>Cholesterol</b> 0mg	<b>0%</b>
<b>Sodium</b> 95mg	<b>4%</b>
<b>Total Carbohydrate</b> 29g	<b>10%</b>
Dietary Fiber 9g	<b>35%</b>
Sugars 10g	
<b>Protein</b> 2g	
Calcium 10%	• Iron 2%

Not a significant source of vitamin A and vitamin C.  
\* Percent Daily Values are based on a 2,000 calorie diet. Your daily values may be higher or lower depending on your calorie needs:

	Calories	2,000	2,500
Total Fat	Less than	65g	80g
Salt Fat	Less than	20g	25g
Cholesterol	Less than	300mg	300mg
Sodium	Less than	2,400mg	2,400mg
Total Carbohydrate		300g	375g
Dietary Fiber		25g	30g

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## **Appendix B: Course syllabus**

### **Introduction to Human Nutrition**

#### **Course Description**

This introductory course for non-majors provides a general overview of basic nutrition principles and current controversies. There is an emphasis on the role of nutrition in maintaining health, the role of nutrition in disease states, and exploring the scientific validity of popular nutrition beliefs.

#### **Course Goals**

After completing the entire course, you should be able to:

1. Recognize the general role of nutrition in health and disease states.
2. Design a healthful diet.
3. Read and understand food labels.
4. Recognize the roles of micronutrients in the body.
5. Recognize the role of macronutrients (carbohydrates, fats, and proteins) in the body.
6. Recognize the collaboration of nutrition and exercise as keys to good health.
7. Recognize the importance of food safety and technology.
8. Recognize the importance and changes of nutrition through the life cycle.

#### **Required Textbooks**

Nutrition: An Applied Approach (4<sup>th</sup> Edition)

- Janice Thompson & Melinda Manore

- [Removed] Benjamin Cummings
- ISBN: 0321908740
- Must include access code to take course

### **Online Course Access**

You may access the course via [removed] and enter your [removed] to log in. If you have difficulty logging in to the course or you do not see the course listed, please contact the [removed]. You *MUST* enable Compatibility View with Internet Explorer 8.

### **Expectations**

#### What you can expect from me

- I will be fair and consistent.
- I will work to help you learn the course material.
- I will respond to your emails in a timely manner (within 24 hours).
- I will be available for phone, email, or skype office hours by appointment.
- I will provide you the opportunity to succeed in the course.

#### What I expect from you

- You will take responsibility for your learning.
- You will be respectful and professional in your interactions with me and with other students.

- You will complete all assignments in a timely fashion to allow for unexpected problems. I give plenty of time for assignments to be completed before they are officially due and I will not be sympathetic to last minute pleas for assistance.
- You will let me know if you need additional help or resources to understand course material. I really want you to succeed and I can't help if you don't communicate that you need additional help.

### Grading Scale

97-100%	=	A+	73-76%	=	C
93-96%	=	A	70-72%	=	C-
90-92%	=	A-	67-69%	=	D+
87-89%	=	B+	63-66%	=	D
83-86%	=	B	60-62%	=	D-
80-82%	=	B-	0-59%	=	F
77-79%	=	C+			

*Late Work Policy:* Late work will automatically be lowered by 25% each day (Day 1: 25%, Day 2: 50%, Day 3: 75%). Assignments more than 3 days late will not be accepted unless *prior* arrangements have been made. **To be absolutely clear -**

Assignments are due at 5 pm on the due date (CST) unless otherwise specified and will be considered one day late until midnight the following day, etc. until the three day limit has been reached when they will no longer be accepted. If you have circumstances that affect your ability to complete assignments, please contact me **at least 3 days in advance** of the due date.

### **IT Help Available**

If you are having any technical difficulties (e.g., logging in, accessing the discussion board) please email [removed] or contact the [removed] *Help Desk* at [removed] (for out-of-area [removed] students, toll-free at [removed]). *Additionally, it is a good idea to let me know if you are having technical difficulties so that I can know that your issues are occurring and that you have sought help.*

### **Online Class Netiquette**

I and your fellow students wish to foster a safe on-line learning environment. All opinions and experiences, no matter how different or controversial they may be perceived, must be respected in the tolerant spirit of academic discourse. You are encouraged to comment, question, or critique an *idea* but you are not to attack an *individual*.

Our differences, some of which are outlined in the University's nondiscrimination statement below, will add richness to this learning experience. Please consider that sarcasm and humor can be misconstrued in online interactions and generate unintended disruptions. Working as a community of learners, we can build a polite and respectful course ambience.

## **Academic Integrity Policy**

Academic honesty is fundamental to the activities and principles of a university. All members of the academic community must be confident that each person's work has been responsibly and honorably acquired, developed, and presented. Any effort to gain an advantage not given to all students is dishonest whether or not the effort is successful. The academic community regards academic dishonesty as an extremely serious matter, with serious consequences that range from probation to expulsion. When in doubt about plagiarism, paraphrasing, quoting, or collaboration, consult the course instructor.

Academic Dishonesty includes but is not necessarily limited to the following:

1. Cheating or knowingly assisting another student in committing an act of cheating or other academic dishonesty. This includes both uploading and downloading assignments to/from online sites such as Course Hero, Study Blue, or Quizlet.
2. Plagiarism which includes but is not necessarily limited to submitting examinations, themes, reports, drawings, laboratory notes, or other material as one's own work when such work has been prepared by another person or copied from another person.
3. Unauthorized possession of examinations or reserve library materials, or laboratory materials or experiments, or any other similar actions.
4. Unauthorized changing of grades or markings on an examination or in an instructor's grade book or such change of any grade report.

**Academic Integrity Pledge:** *"I strive to uphold the University values of respect, responsibility, discovery, and excellence. On my honor, I pledge that I have neither given nor received unauthorized assistance on this work."* Students are expected to adhere to

this pledge on all graded work whether or not they are explicitly asked in advance to do so.

The University has specific academic dishonesty administrative procedures [removed]. Although policy states that cases of academic dishonesty must be reported to the Office of the Provost for possible action, the instructor may assign a failing grade for the assignment or a failing grade for the course, or may adjust the grade as deemed appropriate. The instructor also may require the student to repeat the assignment or to perform additional assignments. In instances where academic integrity is in question, faculty, staff and students should refer to [removed]. Article VI is also available in the [removed]. Article VI provides further information regarding the process by which violations are handled and sets forth a standard of excellence in our community.

### **University of [Removed] Notice of Nondiscrimination**

The University of [Removed] System is an Equal Opportunity/ Affirmative Action institution and is nondiscriminatory relative to race, religion, color, national origin, sex, sexual orientation, age, disability or status as a Vietnam-era veteran. Any person having inquiries concerning the [removed] compliance with implementing Title VI of the Civil Rights Act of 1964, Title IX of the Education Amendments of 1972, Section 504 of the Rehabilitation Act of 1973, the Americans With Disabilities Act of 1990, or other civil rights laws should contact the Assistant Vice Chancellor, [removed], [removed] or the Assistant Secretary for Civil Rights, U.S. Department of Education.

### **Students with Disabilities (Online Courses)**

*If disability related accommodations are necessary (for example, a note taker, extended time on exams, captioning), please register with the Office of Disability Services), [removed], and then notify me of your eligibility for reasonable accommodations. For other [removed] resources for students with disabilities, click on "Disability Resources" on the [removed] homepage.*

### **Intellectual Pluralism Statement**

The University community welcomes intellectual diversity and respects student rights. Students who have questions concerning the quality of instruction in this class may address concerns to either the Departmental Chair or Divisional leader or Director of the [removed]. All students will have the opportunity to submit an anonymous evaluation of the instructor(s) at the end of the course.

### **Grievance Policy**

Information concerning student grade appeal procedures and non-academic grievances and appeals may be found in the Student Handbook.

### **NEP 1034 Course Schedule**

Below is the list of component lessons for the course. There are 500 points total for this course with 400 points assigned to assignments/quizzes and 100 points assigned to the final exam. There will be extra credit available throughout the semester as well (a maximum of 20 points of extra credit). Assignments italicized below can be found on **Canvas** and the other assignments can be accessed via the [redacted] site.

### **Lesson 1 – due by 5 pm on Saturday, January 28th**



- Lesson 1 To Watch: “The Blue Zones”: Sardinian Diet
- Lesson 1 To Watch: How Many Servings Are You Eating?
- Lesson 1 To Watch: Crackdown on Food Labels: Many Not as “Healthy” as Claimed?
- Lesson 1 To Do: DRI Determination (5 pts)
- Lesson 1 To Do: Reading Labels (5 pts)
- Lesson 1 To Do: Math Video Activity: Estimated Energy Requirement (EER) (5 pts)
- Lesson 1 Reading Quiz (15 pts)
- *Food Label/Calorie Calculation Assignment (20 pts)*

**Lesson 2 - due by 5 pm on Saturday, February 11th**

- Lesson 2 To Watch: Food Allergy Myths: Report Says Most False Alarms
- Lesson 2 To Watch: How Much Sugar? Cutting Excess from Your Diet
- Lesson 2 To Watch: Jump Start Your Diet: Put More Fiber on Your Plate
- Lesson 2 To Watch: Role of Enzymes
- Lesson 2 To Watch: Basic Absorption Mechanisms
- Lesson 2 To Watch: Hormonal Control of Blood Glucose
- Lesson 2 To Watch: Carbohydrate Digestion
- Lesson 2 To Watch: Carbohydrate Absorption
- Lesson 2 To Do: Digestion & Absorption (5 pts)
- Lesson 2 To Do: Know Your Carbohydrate Sources (5 pts)
- Lesson 2 To Do: Carbohydrates in Foods and Our Bodies (5 pts)
- Lesson 2 Reading Quiz (15 pts)

- *Disorders Related to Specific Foods Assignment (20 pts)*

**Lesson 3 - due by 5 pm on Saturday, February 25th**

- Lesson 3 To Watch: On Call: Tips to Raise Good Cholesterol
- Lesson 3 To Watch: Fats in Food
- Lesson 3 To Watch: Fat Digestion
- Lesson 3 To Watch: Lipid Absorption
- Lesson 3 To Do: Lipoproteins: VLDL, LDL, and HDL Activity (3 pts)
- Lesson 3 To Do: Know Your Fat Sources Activity (5 pts)
- Lesson 3 Reading Quiz (22 pts)
- *Diabetes Assignment (20 pts)*

**Lesson 4 - due by 5 pm on Saturday, March 11th**

- Lesson 4 To Watch: Protein Synthesis
- Lesson 4 To Watch: Protein Digestion
- Lesson 4 To Watch: Protein Absorption
- Lesson 4 To Do: Know Your Protein Sources (5 pts)
- Lesson 4 To Do: Let's Go to Lunch! Fat-Soluble (5 pts)
- Lesson 4 To Do: Let's Go to Lunch! Minerals (5 pts)
- Lesson 4 To Do: Let's Go to Lunch! Water-Soluble (5 pts)
- Lesson 4 Reading Quiz (10 pts)
- *Lesson 4 Writing Assignment: Build-A-Pizza: Assessing Protein Needs: Case Study*  
– *Parker (20 pts)*

**Lesson 5 - due by 5 pm on Saturday, March 25th**

- Lesson 5 To Watch: Drinking Water: How Much to Drink?
- Lesson 5 To Watch: Americans' Obsession With Bottled Water
- Lesson 5 To Watch: Sloppy Spring Breakers
- Lesson 5 To Watch: Intracellular and Extracellular Fluid
- Lesson 5 To Watch: Water Balance
- Lesson 5 To Watch: Role of Electrolytes in Water Balance
- Lesson 5 To Watch: Free Radical Formation
- Lesson 5 To Watch: Vitamin A and the Visual Cycle
- Lesson 5 To Do: Fluid and Electrolyte Balance (5 pts)
- Lesson 5 To Do: Alcohol Absorption (4 pts)
- Lesson 5 To Do: Mineral Functionality (5 pts)
- Lesson 5 To Do: Vitamin Functionality (5 pts)
- Lesson 5 Reading Quiz (11 pts)
- *Sports Beverage Position Paper (20 pts)*

**Lesson 6 - due by 5 pm on Saturday, April 8th**

- Lesson 6 To Watch: Can You Be Slim and Obese? Hidden Risk of Normal Weight Obesity
- Lesson 6 To Watch: Obesity in America: Low Cost, High Impact Solutions
- Lesson 6 To Watch: Extreme Healthy Eating? - What is Orthorexia?
- Lesson 6 To Watch: Calcium Metabolism
- Lesson 6 To Watch: Activation of Vitamin D

- Lesson 6 To Watch: Vitamin B<sub>12</sub> Absorption
- Lesson 6 To Watch: Increase in Obesity Rates in the United States
- Lesson 6 To Do: Energy Balance (5 pts)
- Lesson 6 To Do: Know Your Calcium Sources (5 pts)
- Lesson 6 To Do: Know Your Iron Sources (5 pts)
- Lesson 6 Reading Quiz (15 pts)
- *Obesity Assignment (20 pts)*

**Lesson 7 - due by 5 pm on Saturday, April 22nd**

- Lesson 7 To Watch: Organic Produce
- Lesson 7 To Watch: Hunger in America: Growing Need
- Lesson 7 To Watch: Dangerous Mercury in Some Fish: Which Fish is Safest to Eat?
- Lesson 7 To Watch: Secrets of Food Safety: Tips to Follow at the Supermarket
- Lesson 7 To Watch: Cori Cycle
- Lesson 7 To Watch: The Energy Currency: ATP
- Lesson 7 To Watch: Glycolysis
- Lesson 7 To Do: Food Safety and Technology (5 pts)
- Lesson 7 To Do: MyDietAnalysis Case Study: Theo- An Athlete Activity (20 pts)
- Lesson 7 Reading Quiz (15 pts)
- **ALL EXTRA CREDIT DUE!!!!**
- *Food Safety Assignment (10 pts)*

**Lesson 8 - due by 5 pm on Thursday, May 4th**

- Lesson 8 To Watch: School Lunch Concerns: Is Processed Meat a Cancer Risk?
- Lesson 8 To Do: Breastfeeding (5 pts)
- Lesson 8 To Do: Math Video Activity: Reading Growth Charts (5 pts)
- Lesson 8 Reading Quiz (10 pts)
- *Movie Assignment (30 points)*
- *FINAL EXAM*

## CHAPTER THREE

### **Restraining Conceptual Learning: Entanglement of Instructor Formative Assessment Practices**

#### **Materiality and Assessment Practices Online**

Science education and assessment research have made vast strides in the understanding of how people learn science, how to support student learning, and what instructors need to know to aid learning (e.g., Black & Wiliam, 1998; Mishra & Koehler, 2006; Ryoo & Linn, 2012). This humanist perspective has been very fruitful in moving these fields forward. In continuing this humanist perspective I considered how instructors use the tools available to support learning (Chapter 2) which yielded forthcoming results. Yet, this did not answer the question I wanted answered. Previously, as an online instructor I began to notice that the materials would influence how and sometimes if I could aid student learning. As the instructor, I became aware that my formative assessment practices were being shaped by material forces and that these intra-actions were having an impact on my students' understanding of important foundational science concepts. I wanted to explore this phenomenon, if and how technological materials influence instructor practices to aid learning in online courses.

When I began to consider how materials become entangled with and act upon the instructor's practices our perspective included the assumption that materials have an impact on what choices an instructor has available to support student learning. This assumption means that one considers the materials as having agency and therefore is post-humanist. By choosing a post-humanist sociomaterial focus I was able to consider

the agency of the technology, acknowledge the agency of the instructor, and how each act upon the other in practice (Leonardi, 2012; Orlikowski & Scott, 2008).

In this research study, experimentation with materiality enabled me to explore sociomaterial perspectives with the aim to inform theory and practice in online science education. I chose to focus my efforts on a biological science focused asynchronous learning environment which consisted of a collection of technological tools designed for undergraduate non-science major students to develop an understanding of nutrition concepts. I explored the data using theoretical perspectives with the aim to shed light on the intertwined roles of materials and humans in online learning in terms of formative assessment practices (Black & Wiliam, 1998) Unlike dichotomous views of assessment where one's knowledge is deemed correct or not, formative assessment rethinks basic views of assessment and uses it as a way to support learning (Black & Wiliam, 1998). Furthermore, formative assessment is especially useful to aid students in the ability to move beyond commonly held assumptions. This work provided an opportunity to examine the social and material dimensions that affect learners in technology enhanced science-learning environments and address assemblages which impact formative assessment practices.

Therefore, in this study I described the role of material elements in formative assessment practices with a consideration that material and human intra-actions can drive discourse. Where discourse is not just what is said but what *can* be said (Barad, 2007). My focus then became a “persistent critique of something you cannot not want” (Spivak, 1993, p.42) where I began to explore the conditions that enabled what could be said and what could not be said (Spivak, 1993; St. Pierre, 2011) by “identifying structures and

discourses that allow people to say certain things and not others” (Aghasaleh & St. Pierre, 2014, p.4). Furthermore, following Foucault (1966/1970) I found what was interesting were the conditions that enabled the structures that influenced what can be said or what cannot be said. Moreover, what people say typically echoes normalized discourse (Spivak, 1993; St. Pierre, 2011) and does not address how the material influences the normalized discourse itself. This means that for this study, I do not focus on what the instructor says about their practice because what the instructor says only reflects their knowledge of how to navigate formative assessment in an online context and would only address how the instructor perceives the materials’ agency within the context of the normalized discourse. Similarly, I do not focus on how or what the students do or say regarding the assessments or instructor feedback because this ignores the role of the materials’ agency. Instead, I chose to use this sociomateriality perspective which aligns with an emerging literature base that emphasizes understanding the practices of how materials, e.g. technology, actively play a role in learning (Bolldén, 2015; Latour, 2005; Orlikowski, 2002, 2010; Orlikowski & Scott, 2008; Suchman, 2007; Johri, 2011). Specifically, this lens leads the research in a direction that aligns with practices as it relates to learning *with* technology (Bolldén, 2015; Howland, Jonassen, & Marra, 2012) and “can assist in research and design of learning technology by providing a pertinent lens to examine emergent socially and materially intertwined learning practices” (Johri, 2011, p. 208). This post-humanist perspective uniquely enabled me to give equal consideration to 1) how the materials acted upon and influenced the instructor’s practices and 2) how the instructor’s practices can entangle with the materials. This focus enabled me to consider what is possible rather than just what is currently done; which is in



contrast to a humanist perspective which privileges the actions and knowledge of the instructor over the agency of material elements. Specifically, there is an extensive teacher knowledge literature base built on the Technological pedagogical content knowledge (TPCK and TPACK) research line first introduced by Mishra and Koehler's (2006) TPCK framework. This framework characterizes what instructors know about how to use technology. While this line of research has provided valuable insight it has missed how the technology is driving the instructor's decisions because it has privileged the instructor over the material. Furthermore, there is a second line of research regarding how well one technology can replace or mimic another (e.g. Annetta & Shymansky, 2006; Bernard, Abrami, Borokhovski, Wade, Tamim, Surkes & Bethel, 2009; Frailich, Kesner & Hofstein 2009; Kyza, 2011; Ryoo & Linn, 2012). Again, while these studies can provide valuable understanding regarding course materials it has not addressed how these materials influence instructor practice.

I began this study using Barad's agential realism theoretical framework which encouraged me to examine the intra-actions (Barad, 2007) between the educational technology tools and the instructor's formative assessment practices in an online science course using this sociomaterial perspective. This study is influenced by my interpretation of theorists such as Leonardi (2012), Müller (2015), Deleuze and Guattari (1987), Latour (2004), Fenwick and Landri (2012), Orlikowski and Scott (2008), and Barad (2003, 2007). I chose to call these assemblages sociomaterial to emphasize the social nature of human and nonhuman materials surrounding formative assessment (Deleuze & Guattari, 1987; Fenwick & Landri, 2012). I suggest that the agency of sociomaterial assemblages entangle and drive instructor formative assessment practices in online courses, and those

involved with online education may want to consider this agency as a way to encourage assessment practices which aid student learning.

### **Asking and Analyzing**

In this study I asked, “What is the nature of assemblages that affect the instructor’s formative assessment practices in an online asynchronous undergraduate non-majors biological science course?”

I began by exploring the implications of materiality-in-practice using the theory agential realism which encouraged me to examine the intra-actions (Barad, 2007) between educational technology tools and the instructor’s formative assessment practices in online science classes using a sociomaterial perspective. This meant that I began interpreting my reading of the data in the online course using Barad’s (2007) theory of agential realism. Therefore, with this research question, thinking with theory meant data analysis focused primarily on the entanglement of the instructor and the material. Where I used my field notes to identify and describe what the assemblages in the course plug into (St. Pierre, 2015, p.89). This focus on “the entangled nature of differences that matter” (Barad, 2007, p.381) enabled me to identify properties within the assessment material, which could enable or limit the instructor’s formative assessment practices in this context. Furthermore, I particularly paid attention to the technological features embedded in the assessments and how those features determined how the technology could be used in the context of formative assessment practice (Norman, 2013). I found that assemblages related to formative assessment plug into the technology features embedded in the course assessments (e.g., writing assignments, quizzes and worksheets) and the instructor. Specifically, how the technology is actually used can be determined by barriers put in

place by the assemblages, regardless of instructor knowledge. For example, the technology places barriers on the instructor's ability to adjust instruction after students complete worksheets. In online worksheets there is an opportunity for the instructor to provide feedback on student answers on the worksheet but there is no feature for the instructor to elicit further feedback from the student or provide additional instructional formative opportunities. Furthermore, my aim was to understand the agency of these assemblages by considering agential cuts as a way to define the boundaries of a sociomaterial assemblage and "peek" inside a phenomenon to observe the agency (Barad, 2007). Specifically, in this study these agential cuts enabled me to consider both how the instructor is using assessments to aid learning and how those same assessments are driving the instructor's formative assessment practice. It was important to consider this because "*All the words are data*" (St. Pierre, 2015, p.6) and all words are open for multiple interpretations based on the theory with which one chooses to understand the data.

I focused my interpretations on 1) the knowledge produced, 2) the force wielded by sociomaterial assemblages, and 3) how the assemblages could be oppressive. Knowledge produced by students illustrates to the instructor students' initial understanding of the content, often providing enough data to show where a student is in their understanding. This is what the intra-actions enable to be said. How and if the instructor is able to aid students in the ability to move beyond commonly held assumptions is also influenced by the assemblages, encouraging conditions that highlight what cannot be said. The force these sociomaterial assemblages wield is powerful in providing or not providing the instructor with opportunities to aid student learning or

worse, these sociomaterial assemblages may create conditions that encourage/solidify previously held assumptions that I seek to help students disrupt. Finally, these assemblages can be considered oppressive if they oppress instructor opportunities to aid student learning.

My data for this study includes 1) everything within the online course such as observations of material elements, course documents, reports, and 2) all words related to my data analysis (e.g., all forms of communication written and verbal). Through diffractive reading, I was able to focus on “the entangled nature of differences that matter” (Barad, 2007, p.381). I considered both the technology’s role and how the instructor could use the technology which enabled me to identify properties within the material, which enabled or limited the instructor’s formative assessment practices in this context. Furthermore, I also considered how the instructor could use the technological features built with a specific intention in mind and how its properties determined how the technology could be used (Norman, 2013).

I chose to try to understand the agency of these assemblages and begin to see phenomena that are born through these intra-actions by using agential cuts to define the boundaries of a sociomaterial assemblage and “peeking” inside the phenomenon to observe the agency (Barad, 2007). The agential cut in this manuscript defines the boundaries of the sociomaterial assemblage as the educational technology tools and the instructor’s formative assessment practices. Through **diffractive data analysis** I was able to consider how those tools are driving the instructor’s practice and entangling the instructor. I considered what these assemblages “plug into”. Following Barad (2007) I asked 1) What knowledge is produced? I considered in my context to explore if the

instructor is able to see student learning. Then I asked 2) What force the sociomaterial assemblages wield?, and I was able to see how the teacher could help the student, by asking what opportunities are available. Last, I asked 3) How these assemblages can be oppressive (to the instructor's formative assessment practices)? And I looked for times the teacher did not help the student while not placing the instructor's knowledge at the center of this question.

I found that these assemblages plug into individual assessments with three intra-acting sociomaterial elements: 1) the content (e.g. the science), 2) the style (e.g. worksheet, writing assignment, quiz etc.) and 3) the technology tools (and any words those tools could facilitate). I found there are assemblages with agency and that the agency influences formative assessment. It is the conditions that these assemblages create that I now describe.

### **Entangled Formative Assessment Practices**

I found that what's interesting are the conditions the assemblages create, and that these conditions plug into the formative assessment cycle (Abell & Siegel, 2011): controlling what can be said regarding instructor formative assessment by enabling or preventing the instructor to complete a formative assessment cycle. Specifically, I found the materiality possessed by assessments may oppress or enable intra-actions regarding formative assessment practices depending on how the material agency entangles the instructor. First, individual assessments that create intra-actions which continuously entangle the instructor with the assessment encourage formative assessment practices. Second, assessment opportunities that builds over time across units entangling the instructor in a looping fashion support formative assessment practices. Additionally, the

materiality of assessments possesses the agency to oppress formative assessment practices when the assemblages neglect instructor entanglement. Over all, these results show that the materiality embedded in online assessments possess the agency to create the conditions where formative assessment practices are supported or oppressed through the intra-actions which entangle the instructor with the material (assessment).

### **Continuous Entanglement**

Assessment opportunities that build over time across units entangle the instructor in a continuous fashion. From the student's view this looks like an instructor who helps multiple times throughout the assessment, from an instructor's perspective it can look like activities looping backward before moving forward. This continuous entanglement of the instructor and the assessment supports assemblages that enable formative assessment practices. Specifically, our interpretations stem from our reading of data such as assessments which included 3 to 4 short quiz-like activities per unit providing the opportunity to support students over several activities; additionally, multiple short papers where students are expected to use the feedback on one paper for the next paper created an assemblage that supported continuous entanglement.

### **Oppressive Entanglement**

The materiality of assessments possesses the agency to oppress formative assessment practices when the assemblages neglect instructor entanglement. These oppressive entanglements engulf most online formative assessment opportunities creating a barrier preventing the instructor from completing the formative assessment cycle. Specifically, after instructors interpret student understanding they are not able to modify

learning opportunities and address student difficulties. For example, while quick automated feedback for students using the technology can provide some help for students it can serve to entangle instructors in an oppressive assemblage, providing the instructor no opportunity to address student difficulties and missing an opportunity to address underlying assumptions. In this course, multiple choice quizzes provided automated answers resulting in quick feedback for students and ease of grading for the instructor, an important and valuable function, yet this type of assessment falls short regarding instructor needs for formative assessment. Additionally, worksheets with multiple choice items acted in the same way as multiple choice quizzes to inhibit the completion of the formative assessment cycle. Specifically, if opportunities for the instructor to adjust instruction based on interpretation of student needs are not supported by the materials the opportunity for an action-taking step in the formative assessment cycle is blocked by the individual assessments. This results in creating an oppressive assemblage regarding formative assessment practices.

I suggest assessments that create intra-actions which continuously entangle the instructor with-in and across assessments encourage formative assessment practices and could eliminate oppressive assemblages. Encouraging the formation of continuous entanglements can help to provide formative assessment opportunities. In addition to the assessments I described in this course, a project that spans several units or a paper where students submit multiple drafts could also encourage the creation of looping assemblages that entangle the instructor and support formative assessment practices. In both examples, the instructor has the opportunity to give feedback, address alternative conceptions, and adjust instruction at multiple points during the assessment.

From a formative assessment perspective what can be said to aid student learning can be supported and suppressed by the material elements in a course. The material elements entangle the instructor in assemblages that encourage and inhibit different interactions with the materials and students. Our study demonstrated that in online education, assessments do not always meet the needs of both the students and the instructor. Providing opportunities for instructor interpretation and action taking needs to be incorporated into the assessments students complete. For example, the worksheet assessments used in this course only partially supported the formative assessment cycle. Worksheets provided a way for the instructor to interpret student understanding and provide feedback however, there were no built in features for students to address that feedback. While trained teacher educators are essential in the teaching and design of effective courses (Lettenber-Tobias et al., 2016) our findings can be used to help develop assessments that fully support the instructors' assessment needs and abilities. Furthermore, while I agree with DeLuca, LaPointe-McEwan, and Luhanga's (2016) conclusion that improving assessment literacy and assessment practices in teacher education can enhance student outcomes I suggest that assessments themselves have a role in how or if instructors have meaningful experiences with students to aid learning.

In this study, I illustrate that assessments can encourage or constrain instructors' ability to support student learning in online classes by impacting their ability to interpret student needs and take action by making informed instructional decisions. This specific post approach provided us a lens that uniquely enabled us to explore the active role the materials play on the instructor's practices, contributing to what can be said. I showed that the materials, such as worksheets and multiple choice questions can create an



oppressive assemblage limiting instructor practices; while assessments such as papers provide instructors opportunities for formative assessment. I suggest that tools that enable multiple intra-actions could help to eliminate oppressive assemblages created by the materials.

### **Implications for Teaching**

In online courses the instructor's role may not be as effective as it could be. These findings are in line with more recent research about the instructor's impact on student learning in technology-rich learning environments, "There are efforts to develop interactive learning environments ... but none that can support responsive teaching as can take place in face-to-face instruction" (Jaber, Dini, Hammer & Danahy, 2018). I have shown that online the material elements can act to obstruct the instructor's formative assessment practices aiding student learning. Our findings that the materiality possessed by assessments may oppress or enable intra-actions regarding formative assessment practices could ultimately contradict previous research on the instructor's role in online courses. Specifically, Bernard, et al.'s (2009) literature review suggested a limited influence in student learning by online instructors, I suggest that the instructor's influence may only be limited by the material's agency. Furthermore, I demonstrate a hole in student centered learning theories and student-centered course design for online education (Cavanaugh, 2009; Lorenzo & Moore 2002; Picciano, 2012; Puziferro & Shelton, 2008; MarylandOnline, 2013). I suggest for assessments in online courses to be student centered; to support student learning they need to explicitly build in material elements that support continuous entanglement of the student, the instructor and the

materials. Additionally, one should consider the possibility that not addressing instructor practices through course design could undermine the ultimate goal of student learning.

Specifically, what is interesting is that the assemblages that form can control if the instructor can complete the formative assessment cycle driving the instructor's formative assessment practices. I suggest that multiple opportunities for the instructor to interact with the students about conceptual ideas within or across learning activities are needed. There have been several computer-supported collaborative learning environments (CSCL) created that provide opportunities for online instruction and formative assessment (e.g., Web-based Inquiry Science Environment (WISE) (Linn et al., 2003)). Yet these tools and the insights they offer typically are applied to face-to-face courses and have not been leveraged in online courses with the aim to support learners' scientific practices (Jaber, et al., 2018) or the instructor's formative assessment practices. What is surprising is that materials designed to support learner engagement with the content can actively prevent student/instructor intra-actions, yet with this knowledge I can intentionally build in opportunities for the instructor to support student learning. I am not suggesting that student centered learning practices are not valuable or that student engagement with the materials should be ignored; rather I suggest that to meet the promise of online education and technology in science we must design online courses to support both the students' scientific practices and the instructor's formative assessment practices. To achieve these aims, I suggest assessments should be evaluated based on two standards 1) student needs such as scaffolding and engagement and 2) instructor needs to support learning, opportunities for continuous entanglement supporting formative

assessment. Furthermore, I have emphasized the significance of online instructor practices to foster student learning.

### **Theoretical/Paradigmatic Contributions**

In contrast to prior humanist studies such as Mishra and Koehler (2006) and studies with a technology focus (e.g. Annetta & Shymansky, 2006; Bernard, et al., 2009; Frailich, Kesner & Hofstein 2009; Kyza, 2011; Ryoo & Linn, 2012), this post-humanist perspective uniquely enabled me to investigate how materials become entangled with and act upon the instructor's practices. In fact, none of these studies have addressed the material influence and related to instructor practice. This sociomaterial focus uniquely provided a way to consider the agency of both the instructor and the technology while considering how each act upon the other in practice (Leonardi, 2012; Orlikowski & Scott, 2008).

Specifically, our unique post perspective has enabled us to explore where student centered learning theories need to expand to better support student learning and incorporate instructor needs as a way to support student learning. We know that instructor-provided formative assessment supports student learning (Black & Wiliam, 1998) and while formative assessment online does a nice job providing students opportunities to improve self-learning (Costa, Mullan, Kothe, & Butow, 2010) I suggest support can be extended. Rather, if we can reconsider why the data suggests that the instructor is the least effective way to support student learning in online situations (Bernard et al., 2009) and go beyond a focus on instructor knowledge (TPCK) to consider a theoretical and paradigmatic approach which enables us to understand how to create opportunities that enable an instructor to support learning in online courses. This study

begins to understand how the technological materials impact an instructor's practice in a way that can further support student learning. Instead of considering three different types of interactions I considered the intra-actions within the course. To fully embrace the educational promise for science curricula in virtual formats (Achieve, 2013; Smetana & Bell, 2012) we must support instructors' assessment practices by using assessments that provide the opportunity for continuous intra-actions with students creating conditions where instructors can interpret student needs and take action to support student learning.

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## CHAPTER FOUR

### **Looping or Linear: Virtual Learning Environments that Enable Instructor Formative Assessment Practices**

#### **Course Materials and Instructor Practice**

My research interests in the sociomaterial were born out of work as a scientist and online instructor. I see the material elements in the online course as having agency. I am interested in the intertwined material and human elements within the context of practice. I see these sociomaterial elements as systems and have noticed that the materials in virtual environments can influence how or if the human element can influence student learning. As a molecular biologist I became comfortable viewing objects within the context of a system of reacting, or intra-acting objects and so I began to suspect there were intra-actions affecting instructor practice. These intra-acting sociomaterial assemblages could have real influences and yet be something that we cannot see; can only describe. I wondered if these may be real and having an impact on students' understanding of important science concepts. I choose to look beyond what the instructor does, says or knows to consider not just what is said but what *could* be said, what drives discourse in this context (Barad, 2007). I am drawn to the idea of intra-acting objects in virtual environments and, therefore, I chose to explore **the intra-actions that entangle the course design and instructor formative assessment practices** in an online course.

I became frustrated with humanist approaches and frameworks (e.g., Mishra and Koehler's (2006) Technological Pedagogical Content Knowledge (TPCK)) that take apart all the elements of the assemblage and treat them as individual inert objects, these studies

that explain all intra-actions on the instructor, consider only what she knows and how she may use, navigate or understand the technological tools. I find this post-humanist sociomaterial perspective affords me a way to consider the assemblages that engulf the course and instructor providing a unique opportunity to inform theory and practice. I focus on one online undergraduate non-majors science education course at a research institution to help me think beyond the boundaries of conventional humanist research. I do this by valuing the contributions of material *and* human elements. To look beyond what the instructor does, says or knows to consider not just what is said but what *could* be said, what drives discourse in this online science course (Barad, 2007). This study took place in a biological science focused asynchronous learning environment which consisted of a collection of technological tools designed for undergraduate non-science major students to develop an understanding of nutrition concepts. I explored the data using theoretical perspectives with the aim to shed light on the intertwined roles of materials and humans in online learning in terms of formative assessment practices. I examined the social and material dimensions that affect learners and instructors in technology enhanced science-learning environments and explored assemblages which impact an instructor's formative assessment practices.

### **Practice and Research**

In this study, materiality provides a unique lens that enabled me to consider the intra-actions which include how the instructor is using the technological tools and at the same time how those same tools are driving the instructor's practice. I explore the role of material elements in formative assessment practices (Abell & Siegel, 2011) with a consideration that material and human intra-actions can drive discourse (Barad, 2007). I

chose to focus on the intra-actions that drive formative assessment practices because formative assessment has been well documented in the literature to improve student learning outcomes (Abell & Siegel, 2011; Black and Wiliam, 1998). My focus became a “persistent critique of something you cannot not want” (Spivak, 1993, p.47) where I began to explore the conditions related to formative assessment that enabled what could be said and what could not be said (Spivak, 1993; St. Pierre, 2011) by focusing on identifying structures within the course design that “allow people to say certain things and not others” (Aghasaleh and St.Pierre, 2014, p.4). Furthermore, following Foucault (1966/1970) I found what was interesting were the conditions that enabled what can be said or what cannot be said. Moreover, what people say typically echoes normalized discourse (Spivak, 1993; St. Pierre, 2011) and does not address how the material influences the normalized discourse itself. This sociomateriality perspective aligns with an emerging literature base that emphasizes understanding practices with regard to how the materials, e.g. course design and related technology, actively play a role in learning (Bolldén, 2015; Johri, 2011; Latour, 2005; Orlikowski, 2002, 2010; Orlikowski and Scott, 2008; Suchman, 2007;). Specifically, this lens leads the research in a direction that aligns with practices as it relates to learning *with* technology (Bolldén, 2015; Howland, Jonassen & Marra, 2012) and “can assist in research and design of learning technology by providing a pertinent lens to examine emergent socially and materially intertwined learning practices” (Johri, 2011, p. 208). This post-humanist perspective uniquely enabled me to give equal consideration to 1) how the materials acted upon and influenced the instructor’s practices and 2) how the instructor’s practices entangled with the materials. This contrasts with a humanist perspective which privileges the actions and

knowledge of the instructor over the agency of material elements. Specifically, there is an extensive literature base that privileges the instructor over the material by discussing how teachers use technology and teachers' knowledge related to technology including the TPACK (technological pedagogical content knowledge) and TPACK (technological pedagogical content knowledge) literature (Mishra & Koehler, 2006), and a line of research regarding how well one technology can replace or mimic another (e.g. Annetta & Shymansky, 2006; Bernard, Abrami, Borokhovski, Wade, Tamim, Surkes & Bethel, 2009; Frailich, Kesner & Hofstein 2009; Kyza, 2011; Ryoo & Linn, 2012). This sociomaterial focus provided a way to consider the agency of both the instructor and the technology while considering how each act upon the other in practice.

### **Theoretical Foundations**

I began this study using Barad's agential realism theoretical framework which encouraged me to examine the intra-actions (Barad, 2007) between the educational technology tools and the instructor's formative assessment practices in an online science course using this sociomaterial perspective. This study is influenced by my interpretation of theorists such as Leonardi (2012), Müller (2015), Deleuze and Guattari (1987), Latour (2004), Fenwick and Landri (2012), Orlikowski and Scott (2008), and Barad (2003, 2007). Following Deleuze and Guattari's (1987) ideas of assemblages and Fenwick and Landri's (2012) lead regarding the *sociomaterial*, I chose to call these assemblages sociomaterial to emphasize the social nature of human and nonhuman materials surrounding formative assessment. I suggested that the agency of sociomaterial assemblages entangle and drive instructor formative assessment practices in online

courses, and those involved with online education may want to consider this agency as a way to encourage assessment practices which aid student learning.

### **The Study**

In this study I asked, “What is the nature of assemblages that affect the instructor’s formative assessment practices in an online asynchronous undergraduate non-majors biological science course?”

In this 16 week online asynchronous course with a focus on nutrition, undergraduate non-science major students were able to meet a general education requirement. Students were able to complete the assigned course activities by or before the assigned due dates. Assessments include multiple choice quizzes based on complementary videos from a multinational education company, worksheets and written papers. There were no required communication opportunities between students. In this study, I focused on sociomaterial assemblages where formative assessment practice opportunities emerged from intra-actions between the course design and the instructor (Barad, 2007; Deleuze & Guattari, 1987). This is where multiple social and material factors worked together (Müller, 2015).

Barad’s (2007) agential realism theoretical framework and diffractive analysis helped me to understand the role of the materials and enabled me to describe the practices that emerge from the sociomaterial assemblages through intra-actions. The agential realism theoretical framework aligns with the “post” methodologies and it enabled me to explore and discuss the “conjoined material-discursive nature of constraints, conditions, and practices” (Barad, 2003, p.823) where practice is socially shaped in a community and activities are negotiated (Leonardi, Nardi & Kalliniko, 2012). The aim was to illustrate

the assemblages, focusing on how the resources, both social and material, enable what the participants are able to say.

### **What I Did and What I Found**

I began by re-reading the theory of agential realism (Barad, 2007) and with those ideas fresh in mind I read the data in the online course. I took field notes and attempted to identify and describe what the assemblages in the course plug into (St. Pierre, 2015, p.89). Thinking with theory for this research question meant I was able to consider the “conjoined material-discursive nature of constraints, conditions, and practices” (Barad, 2003, p.823) by focusing my data analysis primarily on the entanglement of the instructor and the material. This focus on “the entangled nature of differences that matter” (Barad, 2007, p.381) enabled me to identify properties within the material, which enabled or limited the instructor’s formative assessment practices in this context. Furthermore, I also considered how the instructor could use the technological features built with a specific intention in mind and how its properties determined how the technology was used in practice (Norman, 2013). I defined my agential cut (Barad, 2007) so I could “peek” inside the phenomenon to observe the agency regarding the course design (instructional design) and the instructor’s formative assessment practices. **Diffractive data analysis** enabled me to consider how those tools are driving the instructor’s practice and entangling the instructor and is done by considering what the assemblages “plug into”. I asked 1) What knowledge is produced? I looked for cases where student learning was showcased. Then I asked 2) What force the sociomaterial assemblages wield? This prompted me to consider how can the teacher help the student, what opportunities are available?”. Finally, I considered How these assemblages can be oppressive (to the

instructor's formative assessment practices)? I did find it helpful to see if there are times the teacher is does not help the student.

While in Chapter 3 the assemblages plugged into individual assessments, in this manuscript I took a more global view in the same course and I found the assemblages which in the previous study plugged into individual assessments now in this agential cut engulfed multiple assessments. While the individual assessments still consisted of three intra-acting sociomaterial elements, these assessments were also intra-acting and the role of the technology tools could cross multiple assessments.

Thus, I found that assemblages as related to formative assessment plugs into linear structure of the course design, the instructor, and the technology features used to implement the course assessments (e.g. writing assignments, quizzes and worksheets). Furthermore, I chose to aim to understand the agency of these assemblages by considering agential cuts as a way to define the boundaries of a sociomaterial assemblage and "peek" inside a phenomenon to observe the agency (Barad, 2007). These agential cuts enabled me to consider how the instructor is using the technological tools and how those same tools are driving the instructor's practice by focusing on 1) what knowledge is produced, 2) what force the sociomaterial assemblages wield, and 3) how these assemblages can be oppressive. Specifically, knowledge produced by students illustrates to the instructor students' initial understanding of the content, often providing enough data to show students' current understanding. This is what the intra-actions enable to be said. How and if the instructor is able to address a student's current understanding and encourage them to push the boundaries surrounding their current conceptual ideas is also influenced by the assemblages, encouraging conditions that highlight what cannot be



said. The force these sociomaterial assemblages wield is powerful because it drives instructor opportunities to challenge students' to move beyond their commonly held assumptions. Finally, these assemblages can be considered oppressive because they can dictate the opportunities an instructor has to aid student learning.

### **What is Said and What is Not Said**

This “persistent critique of something you cannot not want” (Spivak, 1993, p.47) empowered me to consider the conditions that enabled what could and what could not be said. I found the linear structure of the course (Figure 1) encouraged intra-actions leading to specific discourses. These intra-actions encouraged the instructor to engage students in a logical and systematic fashion that encouraged a clear path for student progression, a positive outcome of the course design. Yet, this same linear structure also limited opportunities for the instructor’s practice to aid students as they struggle to reconsider commonly held assumptions from a formative assessment perspective. Specific structures within the course design (Aghasaleh and St. Pierre, 2014; 2015), rather than specific types of assessment activities, encouraged conditions which enabled what could or could not be said (Foucault, 1966/1970). Precisely, the main finding of this study is that the linear nature of the course design is oppressive. In this circumstance, I use the term oppressive to indicate that while the linear nature of the course design supports students this same structure falls short meeting the needs of the instructor; there is a need for a backend design for the instructor that consists of a progression with opportunities to loop backwards to further student understanding and address conceptual challenges. This could be accomplished for example by including assessments that have features such as

multiple drafts, long term projects, quizzes or work sheets that build on knowledge learned in the course.

Furthermore, I found what was interesting were that these conditions began to arise as a consequence of this unidirectional linear progression course design which guided both students' and the instructor's discourse. This unidirectional progression further intertwined with the fact that content topics were designated for each unit contributed to the content discourse and forms of formative assessment practices available to the instructor. For example, in this course students learned how to read nutrition labels in one unit and then learned about GMOs in a later unit. Both of these topics are important to include in a nutrition course and were well presented from a student perspective; yet, the linear progression of the course combined with the content resulted in intra-actions which entrapped the instructor's formative assessment practices. Figure 1 explains how the linear progression of the course intra-acted with the instructor's practices. The knowledge produced through these intra-actions can severely limit discourse to aid student learning resulting in sociomaterial assemblages which wields an oppressive force limiting formative assessment practices and in turn could limit student learning.

The diffraction pattern as a result of the sociomaterial elements of the course design determines where, when and how often the instructor and students communicate. I am interested in where the effects of differences regarding the material elements appear related to what enables and constrains aspects of the instructor's formative assessment practices. Therefore, I chose to diagram the effects of intra-actions as an assemblage within a formative assessment cycle (Abell & Siegel, 2011) (Figure 15).

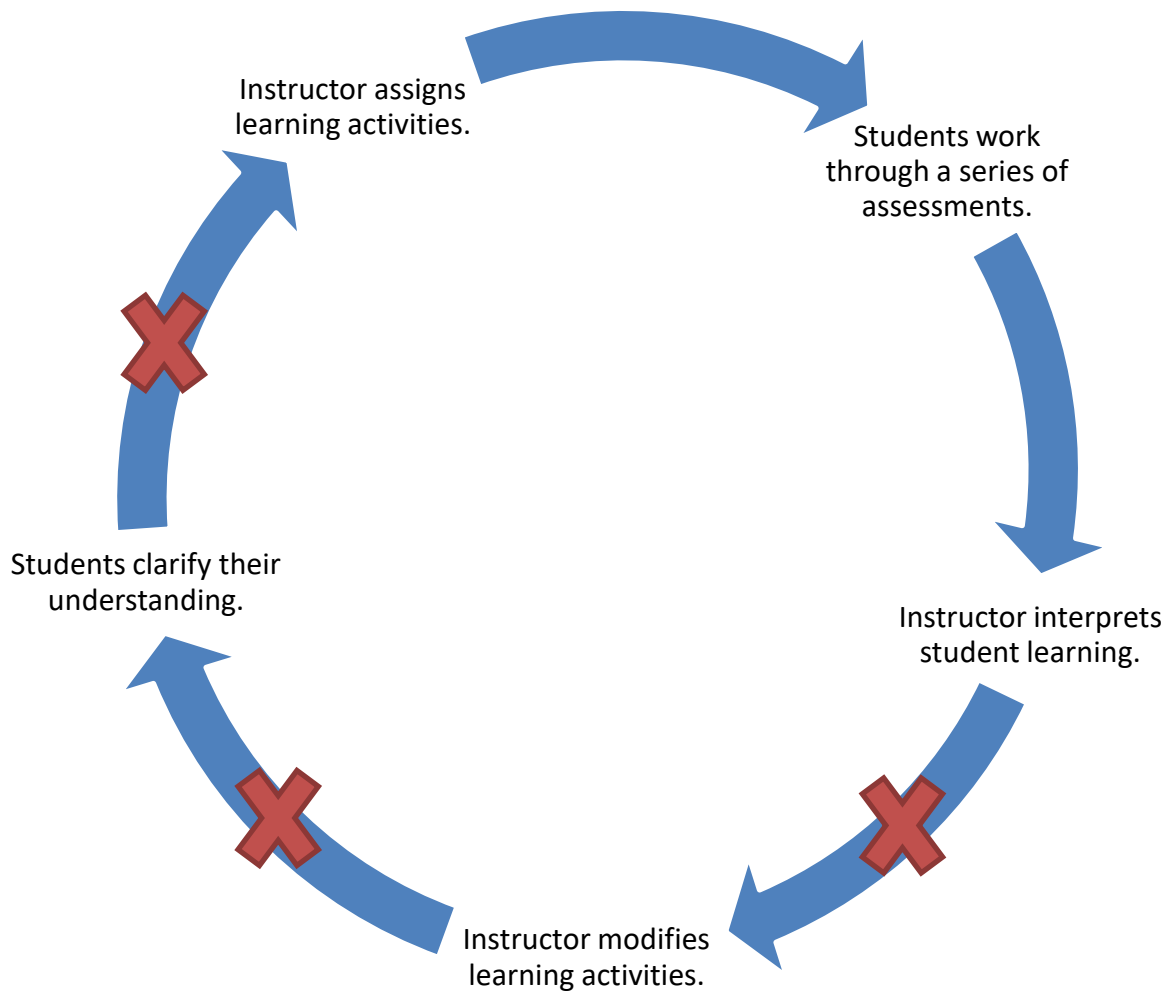


Figure 15. Diagram of sociomaterial intra-action diffraction patterns of formative assessment.

Figure 15 is a diagram that illustrates the assemblages entangling the instructor and the course instructional design. Unlike a more traditional view of assessment where the instructor teaches a topic and then the student is assessed on their ability to learn the information, formative assessment continuously gauges student understanding and is used

as a tool to support learning. The instructor assigns learning activities, and in an online course the course design encourages specific types of learning activities to be assigned (i.e. computer based activities, student centered activities, and sequential quizzes). Students work through the series of assessments. The instructor interprets student learning based on those assessments, and identifies where students need help. Next, the instructor modifies learning activities to align with student needs; however, in online courses the linear course design constrains the ability to modify instruction. This in turn limits the opportunity for students to learn and rethink areas essential for understanding. The effect of this assemblage is to place barriers regarding what can be said specifically related to instructor action taking.

Sociomaterial studies are able to shift the conversation to focus on assemblages and describe *how and why*, “how they move, and how they produce what may appear to be distinct objects, subjects, and events. How and why do certain combinations of things come together to exert particular effects?” (Fenwick & Landri, 2012, p.3). Sociomaterial studies can include the knowledge produced by assemblages (Fenwick & Landri, 2012), and how assemblages drive discourse including not just what is said but what *can* be said (Barad, 2007). This focus also enables a discussion regarding how oppressive assemblages can be interrupted and weakened (Fenwick & Landri, 2012). Specifically, in this study we focus our discussion of sociomaterial assemblages on “how they move, and how they produce what may appear to be distinct objects, subjects, and events. How and why do certain combinations of things come together to exert particular effects?” (Fenwick & Landri, 2012, p.3) and how to interrupt and weaken oppressive aspects of

these assemblages that influence the instructor's practice regarding formative assessment action taking.

### **How, What, Why**

**How They Move and What They Produce.** The previously described assemblages result in emergent teaching practices produced by intra-actions with the instructor and the materials.

These findings align with Bolldén's (2015) findings that technology does not determine a specific way of teaching; rather "... technology and teaching should be seen as relational" (p.93), and "online teaching practices could be understood as emergent" (p. 93). In this study emergent teaching practices arise from intra-actions with the instructor and the course design which produce formative assessment practices that determine what can and cannot be said to aid student learning. Furthermore, Bolldén concluded that online pedagogy should be considered a multifaceted concept, rather than a series of best practices, because the characteristics of materiality are qualitatively different depending on the technology platform (Bolldén, 2015), where practice is affected by a network of social and material interactions.

**How and Why They Exert Particular Effects.** The course design is designed for the student not the instructor. The current course design follows recommended student-centered learning criteria, a positive aspect that is important to support student learning. Yet, this same course design does not consider or accommodate the instructor's needs for opportunities to address student difficulties. One way to move the intra-actions, and as a result interrupt and weaken oppressive assemblages would be to consider the instructor needs regarding formative assessment practices. A course which builds on prior

knowledge may create a looping effect for the instructor yet still give the students the linear progression they need while giving the instructor opportunities to challenge students' current conceptual understanding, even after moving on to the next unit. Semester/course long projects, done in a group or individually, could achieve this goal over the entire semester similar to how assessments can achieve this within one assessment or unit. For example, in this nutrition course the multinational education company's website provides the 3-4 videos that are incorporated into activities in each unit for students to complete. For the instructor this gives an opportunity to evaluate students over several activities and an opportunity to incorporate problems students have in one unit into one of the several mini activities in the next unit.

These findings suggest that from a formative assessment perspective what can be said to aid student learning can be supported or oppressed by the intra-actions which include the material elements in a course. Our findings align with other suggestions that the actual course design properties can determine how the technology can be used (Norman, 2013). This also builds on the findings of Gerard, Spitulnick, & Linn (2010) who discussed opportunities for instructor **interpretation and action taking** using technology and this focus on intra-actions aligns Mishra and Koehler's (2006) suggestion to include in research *how* teachers use technology and the teacher's contribution. Furthermore, Bolldén's (2015) online pedagogy model, illustrates the relationship between teaching practice and the technological arrangement. While our findings build on a literature base identified by Donnelly, Linn, and Ludvigsen (2014) which claims that the contribution of the teacher is important for technology based student activities (e.g. Furberg, Kluge, & Ludvigsen, 2013; Gerard et al., 2010). This study helps to address a

point that Donnelly et al. (2014) found that for most studies the teacher's role in technology based environments needs to be considered, yet has not. While we consider both the material and the human element our results agree with Furberg, Kluge, and Ludvigsen Spitulnick, and Linn (2010) that the teacher can be a major contributor to the success of a technology-based activity.

Furthermore, this study also provides additional insight into the tension described by Gerard et al. (2010), that teachers want the ability to customize the curricula for their students while there is a tendency for researchers (and instructional designers) to be concerned with maintaining the integrity of the learning environment (Barb & Luehmann, 2003; Squire, MaKinster, Barnett, Luehmann, & Barab, 2003). There could be intra-actions involving the teachers and the materials that are oppressive and do not support formative assessment activities. When course design incorporates the needs of the instructor and considers the intra-actions that form it can provide a means to support the needed adaptive curriculum and a way to incorporate collaboration in the process of design (Barb & Luehmann, 2003).

Hennessy, Deaney and Ruthven (2006) alluded to helping students learn when one teacher expressed a desire to create or modify the simulations themselves to account for student difficulties, and the authors pointed out, "The need for teachers 'to walk around and talk things through' (and provide procedural/ technical help) is a feature of much practical work too, but, as one teacher pointed out, computer screens are less visible from a distance and knowing where assistance is needed can be difficult" (p.727). Knowing where students need help both procedurally and conceptually is a unique challenge for teachers' practice when using technology. Furthermore, "iterative

refinement based on student and teacher feedback improves both the curriculum and inquiry teaching strategies” (Donnelly et al., p. 591). Additional research could address how assemblages that support instruction are created.

Additionally, as I suggested in Burcks, Siegel, Murakami and Marra (2019) our findings have implications for instructional design to support science learning illustrating what Barad (2003) explains, “what often appears as separate entities (and separate sets of concerns) with sharp edges does not actually entail a relation of absolute exteriority at all” (Barad, 2003, p.803). In Burcks et. al. (2019) we considered data from student work and suggested that the structure of the course was undermining the course goal to show science as process. Specifically, the implications from the current study for instructors and course designers is that they should consider the course design can affect the discourse possible for science instructors and can in turn affect their formative assessment practices. Furthermore, I found that the linear structure of this course which did not consider the looping needs of the instructor resulted in intra-actions which limited instructor formative assessment practices, possibly limiting the ability of the instructor to aid student learning.



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## CHAPTER FIVE

### Conclusions

In this conclusions section, I explore the overarching ideas and implications that resulted from this study. I also highlight the contributions and differences among the 3 manuscripts. This specific approach provided a lens that uniquely enabled me to explore the active role materials play on the instructor's formative assessment practices. I was able to consider how the instructor shaped the materials in Chapter 2 using a humanist study. Chapters 3 and 4 addressed what the materials enable *could* be said in this context (Barad, 2007). Additionally, I chose to collectively discuss the ideas and implications presented by all three manuscripts. These manuscripts illustrated that assessments at the individual assessment level and the course design level can and do impact instructor practices. Specifically, these studies suggest that the features in assessments can both aid and hinder instructor practices. At this point it should be clear that if assessments have agency that agency can impact instructor formative assessment practices. This agency could have direct consequences on student learning.

In Chapter 2, I considered how the instructor's practices shape the assessments. I found the tools that support the teacher's formative assessment practices provide the instructor the prospect to build in *communication* opportunities and to provide a way to *customize* the assessments. While student centered learning practices are valuable and student engagement with the materials is important, I also suggest that design in virtual learning environments needs to be built to explicitly support the instructor's formative assessment practices. These features can be considered as instructors and course

designers build in affordances into the course (Norman, 2002). This would enable certain actions regarding formative assessment to be made easier to implement.

In Chapter 3, I explore how assessments in virtual learning environments consist of three elements: 1) the content (e.g. the science), 2) the style (e.g. worksheet, writing assignment, quiz etc.), and 3) the technology tools. I consider how and why these three pieces work together to support or hinder formative assessment practices. One contribution of this research is to provide a way for instructors and course designers to consider these three aspects and how they come together to influence ways to support instructor formative assessment practices in virtual learning environments.

In Chapter 4, I consider how the linear structure of the course may be helpful for students to navigate but does not consider what I term the looping needs of the instructor. I diagrammed oppressive entanglements which can engulf online formative assessment opportunities (Figure 15). I explain that course design that supports instructor formative assessment practices that loop can provide the instructor multiple opportunities to aid student learning by moving forward with content. I also suggest that these needs can be met across multiple assessment and multiple educational technology tools.

Taking all three of these studies together I suggest instructor looping needs can be met when assessments provide multiple points for *communication* and *customization*. This may happen with one assessment or across assessments. For example, addressing science content in multiple contexts that span multiple drafts over an extended time frame may be helpful in supporting instructor formative assessment practices. Additionally, assessments that build upon itself (e.g. concept maps, use multiple technology tools, stacked quizzes) may be useful for instructors as well.

In virtual learning environments we get to explicitly build in the opportunities for assessments to support continuous entanglement of the student, the instructor and the materials. This research suggests that future research may want to consider the possibility that student centered learning theories and student centered course design for online education (Cavanaugh, 2009; Lorenzo & Moore 2002; Picciano, 2012; Puziferro & Shelton, 2008; MarylandOnline, 2013) and if instructor practices are left unconsidered it is possible it could undermine student learning.

In online courses it is possible that the instructor could be more effective, and these findings delve into a different view that may be able to better explain the how and why of findings such as Jaber, Dini, Hammer and Danahy (2018) and Bernard et al.'s (2009) literature review. These studies claim that virtual learning environments have yet to show interactive learning opportunities equal to face-to-face and that an instructor has limited influence on student learning, respectively. I suggest that this may be because these opportunities have not yet been built into the course and there is a need to consider that materials designed to support learner engagement with the content can inhibit instructor intra-actions to aid learning. Furthermore, rather than compare face-to-face interactions to virtual learning environments one needs to consider how to build in opportunities for the instructor to *communicate* with students and *customize* assessments.

**Putting It Into Action.** The findings from these studies provide implications for instructor practice, course design and best practices for teaching and learning in virtual environments. This research suggests that assessment in virtual learning environments consists of three elements: 1) the content (e.g. the science), 2) the style (e.g. worksheet, writing assignment, quiz etc.), and 3) the technology tools. These findings can help



develop assessments that fully support student learning by including the instructor's assessment needs and abilities including instructional design by considering how to loop assessments. I acknowledge that instructors may be able to work around some limitations to have meaningful experiences with students which aid learning. Instructors may be able to break free of oppressive assemblages by finding ways to work outside an assessment. For example, instructors could work outside an assessment's oppressive limitations by encouraging students to rework questions and using email to *communicate* and *customize* when needed. Yet, course assessments can be built to intentionally provide opportunities for instructors to interpret and take action to meet student needs by intentionally building in looping assessments that provide opportunities for *customization* and *communication*.

Practical implications of this study include implementing previously established formative assessment practices with assessments that provide opportunities for *communication* and *customization* using tools available in technology-based assessments. For example, Classroom Assessment Techniques (CATs) (Angelo & Cross, 1993) could be implemented using tools such as discussion questions and email in virtual learning environments. Looping opportunities that build in *communication* and *customization* use assessments such as: semester or unit long projects, stacked quizzes, and multiple technology tools. These assessments build on conceptual ideas while providing opportunities to loop back around to revisit areas instructors need to address. Finally, consider the use of more than one technology tool for an assessment as an additional way to incorporate how to meet instructor formative assessment needs. For example, a threaded discussion could ask students to create quiz questions, those questions can be used to create a quiz for students to complete to readdress important material. Quizzes

can be completed multiple times and be used to build a foundation for a concept map. The concept map can then be added to and modified throughout a unit or semester. An instructor can customize research project opportunities based on their own expertise and knowledge of student needs. For example, consider research projects can be completed as assessments in virtual environments by reporting back events that occur in real life over an extended period of time.

Overall, by exploring the active role materials have on the instructor's formative assessment practices I have been able to contribute a new perspective to the research in education. As a post-humanist qualitative study I cannot suggest that these findings are generalizable to all virtual learning opportunities, nor would I want to. Instead, I have brought this issue to the attention of academics and leave it up to the reader to determine if these specific suggestions are applicable in their own circumstances. Yet, my hope is that those involved in teaching with technology begin to consider that the materials can have agency in virtual learning environments. I anticipate others may also see a need to incorporate the agency of materials into student centered learning theories and student-centered course design for online education. I expect that readers will begin to question why instructors may not be as effective as they could be in a particular context and possibly consider what oppressive assemblages may be forming. Finally, I hope that others find the suggestions I offered on how to breakup oppressive assemblages and empower instructors to aid student learning in virtual environments useful. Helping students develop an understanding of science and science concepts in virtual environments is an important and challenging task. As science curricula content and assessment continue to shift to a more diverse offering in virtual formats (Smetana &

Bell, 2012) it becomes increasingly imperative for us as science educators to consider how to best support our own practices that aid student learning in this context.

Furthermore, I believe implementing these practical implications may help educators and students meet the goals set forth for scientific literacy and scientific knowledge in the workforce by undergraduate and K-12 reform policy documents (NRC, 2012; Achieve Inc., 2013) as well as heed to calls set forth by the AAAS (1993, 2013), the NRC (2010, 2011, 2012a, 2012b, 2013) and the CRUSE (2014). Finally, this research study contributes to assessment scholarship by offering instructors, course developers and researchers an different view point to consider when as they make instructional decisions with the aim to aid student learning (e.g. Bell, 2007; Black & Wiliam, 1998, NRC, 2012; Shepard, 2000). I believe there is a vast amount of potential in using virtual formats to reach the goals set forth for science learning and assessment. This potential is and is only held back by our ability to move beyond our current conceptions and consider how the technological tools can be integrated to work synergistically to support both teaching and learning.

**Methodological Reflection.** When I began this research I thought it would not be difficult to switch between human and post-humanist research. I was wrong. I found post-humanist research was intuitive and made sense because the question that I really wanted to ask was only addressed from a post-humanist paradigm. The case study did not enable me to study the structure I saw. The humanist study broke apart the thing I wanted to understand and took it out of context. I found the results of the case study mildly interesting. I have no desire to explore these ideas in future work using a different humanist theoretical framework, such as TPCK (Mishra & Koehler, 2006).

I am interested in the technology itself, *what it encourages* people to do. I would like to consider other post-humanist theories that value the materials and see how or if they can shed new light on online formative assessment practices. However, methodologically I found two points counterproductive. First, the role of data in post-qualitative manuscripts is an important point that I might explore more in the future. Second, I feel that the format of the manuscripts at times can be counterproductive. I enjoyed reading the post-humanist literature especially compared with my intense frustration with conventional manuscripts. However, I understand many people experience the opposite. Therefore, if I want people to read my study and consider a new way to think about these topics then I would like to communicate my research in a way conventional qualitative researchers will see the value, and showing the data is part of that. I think the format of the manuscripts may need to be tailored to appeal to a broader audience. Regardless of these points, I do think post-qualitative inquiry can help move the field of science education forward by encouraging researchers to consider a post-humanist subject.

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## VITA

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