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THE INNOVATION EVALUATION PROCESS OF UNDERGRADUATE BIOLOGY INSTRUCTORS WHO ACTIVELY USE CASE STUDIES IN THEIR INTRODUCTORY BIOLOGY COURSES

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WENDY M. MARTIN
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THE INNOVATION EVALUATION PROCESS OF UNDERGRADUATE BIOLOGY INSTRUCTORS WHO ACTIVELY USE CASE STUDIES IN THEIR INTRODUCTORY BIOLOGY COURSES

A DISSERTATION APPROVED FOR THE
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BY

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Dr. Timothy Laubach, Chair

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Dr. Edmund Marek

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Dr. Lawrence Baines

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Dr. Kansas Conrady

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Dr. John Philip Gibson

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Abstract

There is little detail in the literature that describes how college biology instructors have evaluated case study teaching as an innovative teaching strategy. This study used Diffusion of Innovations (DOI) Theory and innovation evaluation as the theoretical framework to identify and describe the information seeking processes that college biology instructors who actively use case studies in their introductory biology courses (referred to as case study faculty hereafter). The purpose of this study was to understand why and how case study faculty came to know, value, and implement case study teaching with the intention of using this information to help motivate change among college biology instructors who are reluctant or undecided about making a change to their teaching practices. A phenomenological approach was used to describe the experiences that seven case study faculty went through from their first exposure to the decision to implement and adopt case study teaching. Data analysis revealed nine themes or meaning units shared by five or more of the seven participants. The findings show that the meaning units were applicable to DOI Theory and innovation evaluation. The findings also suggest that there could be more places within DOI Theory where innovation evaluation takes place than previously suggested. This study describes the communication channels that case study faculty used to learn about case study teaching, how long it took them to make the decision to implement and adopt case studies in their classroom, their information seeking processes, processes that influenced their decision, and the resources they utilized. Implications for college biology instructors wanting to use case study teaching are provided.

Chapter 1: Introduction

Advances in life science research and the societal and technological issues of the 21st century are some of the reasons that undergraduate biology education is in the process of a widespread transformation according to *Vision and Change in Undergraduate Biology Education: A Call to Action – Final Report* (American Association for the Advancement of Science [AAAS], 2011). Most college students take at least one science course in college, and introductory biology is one of the most highly enrolled undergraduate science courses in the United States (Nehm & Reilly, 2007). *Vision and Change* (V&C) identifies the approaches, content, competencies, and the delivery of effective teaching practices for undergraduate biology education (Vasaly, Feser, Lettrich, Correa, & Denniston, 2014).

The traditional approach to science instruction, the *cover it all* lecture format, may not be optimal and tends to promote low-level learning (AAAS, 2011). However, the authors of V&C address the common misconception that student-centered learning means doing away with lectures altogether. Instead, V&C recommends a different approach, which is to use multiple modes of instruction in addition to lectures. For example, active learning practices such as collaborative and cooperative learning activities (i.e., peer instruction), and project-based learning activities (i.e., case-based learning) that are interactive, team-based, and inquiry driven (AAAS, 2011) could be used to supplement lecturing. Additionally, the Partnership for 21st Century (P21) Framework for 21st Century Learning describes a number of competencies that students need in order to successfully work and live in the 21st century (P21, 2015). Some of these competencies include critical thinking, problem solving, communication and collaboration. V&C also indicates that active learning can produce significant gains in critical thinking, problem solving, effective communication, and collaboration (AAAS, 2011).

In order to address these concerns and recommendations, college faculty are being asked to shift their focus from teacher-centered learning to student-centered learning and also away from attempting to present all of the content within the textbook (AAAS, 2011). In addition, college faculty are being urged to actively engage students by involving them in the learning process (Allen & Tanner, 2005; Bonwell & Eison, 1991; Michael, 2006; National Institute of Education [NIE], 1984; National Research Council [NRC], 1999, 2000; National Science Foundation [NSF], 1996). Using active-learning teaching practices, faculty can (a) promote teamwork and collaboration through group projects; (b) provide immediate feedback, usually with the use of student response systems such as clickers, to ensure that student have grasped the material; (c) implement material that is more relevant to the students' lives; and (d) improve critical-thinking skills with problem-based learning (PBL) (Ebert-May, Brewer, & Allred, 1997; Gasiewski, Eagan, Garcia, Hurtado, & Chang, 2012; Knight & Wood, 2005; Prince, 2004). While there are other uses and outcomes resulting from active learning, this study focused primarily on these four teaching practices (teamwork and collaboration, immediate feedback, relevance of the material, and PBL) and how they relate to an active-learning teaching strategy termed case-based instruction (referred to as case study teaching hereafter).

Understanding how college biology instructors view different innovative instructional strategies could increase the chance of successful implementation of active-learning strategies, such as those recommended by V&C (Brown, Abell, Demir, & Schmidt, 2006) and P21 (Voogt, Erstad, Dede, & Mishra, 2013) by college biology instructors who may be reluctant or undecided to incorporate these strategies. This study explored the experiences that college biology instructors have had with regard to the evaluation of information processes that influenced their decision to use an innovative active-learning strategy such as case study teaching.

Diffusion of Innovation (DOI) Theory (Rogers, 1995) explains the process by which an innovation is communicated through certain channels over time among members of a social system (Rogers, 1995). Within DOI Theory, Rogers described innovation-evaluation information, which is the subjective evaluation of information derived from individuals' personal experiences and perceptions of an innovation. Innovation-evaluation information can be found within different areas of DOI Theory; therefore, both the influence of innovation-evaluation information (referred to as innovation evaluation hereafter) and DOI Theory served as the theoretical framework for this study to describe how college biology instructors arrived at their decision to use the innovative active-learning teaching strategy called case study teaching.

Problem Statement

There is little detail regarding the evaluation and information seeking processes used by college biology instructors who have chosen to use case study teaching in their introductory biology courses. Due to the emphasis for widespread transformation of undergraduate biology education to move away from lecturing as the primary teaching method to the use of active-learning practices (Bonwell & Eison, 1991; Freeman et al., 2014; NRC, 1997), it is important to investigate the factors that influenced college biology instructors who chose to implement case study teaching practices. These findings could provide support and motivation to others (Millar, 2003). Even with evidence that active learning shows increases in student engagement and achievement, lectures continue to prevail as the dominant teaching method in undergraduate biology courses (Knight & Wood, 2005; Walker, Cotner, Baepler, & Decker, 2008). By gaining information about the evaluation process, professional development programs could present case study teaching, or any active-learning strategy, in a more effective manner. This could, in turn, increase the likelihood that college biology instructors who may be reluctant or undecided to use case study teaching respond more favorably to this innovative teaching strategy.

Background and Need

Active learning is an umbrella term for pedagogies that focus on student academic engagement and activity during the learning process (Prince, 2004). The impacts of active-learning practices that show increases in student learning at the college level have been well documented (Bonwell & Eison, 1991; Freeman et al., 2014; Knight & Wood, 2005; McClanahan & McClanahan, 2002). While it is important to know about promising practices that fall under the active-learning umbrella such as collaborative and cooperative learning activities, project-based learning, peer teaching, and case-based learning (Prince, 2004; Zayapragassarazan & Kumar, 2012), it is equally important to understand not only the barriers that have caused resistance but also the promotion of favorable responses if we are to continually promote the transformation of college biology education (Henderson, 2012; Sorcinelli, 2007).

Case study teaching encompasses many of the skills and competencies that the Partnership for 21st Century Learning (P21, 2015) and V&C (AAAS, 2011) believe are necessary for students to function in today's society, such as, critical thinking (Chaplin, 2009; Noblitt, Vance, & DePloy Smith, 2010), communication (Noblitt et al., 2010), collaboration, and decision-making (Dabbagh & Dass, 2013). Case study teaching, which is a form of PBL, is an adaptable instructional method that has been shown to actively involve students in the learning process (Bilica, 2004; Bowe, Voss, & Artez, 2009; Chaplin, 2009; Dori, Tal, & Tsaushu, 2003; Herreid, 1994a, 2007). Case studies are built around a central story that can provide college biology instructors with a flexible teaching strategy that connects real-world contexts with science content and inquiry, which can lead to better conceptual learning and critical-thinking skills (Herreid, 1994a).

Studies have uncovered some of the barriers leading to the resistance to active-learning teaching by college biology instructors. These include a mistrust of education research data (DeHaan, 2005; Herreid, 2011b; Wood, 2009), not enough time to make changes to their courses (D'Avanzo, 2013; Marsteller & Kohlhorst, 2014; Silverthorn, Thorn, & Svinicki, 2006), difficulty assessing learning (D'Avanzo, 2013; Yadav et al., 2007), and less content coverage (Marsteller & Kohlhorst, 2014; Silverthorn et al., 2006). Despite these barriers, however, a growing number of college biology instructors are using active-learning teaching methods (Knight & Wood, 2005; McPhearson, Gill, Pollack, & Sable, 2008), and more specifically, case study teaching (Alvarez, 1993; Dori et al., 2003; Herreid, 1994a; Yadav et al., 2007).

In order for case study teaching to become successful in undergraduate biology courses, college biology instructors must be open to the disposition of change (McPhearson et al., 2008). Unfortunately, there are college instructors unwilling to change their teaching methods from a passive, lecture-style approach to more active, student-centered strategies even though there is evidence that lecturing is less successful than active learning (Dancy & Henderson, 2008; Seymour, 2001). In order to persuade more college biology instructors that case study teaching is an effective, innovative teaching strategy, we need to find something that inspires or motivates them in order to suggest change. Perhaps looking at what inspired or motivated change among others could make a difference.

Research shows that there is a personal bias as to why some instructors have positive attitudes toward the use of innovative instructional strategies (Andrews & Lemons, 2015; Gess-Newsome, Southerland, Johnston, & Woodbury, 2003; Henderson, Dancy, & Niewiadomska-Bugaj, 2012; Millar, 2003; Sunal et al., 2001). Andrews and Lemons (2015) reported some of the personal reasons college biology instructors implemented and adopted active-learning teaching practices. They chose case studies as their model system for examination. The key finding from their study was that the participants' desire to make changes to their teaching style is less influenced by empirical evidence but more influenced by personal reasons, such as, the dislike of lectures, the compatibility with their personality and teaching style, and the opportunity to interact with students.

The four active-learning teaching practices profiled earlier (teamwork and collaboration, immediate feedback, relevance of the material, and PBL) have been shown to increase learning gains, conceptual understanding, and foster student academic engagement (Ebert-May, et al., 1997; Gasiewski, et al., 2012; Knight & Wood, 2005; Prince, 2004). These active-learning practices have also shown great promise among today's students, referred to as Millennials (Roberts, Newman, & Schwartzstein, 2012; Roehl, Reddy, & Shannon, 2013).

Millennials, born between 1982 and 2002 (Howe & Strauss, 2000), have grown up with technology that provides quick answers plus instant gratification, usually provided by Google at their fingertips. It is this rapid growth of technology that makes active learning and academic engagement so crucial (Roberts et al., 2012; Roehl et al., 2013). A component of active learning is teamwork. Millennials are generally successful team players and less limited by social boundaries; thus, teamwork becomes an important element for their successful learning environments (Roberts et al., 2012). This can also be beneficial for students to develop the team-player skills that many employers demand (Eng, 2013). However, actively engaging Millennials, or any type of student for that matter, in the learning process by way of active-learning practices means an adjustment by many college biology instructors in their teaching approach (Eng, 2013; McPhearson et al., 2008; Nikirk, 2012; Roehl et al., 2013). Educators who have had Millennials in their classrooms reported that these students prefer active and engaging activities rather than traditional lectures (Brown, Hansen-Brown, & Conte, 2011; Pardue & Morgan, 2008; Roberts et al., 2012; Roehl et al., 2013).

There are many studies that have examined the academic outcome of case study teaching (Chaplin, 2009; Noblitt et al., 2010; Dabbagh & Dass, 2013; Herreid, 2007) and the reasons college biology instructors are for (Herreid, 1994a, 2007) or against implementing case study teaching (DeHaan, 2005; Herreid, 2011b; Wood, 2009). There is also a study showing that personal reasons override empirical evidence with regards to choosing to implement case study teaching (Andrews & Lemons, 2015). If this is the case, where do faculty who are actively using case studies as a part of their teaching practice (referred to as case study faculty hereafter) turn for information about using case study teaching? While it seems reasonable that case study faculty first heard about using case study teaching from someone else, we do not know what they did with that information or where they turned next. What was pivotal in their decision to implement case studies as a teaching strategy? Using DOI Theory and innovation evaluation (Rogers, 1995), this study attempted to uncover how some case study faculty learned about case study teaching and the information seeking processes that they used to influence their decision to implement and adopt case study teaching.

Purpose of the Study

Purpose. The purpose of this phenomenological study (Creswell, 2007; Moustakas, 1994) was to identify and describe the processes that underlie the initial evaluation of an innovation (case study teaching) by case study faculty and how it influenced their decision to implement and adopt case study teaching in their introductory biology courses.

Rationale. There are college biology instructors who have restructured their introductory biology courses to include the use of case studies. Some have even extended their interest in this teaching strategy to include attending or presenting at the Conference on Case Study Teaching in Science that is hosted every year by the National Center for Case Study Teaching in Science (NCCSTS) at the University of Buffalo

(Herreid, Schiller, Herreid, & Wright, 2011, 2012). These particular college biology instructors have demonstrated more than just the occasional attempt at using case studies; they have truly embraced this innovative teaching strategy (Herreid, 2011a).

Due to the passion that these college biology instructors have for case study teaching, understanding why and how they came to use case studies might provide inspiration for reluctant or undecided instructors as a motivation for change. It has been shown that case study faculty are motivated by personal reasons, such as, the dislike of lectures, the compatibility with their personality and teaching style, and the opportunity to interact with students (Andrews & Lemons, 2015). Andrews and Lemons also showed that the participants in their study downplayed the role that empirical evidence made in their decision to use case studies. If there were any sources of empirical evidence used by case study faculty, knowing where these faculty members turned for this information and how it influenced their decision to implement and adopt case study teaching could be beneficial. If empirical evidence had less of an effect on their decision to use case study teaching as Andrews & Lemons suggested, what then, does have an effect? Rogers's (1995) DOI Theory and innovation evaluation seemed most relevant as a theoretical framework to describe the information seeking processes that case study faculty followed to influence their decision to utilize case study teaching.

Description of the study. A qualitative methodology with a phenomenological approach (Moustakas, 1994) was used to conduct exploratory interviews consisting of semi-structured, open-ended questions (Berg, 2007; Creswell, 2007) with faculty who use case studies in their introductory biology courses. The research data were collected via Skype interviews, which enabled me to observe additional indicators such as facial features, behaviors, hand gestures, etc. that may have been lost during a phone interview. One interview, however, was conducted by phone because the participant did not use Skype. For this participant, the observable indicators were changes in voice, laughter, pauses, and inflection.

Faculty who teach introductory biology and who have also attended the Conference on Case Study Teaching in Science were purposefully selected for this study. Interviews were recorded on a digital recorder while field notes containing participants' exhibited behaviors were compiled in a journal. The transcribed data and field notes were analyzed using a systematic content analysis strategy to develop a list of significant statements and to look for major themes (Creswell, 2007; Moustakas, 1994). Analysis was conducted in a line-by-line format of the verbatim transcripts, considering all statements relevant to the phenomenon with equal value, and removing redundant statements to reveal a textural description. From each textural description, I constructed structural descriptions, reflecting my representation of the participants' experiences with the phenomenon. Finally, I combined the textural and structural descriptions to form a composite description of the phenomenon and a universal description representing all participants as a whole (Moustakas, 1994). Meaning units shared by the participants were consistently checked against the research questions throughout the data analysis process in order to keep the data pertinent to the objective of this study (Creswell, 2007).

Expected outcomes. The data from this study could be used to fill a void in the literature by determining what kind of outside knowledge case study faculty seek to influence their decision to use case studies in their classrooms. By filling this void in the literature, I hope to further the transformation of college biology education. In addition, I would like to incorporate this information into professional development programs for college biology instructors who are interested in learning more about using case studies as an innovative teaching strategy.

Research Questions

If we are to continue to transform undergraduate biology education, which is directed at the implementation of active-learning practices, we need to persuade more college biology instructors to make changes to their teaching practices. Understanding why and how college biology instructors came to know, value, and implement these practices could be useful to motivate change among those who are reluctant or undecided. For case study faculty, specifically, it was my intention to discover when and where they turned for supportive evidence (personal or empirical) that influenced them to implement and adopt case studies in their classroom by asking the following questions:

1. What are the communication channels in which case study faculty use to learn about case study teaching and how much time did it take for them to make the decision to implement case studies in their classroom?
2. What are the information seeking processes that case study faculty use to evaluate the innovative teaching approach, case study teaching, and how did that innovation evaluation influence their decision to implement and adopt case studies in their classroom?
3. What resources are critical for college biology instructors to receive in order to feel more informed about their decision to use case study teaching?

Definitions

Diffusion. Diffusion is the process by which an innovation is communicated through certain channels over time among the members of a social system. Diffusion is also considered a special kind of communication where the spread of information is about new ideas (Rogers, 1995). For the purposes of this study, diffusion was the entire process from when the participants first learned about case study teaching through the point at which they were the ones sharing the idea with others who were possibly hearing about it for the first time.

Innovation. Innovation is considered to be an idea that is perceived as new by an individual or set of individuals and characteristic of an innovation, as perceived by individuals in a social system (Rogers, 1995). For the purposes of this study, the innovation was case study teaching.

Evaluation. Evaluation is the process individuals use to obtain information that informs them how well an innovation works (Rogers, 1995). Gaining this insight may present the innovation in a more effective manner, thus increasing the likelihood that the innovation will be implemented. For the purposes of this study, evaluation involved the information seeking process used by the participants to learn more about case study teaching after their initial exposure to it.

Implementation. Implementation is when the innovation is put into practice after the decision to use it has occurred (Rogers, 1995). For the purposes of this study, implementation was when the participants made an attempt to use case studies in their classroom for the first time.

Adoption. Adoption is seen as the decision to make full use of an innovation as the best course of action available (Rogers, 1995). For the purposes of this study, adoption means sustaining the use of case study teaching after implementation.

Limitations

There are a few limitations to this study. First, even though several participants were included in the study, the small number of participants leaves many stories and experiences untold. There seems to be a void in the literature regarding innovation evaluation as a framework for determining the information seeking processes that college biology instructors use to influence their decision about case study teaching. The small number of participants in this study could be used as a starting point for continued research; however, this study was not meant to be used as a generalization to a population of college biology instructors. Instead, the participants in this study only represented a subset of college biology instructors who actively use case study teaching.

My prior experiences and expertise with case study teaching were also a limitation. I have strong personal reasons for using case studies in my teaching; therefore, I needed to ensure not including my bias during the interviews. Moustakas (1994) suggested that researchers initially take a moment to describe their own experiences with the phenomenon, a process known as reflexivity, in order to bracket out their views (an epoché) before proceeding with the experiences of others. My epoché is included in Chapter 3.

Chapter 2: Review of the Literature

Introduction

Bringing about widespread transformation of college biology education has been directed at reducing the amount of lecturing and incorporating more active-learning practices according to *Vision and Change in Undergraduate Biology Education: A Call to Action – Final Report* (American Association for the Advancement of Science [AAAS], 2011). Because most college students take at least one science course in college, most enrolling in introductory biology, *Vision and Change* (V&C) has identified the approaches, content, competencies, and delivery methods for introductory biology education (Vasaly, Feser, Lettrich, Correa, & Denniston, 2014). Over the past couple of decades, active-learning practices have received considerable attention in the biological sciences (Fata-Hartley, 2011; Gardner & Belland, 2012; Michael, 2006; Prince, 2004).

Active learning is an umbrella term for pedagogies that focus on student academic engagement by actively involving students in the learning process (Prince, 2004). Multiple studies have shown evidence that active learning does increase student academic engagement and learning (Bonwell & Eison, 1991; Freeman et al., 2014; Knight & Wood, 2005; Smith et al., 2005). Under the umbrella of active learning are many promising practices, some of which include collaborative and cooperative learning activities, project-based learning, peer teaching, and case-based instruction (Prince, 2004; Zayapragassarazan & Kumar, 2012). Studies primarily reported the effect that active learning has had on the recipient students and rarely on the implementing faculty or instructors (Bailey & Nagamine, 2012).

Research suggests that actively engaging students in the learning process is important for student learning, which is why college instructors are being urged to incorporate more active-learning practices in their courses (Allen & Tanner, 2005; Bonwell & Eison, 1991; Michael, 2006; National Institute of Education [NIE], 1984; NRC, 1999, 2000; NSF, 1996). Doing so gives faculty the opportunity to (a) promote teamwork and collaboration through group projects; (b) provide immediate feedback, usually with the use of student response systems such as clickers, to ensure that student have grasped the material; (c) implement material that is more relevant to the students' lives; and (d) improve critical-thinking skills with problem-based learning (PBL). All four of these active-learning teaching practices have been shown to increase learning gains, develop conceptual understanding, and foster student academic engagement (Ebert-May, Brewer, & Allred, 1997; Gasiewski, Eagan, Garcia, Hurtado, & Chang, 2012; Knight & Wood, 2005; Prince, 2004).

The increase in learning gains, conceptual understanding, and academic engagement is especially important for today's students, also referred to as Millennials (Roberts, Newman, & Schwartzstein, 2012; Roehl, Reddy, & Shannon, 2013). It is the rapid growth of technology that makes academic engagement so important for Millennials. They are accustomed to Google and instant information at their fingertips and explicitly and implicitly bombarded daily by articles that claim to be scientific studies on social media (Ossola, 2014). Millennials, defined as those born between 1982 and 2002, are generally successful team players and less limited by social barriers. As a result, the teamwork aspect of active learning becomes an important element for their successful learning environment (Roberts et al., 2012), especially since future employers are looking for a workforce with skills and competencies such as critical thinking, communication, collaboration, problem solving, and decision-making.

Case-based instruction is an active-learning strategy that encompasses most of the skills and competencies reported by V&C (AAAS, 2011) and the Partnership for 21st Century (P21) Framework for 21st Century Learning (P21, 2015) that are necessary for students to function in today's society such as critical-thinking (Chaplin, 2009; Hoag, Lillie & Hoppe, 2005; Noblitt, Vance, & DePloy Smith, 2010), communication (Noblitt et al., 2010), collaboration, and decision-making (Dabbagh & Dass, 2013). As an adaptable instructional strategy, case study teaching has been shown to actively involve students in the learning process (Bilica, 2004; Bowe, Voss, & Artez, 2009; Chaplin, 2009; Dori, Tal, & Tsaushu, 2003; Herreid, 1994a, 2007). Case studies are built around a central story that can provide college biology instructors with a teaching strategy that is flexible to use and connects real-world contexts with science content and inquiry, which can lead to higher conceptual learning and critical thinking skills (Herreid, 1994a).

For case studies to be a successful, college biology instructors must be open to the disposition of change (McPhearson, Gill, Pollack, & Sable, 2008). However, despite the growing number of reports showing empirical evidence that active learning practices improve student learning, engagement, and conceptual understanding, lecture continues to dominate the college classroom (Knight & Wood, 2005; Walker, Cotner, Baepler, & Decker, 2008). Some of the barriers causing resistance include: not enough time to make changes to their course(s) (D'Avanzo, 2013; Marsteller & Kohlhorst, 2014; Silverthorn, Thorn, & Svinicki, 2006), difficulty assessing learning using an active-learning teaching approach (D'Avanzo, 2013; Yadav et al., 2007), and less content coverage (Marsteller & Kohlhorst, 2014; Silverthorn et al., 2006). There are also some college biology instructors who are unaware of the evidence presented in biology education research showing the successful outcomes from active learning (Herreid, 2011b; Wood, 2009) and many who are aware of the data but mistrust it (DeHaan, 2005; Herreid, 2011b; Wood, 2009). In addition, there are those who believe that their current instruction is effective and see no reason to change (Dancy & Henderson, 2008).

Even with so much resistance, a growing number of college biology instructors are using active-learning teaching strategies in their classrooms (Knight & Wood, 2005; McPherson et al., 2008; Norton et al., 1997), and more specifically, case studies (Dori et al., 2003; Herreid, 1994a; Yadav et al., 2007). Perhaps these college biology instructors who have been successful with active-learning teaching strategies, especially case studies, could motivate those faculty members who are still reluctant or undecided about the value of this innovative teaching strategy to make changes to their teaching practices.

Some of the reasons that have had a positive impact on college biology instructors in favor of using case studies include increased learning gains, enhanced conceptual understanding, and increased student engagement (Ebert-May et al., 1997; Gasiewski et al., 2012; Knight & Wood, 2005). The empirical evidence showing these favorable outcomes listed above have been both quantitatively (Chaplin, 2009; Gasiewski et al., 2012; Knight & Wood, 2005; Yadav et al., 2007) and qualitatively

(Ebert-May et al., 1997; Ertmer & Dillon, 1998; Ertmer et al., 1996; Lundeberg & Scheurman, 1997) measured and reported in the literature.

Looking at case-based instruction specifically, Andrews and Lemons (2015) asked case study faculty what made this teaching strategy so appealing. To Andrews and Lemons, there was a "critical need to better understand the process by which undergraduate biology instructors decide to incorporate active-learning strategies…" (p. 1). The key finding from their study showed that the desire to change teaching practices came from personal reasons instead of the evidence from empirical investigations. Personal reasons were more motivating and were a higher priority for promoting change. Hearing about case teaching from other instructors seemed to be the most common way of learning about this innovative teaching strategy (Andrews & Lemons, 2015). In an earlier study by Gess-Newsome, Sutherland, Johnston, and Woodbury (2003), personal reasons such as life experiences and histories were reported as being more influential than professional factors when it came to bringing about the enactment of change.

With there being college biology instructors reluctant or undecided to change their teaching practices from a passive, lecture-style to a more active, student-centered approach even though there is evidence that lecturing is less successful, what are we lacking, then, as argument for change? What can we provide to college biology instructors who are resistant to making this change when empirical evidence is not sufficient enough? Andrews and Lemons (2015) explained that personal reasons play a bigger role in the decision to implement case studies than empirical evidence. Where, then, do case study faculty turn for more information before making the decision to use case studies in their classrooms? This research study used Rogers' (1995) Diffusion of Innovation (DOI) Theory and the influence of innovation-evaluation information (referred to as innovation evaluation hereafter) to explore where case study faculty first learned about case study teaching and the information seeking processes that they used to influence their decision to implement and adopt case study teaching as an innovative form of active-learning teaching.

To summarize, research consistently suggests that the traditional lecture method prevails in college classrooms despite the urgency placed on the transformation of undergraduate biology education to include active learning. Therefore, it is important to understand what active learning involves, the empirical research on its use, the common barriers that cause resistance among college biology instructors, and what we can provide to motivate a desire for change (Dori & Belcher, 2005; Woodin, Feser, & Herrera, 2012). The first section of the literature review provides a detailed explanation of the Diffusion of Innovation (DOI) Theory (Rogers, 1995) and innovation evaluation including how this theoretical framework applies to this study. The second and third sections of the literature review address the need for biology education transformation and describe some of the research related to the importance of active learning. Because I have chosen case-based instruction as the active-learning innovation to be used within the framework of DOI Theory and innovation evaluation, the fourth section of the literature review describes evidence supporting case-based instruction as a successful active-learning teaching strategy. The final section of the literature review addresses some of the reports made by instructors regarding barriers to change in addition to reports made in favor of change.

Body of the Review

Theoretical framework. For decades, educational researchers have considered how to make changes to instructional practices in higher education (Borrego & Henderson, 2014) usually under the assumption that an innovative teaching strategy that documented successful student learning outcomes would be enough to produce large-scale transformation (Foote, Neumeyer, Henderson, Dancy, & Beichner, 2014). Foote and colleagues described this as a “show them and they will adopt” approach (p. 1). According to Rogers (1995), the attributes of an innovation are the indicators of the potential for adoption.

First, what is an innovation? It is an idea that is perceived as new by an individual or set of individuals and characteristics of an innovation, as perceived by individuals in a social system (Rogers, 1995). Thus, DOI Theory is the process by which an innovation is communicated through certain channels over time among members of a social system. Diffusion can also be considered a special kind of communication where the spread of information is about new ideas (Rogers, 1995). Four elements are revealed from this definition of diffusion: the innovation, the communication channels used, time, and the social system.

DOI Theory has been used to examine factors such as the rate of adoption, the characteristics of the people who do adopt, and the channels and social networks in which the innovation spread (Rogers, 1995). However, research that focuses primarily on the information seeking process within DOI Theory seems to be understudied. Therefore, it is my intention to understand the information seeking process for case study faculty using DOI Theory. The participants for this study have already adopted the innovation. What we do not know is the information seeking process they used to help them with their decision to adopt case study methodology.

To show where innovation evaluation fits within DOI Theory, I describe components of the theory paying special attention to the areas that directly involve the evaluation of information about an innovation (Rogers, 1995). Figure 1 combines all of the elements of DOI theory. As mentioned previously, the four main elements of DOI Theory are revealed in the definition of diffusion: the innovation, the communication channels, time, and the social system.

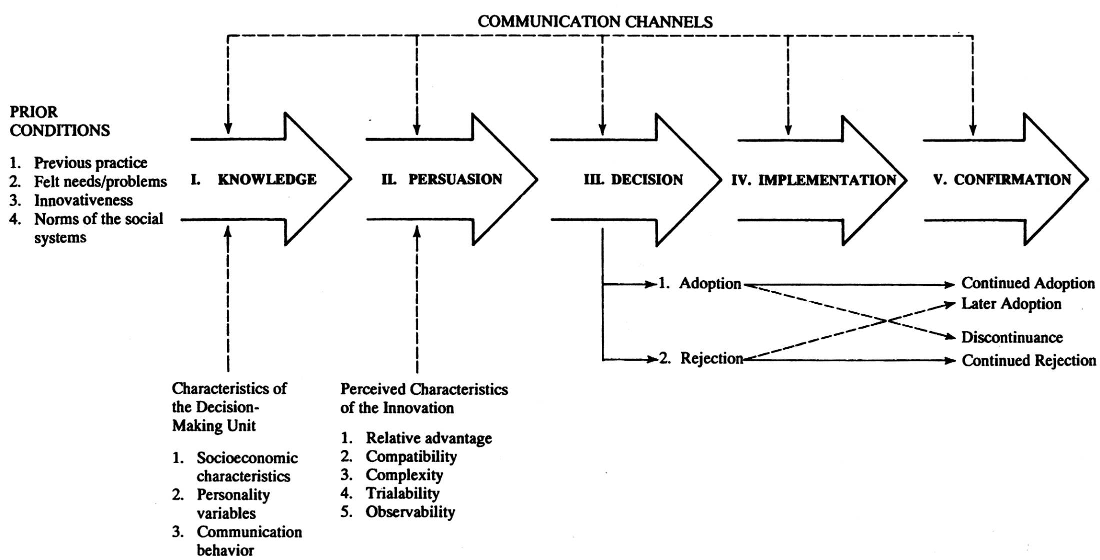

Figure 1. A model of stages in the innovation-decision process. Adapted from "Diffusion of Innovations," (p. 165), by E. Rogers, 1995, New York: Free Press. Copyright 1983 by The Free Press: A Division of Macmillan Publishing Co., Inc.

Starting with the innovation (the idea that is perceived as new by an individual or set of individuals), it is important to understand how certain characteristics of the innovation are perceived by members of a social system that determine the rate of adoption. These characteristics, or attributes, include: relative advantage (the degree in which the innovation is perceived to be better than what it supersedes), compatibility (the degree in which the innovation is perceived as being consistent with existing values), complexity (the degree in which the innovation is perceived to be difficult to understand and use), trialability (the degree to which the innovation can be experimented with on a limited basis), and observability (the degree to which the results of an innovation are visible to others). Among these attributes, relative advantage and observability are associated with innovation evaluation (Rogers, 1995). In order to reduce the uncertainty of an innovation, relative advantages and disadvantages are evaluated by seeking outside knowledge about the innovation (Schmidt & Brown, 2007). Observability can also be associated with innovation evaluation because the level at which the results are visible to others can stimulate peer discussion (Rogers, 1995). This often results in the potential adopter requesting more information about the innovation (Zhang, Wen, Li, Fu, & Cui, 2010).

The next element, communication channels, is pivotal for innovation evaluation because of the information conveyed during the communication of the innovation among peers and other groups (Rogers, 1995). Information about an innovation can be communicated either through mass media (e.g., journals, internet) or interpersonal channels (e.g., face-to-face exchange of information). Communication channels create awareness of the innovation that may promote a potential adopter to seek additional information about how well the innovation works. Subjective opinions communicated by peers who have already adopted the innovation tend to be what most people use to evaluate an innovation (Rogers, 1995).

The element of time can be associated with innovation evaluation at two different places within DOI Theory. The first stage involves the innovation-decision process (see Figure 1) where different stages of decision-making results in the confirmed adoption of the innovation. The second stage involves the innovativeness of the individual (see Figure 2), which equates to the readiness and quickness in which an individual is likely to adopt an innovation (Rogers, 1995). First, I discuss time in relation to the innovation-decision process.

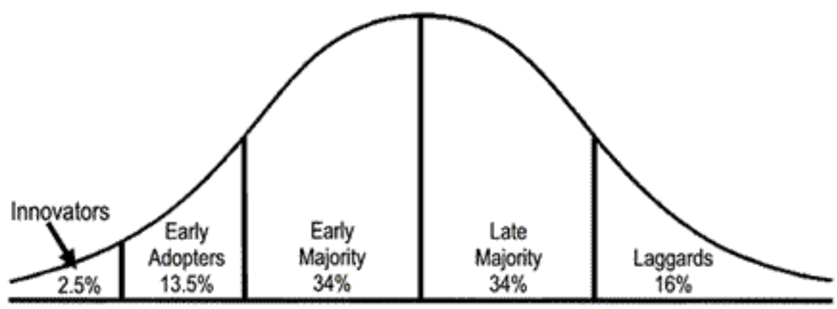

Figure 2. Adopter categories on the basis of innovativeness. Adapted from "Diffusion of Innovations," (p. 247), by E. Rogers, 1995, New York: Free Press. Copyright 1983 by The Free Press: A Division of Macmillan Publishing Co., Inc.

Rogers (1995) described the innovation-decision process as the steps a potential adopter takes between initial awareness and full adoption of an innovation. According to this model, there are five steps in this process: (a) knowledge (first exposure to the innovation), (b) persuasion (formation of a favorable or unfavorable opinion about the innovation), (c) decision (choosing to adopt or reject the innovation), (d) implementation (using the innovation), and (e) confirmation (seeking evidence that supports the decision to adopt or reject the innovation) (Rogers, 1995). Even though the confirmation step is described as the step where evidence is sought, this is evidence that *supports* the decision not evidence that *influences* the decision. I was interested in the evidence that influences the decision to move beyond the initial exposure to an innovation. This happens primarily at the knowledge step of the innovation-decision process and at the persuasion step.

Knowledge acquisition can be initiated through mass media and interpersonal communication. However, the knowledge step of the innovation-decision process involves much more than just first exposure. There are three levels of knowledge: (a) awareness knowledge (information that the innovation exists), (b) how-to-knowledge (practical information needed to implement the innovation), and (c) principles knowledge (functioning principles which underlie how the innovation works and how to deal with problems that may arise during implementation) (Pundak & Rozner, 2007; Rogers, 1995). It is at the knowledge step where potential adopters seek information about the innovation asking the critical questions, "what?," "how?," and "why?" (Sahin, 2006). It is at this point where most of the exploration for my study took place. I was interested in knowing what the participants in my study did immediately following their initial exposure to case studies.

The persuasion step of the innovation-decision process is also involved with innovation evaluation. Rogers (1995) stated that the knowledge step is more cognitive-centered while the persuasion step is more affective-centered. In other words, while knowledge deals with knowing, persuasion deals with feeling. Uncertainty can be strengthened or weakened by close peers' subjective evaluations of the innovation (Sahin, 2006). The attributes mentioned earlier (relative advantage, compatibility, complexity, trialability, and observability) have a tendency to influence the persuasion step (Pundak & Rozner, 2007). However, when it comes to innovation evaluation, relative advantage and observability (see Figure 3 bold print) are the two attributes where individuals are seeking information (Rogers, 1995).

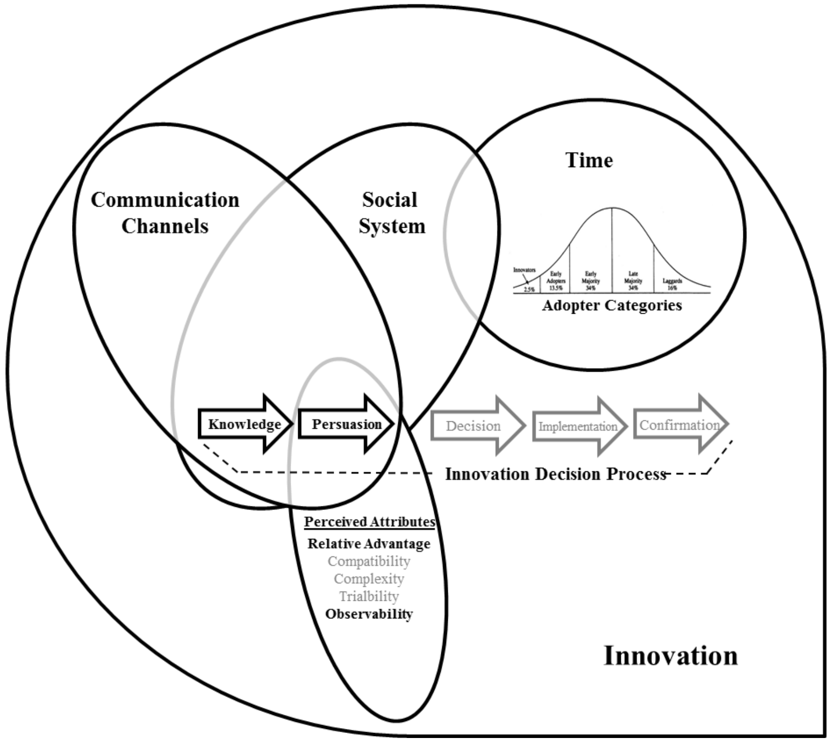

Figure 3. Model of innovation evaluation combined within the Diffusion of Innovation (DOI) Theory. Adapted from "Diffusion of Innovations," (p. 165 and p. 247), by E. Rogers, 1995, New York: Free Press. Copyright 1983 by the Free Press: A Division of Macmillan Publishing Co., Inc.

Continuing with the second part of the time element, Rogers (1995) classified adopter categories (see Figure 2) in terms of "innovativeness" based on how fast or slow the potential adopter proceeds through the processes of the innovation-decision process. The adopter categories include: innovators (aka "techies" have a willingness to take on risks and try new things); early adopters (aka "visionaries" utilizes resources for information that carries the innovation forward); early majority (aka "pragmatics" deliberate longer before embracing the innovation); late majority (aka "conservatives" remove uncertainty only when most of their peers have adopted the innovation); and laggards (aka "skeptics" hold a more traditional view and are suspicious of innovations). The early adopters are the group most involved with innovation evaluation (Rogers, 1995). They tend to be role models, which makes their opinions and attitudes about an innovation important to other members in the social system (Sahin, 2006). They communicate their evaluations about an innovation through interpersonal networks. They are the ones that everyone typically looks to for the "stamp of approval" for an innovation by adopting it (Sahin, 2006).

The final element of DOI Theory is social system. As shown in Figure 3, it is within the social system where communication occurs. Rogers (1995) defined the social system as a set of interrelated units that are engaged in joint problem solving in order to accomplish a common goal. It is the nature of the social system that affects individuals' innovativeness, which is the main criterion for categorizing the adopters (Sahin, 2006).

In summary, there are several places within DOI Theory where evaluation of the innovation takes place. Figure 3 combines the Rogers' (1995) models for the innovation-decision process and the adopter categories to show where innovation evaluation takes place: the *time* it takes for individuals to adopt can be shown in the adopter category bell curve; the *knowledge* and *persuasion* components of the innovation-decision process involve *communication channels* among members of a *social system*; and the *relative advantages* that the innovation could bring plus the *observability* of others' use and benefit of the innovation help the *persuasion* of a favorable or unfavorable opinion about the innovation. It was my goal to identify the point where innovation evaluation took place among case study faculty. This study used DOI Theory and innovation evaluation as a theoretical framework to uncover the information seeking process that case study faculty use to influence their decision to implement and adopt case study teaching immediately following their initial exposure to this innovative teaching strategy.

Transformation of undergraduate biology education. In the past 50 years, numerous reports have been introduced in an effort to transform science education. These reports have focused on primary and secondary education, in addition to undergraduate (NRC, 1996) and graduate level education (Association of American Medical Colleges and Howard Hughes Medical Institute [AAMC-HHMI], 2009). These reports also focus on courses in the disciplines of science, technology, engineering, and mathematics, also known as STEM courses (NRC, 1996).

Reports supporting change. The V&C document (AAAS, 2011) focuses specifically on biology education transformation. Not unlike other reports, V&C has its own message regarding the transformation of biology education at the college level. In addition to suggestions for making changes to the curricula, the authors of V&C also made suggestions to college instructors on how to implement these changes. Additionally, P21 describes a number of competencies that students need in order to work and live in the 21st century (P21, 2015). Both V&C and P21 offer recommendations and guidelines for increasing the chance for successful implementation of instructional practices that involve active-learning teaching practices. The scale and critical importance of the challenges set forth by V&C prompts us to ask fundamental questions about the widespread transformation of college biology education (D'Avanzo, 2013). Primarily, the focus of V&C is to integrate core concepts into the curriculum and incorporate active-learning teaching practices to enhance the learning of biology (Vasaly et al., 2014). Five core concepts were outlined as a guide for undergraduate biology education: (a) evolution; (b) structure and function; (c) information flow, exchange, and storage; (d) pathways and transformations of energy and matter; and (e) systems. The intent of this effort was to form a consensus framework that the biology community could use for biological scientists and educators.

D'Avanzo (2013) was concerned with how these biological scientists and educators would obtain the pedagogical information that they would need to make these changes. If the aim of V&C is to ensure that college biology instructors change the way they teach so that it reflects the current knowledge about how people learn (NRC, 2000), it is important to address the barriers to change and how those barriers can be overcome (Dolan, 2012). One effort to help college biology instructors is the formation of the Partnership for Undergraduate Life Science Education (PULSE), which was designed to support college biology instructors as they develop and revise their courses to achieve the outcomes described in V&C (Dolan, 2012; Musante, 2013). In addition, there are faculty networks in place to share knowledge about change initiatives (Musante, 2013). In their efforts to catalog changes brought about by V&C, several resources have become available to help support college biology instructors in their efforts to implement the recommended changes intended to unify the transformation of undergraduate biology education such as the BioCore Guide (Brownell, Freeman, Wenderoth, & Crowe, 2014), the Partnership for Undergraduate Life Sciences Education (PULSE) (Musante, 2013), and the Transforming Undergraduate Education in STEM (TUES) program (Vasaly et al., 2014).

National economies are becoming more globalized and internationalized due to the rapid development of information and technologies, which are transforming how we live, work, and learn (Kivunja, 2015; Voogt, Erstad, & Mishra, 2013). With jobs that did not exist a decade ago and the need to be educated for jobs that do not yet exist, it is imperative that we make changes not only to what needs to be learned, but also how this learning should take place (Voogt et al., 2013). As V&C recommends new approaches to instruction, the Partnership for 21st Century Skills postulates specific competencies that students need in order to successfully work and live in the 21st century (Kivunja, 2015).

Formed in 2002, the Partnership for 21st Century Skills is comprised of leaders from education (such as the National Education Association), business (such as Apple Computer Inc., Dell computer and Microsoft Corporations), and community and government institutions (such as the U.S. Department of Education) that play roles in education and in the development of modern technologies in education (P21, 2014). The vision put forth by the Partnership for moving the American education system forward into the digital world and characterizing it is called the *Rainbow* or *Framework for 21st Century Skills*. The Framework is categorized into four groups of student outcomes: (a) content knowledge and 21st century subject themes; (b) life and career skills; (c) learning and innovation skills; and (d) information, media, and technology skills (P21, 2015). Of particular importance to my study are the learning and innovation skills, which include creativity and innovation, critical thinking and problem solving, and communication and collaboration. Research suggests that case study teaching encompasses the skills and competencies for critical thinking (Chaplin, 2009; Noblitt et al., 2010), communication (Noblitt et al., 2010), collaboration, and decision-making (Dabbagh & Dass, 2013).

Bringing about change. Reports such as V&C and the Framework promote a change in undergraduate biology education. To what changes exactly are they referring? Because V&C is one of the more recent reports and probably the most discussed with regards to current change initiatives in biology education, it is the source I used to answer this question. V&C provides four recommendations for implementing such a widespread transformation in biology education. These are (a) integrating core concepts and competencies throughout the curriculum, (b) focusing on student-centered learning, (c) promoting campus wide commitments to change, and (d) engaging the biology community in the implementation of these changes (AAAS, 2011, pp. xiv-xv). Of these four recommendations, my study focused on student-centered learning (AAAS, 2011). It is here that V&C addresses the importance of actively engaging students in the learning process instead of allowing them to be passive recipients of information.

V&C expresses how easy it is to offer lectures that promote rote memorization of isolated facts, which promotes low-level learning and a decrease in student engagement. They are not suggesting to completely abandon lecturing altogether, but to supplement it with interactive activities. Increasing research in undergraduate biology education has suggested the educational potential of active-learning techniques; however, lecture prevails as the dominant teaching method (Dancy & Henderson, 2008; DeHaan, 2005; Knight & Wood, 2005).

Knight and Wood (2005) stressed the importance of increasing active-learning techniques in favor of lecturing. Their study compared student-learning gains in a required upper-division developmental biology course for biology majors using either traditional lecturing or an interactive classroom format. For the control group, they did not make any changes to the course, keeping it as it was traditionally taught using lectures as the primary delivery of information. For the experimental group, some of the lecture time was replaced by various active-learning activities including collaborative work, group discussion, and in-class formative assessments. For each section (n = 73 students), performance from pretests and posttests combined with homework problems were used to compare student-learning gains between the two formats. The more interactive course showed significantly higher learning gains and better conceptual understanding than the lecture-alone format with reproducible results after a repeat of the same study. Knight and Wood concluded that even a partial shift toward a more interactive and collaborative course format can lead to significant gains in student learning and the development of the skills necessary for solving conceptual understanding problems that students who are taught by lecturing alone.

To determine if one method is more effective than the other, or even to find a balance between lecturing and active learning techniques, Walker et al. (2008) conducted a study that described, implemented, and evaluated a large-enrollment, introductory biology class that adopted a variety of active-learning activities. The university divided its largest course, Biology 101, into two sections. The control group (n = 240 students) was taught using a traditional lecture format and the experimental group (n = 263 students) experienced a reduction in lecture time in favor of in-class active-learning activities. Evaluations included in-class quizzes and exams, a comparison of student responses on a survey of science confidence, interest and understanding, and a student evaluation of teaching form. The learning outcome data indicated that students learned as well as, and somewhat better, in the section with the markedly reduced lecture, especially students at the bottom end of the performance curve. Based on narrative data from a focus group of nine students enrolled in the active-learning section, Walker and colleagues determined that a blend of active-learning activities alongside customized mini-lectures might be the most effective approach.

One criticism for using active-learning practices is that they can be difficult to use in large classrooms. While the study by Knight and Wood contained a small number of participants (n = 73), there are studies that have investigated active learning in courses with even fewer students (Campisi & Finn, 2011; Dallimore, Hertenstein, & Platt, 2004; Derting & Ebert-May, 2010). Taking that into consideration, more studies are being conducted to show that active learning can be included in classrooms with a larger student body (Walker et al, 2008). Furthermore, Ebert-May et al. (1997) conducted a study specifically to show the positive effects of active learning in large classrooms.

Ebert-May et al. (1997) reported on two experimental designs within the same paper. The first study divided non-major introductory biology students (n = 559) into four sections. Two of the sections used traditional lectures and the other two used the learning cycle mode of instruction (Allard & Barman, 1994; Biological Sciences Curriculum Study [BSCS], 1993). The second study investigated the effect of personalizing the lecture experience for introductory biology students (n = 450) using cooperative learning and calling on students by name. To overcome the daunting task of knowing the names of that many students, each student raised a large card with their name on it whenever they wanted to be called upon.

Results from the first study showed that students who experienced the active-learning format had higher self-efficacy and more developed process skills than students in the traditional lecture format. Additionally, the second study, which used focus group interviews, revealed that students enjoyed the social interaction of cooperative learning, describing it as friendly, non-threatening, fun, and dynamic. The students also reported that they learned better in their cooperative groups. The use of the name cards resulted in more students raising their cards to be called on than previous courses where students raised their hands. Both of these studies indicated that active learning generated a positive environment, including a sense of personal connectedness, and the improved understanding of the content and processes in courses with large enrollments.

Teaching Millennials. A growing reason for the urgency in transforming undergraduate biology education is due to the characteristics, motivations, and learning styles of today's students, referred to as Millennials. Born between 1982 and 2002, Millennial students' access to technology, information, and digital media is greater than any prior generation (Roehl et al., 2013). These students have been raised by parents who are extremely involved in their lives, also known as "helicopter" parents, who tend to hover close by so that they are immediately available if their child is faced with any challenge (Roberts et al., 2012). However, these highly involved parents have inspired their children to pursue higher education, which may result in the most educated generation so far (Ossola, 2014). Millennials' strong sense of community plays a role in their interest in science, because they like what science innovations can do for their community or even the whole world.

Having this demographic group like science or even to think it is *cool* is one thing; teaching science to them is another. Being motivated differently than generations before them requires a significant change in course design and teaching methodology (Brown, Hansen-Brown, & Conte, 2011). Fortunately, we are making progress with the current change initiatives involving active learning. Coincidence? Many educators have reported that Millennials prefer active and engaging activities rather than traditional lectures (Brown et al., 2011; Pardue & Morgan, 2008; Roberts et al., 2012; Roel et al., 2013). Yet, most of the literature regarding Millennials focuses on their personality traits and less on the influence that teaching and learning has on them.

Price (2009) conducted a qualitative analysis of narratives provided by over 100 Millennial students. The narratives focused on Millennials' perceptions of three main areas: (a) whether or not professors were familiar with Millennial culture; (b) their ideal professor, and (c) their ideal learning environment. With regard to what Millennials considered an indicator of whether they felt their professor was connected to their culture included being techno-savvy, using current examples, using humor, and being relaxed and relatable. Millennials described their ideal professor as being upbeat, open-minded and flexible (with assignments and course policy), alert to students' understanding of the material, friendly, and approachable. In other words, these students want someone to treat them similarly as their parents. Price pointed out that Millennials seem to care about how we interact with them more than they care about what we know as instructors. Positive interactions with their professors are something Millennials highly value. Finally, Millennials described their ideal learning environment as one where students know each other and work in groups, relaxed, and use multimedia formats and real examples. The primary characteristic that Millennials desire in an ideal learning environment is that it is interactive and participatory. The students in Price's study did not entirely oppose lectures; they just wanted a mixture of activities. One student responded that they would stay awake and learn more if there was constant change from lecture, to discussion, to group work. All of these things reflect the active learning changes being implemented in the current undergraduate biology education transformation.

Evidence of promising active-learning practices. Active learning provides mutual benefits for both the student and the instructor (D'Avanzo, 2013). I have chosen four active-learning teaching practices as a focus for my study. My main reason for choosing these four in particular was because they can all be demonstrated using case study teaching, and they all fit the characteristics of the Millennial learner. First, the promotion of teamwork and collaboration through group projects inspires peer instruction where students have the opportunity to help out each other. Also, it has been shown that students come to class more prepared when they have to work in groups (Armstrong, Chang, & Brickman, 2007; Wijnia, Loyens, & Derous, 2011). Second, the use of student response systems, such as clickers, provides immediate feedback for the student so they know how they are doing and what they need to improve. Concurrently, this immediate feedback could be useful for the instructor to know when it is safe to move on and what needs more explanation. The third practice, making the material more relevant to the students' lives, creates a positive learning environment and reduces the intimidation of science by directly relating real-world examples (Garcia, Rahman, and Klein, 2015). Students who view a topic as more relevant to their lives tend to be more motivated to learn (Wolter, Lundeberg, & Bergland, 2013). Finally, problem-based learning (PBL) has been shown to improve critical-thinking skills in students (Allen & Tanner, 2003; Czabanowska, Moust, Meijer, Schroder-Back, & Roebertsen, 2012). While research is less conclusive about knowledge acquisition, there is more evidence regarding the problem-solving ability of students with PBL (Gijbels, Dochy, Van den Bossche, & Segers, 2005). In the following section, I describe some empirical evidence showcasing the success of these four practices.

Teamwork and collaboration. As mentioned previously, large class sizes are a challenge to many college biology instructors when it comes to incorporating active learning practices, especially the incorporation of cooperative learning to promote teamwork and collaboration. Armstrong et al. (2007) determined if a single instructor could implement cooperative learning activities in a large introductory biology course (n = > 300 students). They compared students taught using cooperative learning (experimental group) or with a traditional lecture (control group). Student performance was measured using multiple-choice exams, quizzes, and a final exam. A comparison of pre-test and final exam scores found that students in the cooperative learning group showed a 47.6% improvement in scores, whereas the control group improved by 44.7%. Even though the difference in improvement between the two groups is fairly small, the researchers felt that multiple-choice exams were the most efficient means of evaluating student performance due to the class size. They argue that it is possible that greater differences existed between the two groups, but these differences could not be detected due to their assessment method.

Other favorable outcomes resulted from the Armstrong et al. (2007) study. These included an increase in average classroom attendance in the cooperative learning group relative to the control. Additionally, students in the cooperative groups reported that the in-class group tests encouraged them to prepare more rigorously than they might have otherwise. Ebert-May et al. (1997) examined cooperative learning between treatment and control groups and found that student participation, attendance, and satisfaction with the course increased in the cooperative learning group in comparison with the control group taught using traditional lectures. The experimental outcomes of the study by Ebert-May and colleagues suggest that students in the cooperative learning group had a higher self-efficacy about doing, analyzing, and explaining science than students in the traditional group. Both of these studies provide a variety of ways in which student engagement could be increased using cooperative learning practices.

Impressed with the positive results of Lord's (1998) use of constructivism, active learning, and cooperative groups as a teaching technique applicable to both small and large classes, Burrowes (2003) tested Lord's ideas in her large lecture section of General Biology. The purpose of this study was to provide further evidence in favor of constructivist, student-centered teaching as motivation for other university professors to make this change in their teaching practices. Learning outcomes were compared in two sections of the same course taught by the same teacher. The control group (n = 100 students) was taught in the traditional manner and the experimental group (n = 104 students) was taught based on Lord's (1998) constructivist ideas. The evaluation criteria involved midterm exams, quizzes, lab work and a final exam for both classes. The experimental group was also evaluated on cooperative group class work. The mean exam scores of the experimental group were significantly higher than those of the control group. In addition, the experimental group demonstrated greater conceptual understanding on questions that specifically tested higher-order thinking skills than the control group. This study provides further evidence that active learning based on constructivism using cooperative groups increases academic achievement, enhances conceptual understanding, and promotes higher levels of thinking.

Immediate feedback/clickers. Even with the availability of different active-learning practices, such as those mentioned previously, college biology instructors can still find it difficult to maintain student engagement in large-enrollment lecture courses. An effective way to overcome this problem may be to keep students engaged with immediate feedback throughout the span of each class. Studies have shown that student response systems, or clickers, have a positive effect on student learning when used with other active-learning practices (Freeman et al., 2007; Knight & Wood, 2005; Smith, Wood, Krauter, & Knight, 2011).

Cotner, Fall, Wick, Walker, and Baepler (2008) chose to compare two different student response techniques, the Immediate Feedback Assessment Technique (IF-AT) and the electronic classroom response system, also called clickers. They conducted their study across three sections of introductory biology, which is a class primarily taken by non-majors fulfilling a requirement, not because of their interest in biology. They asked different research questions for each of the three sections, which they called Course A, Course B, and Course C for clarity. In Course A, which had 247 students, Cotner and colleagues were just concerned with whether or not students liked the IF-AT cards and what they valued about the feedback. Students responded quite positively and viewed the rapid feedback as helpful to their learning. Knowing that students like using the IF-AT cards, for Course B the researchers were concerned with the longevity of student engagement even when the cards were used every day. They found that most students did not tire of the IF-AT activities and still found them valuable even though they were used daily and not graded. In Course C, they compared using IF-AT cards with using clickers. Some lessons were taught using the cards and some with the clickers. At the end of the course, students favored clickers over IF-AT cards. What Cotner and colleagues did not investigate, or at least did not mention in their paper, is whether or not IF-AT cards or clickers improved students' attitudes about biology.

In another comparison study using clickers, Crossgrove and Curran (2007) compared student opinion and achievement among students in a non-majors introductory biology course (n = 194 students) and a sophomore-level genetics course (n = 46 students). For each course they conducted ten lessons, five using clickers and five without. Exams questions for both courses were classified as either a "clicker" question or a "nonclicker" question based on whether that material had been covered using clickers or not. To assess how well the students retained the material from each class, students took a post-course test four months after the completion of the course. For the post-course test, 20 questions were selected that had been given on exams given during each course. Ten questions covered material using clickers and ten on material that did not. The students from both courses also took an opinion survey with respect to their use of clickers.

It is not surprising that students performed better on concepts taught with clickers compared to concepts taught without using clickers for both the non-majors course and the genetics course. Similar results are found when looking at long-term retention of concepts. When re-tested four months later, there was no significant difference in student performance on concepts taught with clickers for the non-majors, indicating retention of the concepts. There was a lower retention with non-clicker questions. For the genetics students, there was no significant difference in the retention of material taught with clickers versus without clickers, but there was more variation in the responses for non-clicker questions than clicker questions. An explanation for this given by Crossgrove and Curran was that clickers were used to solve genetic problems so questions tended to be mostly application questions, where non-clicker questions tended to be comprehension questions. Nonetheless, Crossgrove and Curran showed that clickers are a useful tool for increasing student learning and retention. Results of the opinion survey suggested that students felt that clickers helped them learn, interact with their peers, connect ideas together, and have a better understanding of concepts.

Relevance to students' lives. Addressing some problems faced by undergraduate biology education, such as, a high attrition rate, poor attitude, and low scientific literacy, Partin and Haney (2012) examined the effects of attitude and motivation on learning environments and course performance. At a mid-sized university, all of the students enrolled in an introductory biology course for non-majors participated in the study. The course was taught by either a traditional lecture format (control group) or a constructivist-inspired inquiry format (experimental group). Using five variables, Partin and Haney assessed students' perceptions of their learning environment. The Constructivist Learning Environment and Motivation (CLEM) model was used to see how, or if, any of the five variables contribute to course performance, self-efficacy, intrinsic goal orientation, and attitudes toward biology. The five variables were (a) the personal relevance to students' lives, (b) the uncertainty of science knowledge, (c) expressing a critical opinion, (d) shared participation, and (e) student involvement to negotiate new ideas. Course performance was determined by final grades. Standard multiple regression was used to determine the accuracy of each variable. For course performance, only personal relevance contributed; for self-efficacy, personal relevance and expressing critical opinion contributed; for intrinsic goal orientation, personal relevance and shared participation contributed; and for attitudes toward biology, only personal relevance contributed. Partin and Haney concluded that when students find biology to be meaningful to their lives, they have a better attitude, have a higher self-efficacy, and are more likely to be motivated to prepare for class and participate in class activities.

Garcia, Rahman, and Klein (2015) reported that students often feel a disconnect between biological concepts and their daily lives, which, in turn, hinders scientific literacy. They believed that by presenting biology in a manner that students find exciting and relevant to their lives helps engage the interest of biology students, especially non-majors. With relevancy in mind, Garcia and colleagues created a non-majors human biology course using the familiarity of health-related diseases to introduce fundamental biological principles. They only collected data from one course that was modified to use a topic-centered approach. While grades were tallied at the end of the course to assess that the students met the expected learning objectives, the main purpose of this study was to examine the effect of relevance to biological concepts had on student attitude. The survey questions were designed to gain preliminary feedback and elicit an opinion from the students. There were 41 students in this study and they all anonymously took an attitude survey at the end of the course that considered their study habits, evaluation of the course, and their views on the field of science. Students responded favorably to questions about content and applicability of the course, and 87% said they would recommend this course to a peer. Garcia and colleagues found that the method they used for this course had a positive and significant impact on student attitude toward biology. In other words, relevance matters. Results from their attitude survey supported their belief that students who completed this course had a positive outlook on their ability to learn biological concepts and also had an appreciation for the role that science has in their lives.

Problem-based learning. Instructors often lose enthusiasm when teaching a large-enrollment introductory biology course. This wane in enthusiasm may be primarily due to poor student attitudes, limited participation, and suboptimal student performance (Armbruster, Patel, Johnson, Weiss, 2009). To combat this problem, Armbruster and colleagues redesigned their second-semester introductory biology course to incorporate more active-learning and student-centered pedagogies such as problem-based learning (PBL). They compared student performance and attitude across three years. The first year was taught with traditional lecture, but the second and third year were taught using PBL activities. Students worked through group problems during class for the PBL portion and used clickers to promote active learning. Class scores on identical final exams for each class year were used to measure student performance, and a questionnaire using both Likert-scale and free response questions was used to measure student attitudes. It is not surprising that student performance was higher in the interactive second and third year using PBL compared to the first year taught with traditional lecture. Furthermore, student satisfaction was higher in the second and third year compared to the first. Students reported that the use of clickers and alignment of the learning goals with quizzes and other formative assessments were the most helpful in their learning. The results suggest that implementing PBL activities improved self-reported student engagement, satisfaction, and academic performance.

Carrió, Larramona, Baños, and Pérez (2011) went beyond investigating the use of PBL in promoting critical-thinking, communication, cooperative work and motivation. This group wanted to examine if PBL could help students with the factual knowledge that they need in upper-division courses or professional skills. This study was carried out in a university with two cohorts of second-year biology students. One cohort (n = 52 students) only experienced lecture-based learning (LBL), and the second cohort (n = 42 students) experienced what Carrió and colleagues referred to as hybrid problem-based learning (H-PBL). The two cohorts were evaluated using an instrument to test factual knowledge of basic science acquired by the first year of instruction. Part A of the evaluation instrument was comprised of 22 multiple-choice questions (MCQ) and part B had nine short-answer questions (SAQ). Students also gave responses to a questionnaire, which asked them to assess several of the developed competencies from H-PBL instruction such as hypothesis formulation, argumentation, communicating skills, cooperative work, and time management. The study showed no significant difference between MCQ and SAQ scores. Carrió and colleagues concluded that H-PBL instruction did not negatively affect the acquisition and retention of factual knowledge. So, while they stated that H-PBL was as good as LBL with respect to factual knowledge, student satisfaction was greater with H-PBL and so were the competencies assessed by the questionnaire.

The implications from this study suggest that there is more to teaching than just providing the facts. Students can acquire factual knowledge from either of the researched teaching methods. However, in order to prepare students for upper-division courses or professional skills, problem-based learning, even in a hybrid format alongside lectures, contributed in the development of an extended range of skills and competencies.

Case study teaching. First introduced by Dean Christopher Langdell at the Harvard Law School in 1870, law students read original law cases and were asked to draw their own conclusions. Other elite law schools adopted the case method of instruction in the late 1890s and early 1900s (Garvin, 2003). In 1920, Harvard Business School adopted the case method of instruction; but, rather than reading law cases, professors chose real-life examples from the business world that involved a dilemma (Harvard Law School, 2014). Pioneering medical schools, particularly McMaster University in Canada in the 1960s and 1970s followed suite with their approach, which they called problem-based learning (PBL) (Waterman & Stanley, 2005). In recent years, case method instruction has grown to encompass many disciplines and courses such as sociology, psychology, American literature, statistics, history and human relations (Gullahorn, 1959), management courses (e.g., Charan, 1976), political science (e.g., Knirk, 1991), teacher education (e.g., Kagan, 1993), instructional design (Ertmer & Russell, 1995), educational psychology and measurement (Ertmer, Newby, & McDougall, 1996), ethics (e.g., Winston, 2000), criminal justice (Kunselman &

Johnson, 2004), and mechanical engineering (Yadav, Vinh, Shaver, Meckl, & Firebaugh, 2014).

Case studies are effective teaching tools to bring active learning into a classroom. Unlike traditional lecture-style instruction where students are passive learners of information, case study teaching allows students to engage in discussions, to debate different points of view, and to better understand the content knowledge about a given topic because students can relate to stories that are relevant to their lives (Alvarez, 1993; Ertmer et al., 1996; Chaplin, 2009). The case study teaching has been used to promote active learning (Kunselman & Johnson, 2004; Popil, 2011), assist students in acquiring content knowledge (Camill, 2006; Gullahorn, 1959), foster critical thinking and schema construction (Alvarez, 1993; Chaplin, 2009; Nava-Whitehead, Augusto, & Gow, 2011; Noblitt et al., 2010; Popil, 2011), promote greater engagement and enthusiasm for the course content plus the ability to transfer knowledge to new situations (Camill, 2006; Chaplin, 2009; Gullahorn, 1959; Nava-Whitehead et al., 2011; Yadav et al., 2007), and provide students with the opportunities to discuss, debate and reflect on what they are learning, which encourages metacognition (Herreid, 2007; Terry, 2012).

Case study teaching in the science classroom. James B. Conant, a chemist who served as President of Harvard University from 1933 to 1953, was one of the first science educators to use case-based teaching in his class (Conant, 1949). But, his approach did not survive him, and there is little known about other attempts to use the case method until recently (Herreid, 1994a). One of the first published articles that involved using case studies in the college science classroom was by Wheatley (1986).

Wheatley's paper demonstrated how to use case studies to develop scientific literacy among students. Wheatley briefly explained that providing students with the circumstances surrounding an event described within a case would teach them how to review the facts and frame a response or argument. He then provided two case study examples that dealt with the American conservation movement. There is, however, very little instruction or real applicability described in Wheatley's paper to launch the use of case studies in science courses. It is not until Herreid (1994a) revived this approach eight years later that using case studies in a science course gained popularity.

Herreid's (1994a) paper is the first in a series of articles using case studies in science. He referenced Miller's (1983) paper that revealed the need for science literacy and addressed the need for science education reform in undergraduate science courses. Yadav et al. (2007) explained that memorization, lack of application of concepts, and failure to encourage connections among concepts is part of the problem contributing to poor teaching in science. In an effort to improve the teaching and learning of science in undergraduate science courses, the use of case-based methods and PBL was proposed (Dori et al., 2003; Herreid, 1994a; Yadav et al., 2007). Although case-based teaching methods, particularly PBL, had been used more extensively in medical schools (Barrows, 1986; Prince et al., 2003; Schuwirth, 1999; Wilkerson & Feletti, 1989), and only a few articles had been written about using it for science education (Wheatley, 1986; Waterman, 1998), it did not become popular until Herreid's (1994a) article.

What makes Herreid's (1994a) article so significant? He described using case studies as an extraordinarily flexible teaching technique that involves learning by doing, which can appeal to students who are turned off by traditional science courses. He also explained how to write a case, the different kinds of cases, and most importantly, how to teach a case. Herreid wrote several more papers on the topic before it gained momentum (Fourtner, Fourtner, & Herreid, 1994; Herreid, 1994b; Herreid, 1994c). Yadav et al. (2007) pointed out that many of the papers published following Herreid's (1994a) manuscript only described *perceived* results based on surveys taken by faculty. Faculty using case studies in their undergraduate science courses self-reported a perceived increase in students' critical-thinking skills, better connections made across multiple content areas, enhanced student learning, and increased student engagement. Within those years between Herreid (1994a) and Yadav et al. (2007) there were some researchers who actually obtained empirical results. A few of the papers reporting empirical data are described in the following section.

Research on case study teaching. When looking at the research on case study teaching specifically, I find that it is difficult to categorize the research into the four teaching practices as they were categorized for evidence of promising active-learning practices in general. The reason is because the research on case study teaching can fall into multiple categories at once. For example, the study that I described below by Hoag et al. (2005) would fit under the categories of cooperative learning, relevance to students' lives, and PBL. Three studies, Chaplin (2009), Noblitt et al. (2011), and Prince et al. (2003) all included aspects of being relevant to students' lives and PBL. Other studies that I presented below could be placed in more than one category, but I tried to categorize them based on the active-learning teaching practice that is at the forefront. First, though, I describe a study that seems more generic in nature and really does not specifically pertain to one of the four teaching practices that I have been focusing on in particular, just case study teaching in general.

Pai et al. (2010) conducted a correlational study to answer three main questions regarding case-based instruction: (1) What are students' responses to case study activities? (2) Do students show a gain in course content knowledge? and (3) How does students' perception of their learning in this class compare with the previous introductory biology class? Pai and researchers designed two separate surveys, one to measure students' response to case study work and the other to measure students' gain in course content knowledge. They then used data from a college-administered, end-of-semester course evaluation survey to compare students' perception of their learning between the case-based class and the previous non-case class. This study compiled a great deal of data because they compared two different methods of instruction for two consecutive years. Overall, the study showed that students' perception of the case-based class was more positive than the non-case class. Students' knowledge of course content significantly improved using pre-test and post-test data. Also, students' rating of case study activities did not correlate to the grades they received even though students *thought* they performed better in the case-based class. Therefore, this study not only showed an improvement in student achievement, but also an improvement in student engagement.

Cooperative learning. Ertmer, Newby, and MacDougall (1996) conducted an exploratory study, which examined how students with high and low levels of self-regulation responded to case-based instruction. Their study included both a grounded theory qualitative method and a survey methodology for quantitative data. Two selfreport inventories, the Motivated Strategies for Learning Questionnaire (MSLQ) and the Self-Regulated Learning Inventory (SRLI), both a Likert-type survey, were used to classify the level of self-regulation in students. Students at the high and low ends of the inventory were then interviewed three times during the semester after the completion of three individual cases. Inventories were surveyed for patterns using the constant comparison qualitative method (Glaser & Strauss, 1967). Their goal was to determine how students working in small groups responded to and approached learning from case-based instruction. Students with high self-regulation tended to feel more confident about their learning from cases and valued them to be relevant to their needs. Students with low self-regulation, however, fluctuated in their value of and confidence for learning from cases and wanted to focus their efforts on learning the facts and being correct. What they also found was that both the low self-regulation students and the high self-regulation students benefited from the team effort because everyone had expertise to share. They concluded that students responded differently to the same instructional method depending on their level of self-regulation; therefore, it is important that students' perceptions and orientations toward learning are addressed (Ertmer et al., 1996).

Looking at the importance of instructor involvement, Hoag et al. (2005) conducted a study to measure the effect of case-based instruction on cooperative learning, critical thinking, class attendance, and students' satisfaction in an upper-level clinical immunology course. In the experimental group, nine case studies were interspersed between lectures throughout the semester. The control group just received regular lectures without any cases studies introduced. This mixed-method study analyzed the following outcomes: five analysis/application level multiple choice exams, student attendance for lecture only days versus lecture plus case days, data from course evaluations of course/instructor satisfaction, and the opinions from a focus group of students. The results suggested that case studies did not significantly improve student performance on critical thinking questions, but case studies and working in groups did positively affect student attendance, student-instructor interaction, and instructor involvement.

Immediate feedback/clickers. Lundeberg et al. (2011) explored the effects of "clicker cases" on student performance. There were twenty-two faculty on this project who attended a Conference on Case Study Teaching in Science that is hosted every year by the National Center for Case Study Teaching in Science at the University of Buffalo (Herreid, Schiller, Herreid, & Wright, 2011, 2012). These faculty decided on eight topics common to most of their introductory biology classes: cell theory, cellular division, Mendelian genetics, DNA, the scientific method, characteristics of life, cancer, and microevolution. They also chose six criteria that all of the cases must have to be used in the study: authentic and relevant, appropriate in regards to curriculum payoff, controversial or ill-structured, clear about participants' roles, engaging, and appropriately complex enough to provide only the information students would really have if they encountered this problem in a real-life situation. The faculty self-selected into groups to develop a clicker case study and a corresponding PowerPoint lecture, five pre-and post-test multiple-choice questions, and one transfer question to test application of ideas for each of the eight topics. The overall analysis of the pre-and post-test (before and after each case was presented) and a final exam at the end of a semester taught using this format indicated that students experiencing the clicker cases showed more understanding of course material than students experiencing PowerPoint lectures. Also, students in the clicker case course tended to better retain the information at the end of the semester than students receiving PowerPoint lectures.

Herreid et al. (2014) wanted to know what impact emotion and case studies had on learning. Using case studies and personal response systems (clickers), three college faculty taught two sections of a large general biology course. The same eight cases, all designed to deal with fundamental topics typically taught in an introductory biology course, were used in two sections. The only difference was that in one section the questions associated with the cases throughout the semester were lower order (LO) knowledge and comprehension inquiries, whereas in the other section the questions were higher order (HO) application, analysis, or evaluation inquiries according to the levels of Bloom's hierarchy of levels of thinking (Bloom, 1956). For each clicker case, the last two slides asked students to rank their engagement and their emotional involvement with the case. Three different evaluation instruments were used to assess learning and critical thinking at the beginning and end of the course: the Watson-Glaser Critical Thinking Appraisal (WGCTA; Watson & Glaser, 1994), a multiple-choice test, and two essay questions.

A two-way contingency table analysis determined that students in the LO case study sections rated the case studies as being more engaging and more emotional than the students in the HO case study sections. A one-way analysis of covariance (ANCOVA) was used to determine that there was a statistically significant ($p < .01$) but extremely weak negative correlation found between case-specific multiple-choice test mean learning gains and case-specific engagement levels and a statistically significant ($p < .01$) but an extremely weak positive correlation between case-specific multiple-choice mean learning gains and case-specific emotion level. They attributed the lack of significant difference to a small sample size (only eight cases). Herreid and colleagues point out that the potential for learning gains was undoubtedly different depending on the case. This could be due to the varying backgrounds students come into class with or it could be due to the varying degrees of difficulty with the information and challenges presented with each case. They also suggested that there were varying degrees in how engaging or emotional cases can be for different students. The implications from this study are directed at case study design. If learning outcomes are what we seem to be interested in, then it is important to dissect what it is about cases that make them so successful.

Relevance to students' lives. Noblitt et al. (2010) took a different approach to measuring student learning outcomes by using a traditional paper presentation (non-case format) and a case study format to measure oral communication and critical-thinking skills. Two groups of students were given the same series of lectures and in-class activities on legal concepts with real-life contexts, and the same information on communication goals and skills. Textbook and other reading assignments were also the same for both groups. Students in the non-case format selected a research paper from about 20 published, peer-reviewed papers that the instructors had selected. For students in the case study format, instructors assigned students to an expert role to play in a mock trial simulation as part of the case study. All students in the case study group were given identical packets containing court filings, witness affidavits, and other materials related to the case. Students were given the opportunity to select, as a topic of their choice, from five different data sets to analyze (DNA, bullet comparison, solid-dosage drug identification, blood alcohol determination, and gunshot residue analysis).

The instructors designed a grading rubric to encompass the oral communication and critical-thinking skills that students were expected to demonstrate during oral performances. The validity and reliability of the rubric were carefully monitored throughout the design process. Students were graded on their ability to adapt scientific information to a lay audience and to integrate a message through presentation of the scientific information. The rubric scores clearly indicated that students' communication and critical-thinking skills improved greatly when using the case method rather than the paper presentation method. This experimental methodology study showed that the case method of instruction, with topics that bring relevance to students' lives, improved communication and critical-thinking skills. In particular, students' ability to adapt scientific information to a lay audience and to integrate a message through presentation of the scientific information also showed that students can think more deeply and critically about scientific information when provided real-life context surrounding the material.

Wolter, Lundeberg, Kang, and Herreid (2011) used real-world scenarios to explain their findings regarding how case studies, in addition to clickers, play a role in student perceptions about science. In their study, case study teaching using personal response systems (clickers) was used to explore improvement in students' perceptions of their understanding of science. This was a large study that included twelve faculty from nine institutions and 1,457 students across the United States and Canada that investigated student perceptions with regards to using clickers in large introductory biology courses and what variables, including gender, major, class status, and type of clickers used, influence those perceptions. A 35-question instrument, which combined the instrument used by Duncan (2005) to measure the use of clickers and the survey by Yadav et al. (2007) to measure case study use. Five different scales were identified. In the first scale, nine items measured students' general attitude toward using clickers to help them learn. The second scale, consisting of four items, measured students' comfort level with the ease of using clickers. For the third scale, six items measured students' perception of the impact of cases in learning science. The fourth scale consisted of five items, which measured the effects of clicker cases on classroom interaction. Finally, the fifth scale consisting of two items measured whether students attended class more regularly when they knew they were using clicker cases. A multivariate analysis of variance (MANOVA) was used with the five scales' composite scores as dependent variables and all variables of learner characteristics listed within the remaining nine demographic items, which included gender, major, class standing, types of clickers (three different clicker systems were used), experience with cases, experience with clickers, and initial reason for taking the course (required or elective) were scored as independent variables. The three types of clicker systems included Interwrite (PRS), Turning Point (TP), and Classroom Performance Systems (CPS).

Overall, students were generally positive toward the use of both clickers and cases, especially female students and non-majors. However, the type of clicker did influence the general attitudes toward clickers. Students rated PRS and TP higher and easier to use than CPS. Also, freshman responded more favorably to clickers than upperclassmen. With regard to cases, female students had more positive perceptions that using case studies influenced their understanding of science than male students as well as non-science majors. Wolter and colleagues believed these findings may be attributed to science majors being more comfortable with the content and not seeing a need for an alternative teaching strategy or that real-world scenarios presented within the case studies allows non-majors to relate the material to their own lives making it more enjoyable to learn. The implications of this study are that incorporating clickers and cases can be beneficial to those students who are not typically represented in science classrooms. Wolter and colleagues suggested, however, that faculty should be purposeful when selecting the type of clicker systems.

Problem-based learning. Prince et al. (2003) explored the difference in level of knowledge among anatomy students between schools that used PBL and schools that did not. They were primarily interested in knowing if using PBL instruction caused a deficiency in the students' knowledge as compared to non-PBL instruction. Students at both schools took a short questionnaire at the beginning of the semester to determine students' perceived level of anatomy knowledge before taking the class. At the end of the class, students from both school types (the PBL schools, which used clinical cases as part of their teaching strategies, and non-PBL schools) took the Maastricht Progress Test (MPT) to determine their anatomy knowledge. The scores were calculated as the percentage of correct answers. The study showed no difference between levels of anatomy knowledge between PBL and non-PBL schools, indicating that there is not a deficiency in knowledge using the PBL method.

Chaplin (2009) compared student performance between two different years that she taught introductory biology, one using traditional lecture and one using case-based instruction that emphasized problem solving. She had taught using lectures from 1994 to 1999 and case-based instruction from 2003 to 2006. To rule out variables that could contribute to outcome credibility, Chaplin only chose data from 1998 and 2006. Both classes were approximately the same size (n = 45-50 students), taught at the same time of day, in the same room, and with the same technology. The only difference was the instructional method (lecture for 1998 and case studies for 2006). Chaplin had several years of experience with each method and she was the instructor for both classes, which ruled out instructor differences and instructor experience as a variable. She tested composite ACT scores for each student as the covariant in an analysis of covariance of percentage of total exam points per year (1998 versus 2006) and there was no significant difference in differing ability between the two groups of students. She had also designed her exams the same way for both years, using both knowledge-comprehension type questions and application-analysis type questions according to the levels of Bloom's hierarchy of levels of thinking (Lord & Baviskar, 2007). The results of her study showed a significant and marked impact of case-based instruction (80% improvement) compared to the lecture-based instruction (50% improvement). Also, more students in the case-based class showed more improvement from the first exam to the last exam in answering application-analysis type questions than students in the lecture class.

Reports of resistance and support for active learning. Research indicates that some active-learning strategies are attempted and then discontinued when problems or challenges arise (Borrego & Henderson, 2014; Henderson, Dancy, & Niewiadomska-Bugaj, 2012). This finding suggests a lack of resources or support to help faculty after they have begun to use active-learning strategies.

Resistance to active learning. Despite the awareness of successful active-learning strategies, there is still a resistance to making the transition from the traditional, passive, lecture-based teaching approach to an active-learning approach in college biology courses. Some of the obstacles or barriers causing resistance include not enough time to make changes to their course(s) (D'Avanzo, 2013; Marsteller & Kohlhorst, 2014; Silverthorn et al., 2006), difficulty assessing learning using an active-learning teaching approach (D'Avanzo, 2013; Yadav et al., 2007), and less content coverage (Marsteller & Kohlhorst, 2014; Silverthorn et al., 2006). There are also some college biology instructors who are unaware of the evidence presented in biology education research showing the successful outcomes from active learning (Herreid, 2011b; Wood, 2009) and many who are aware of the data but mistrust it (DeHaan, 2005; Herreid, 2011b; Wood, 2009). In addition, there are those who believe that their current instruction is effective and see no reason to change (Dancy & Henderson, 2008).

To understand the resistance to active leaning and determine what could support efforts for change, Henderson and Dancy (2008) conducted interviews with five tenured physics faculty from four different institutions who were all inclined to consider making changes in their instructional practices. The interviewed faculty did not see educational researchers as being interested in them or their students. They described physics educational researchers (PERs) as having a "sales or evangelistic mentality" (p. 85) and did not like being told that the educational packages being pushed would work in any environment. The interviewees felt a sense of mistrust from the PERs. The interviewees also reported the feeling that they were being judged as bad instructors. They agreed that they wanted to improve their instruction but also wanted their experience and expertise to be respected. Finally, the interviewees believed that educational research has good things to offer but that the faculty themselves have expertise in teaching and learning that could also be valuable. In other words, they want to be a part of the solution.

Michael (2007) conducted a workshop on active learning to faculty with the intention of providing a discussion on the resistance to active learning. Twenty-nine faculty members attended. Seven of the participants taught science courses and the remaining faculty taught courses in the humanities, social sciences, and education. Placed into four groups, they were asked to list their perceived barriers to active learning. Michael placed all seven science faculty into one group to see if they perceived things differently than the other faculty members. The participants identified twenty-two significant items, with some items repeated across the four groups. Two items appeared on all four lists; these were too much preparation time and classroom design that was not conducive to active learning. Seven items appeared on three of the lists including things, such as, not enough content coverage, instructors have less control, and students do not come to class prepared. Other items worth mentioning include assessment is difficult, class size is an impediment, and poor student evaluations. I mention these three because they appear in the literature more often (e.g., D'Avanzo, 2013; Marsteller & Kohlhorst, 2014; Silverthorn et al., 2006; Yadav et al., 2007).

Michael (2007) devoted time to address what could be done to help faculty change their perceptions of these barriers and overcome their resistance. Obviously, there are studies that show how some instructors have overcome many of these barriers as shown in the previously mentioned studies. These studies, however, are not always enough to change the minds of everyone. That said, Michael suggested there are two recommendations that can be considered. First, what he calls the “quick fix” is increasing faculty development programs locally on campuses or at national meetings to give instructors opportunities to see the techniques and practice them. The second is a more profound change to academia. Michael recommended that we treat teaching like a truly scholarly activity. Rather than keeping teaching to ourselves, as is common in the science disciplines, we need to make teaching a more public enterprise. We must talk about it with our own departmental colleagues and with members of other departments or institutions. Creating a community effort can help by sharing our own teaching experiences and insights with others.

With regard to case study teaching specifically, Yadav et al. (2007) conducted a survey of science faculty (n = 101) at higher education institutions in the United States and Canada. The goal of the study was to investigate the contexts in which case studies were being used in science courses. They also wanted to know what barriers were keeping faculty from implementing the use of case studies. Many faculty (78.7%) reported a lack of preparation time as one of the main obstacles to case study teaching, and 68% said that they had difficulty with assessing student learning using case studies. Other barriers mentioned were feeling that they were giving up content coverage, sensing a lack of relevant case studies, and increasing student resistance.

Support for active learning. Despite the barriers that surround active-learning teaching practices, there are many studies that report in *favor* of making this change. The positive outcomes reported in empirical studies include an increase in student learning, engagement, and critical thinking skills (e.g., Freeman et al., 2007). Personal reasons are also being reported such as dissatisfaction with lecturing and how case study teaching better aligns with instructors' personalities (Andrews & Lemons, 2015). Furthermore, case-based instruction promotes active learning (e.g., Popil, 2011), assists students in acquiring content knowledge (e.g., Camill, 2006), fosters critical thinking (e.g., Nava-Whitehead et al., 2011), and promotes greater engagement and enthusiasm for course content (e.g., Chaplin, 2009). What more do we need? There is growing evidence suggesting that changing strongly held attitudes usually occurs through personal interactions, small group discussions, or interpersonal channels (i.e., word of mouth) (Borrego & Henderson, 2014).

Even in the study by Yadav et al. (2007), the faculty surveyed reported that when they did attempt to use case study teaching, they felt that students demonstrated stronger critical thinking skills, were able to make connections across multiple content areas, developed deeper understanding of concepts, and were better able to view an issue from multiple perspectives. An overwhelming majority of the faculty surveyed (95.1%) agreed that students took an active part in the learning process when they used case studies.

How do we overcome the barriers that are causing resistance despite the evidence that case study teaching, or any active-learning strategy, are successful? Faculty see that their students are doing well (Yadav et al., 2007), but are still resistant.

For some faculty, positive attitudes about implementing active-learning strategies come from a more personal bias (Sunal et al., 2001).

Personal reasons specifically. Millar (2003) reported on the need to explore further the personality features of science faculty who have been successful at affecting change in their classrooms in an effort to help other faculty. Millar reported that people are more able to recognize their own personal biases when they compare themselves to others. While Miller's (1983) study reported on STEM faculty in general without any specific teaching strategy identified, one can make the argument for a need to explore some of the personal reasons that some faculty have embraced and are successful at using case studies in their classrooms. If the measured student outcomes reported in the literature are not enough for faculty to consider using case studies, or any form of active-learning teaching strategies, then perhaps reluctant or undecided faculty can find inspiration in some of the personal reasons.

Gess-Newsome, Southerland, Johnston, & Woodbury (2003) showed that personal factors, such as life experiences and histories, in addition to professional factors, such as teacher preparation, can have a powerful influence on bringing about the enactment of transformation. Another study by Brown, Abell, Demir, & Schmidt (2006) showed that with regard to inquiry-based instruction, faculty are more likely to change their teaching methods when they can see examples of successful implementation of inquiry. If this is true for inquiry-based instruction, one could argue the same for case-based instruction.

Using the Teacher-Centered Systemic Reform (TCSR) model, teachers' personal practical theories, and conceptual change as a framework, Gess-Newsome et al. (2003) examined the design and implementation of a new science course using inquiry-based instruction. The purpose was to understand how teachers' knowledge and beliefs mediate efforts for change. Three science faculty members at a private, independent, 4-year college were involved in the planning and enactment of a new science course. One of the three faculty was a physicist/chemist, one was a biologist, and one was a physicist. Instructors' personal characteristics, their course goals, and their knowledge and beliefs about teaching, learners, learning, and content knowledge were collected, synthesized, and analyzed from interviews and course planning sessions. Interviews were coded to generate datasets and concept maps were used to construct broad theme categories and make explicit interconnections among narratives for each participant.

The TCSR model, which included personal factors influencing teachers' thinking and practice and a comparison of patterns of curricular development by the three participants, allowed for an in-depth analysis of the personal factors affecting instructional transformation. Conceptual change theory offered a lens for the examination of the participants' thinking and practice as influenced by previous reform efforts such as dissatisfaction with their current practices as a precursor for change. The results showed that the physicist/chemist and the biologist were both satisfied with their teaching beliefs and practices and thus perceived no pedagogical dissatisfaction and only a degree of contextual dissatisfaction. Further, because the biologist held no dissatisfaction with his teaching goals or his practice, he saw no need to change. The physicist was the only participant who entered the project with a sense of personal dissatisfaction with his current teaching practices and a strong motivation to learn and implement change. Thus, the researchers concluded that instructors' personal practical theories are central to the success of educational transformation efforts. In other words, pedagogical dissatisfaction must exist for instructional practice to change (Gess-Newsome et al., 2003).

In order to understand the how personal views and perceptions affect college science instructors with regards to designing and using inquiry-based teaching methods, Brown et al. (2006) conducted a phenomenological study with interviews of science instructors (n = 19) in both life and physical science disciplines. The interviews were approached as dialogue in order to explore the participants' meanings and experiences with inquiry. Interviews were analyzed using coding which determined patterns and themes in addition to a profile of each participant. The study showed that college science instructors hold an uncompromising view of inquiry. Although they valued the idea of inquiry, their perceived limitations of inquiry included time, class size, student motivation, and student ability. However, the participants also recognized a number of benefits to inquiry-based instruction, including increased critical thinking and problem solving, increased student engagement and motivation, and in a few cases, increased science learning. Interestingly, the benefits listed directly affected the students while the limitations directly affected the instructors. The researchers concluded based on the interview data that it is important to recognize common concerns and gaps in understanding about inquiry in the classroom if we are to improve college science teaching. Participants in this study discussed the need to see examples of classrooms where inquiry is being successfully implemented. Information from studies such as this are early steps in reaching biology education transformation goals by helping persuade college instructors to change their teaching practices (Brown et al., 2006).

Andrews and Lemons (2015) characterized the personal reasons biology instructors use active learning teaching strategies, in other words, how individuals adopt innovations. The specific innovation for their study was case study teaching. They interviewed biology instructors (n = 17) from a range of institutions who had attempted to implement case study teaching and who had also attended the professional development conference on case study teaching in science provided by the National Center for Case Study Teaching in Science (NCCSTS). Using semi-structured interviews designed to uncover the participants' perceptions of their personal process of instructional change, Andrews and Lemons were able to obtain the participants' ideas regarding their motivation, attitude, understanding, and implementation of case study teaching. Andrews and Lemons used Rogers' (2003) innovation-decision process to form their questions and synthesize their findings. Transcripts were analyzed using content analysis to identify and describe the factors and conditions that may have influenced the participants to start, sustain, and improve their use of case studies.

Their findings revealed that personal experience was prioritized over empirical evidence when it came to deciding whether or not to use case study teaching. Many personal reasons that promoted the use of case studies were identified, such as, the dislike of lecturing, better personality fit, getting to interact with students, and anecdotal observations of student outcomes. In addition, the participants identified some of the barriers that they felt hindered using case studies, such as, a lack of training and even their professional identity. These researchers stressed that despite some of the barriers mentioned, most of the personal experiences they identified promoted case study teaching. Ultimately, Andrews and Lemons modified the innovation-decision process (Rogers, 2003) to be more specific to case study teaching. Most importantly, they changed it from a linear to a cyclic process because the participants reported that they continually made small changes over time, often over many years. Additionally, Andrews and Lemons devoted a large section of their paper on hypotheses that should be tested with future research. It was from some of these suggestions that I developed the ideas for my study.

Like Andrews and Lemons, others have used DOI Theory and the innovation-decision process (Rogers, 1995, 2003) to evaluate the degree of adoption for various innovative teaching strategies. Pundak and Rozner (2007), for example, identified four factors that influenced the degree of innovation adoption for various active learning strategies. The active learning strategies analyzed for their study included peer instruction, animations, interactive demonstrations, Web assignment feedback, collaborative problem solving, and interactive presentations. The results suggested that teacher readiness, customizing the innovation to the instructors' beliefs, teacher expertise in information technologies, and instructors' design of creative solutions to problems had the greatest impact in the adoption of the innovation. Also, as mentioned previously, an important condition for the adoption of the innovation was some degree of dissatisfaction with the participants' existing situation.

Looking specifically at research-based instructional strategies (RBIS), Henderson, Dancy, and Niewiadomska-Bugaj (2012) investigated where faculty leave the innovation-decision process and why. They were able to reveal several reasons why many faculty discontinue use of an RBIS. One reason was when faculty first learned about the RBIS, they were given a promising impression of how well the innovation worked but were not prepared for potential difficulties. These difficulties included things such as student complaints, weaker than promised student outcomes, and not being able to cover as much content as they wanted. This study showed that the dissemination (talks, workshops, publications) of innovative teaching strategies should be careful to articulate potential problems, reasonable expectations, and essential features of the intended use of the innovation (Henderson et al., 2012).

This is what makes using case studies so appealing, especially those published through the NCCSTS Web site (see http://sciencecases.lib.buffalo.edu/cs/). Each case author typically provides different ways that the case study can be presented, such as, the course type (introductory biology, botany, human physiology, etc.), the course level (high school, freshman, upper-division, etc.), and format options (interrupted case, clicker case, dilemma case, etc.) within their teaching notes, adding to their flexibility. Moreover, the anticipated expectations and essential features of the intended use of each case study are usually articulated by the author; however, potential problems may or may not be included. With that said, it was my intention to determine how the dissemination of information played a role in the implementation and adopt case studies as an innovative teaching strategy for some case study faculty. More specifically, I intended to uncover the influence of innovation evaluation described within DOI Theory (Rogers, 1995) to determine where these faculty initially received information about case study teaching. While there are studies that use Rogers' (1995, 2003) innovation decision model as a framework for studying the degree of adoption of an innovative teaching strategy (Andrews & Lemons, 2015; Henderson et al., 2012), I am unaware of any studies that utilized innovation evaluation as a framework for determining the information seeking process that college biology instructors use to influence their decision about innovative teaching strategies, such as case study teaching.

Chapter Summary

There is a current emphasis for widespread transformation of undergraduate biology education. This transformation is directed at reducing the amount of lecturing in favor of more active learning teaching practices (Bonwell & Eison, 1991; Freeman et al., 2014; NRC, 1997). Reports such as *Vision and Change* (AAAS, 2011) and the Partnership for 21st Century Framework for 21st Century (P21, 2015) identified the approaches necessary to deliver effective teaching practices and the competencies that students need in order to work and live in today's society. These changes are especially important for the learning styles of today's students, known as Millennials.

To better explain the importance of active learning, I summarized research involved in the use of active learning practices, particularly cooperative learning, immediate feedback using clickers, making learning relevant to students' lives, problem-based learning, and case study teaching. In addition, I explained some of the common obstacles and barriers that cause resistance among college biology instructors, and what we can provide as inspiration for change, and showed that personal reasons prevail over empirical data when it comes to promoting change (Andrews & Lemons, 2015).

DOI Theory and has been used to examine factors such as the rate of adoption, adopter characteristics, and how the innovations are spread through communication channels and social networks (Rogers, 1995). There is little research, however, that focuses on the information seeking processes, referred to by Rogers (1995) as innovation evaluation, that have been used to move beyond initial exposure to an innovation. Using DOI Theory and the influence of innovation evaluation, this study attempted to identify and describe the information seeking processes that case study faculty used to move them from initial exposure to the implementation and adopt case study teaching. I believe this is an important, yet somewhat missing, piece of information in the literature. It is evident that active learning is an essential component to the transformation of undergraduate college biology education, which means we need more instructors implementing its use. If the information obtained from this study could potentially help even a few college biology instructors who are reluctant or undecided to incorporate active-learning strategies in their classrooms, then this study was a success!

Chapter 3: Methods

Introduction

This qualitative research study used phenomenology to investigate the lived experiences of college biology faculty who actively use case study teaching in their introductory biology classroom (referred to as case study faculty hereafter). This methodology was selected because I was interested in the lived experiences that each participant went through as they learned about case study teaching, evaluated it, and made the decision to implement and adopt case studies. Based on the work of Moustakas (1994), the following sections provide the methodology of phenomenology in more detail including how it informed this study.

Research Methodology

Phenomenology, formally introduced by Edmund Husserl at the beginning of the twentieth century, emphasizes the description of a person's lived experience (Moustakas, 1994). Creswell (2007) detailed two types of phenomenology, hermeneutical and transcendental. Hermeneutical phenomenology is where the researcher interprets texts to explore lived experiences and achieve meaningful understanding. Transcendental phenomenology puts less focus on the interpretations of the researcher, but rather on the description of the experiences of the participants' meaning of a lived experience of a concept or phenomenon. A transcendental phenomenological approach was utilized in this study to focus on the lived experiences of case study faculty. It was the intention of this study to capture the experiences of college biology faculty as they went through the process of evaluating information that led them to implement and adopt the innovative case study teaching.

According to Moustakas (1994), when conducting transcendental phenomenological research, we should set aside our biases, prejudgments, and preconceived ideas so that we can experience things naively and with fresh eyes. This process is referred to as epoché or bracketing where the researcher writes a complete description of their experiences with the phenomenon with the intention of setting aside biases. Bracketing is the central component of phenomenological reduction, which means isolating the description of the phenomenon as it is for the participant while excluding the experiences of the researcher.

The transcendental phenomenology approach involves a set of procedures that the researcher follows, which include epoché, phenomenological reduction, imaginative variation, and synthesis (Moustakas, 1994). My epoché is provided in the following section, however, I wait until the data analysis section to explain phenomenological reduction, imaginative variation, and synthesis in greater detail.

Epoché. For myself, I have written a complete description of how I came to know about case study teaching and the information seeking process that I experienced. Before I conducted any interviews, I read back through my epoché and bracketed out my experiences again in order to take a fresh perspective. As Moustakas explained, this type of phenomenological research is transcendental because "everything is perceived freshly, as if for the first time" (p. 34).

For my epoché, I thought about my experiences regarding my first exposure to case study teaching and the information seeking processes that I encountered. Before I address the actual phenomenon, I deem it necessary to provide relevant context. I was the kid who could always be found outside in a creek, pond, ditch, tree, or wherever I thought I could find things that were “cool” in nature. I raised tadpoles into frogs, played with snakes, and was not afraid of spiders. At a very young age, I loved watching my grandfather skin and filet catfish after a night of fishing. I wanted to study the insides of this fish after it had been cut open, and if I found eggs inside, that was awesome! Naturally, I took every science course my high school offered, and I enrolled in college as a biology major. In college, I was drawn to plants, so I took every botany course my college offered, and ultimately earned my master’s degree in botany. While in graduate school, I had the opportunity to do an independent project on the Human Genome Project in the biochemistry department. I fell in love with molecular biology and did not look back. I have worked as a research associate in various molecular biology laboratories for over a decade. During that time, I enjoyed teaching students who passed through the labs where I worked and discovered that I really enjoyed sharing my love of biology with others. However, grant-funding difficulties on the research job market in addition to my years of working with and teaching students gave me a new outlook. I wanted to become a biology professor. While my master’s degree allowed me to teach as an adjunct, it did not provide job security. So, to make a career out of teaching, I needed a doctoral degree. I decided to get a Ph.D. in science education rather than in the natural sciences. I felt that an education degree would be a great compliment to my existing degrees and research experience in the natural sciences.

Having been in the natural sciences my entire career, courses in education seemed strange to me and it was challenging for me to let go of the teacher-centered ideology that I had experienced as a student. When I was first introduced to the learner-centered ideology, it seemed almost absurd. However, my mind was forever changed after my first exposure to case study teaching. An assignment in one of my science education courses was to observe ten hours of another science teacher who taught an age group of interest. The only age group I was interested in was college, whereas most of my fellow classmates were interested in an age group somewhere within K-12. My professor said it would be okay for me to observe a college class instead of a middle school class, for example. A professor in the biology department, Dr. Green (pseudonym) graciously allowed me to observe his class. During my first observation, I watched Dr. Green use a case study within the lecture. I was enthralled. Seeing the students work in groups, use clickers, and remain engaged throughout the lecture was an eye-opening experience for me. Of course, I asked Dr. Green about this method of teaching after class that day. He explained to me how he came across case study teaching and the conference he had attended on case study teaching. He also guided me to the National Center for Case Study Teaching in Science (NCCSTS) web site. I could not wait to get home so that I could check out this web site. I spent hours on that web site. It was as if a switch was flipped in my head. This was the first time I have ever considered a learner-centered style of teaching within a science classroom. I guess I needed to "see it to believe it."

At that time, I was also teaching as an adjunct at a small liberal arts college and was eager to use a case study with my students. I remember the fulfillment I felt when my students stayed engaged during the lecture. It was a team-taught course, so I taught alongside another professor, Dr. Jones (pseudonym). This was also the first time for Dr. Jones to hear about using case studies. I introduced her to the NCCSTS web site and she looked for a case study to use with one of the upcoming lectures where she was the primary instructor. The following semester, I taught General Botany at the same college. I incorporated case studies that corresponded with particular concepts throughout the semester. I found that the students responded well to the case studies and they experienced many "aha" moments as they related botany to real-world scenarios. I resigned after only teaching for three semesters. This was in part due to the changes they were in the process of making to their curriculum. Three semesters after my arrival, those changes were implemented and there was no longer an adjunct position available. It was a blessing in disguise really, because I was getting deeper into my doctoral program and needed to spend my time on that venture.

Remember that I was early in my doctoral program and fairly new to education research. With that said, I did not turn to the literature to determine others' success with case study teaching. It was not until I began working on my general examination that I delved into the literature regarding case study teaching. The literature, of course, only furthered my interest in it. Now it has become the focus of my dissertation research and not only do I enjoy sharing my love of biology with others, I also enjoy sharing my love of case study teaching with others.

Data collection. There is little detail in the literature regarding case study faculty being asked to describe the information seeking process that influenced their decision to implement and adopt case study teaching. To fully understand their experiences, I conducted exploratory, semi-structured, open-ended interviews (Creswell, 2007) with case study faculty in order to collect the data necessary to answer the following research questions:

1. What are the communication channels in which case study faculty use to learn about case study teaching and how much time did it take for them to make the decision to implement case studies in their classroom?
2. What are the information seeking processes that case study faculty use to evaluate the innovative teaching approach, case study teaching, and how did that innovation evaluation influence their decision to implement and adopt case studies in their classroom?
3. What resources are critical for college biology instructors to receive in order to feel more informed about their decision to use case study teaching?

Institutional Review Board (IRB). I applied for research approval with the University of Oklahoma IRB. The IRB Approval Outcome Letter is shown in Appendix A and the IRB-Approved Informed Consent letter that I sent to each participant is shown in Appendix B.

Participants. In a phenomenological study, the participants should have significant and meaningful experiences with the phenomenon being investigated (Creswell, 2007; Moustakas, 1994). Purposeful sampling is commonly used in qualitative research to ensure that the researcher selects participants who have had experience with the phenomenon. In addition, there is a criterion-based element to the sampling method in qualitative research for quality assurance (Creswell, 2007). The criterion for the participants in this study included: (a) being a college biology instructor; (b) teaching an introductory biology course; (c) actively using case studies in their course; and (d) having attended or presented at the NCCSTS Conference on Case Study Teaching in Science. I knew that the participants in this study met these criteria, because I had personally met them while attending the case study conference. I met some potential participants at the conference in October 2014 and I met others at the conference in October 2015. At each conference, I was able to connect with people who met my criteria, so I briefly discussed my dissertation research with them and they agreed to be interviewed for my research. After the interviews were underway, I was able to obtain additional participants for the study through snowball sampling (Creswell, 2007). This came about when one of the participants recommended another person to me.

Setting. Interviews took place via Skype with each participant, except for one participant who did not have a Skype account. Thus, a phone interview was conducted for this particular participant. Because this study was exploring personal experiences of the participants, I thought Skype would be more useful than phone interviews so that I could take field notes as a secondary form of data (Moustakas, 1994). Field notes in this case consisted of facial features and gestures exhibited by the participants as they described their experiences with the phenomenon. These facial features and gestures were important indicators of the participants' personal feelings about the phenomenon that could have been lost with a phone interview. However, I did not let it deter me from conducting one interview over the phone just because this participant did not have a Skype account. As we talked, I took careful notes to try and capture his behavior the best that I could.

Materials. I used a digital recorder for the interviews plus a journal for hand-written field notes to capture additional information that may have been missed in the recordings (Berg, 2007), such as behavior, body language, gestures, facial features, etc.

Interview protocol. An ideal method for collecting phenomenological data is conducting in-depth interviews (Guest, Namey, & Mitchell, 2013). Interviews attempt to understand individuals' lived experiences and the behavioral and social meanings that these experiences have for them; therefore, open-ended questions allow the participants to talk about a topic in their own words, free of constraints imposed by structured or fixed-response questions (Guest et al., 2013).

Data collection involved exploratory, semi-structured, open-ended interview questions. The open-ended questions were designed to encourage participants to describe their experiences regarding the information seeking process that they went through between initial exposure to case study teaching to the decision to implement and adopt case studies in their courses. The interview questions were also designed to show where the participants' information seeking actions occur within Rogers' (1995) DOI Theory and innovation evaluation. Of importance were identifying which of the four main principles of DOI Theory were most influential, such as: the innovation itself, the communication channels used, the influence of their social systems, and the time it took from initial exposure to the decision to implement and adopt. Also, the interview questions were designed to identify where the participants' innovation evaluation took place regarding the knowledge and persuasion steps of the innovation-decision process and the relative advantage and observability attributes associated with the persuasion step. According to Moustakas (1994), researchers in phenomenological investigations develop a set of questions to guide the lengthy one-on-one interview process designed to reveal the essences and meanings of the participants' experiences. In addition, I included probing questions throughout the interview in order to draw out a more complete understanding of the participants' experiences (Berg, 2007). The following guiding questions comprised the semi-structured nature of the interview:

1. Basic demographic information: How long have you been teaching?; what type of position do you hold?; in what type of institution do you teach?; and with how many/kinds of institutions have you been associated?; what specific introductory biology course(s) do you teach?; and ,in which ones do you use case studies?
2. Prior to using case studies, how would you describe your teaching strategy/method?
3. Describe your initial exposure to case study teaching.
4. Describe the information/evidence that influenced your decision to implement case study teaching.
5. What challenges did you foresee in implementing case study teaching?
6. After your initial exposure to case study teaching, how long did it take before you used a case study in your classroom?
7. Describe what made case study teaching more advantageous than what you were using before case study teaching.
8. Did you have the opportunity to observe a peer/colleague use case study teaching? If so, what were the benefits of those observations?
9. What resources do you think are critical for instructors to receive in order to feel better informed about the benefits of case study teaching?
10. Describe how you have disseminated information about case study teaching to others, inside and outside of your institution.

11. Describe your participation in professional such as the NCCSTS Conference on Case Study Teaching and any other workshops or conferences.
12. Describe the effect that networking with peers/colleagues has had on your use of case study teaching.

Interviews were arranged during a time that worked best for each participant and lasted between thirty minutes and one hour, depending on how many stories the participants shared.

Field notes. Throughout the interview, I took field notes that served several purposes. As I mentioned earlier, conducting my interviews via Skype allowed me to take notes on things such as participants' behavior, body language, gestures, and facial features. I went back and incorporated these behaviors and gestures into the transcript where they belonged. So, as I read the transcript for themes and units of meaning, it gave me a richer understanding of the descriptions given by each participant. While writing in my field note journal, I also made note of probing questions that arose as the participant was talking. On a personal level, this helped me remember any follow up questions that came to me without having to interrupt the participant as they were telling their story.

Data analysis. As I mentioned previously, the transcendental phenomenology approach involved a set of procedures that the researcher follows, including epoché or bracketing, phenomenological reduction, imaginative variation, and synthesis (Moustakas, 1994). I previously included my epoché, so now I will provide greater detail about how the data were analyzed once collected.

Phenomenological reduction. The reduction process in a phenomenological study involves several steps that derive a textural description of the meanings and essences of the phenomenon (Moustakas, 1994). First, the interviews were transcribed verbatim, and all participants were given pseudonyms to protect their privacy. After reading the transcripts several times, I considered each statement with respect to its relevance to the research questions and phenomenon, giving each statement equal value. This step is called horizonalization (Moustakas, 1994). Next, I eliminated all redundant or overlapping statements leaving behind only significant statements that represent meaningful units of the experience. Moustakas called this reduction of irrelevant statements or delimiting. The remaining statements are what Moustakas called horizons, also referred to as textural descriptions or invariant constituents of the phenomenon. Next, the horizons were clustered into themes or meaning units. The outcome is what Moustakas called a textural description of the phenomenon. This established *what* is significant.

Imaginative variation. This process involved taking the textural descriptions and using them to explain each participants' feelings and thoughts that are connected with the phenomenon, referred to as structural descriptions, which "provides a vivid account of the underlying dynamics of the experience" (Moustakas, 1994, p. 135). At this step, I took the textural descriptions and incorporated a structural explanation of *how* the experience occurred.

Synthesis. Finally, the textural and structural descriptions were synthesized into a composite description of the phenomenon. This final portion of the analysis provides a descriptive passage that captures the essence of the experience of the phenomenon. Figure 4 summarizes the steps of data analysis.

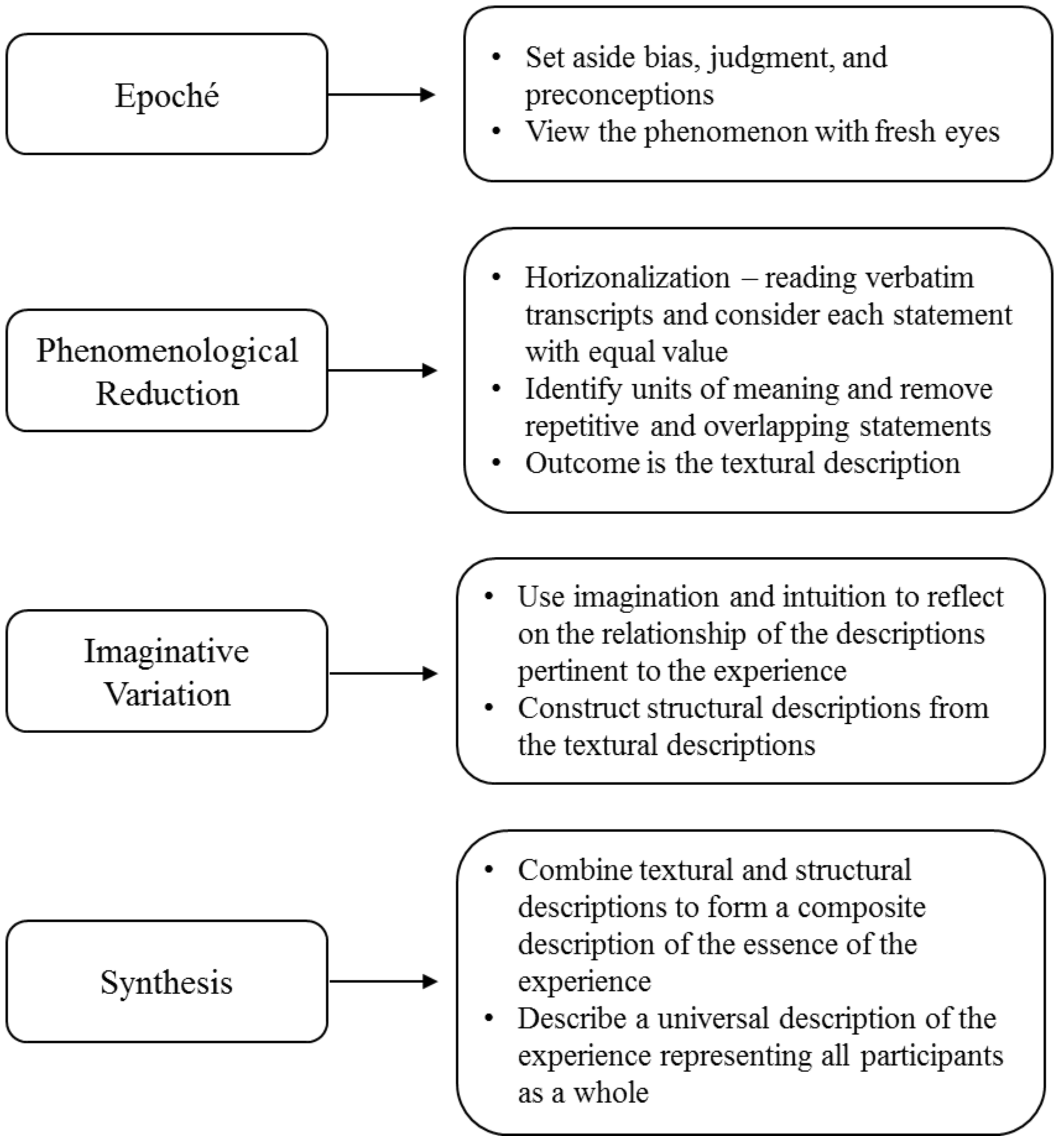

Figure 4. The steps of phenomenological data analysis.

Validity Considerations of Phenomenological Researchers

In qualitative research, validity refers to the trustworthiness of the data interpretation (Merriam, 1995). In a phenomenological study, there are several measures that a researcher can take to address validity. The first is the epoché, which is designed to help researchers remove their personal biases throughout the study (Moustakas, 1994). Another measure of validity is having the participants review the data to confirm that the reported analysis is "true" in the eyes of the participants. Creswell (2012) described this as member checking for credibility of the findings and interpretations. Participants in transcendental phenomenological research are often referred to as co-researchers because they form a partnership with the researcher in order to fully capture the essence of the phenomenon (Moustakas, 1994). The participants are considered co-researchers because they play an active role in the validity of the research data. I did not give the verbatim transcript back to the participants, but I did send them the textural description to make sure that I captured the essence of their experience.

Chapter 4: Results

The phenomenon investigated in this study was the innovation-evaluation process that college biology instructors underwent following initial exposure to case study teaching. Understanding why and how college biology instructors came to know, value, and implement case study teaching could be useful to motivate others to make a change to their teaching practices. Therefore, it was the intention of this study to learn where college biology instructors who actively use case study teaching turned for supportive evidence that influenced their decision to implement and adopt case study teaching by asking the following research questions:

1. What are the communication channels in which case study faculty use to learn about case study teaching and how much time did it take for them to make the decision to implement case studies in their classroom?
2. What are the information seeking processes that case study faculty use to evaluate the innovative teaching approach, case study teaching, and how did that innovation evaluation influence their decision to implement and adopt case studies in their classroom?
3. What resources are critical for college biology instructors to receive in order to feel more informed about their decision to use case study teaching?

Data analysis involves three main processes: phenomenological reduction, imaginative variation, and synthesis of textural and structural descriptions. During phenomenological reduction, interviews were transcribed verbatim and each statement was given equal value and considered with respect to its relevance to the phenomenon and the research questions. All redundant or overlapping statements were eliminated leaving behind significant statements that represent meaningful units of the experience. The statements that remained are what Moustakas (1994) called horizons. The horizons are clustered into themes or meaning units and the outcome is called the textural description of the phenomenon. Imaginative variation is the process of using the textural descriptions to explain the participants' feelings and thoughts through the eyes of the researcher. It is the researcher's representation of the textural descriptions. The final portion of analysis, the synthesis of the textural and structural descriptions, provides an in-depth description of the participants' experiences of the phenomenon and represents the essence (Moustakas, 1994). It is also within the synthesis that the research questions are answered.

The data analysis for this study resulted in 15 narratives: one set of textural and structural descriptions for each of the seven participants and one textural-structural synthesis representing the essence of the experience. From the verbatim transcripts, significant statements were identified and clustered into meaning units. It is essential to understand that each narrative for the textural descriptions was provided in the participants' own words. The words enclosed by brackets represent an addition or explanation that I added to provide a logical flow to the interview. For example, the participants rarely repeated the interview questions they were asked, nor did they repeat my words during conversation. These results reflect the experiences of the participants of this study; hence no generalization beyond the participants and context studied is intended (American Educational Research Association [AERA], 2006). The results are reported in the following manner: general biographical information about the participant showing how they met the criterion for the study (being a college biology instructor, teaching an introductory biology course, actively using case studies in their course, and having attended or presented at the National Center for Case Study Teaching in Science (NCCSTS) Conference (referred to as case study conference hereafter); the textural description, or phenomenological reduction of the participants' experiences of the phenomenon from the verbatim transcripts; and the structural descriptions, which represent the imaginative variation of the researcher. Finally, after all of the participants' experiences have been described, the synthesis of the textural and structural description and how the experiences of these participants pertain to the phenomenon and the research question will be described. All names used for the participants are pseudonyms and any identifiers have been removed.

Dr. Kendra Gentry

Biographical information. Kendra Gentry is an associate professor at a medium-sized master's level university where she has taught for 32 years. She taught three years of high school prior to that. She teaches an integrated lecture/lab introductory biology course for non-majors and uses case studies in this course. She has attended, presented, and been a plenary speaker at the case study conference. Kendra is a case study author for the NCCSTS case study collection.

> **Textural description.** [Prior to case study teaching, my teaching strategy involved] using a lot of scenarios and I would jump start a topic with a story. It wasn't an *official* [emphasis added] case study. I would outline the material from the textbook and try to have some activities with it. Sometimes it was just lecture. It's hard to [say when I was first exposed to case study teaching] because I think I was sort of doing it and didn't really call it that. But I have colleagues in my department who were talking about case studies in physiology and I had conversations with them. Actually one of my colleagues went to the Buffalo workshop before I did. And so when she came back, we had a pretty long conversation about that. So, I guess it was just through colleagues. I may have gone to something, some presentations but I can't really be sure if it was at the same time. I don't know what order everything happened.

When I saw students getting excited about the material, even though they were non-majors, when I saw them asking interesting questions, [that is some of what influenced my decision to use case study teaching]. I think what I love about teaching non-majors, and there's a lot of things that are hard about teaching non-majors, but what I like is that they ask really different questions. [Non-majors] are coming from a different place and the case studies would actually give them the incentive I think, to explore things, ask questions, peruse…because they were interested…not because they had to pass a test. I think [case studies] piqued their interest. [I did not necessarily go to the education literature to look up data on case studies] because the problem back then was there wasn't a lot of data. There wasn't a lot of studies being done. People were not *measuring* [emphasis added] learning back then…with case studies, which is why I did my dissertation on what I did. I remember talking to [Mary] Lundeberg. I turned to her and I said, "What kind of information is out there, what kind of data, what are people reporting?" She steered me to a few studies and she had done some [as well]. [But there was] really not a lot [back then]. But I did jump on with the literature list that she gave me.

The problem at first [regarding challenges with using case studies] is what Kipp [Herreid] always says; he says that he would still have enough time for content, but I felt that that was really a big issue…the content. So, you are telling a story, everybody is excited, and are [the students] really learning the content that we want them to learn? I think that was probably the biggest challenge. And that's something that I struggled with for so long that I decided to flip my class. We're going to have good conversations, and I have an integrated lab, so I've got to get labs in here too. There's no time really to lecture. Between case studies and labs, I felt like, if they could just read my PowerPoints ahead of time, you know. So, I started to think [about] things like posting my PowerPoints ahead of time so [the students] would be familiar with them so I wouldn't have to start from the ground up. That helped some, but it was hard to get them motivated to do that. So I think I really struggled with that. I can really give them an interesting case, but then can we really get down to the concepts that are behind it and the meaning behind it? Certainly we *got* [emphasis added] to them. And the beauty of teaching non-majors is they don't have to have to learn as much depth. So it's another *advantage* [emphasis added] for me to be teaching non-majors. I don't have to worry that they have the foundations to take with them to the next level. Did I fail them because I want my students to walk out with the feeling that science is interesting and "I can do it" and it's not the "boogey man" that everybody thinks it is. So, this is my third semester flipping and I'm still working on it so to speak.

It's difficult to [say how long after my initial exposure to case study teaching I made the decision to use them] because I think I was using case studies before I called them that. I think it was probably early on, but they weren't necessarily formal cases. Early on I was teaching with scenarios and examples. The case study movement and NCCSTS that idea and helped me to formalize it. In fact, the case study that I wrote is based on a newspaper article. And that's pretty much what I was doing. I was grabbing things out of newspaper or magazine articles or a news story…those were the kind of cases that I was using early on. And students would hear the same thing depending on if they were listening to the news or not. So it was always of interest to them. They would say, "Yeah, I heard about that…what do they mean when they say this disease can spread like that?" I was pulling [at] an interest that might have already been there.

I think one of the things [that makes case study teaching advantageous], especially that I learned in my research, is that you have to have a concept attached to something. There's a connection. So, interestingly, when students had struggled with a concept, I would say, "Remember Desiree's baby?" or "Remember…a character in a case…" that would remind them what the concept was. So, it was the connections with the story and the concepts that I thought was really very valuable. In fact, occasionally I put a hint in parenthesis (remember this…). I don't say anything other than the name of the case study, but that's enough to remind them what I'm talking about. They actually sometimes think of the concepts within the cases, which maybe is not a good thing. I'd like for them to be able to separate it, but at least it helps them answer the questions.

I have [had the opportunity to observe a colleague use case study teaching] in the past. But the two colleagues that were teaching general biology that were using case studies are no longer at [my institution]. One has retired and one has moved. So, I did [observe them use case studies]. That [was] part of my research; going and observing their classes. I think [that was beneficial] because cases can be messy. So, when you're doing a case and it's messy, you might say, "Oh, it must be me." "I don't know how to do this right" or "I'm not making the best use of my time." But I saw that the same messiness was happening in their class. You know the students were maybe confused or going off topic, or not getting the questions. So, I realized that it's kind of just a trait of a case study class. Actually it gave me a little bit more confidence to see other people struggle. There's always improvement. You always think, "Oh, I have to work on that" just like they're showing me that they're working on it. I think looking at the literature [can be a good resource to help others feel better informed about case study teaching] although if you're not doing research to begin with, you might not be looking at the literature all that much. I think textbooks are using case studies a lot, to introduce a chapter. I think that probably gets people more motivated to do it because you're reading it in the textbook. So, if [textbooks] are using case studies, then you might be using *their* [emphasis added] case studies. What I don't like about that is, I have my *own* [emphasis added] case studies. So, I have struggled with textbooks because of that. I think textbooks try to do too much. But for people who don't use case studies…[and] there's people in the department that like certain textbooks because they have case studies in them. That would be one [resource]. Talking with colleagues, going to meetings, looking at the literature, [and] asking students [are other resources].

I think [getting scientists who have to teach an introductory biology course to turn to education literature] is a problem that a lot of people are forced to have that maybe [we] haven't solved. But if they're hard-core scientists, they like data. I think showing them the *data* [emphasis added] or just a quote with data in it [will help]. One of my colleagues, who is not a case study teacher, had a quote on his door about how students can learn more by hand-writing notes versus typing notes and he has a statistic in there about how much more they would learn to convince his students not to use their computers but to hand write notes. So that drew him to that study…that statistic. So, I think if we can have a little vignette from the study about how it works and how learning had improved, that might be good. Say students learn 30% more with a case study than they do with a textbook or something. That would get their attention. I would think. But I feel that hard core scientists who teach only occasionally, which we have that problem, are not as invested. They might just sort of get through it and then hopefully students learn something and if they use a few case studies and that helped…well, so much the better [but] not necessarily making it their life's work. I think there are almost two types of science teachers. There's [ones who are] really all about having the students learn, not to say that the others are not. Then there's the ones who are all about "science is so exciting," of course you want to learn this. I think that science people, people who are hard core scientist and researchers, and we have a lot in our department, they are coming from the "science is exciting" and I'm trying to come from "the way that I *present* [emphasis added] it will make it exciting." And that assumption could be made with non-majors. I like teaching non-majors because I feel there's a real need for people who are not going to be scientists to know science. And so it's like, this is real important stuff to make sure that these guys are getting [it], that science is doable, understandable, exciting, something to talk about outside of class with your friends.

[My dissemination of information about case study teaching involves] a couple of publications. Not as many as I should have had. I feel like I need to move on that a little bit. Presenting at conferences; I presented on the case study method either directly or indirectly, which means sometimes it was about the cases and sometimes I showed the cases that I used to teach a class. For maybe ten years now [I've been] going to the Buffalo conference on and off. And at the end of the year, we have a department retreat [where] we try to share what we're doing. I showed some of my flipped videos and how I flipped the course at the last department retreat. [My use of case studies] comes up in department meetings and it comes up in discussions in the hall. A lot of it is pretty informal but it's interesting to me that you can be known as a case study teacher so people will ask you questions…it comes up sometimes. I'm [also] involved in NABT [National Association for Biology Teachers] and the Academy of Sciences [for our state] is very big in our department. I also presented at the Buffalo conference twice and I was invited to do a Plenary, which was exciting. I've gone to ISSOTL, which is the International Society for the Scholarship of Teaching and Learning. They had a meeting in Raleigh [North Carolina] and they had one in Quebec City. I presented [at Quebec City] and then the next one was in Australia, but I did not attend this one. It's a pretty interesting group because it's all about how you teach. ABLE is a group that I haven't really been involved in since way back, but ABLE is the Association for Biology Lab Educators. I went to it back in the 1990s. It was more about upper-level, it wasn't about intro, and so I just decided that it wasn't a good fit for me. I think case studies are pretty well received at [my institution]. People think they're great. It's not, you know, that I'm a pioneer or anything, it's just [that] there's a lot of people using case studies in a lot of disciplines. It's a pretty well accepted pedagogy. It's not like it was a, "What is that?" Everybody pretty much knows what it is. People are buying into it. People are using it. Now I hear from other institutions that it's not always the case. [It's] not really an issue for us at all. We've got a lot of people in our science department [who] do case studies [and] write case studies. We've had the people from Buffalo come to our area twice to do workshops. They haven't come to our institution, but an institution in the area. I think that their emphasis has been getting people *started* [emphasis added] in it more than sustaining people who are further along.

[Networking has had] a pretty positive effect [on my use of case studies]. It comes up in conversation kind of spontaneously. "Oh, I saw this new case…blah, blah, blah"…people talk about it at lunch or something. [Our department has] a thing at the beginning of the semester, which [involves] engaged learning. We have an hour and fifteen minute block of time where faculty members go in and talk to freshmen groups about engaged learning and what it means to be college students. And a lot of my colleagues do a case study during that. It's what they want us to do and I feel guilty to say that I'm not using a case study then. But they want us to show a different side of learning…that it's not just write notes, memorize them and take a test. I do a lot of polling and discussion. But one of my colleagues, who teaches a sophomore level genetics course, always does a case study and she makes them work on it and she makes them answer questions. She makes them discuss. She makes them jump right into what she thinks will be the kinds of classes they'll be taking. So, case studies are being used for things other than just teaching content. Yeah, so I think there's that conversation on campus, that people will say, "I'll use a case study" or "If you use a case study…this will happen." So there's that kind of conversation. It's a pretty positive atmosphere here for cases.

I looked for case studies on other websites, besides Buffalo. But some of them aren't peer reviewed and so you can find a lot of case studies online that aren't that good or aren't complete. I am always interested in looking at them but I always go back to the Buffalo site. [The Buffalo case study collection is] more formal, more complete. I don't use everything in them. I tend to take a case and use it differently than it was intended. I use them on exams. I like the fact that

> there's a lot there and I can pick and choose how I want to use it. So, it's not just a scenario. It's not just a story. There are lots of suggestions. And then some of them tell you how to do it for upper-level versus intro. So, it's really very intensive, and the information there is pretty good. I wrote an article about the case-concept connection and I said it's all about connecting [the case] with the concept, which is what I found to be the most useful. And so I might just take part of a case and just take the story and talk about the concept. I think some people don't want to do case studies because they feel like once they've got a case study, they have to do it the way it was written. And I think that's something that people should really think about. If people who are trying to do case studies would think about that, they could get three or four really good case studies that are multi-topic, not necessarily interdisciplinary. They might be willing to buy into using cases because they'll get a lot out of them; bringing them up again and again in a different light. I really like doing that because it really does bring [the concept] home to [the students]. Most of the time they [are] reading case studies and they're like, "I better go back and read that case study because I didn't really read it very carefully the first time." So by the end of the semester, they know some of those case studies, because they just came up too many times. The idea that cases can be very useful on different levels [would help other instructors feel better about them because they shouldn't] ever feel like the way it's written is the way you have to use it. Sometimes just getting the *story* [emphasis added] is the most important thing.

Structural description. Kendra had difficulty determining the timing of when she officially began to use case studies because she felt that her teaching style was very similar to case study teaching already. She just did not call it "case study teaching" early on. That made her transition into case study teaching very easy because it really did not seem like anything new or different. What Kendra did struggle with, like many science instructors do, is content coverage. However, Kendra figured out a way to have a little of both. She flipped her class. Kendra primarily teaches non-majors, who she believes benefits from case studies. Case studies make science less intimidating and cases also help the students connect the concept with the story. She will even drop hints on her exams to remind students of the case study to which certain concepts are connected. While she wishes her students could separate the concept from the story, she is not bothered by it too much because that is the beauty of teaching non-majors; they do not really need to be able to do that. They do not need that much depth nor do they need the strong foundation to carry with them to their upper-level courses. Also, she utilizes the flexibility that case studies offer by being able to use them to fit her needs. She says that she does not always use them as they were intended. Kendra is the only participant who has actually sat in another colleague's class to watch them teach using case studies. She was conducting research for her dissertation at the time, so whether or not she would have attempted to make those observations otherwise of another colleague teaching with case studies are unknown. She says, however, that watching another colleague use case studies really helped to boost her own confidence in using cases because she had the opportunity to see another person deal with what Kendra calls the "messiness" of case study teaching. Case studies do not always play out in the classroom as the instructor envisions. Kendra witnessed her colleague deal with things such as students wandering off topic, not being able to answer any questions, and just being confused. She saw her colleague overcome those issues, which gave Kendra a better sense of what to expect and how to deal with it. Kendra has stayed busy with various conferences and she has not only presented at the case study conference in Buffalo, she has also been asked to be a plenary speaker, which she was very excited about. She may not be as involved with the group in Buffalo as much these days, but she does stay in touch. Networking is very important to Kendra. She enjoys engaging in conversation with other people about what they are doing with case study teaching either at department meetings or conversations over lunch. She is fortunate to be at an institution where case study teaching is well received.

Dr. Anne Howell

Biographical information. Anne Howell is a senior lecturer at a private, Ivy League, research university where she has taught for 12 years. She was a lecturer for the first eight of those 12 years before becoming a senior lecturer. She has only taught at this institution. In addition to other classes, she teaches a portion, the developmental biology part, of an introductory biology course where she uses case studies. She has attended the case study conference once.

> **Textural description.** [Prior to case study teaching, my teaching strategy] in intro bio, from almost the very beginning, which I've done for I guess ten years, is you come to two days of lecture but one day a week you go to recitation and that's required. Those recitations are anywhere from 18-25 people. And in those recitations, every week we do problems. Now [those problems] are probably tweaked a little bit more because you can see where [students] had issues with them because when we get to the exam, they're all new problems [that the] students haven't seen. So we tweak to take care of any issues that we had when we did the exam. So when I started teaching the development part, I saw where there was a very good example. One of the things I teach is sex determination, about how gray it is, that there are really four decisions and the decisions don't have to turn out…it's not black or white. I use sex as my example. It's a nice way to kind of bring together all of these things…that there's four different decisions, [which] means differences in transcription and chromatin and DNA methylation and everything that's going on there. You can make it into a nice case. And so it's a really nice way for [the students to] feel like it's relatable to them. It's a nice way to make it personal.
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> [For my initial exposure to case study teaching], I was lucky enough to have Clyde [Herreid] give a one day seminar here [at my city] so that I didn't have to go far away. My colleague said to me, "You know, Herreid is really good, you should go hear him." Well I think it was like fifty bucks or free at the time, and it was in the city, so I just took the subway. He is very good. He gets you to where he wants you to go in the end. And I think that isn't always scalable to everybody because not everybody has his abilities, but it was wonderful to see. And it was convincing to me that that's a way you could definitely go. Of course, look at the things he talks about, how he first started and even though he was tenured and really cared about teaching, that he had a lot of push back and he had to convince his Chair. So, you know, he kind of also gave me a good idea of what I was going to be up against. But, yeah, the fact that my colleague told me to go and to hear Herreid really made a big difference. I think that having a demonstration where he actually made us do the case was really what was

convincing, not [just] that someone talked about cases [being] good. Most of these pedagogical things you have to see to believe.

I think that I wouldn't have been convinced if [Herreid hadn't put me through the experience as a student]. So, I went to [Herreid's] case study collection and at the time, of course, there were [fewer] case studies; now there are more. I also got onto their mailing list so that whenever there's a new case study, I get that information. It's much easier to have it be there as it comes out. You get to review it, as opposed to going [to the collection] and look through all of that. But definitely, [something that influenced my decision to implement case study teaching was] the fact that [there was] a collection that I could then look and see if [there] was something that was at the appropriate level and the appropriate topic.

[Regarding challenges with case study teaching], time management is an obvious issue. As soon as you start doing it, you start to realize what [the students] need to do beforehand and how much time will you allow them to do each thing in class? You have to always remember that if you don't give [the students] enough time, they're not going to get what they need out of it. So, you have to be willing to decide what you will cut form your lecture in order to have a case study. Because now all of a sudden, it's not just lecture, and content of lecture, it's also managing cases. It's all of these procedural things. It's like directing a play, right? It's not just the content of the play, it's the timing of the play, the lighting, the director, and all the things that go along with it. So, I think that every time I do it, something new like that, it's always a question first of all, "What will I cut out to make [time] for [the case study]?" Being sure that I don't just jam it in but that I execute people's time, because the whole point of a case is that they get to discuss with their peers and if they don't get to do that, that's an issue. They get to actually work through that and I think that that's really an important part of case studies…is giving [the students] enough time to discuss. [The students] also get more confident as a result of their discussing and then when you talk in the bigger group, they're more likely to talk. It's only later when you start to think about how you will manage the time.

I was convinced right away after my [initial] exposure to [case study teaching]. I had [the workshop by] Herreid in the fall and I didn't [use a case] that next spring, but I did the spring after. It had taken a long time to find appropriate cases. So, actually the next summer I spent some time looking through the case studies. It really was a matter of timing.

[What made case study teaching more advantageous for me was] making it sink in with the students. They get a chance to talk about it and [by giving them] personal scenarios, you give them a chance to see how the science was done. You know, the "gray-ness" of the fact that science is not just black and white. They interpret data and it's not always perfect. So, I do kind of strategically, on purpose, give them chances to think in class, you know, talk to each other.

[Other than Herreid's workshop, I did not have the opportunity to actually observe someone else teach a case], I think that people can talk to you all day about it, but [to] actually see it done [would be a good resource to help someone feel better informed about the benefits of case study teaching]. I think the fact that I saw [Herreid, a scientist] doing [a case] opposed to if someone did it for me in the humanities, I might feel like okay, "How do I take that and apply it?" [Another resource is] to have the database that was with cases and then to see other people who are trying to find ways to get students to interact. All of those things I think were helpful. [As far as getting information from the literature], there's been all kinds of those numbers in *CBE* [- *Life Science*]. It comes to my in-box. There's a bunch of [articles] that show numbers [regarding data on case study benefits]; I've seen those.

So, I think that one of the best ways [for me to disseminate information about case study teaching comes from my] students talking to each other and sometimes that [carries over and other] professors hear [about it]. [Additionally], I'm on a committee that's talking about things we could do to improve teaching at [my university]. One of the things we talked about [includes] what we [are] actually doing at the moment [regarding our teaching]. I was assigned to find that out in four departments, mine and three others. And what we all seemed to find when we came back together and talked was that a lot of our colleagues don't know what the people in their department are doing. So, in the undergraduate committee we were saying that we should do something to make that happen. I [suggested that] we do it during our normal faculty lunches where people talk about their research but we could [also] talk about our teaching. So I signed up for one of those where people talk about their teaching. We talked about what we *are* [emphasis added] doing and a bunch of people are doing articles in different ways. It was fruitful to talk about how we do articles and what we're doing. And I do consider that a type of case study. So, it was interesting. But yeah, I would say that it probably isn't disseminated as much as it should be.

You know, so, I did get to hear about a whole bunch of different ways to use case studies when we were at [the case study] conference [in Buffalo]. [In addition] HHMI does these teaching institutes that my colleague has gone to. And I know that next summer we're going to actually have one at [my university] for the faculty [here.] So, I'll probably go to that. And I know that they talk about case studies as one of the ways [to teach]. I did go to [a conference] that was offered in the city by a publishing company where different teachers talked about interactive things they do and one of the examples was case studies.

If my colleague hadn't told me about that first [workshop] when I first got to go see Herreid's [demonstration of case study teaching], I wouldn't have even gotten started. It wasn't something that I knew about on my own, [so networking

> had quite an effect on my use of case studies]. And [this] colleague has been teaching intro bio for forty years. She has gone to Herreid's stuff before and yeah, [she] definitely got me started. So, yes, it's exposure to it. You're not going to be convinced of it if you're not exposed to it. So, how do you get exposed to it? How do you deal with it? [There are the] conferences that you can go to and of course having the money to even be able to go to those conferences. I was lucky enough to be able to have the money to [attend the case study conference] this past year. If you can see that someone else is [using case studies] at your institution, that's always going to help because that's a cheap way to get exposed to it.

Structural description. Anne seems like a very analytical person. She went into great detail about how she teaches her course during our discussion. She feels lucky that someone suggested that she go to a one-day seminar given by Clyde Herreid in her city. Not only did she learn about case study teaching, Herreid also talked about his early experiences including how he had to deal with opposition. She was, of course, convinced right away after attending Herreid's seminar, and she attributes that seminar to her implementation of case study teaching, believing that she would not have been convinced without the impression that Herreid made on her. Anne found that to be very informative because it gave her the tools to be prepared should she find herself in a similar situation. Fortunately, she has not had to deal with opposition. In fact, she is on a committee that looks at ways to improve teaching at her university. She gets the opportunity to talk about case study teaching in a non-hostile environment. One of the things that Anne emphasized regarding her use of case studies, is how well cases show students what she calls the "gray-ness" of science and that it is not black and white. She purposefully selects case studies that give her students a chance to interpret data and see that it is not always perfect. She compares the classroom management procedures of case study teaching to the procedures of directing a play. I thought this was a great analogy to show the fun that instructors can have with case study teaching.

Dr. Evan Robertson

Biographical information. Evan Robertson is a full, tenured, professor at a public university that awards master's degrees and some doctoral degrees. Prior to his current institution, where he has been for 17 years, Evan has also been a faculty member at a small, private liberal arts university for two and a half years and a men's Catholic liberal arts college for three years. He has taught a variety of courses, but specializes in the non-majors introductory biology class and in the introductory botany class, using case studies in both classes. He has attended and presented at the case study conference and is a case study author for the NCCSTS case study collection.

> **Textural description.** [Prior to using case study teaching, my teaching strategy was] boring! I lectured [and] back then I was writing on the chalkboard. Like most people, I came out of grad school with no training in how to teach and I discovered that while I tried hard, I wasn't a bad teacher, but I was kind of boring. [The] students were very polite, but there wasn't a lot of indication that I was a terribly memorable teacher. I learned [about case study teaching] in the late 1990s, maybe 1998, about a week long workshop in teaching cases at Buffalo. I didn't really go with any expectation of *changing* [emphasis added] my teaching, I just went because first of all it was free and secondly, it was something to impress my dean with. [After learning about case study teaching at the workshop] I became fascinated with the *idea* [emphasis added]. I came to realize that cases can substantially improve students' retention of the material. And I also found that cases were kind of fun to teach. I wrote a case [at the workshop] that week and actually was one of the students chosen to demonstrate a case. I came away convinced that cases were important and right after I took the workshop, I decide to try to teach a case. [I taught my first case] the [following] semester. It was only gradually that I became competent in teaching them [and] I realized that if they're important, why not do them a lot?
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> I was quite impressed first of all with the evidence that if you teach a class with lectures, [the students] are going to remember some of it and if you teach a class with cases, they're probably only going to remember about the same. But, if you ask them six months or a year later, [the students who learned] with the cases will *remember* [emphasis added] much, much more than [the students who

learned] with the lecture. What's the whole point of doing a lecture if they're just going to forget about it anyhow? It takes students time to adjust [to cases]. If you only do one or two cases, they barely adjust to it and not all that much learning [is] going on. I gradually realized that if I was serious about teaching with cases, I needed to do them regularly. So, I'm a passionate believer now in teaching lots of cases.

I have also been involved in two multi-institutional research projects to study cases. In one of the studies, we were comparing teaching cases with higher-order learning questions versus comparing cases with lower-order questions. And rather interestingly, we found that students learned better with [cases that use lower-order questions]. The second study that I was involved in was looking at the emotional hook that you can sometimes get in a case. And we found that if a student gets emotionally invested that they are much more likely to remember. Another thing that I found is that good [cases] gets students' interests. I have become increasingly convinced that a good case should have some sort of hook or connection with the students. The Santhi case for example. It's a story about a woman who won the silver medal in the Asian games and then had the medal stripped from her. That's a good example of an emotional hook. My students really start feeling passionately about her because they don't think she was treated fairly. So the thing that I like about cases is that the students aren't bored, [and] secondly, ideally, they really, really learn something and remember [it].

I think [a challenge that I saw] right away [was] I knew that I would have to be a little cautious about using cases. Now to put this in context, I was teaching at [a small, private, liberal arts university located in the Midwest] and the expectations for tenure are very, very, very informal. Basically, if you want to get tenure, you need to make the dean happy. Therefore, I wanted to use cases pretty cautiously at first. [Even at my most recent job] my colleagues don't understand what I'm doing. They've been tolerant of me doing cases, but I suspect that if I asked them, that many of them would feel that it's a little bit of a waste of time. [Another challenge that I have encountered is that] while students enjoy cases, they're used to lectures and even though they find the lecture boring, they understand, or think they understand, how it works. There's actually some inertia or resistance to doing other things, especially the idea that they are not passive recipients but that you want them to participate. That's not been a big problem, but it has given me some issues. [Additionally], when I started using cases, especially quite a few cases, my teaching evaluations went down. [It bothered me] on one level. On another level, [my evaluations] have always been high enough that I haven't had to worry about them. And, I think that teaching evaluations are a rather biased method of evaluations, so I never particularly lived or died by them.

I typically teach cases to large classes, [which means] that I am pretty much restricted to mostly using the interrupted method, with a PowerPoint and with clickers. And I think there are several challenges associated with them. First of all, that fact that the student might ask a question that you're not prepared for. I mean, lectures are very, very safe for the professor because, hey, you know it's all you; students are just recipients. I've found occasionally that cases wandered a bit off topic and I have found that sometimes they fail. Wandering off topic usually means that the students are getting into it and it goes in an interesting direction that you didn't expect. Failure is more difficult. It's a risk that you take and it's a part of it. And, I actually think that having a case not work isn't necessarily all bad. I've also found that telling [students] about my [failures] makes me seem more human, and things like that. I've learned to use strategies to make myself more accessible and I've also learned to use strategies to convince students that class is a safe place. I also find that once students get into clickers [it] really helps because clickers enable everyone to participate at a very safe level.

[One thing that makes teaching with cases advantageous is that] I don't think you need to know all that much to teach a case. If somebody was brand new to cases, I would advise them, first of all, to be a risk-taker. Go ahead and do it. It's okay to make mistakes. It's okay to have problems. And probably the most important attribute to teach cases well is to be able to accept mistakes or problems. You can [also] do short cases. I have a case that takes only fifteen minutes. And part of that fits with my philosophy of teaching lots of cases. [Cases are also an advantage for] my non-majors class, [which] needs more attention-getting kind of stuff [and] there's just more opportunities [that cases can provide for that]. People should [also] know that cases strongly increase long-term retention!

[My communication about case study teaching with others involves doing] workshops on how to teach cases, [and] a workshop or two on how to teach lots of cases. I've done a couple of workshops inside my institution. I have also been involved, I think four or five times now, in [the Buffalo] workshops. I have also given two workshops outside of [my institution] to different audiences including one national presentation. [Even though] I sometimes feel like I'm preaching to the choir because often times people [attending my workshops] already *have* [emphasis added]been teaching with cases, I've got quite a bit of experience and I've found that I have some things to share. On a very informal level, I am always happy to talk about [cases] and encourage people who are interested. [Networking has allowed me to] run into people at the workshops. That's probably the main way that I have interacted [with people in addition to] the two grants that I was involved in. The first [grant especially], because everybody [involved wrote] three cases and I was the initial editor before the cases were formally submitted. I've learned quite a bit about cases in the process and I also learned quite a bit about talking to other people about them.

Structural description. It was interesting to hear Evan describe his teaching method prior to case study teaching. He adamantly said it was boring and that he was not very memorable. Things have changed for Evan now. He no longer considers himself to be boring. He not only thinks passionately about using case studies, he is a firm believer in using many cases in his class. His reasoning for using so many cases within one class is to help the students make the adjustment to them. Evan says that if you only use a couple of case studies, the students do not get a chance to get used to them and you will encounter some resistance. However, if they use them often enough, the students begin to feel more comfortable with them. Evan states that one thing that seems to be important about a case study is that it has some kind of hook or emotional connection to the students. It gets them invested in the case, they learn more, and most importantly, they remember it. When Evan first started using cases, which he learned about by attending the case study workshop in Buffalo, he felt that he needed to be a little cautious at first. He knew that tenure expectations involved making the dean happy as opposed to innovative teaching strategies. It seems that case studies were not very well received at his first institution, a small liberal arts college. It has not seemed to change much for him at his current institution, a four-year public university, where he is a full tenured professor. Other faculty in his department do not seem to be interested in case study teaching and would probably deem them to be a waste of time if asked. Evan made a point to say that teaching with cases requires very little skill. He says he would advise someone brand new to case study teaching to be a risk-taker and just do it. Mistakes are going to be made, but that is okay. In fact, he says that mistakes should be expected. He has found that exposing his failures to his students makes him seem more human, which in turn, helps the students feel that his class is a safe place. He wants students to be able to participate in his class at a safe level, which can be challenging sometimes in a large classroom. So, he primarily uses clicker case studies so that the students can answer the questions without other classmates knowing their answer. I suspect that if someone were to ask Evan about case study teaching, he could summarize that he is passionate about using case studies with this statement: Cases are a good way to get your students invested in the material because they are not boring; they promote great discussions because students will occasionally wander off topic; students will remember the material better; and you do not have to be an expert to use them. Just do it!

Dr. Mark Rowling

Biographical information. Mark Rowling currently holds a fixed-term, non-tenured track position at a large, public research university. Prior to that, he held tenured positions at a comprehensive master's level public coeducational university and also at a public university that offers bachelor's, master's, and doctoral programs. Mark gave up tenure to be at the same university as his wife. Altogether he has been teaching for 33 years. He teaches an introductory integrated science course where he uses case studies at his current institution. He has attended and presented at the case study conference and is a case study author for the NCCSTS case study collection.

> **Textural description.** [Prior to case study teaching, my teaching strategy] was just a standard, classic, lecture course and it was very content-focused. And, I grew very dissatisfied with that. So, the impetus for the case studies and for my changing things up a bit [started when a fellow colleague and I] were both really dissatisfied with the level of scientific illiteracy among college graduates and the general lack of critical thinking skills that college graduates had. So [my colleague and I] began brainstorming. [Our institution] was coming up for tenure reaccreditation under the Southern Association of College and Schools

(SACS). SACS implemented a new requirement a couple of years before our reaccreditation that basically charged the university to identify a significant, unmet student learning outcome. So, [our institution] put out an RFP, Request for Proposals, among the faculty and staff to identify a significant unmet student learning objective that we would tackle as the centerpiece for reaccreditation. [My colleague] put together a package wherein we were going to have to build a new course that took head-on the problem of pedantic, content-based, memorization, regurgitation…intro science courses for non-majors. So a small team was put together, [my colleague] and me and a couple of other people and we set about building a course to do a much better job of teaching science as a process and helping students understand and recognize the power of the way of knowing and increasing critical-thinking skills. One of the members of the team, the coordinator for the laboratory sections in the biology department at [our institution], had been to one of Kipp [Herreid's] training sessions [for case study teaching]. We thought about other approaches, but we really latched onto the power of case studies as a way of teaching process and content at the same time. So, in preparation for building this course, several of us took the fall session [of the case study conference] and all of us took the summer session, the one where you actually build a case study. [The lab coordinator] was familiar with the case study approach and argued eloquently for having that be [the way to go]. Basically, all the labs are case studies and then we built several that we actually incorporated into the lecture as well.

[The evidence that influenced my decision to use case studies came from several places] including the great results [that we got from our publication] last year documenting how well the approach works not only helping students improve their critical thinking skills, i.e. reasoning skills, but also increases their willingness to tackle [what] a lot of the lay public struggles with and rebels against including evolutionary theory. So, yeah, we were very pleased. [Also] it was both anecdotal evidence from our own teaching and reports like Arum and Roska's study that they published where they followed a couple of thousand students at a number of institutions. They looked at primarily over the course of [the students'] core experience [for] the first couple of years and [for] some of them through graduation. [A number of the students] didn't show any change or improvement in critical thinking skills over their first two years and about half of them showed no improvement over all four years. In another study, Chris Impey, who would have been teaching intro astronomy courses in the physics program for non-majors, demonstrated minimal improvement [in critical thinking skills]. [Impey] tracked students until graduation and basically had a pre- and post-test. He discovered that there was minimal improvement in [the students'] science content knowledge. But what was really worrisome is that about a third of them or more come in believing in pseudoscientific nonsense. And that doesn't change in their four years in college, even if they've had two or three science courses. This was helping us make sense of the national trends; the reports that come out every couple of years from NSF that science and engineering indicators show the dismal lack of content knowledge and lack of acceptance among the general public of evolutionary theory. Most Americans believe in really bizarre conspiracy theories and it was all of that.

There are a couple of levels at which I wanted to address [challenges]. The biggest impediment we had at [the institution where we wrote the case study course described earlier] wasn't from the administration because this class and its success was at the centerpiece of our reaccreditation. We were very lucky in that because it meant that the university had to pour resources into it. The biggest impediment was from fellow professors, other faculty members. A number of faculty thought that we were going to be teaching a watered-down science course. And these are the faculty that tend to think that content is everything. And so they really poo-pooed the course and they badmouthed the course. So the biggest hurdle we had to overcome was the bad mouthing behind our back to the upper level administrators of fellow faculty. When we assessed the course, we assessed it not only pre- and post- for our course, but other gen-ed science courses taught at our institution. There was absolutely no change in critical thinking in the traditionally taught gen-ed science courses. There was no change in *any* [emphasis added] of them! And in ours, there was a huge improvement. Yeah, so we had evidence to back [it] up. We could demonstrate that it was very effective. I don't know if it changed our colleagues' minds. [However], one physics professor, who while we were developing this course, adamantly stated that he was doing a good job teaching critical thinking, did compliment us after the results came back and showed that his class was not and this new class was. Yeah, so sometimes evidence changes people's minds.

[After my initial exposure to case study teaching], we first started teaching our experimental course in the fall of 2009. We'd been planning/building it for a couple of years. As I mentioned, [the lab coordinator] member of our team had been using case studies and convinced us of their possible utility. [The lab coordinator] and I attended the fall NCCSTS workshops and then the whole team (five of us) attended the summer "build your own case study" workshop the next June. This was likely the summer of 2008. After that, we were all "hooked." However, I never employed a true case study, what the [NCCSTS] center teaches outside of the context of this new course.

[Even though it is challenging to teach cases with] anywhere from 140-200 students, auditorium seating and big wooden chairs that you can't turn around, [what I found to be most advantageous about case study teaching is that] the students are more engaged. We were looking for an approach that would engage students and we were looking for an approach that got us out of our comfort zone of standing up in front of students, especially the non-majors, many of whom come in hating science because it's been poorly taught to them. We had to get away from standing up and giving them these terms that we force them to memorize. Then they would regurgitate it in an exam, and then forget.

[The only opportunity that I had to observe another peer or colleague use case study teaching was] at the summer workshop. After you build [your case study], they have a group of honors students who you teach your case to. So, you actually not only build it, you teach it and it was really great. The feedback that we got from these honors students…they were engaged. It was instructive to see novices like me present their first case to this group of honors students. [Regarding resources that instructors need in order to feel better informed about the benefits of case study teaching], the evidence that active learning is a much better way to reach our students is pretty overwhelming now. [The students] learn more, retention is better, it works better for at-risk kids, and the evidence is so strong; and I would include our study in that. There's a better way to teach non-majors. Sometimes the evidence is sufficient for people who are scientists to change their mind. On the other hand, there was a recent study by Seth Mnookin, where evidence doesn't *always* [emphasis added] matter. If you've already formed an opinion about something, evidence may not [matter]. [For example], I'm sitting on a committee here at [my current institution] and there is a faculty member who does all of the things that we know are horrible. And she is very insistent that she's doing a good job and she doesn't need any of this new fandangled teaching methodology forced upon her. So, part of that I think, those faculty need to recognize that it's *not* [emphasis added] being forced upon them and for people like me to do a better job of not alienating them right out of the box…preaching at them. [On the other hand] for faculty who would like to better engage students through any form of active learning, including case studies, obviously support, [and] encouragement [can be helpful] from the people that have done it before; helping them understand that they don't have to change everything right away. One of the points that Kipp [Herreid] made is you don't have to change your entire course. So start by adding a couple of case studies and see how they go. It's encouraging to see that the newer faculty that *we're* turning out, certainly the graduate students that we're turning out are much more receptive to engaged learning…active learning.

[I have disseminated information about case study teaching through] the paper we published last fall. And, I've published two case studies that have been accepted and deposited in the National Center for Case Study Teaching in Buffalo. I built a case study [that] really focused on helping the students understand the distinction between good science, bad science, and pseudo-science while learning some content. I published that at NCCSTS and Kipp [Herreid] thought highly enough of it [that] he [included it in his] column called Case Studies in the *Journal of College Science Teaching*. He published a shorter version of my case study. [My communication about case study teaching with others involves] talking up case studies. I talk of active learning. The director who oversees all of the gen-ed courses [at my current institution] knows about my course. He's got a copy of the paper we published last year. I think the likes the approach. I'm always talking of active learning when we have our faculty meetings for that group [but] I think [the director] is constrained by a lack of resources. [My participation in professional development includes] teacher

> training workshops and active learning workshops [at my current institution]. And then the Lily Foundation funs a few workshops [here as well]. I've participated in a number of those.
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> [As far as the effect that networking has had on my use of case study teaching], I was lucky to have been part of a group [who designed that experimental case study course]. If I had attempted to have done this on my own and changed the class that I had been teaching into what I'm teaching now, it would have been much harder. I was lucky that I had three colleagues [who] were mutually supportive of each other and we could take the slings and arrows from our colleagues; we could deflect them better. So, at that level, that kind of collegiality, that kind of networking…in retrospect…I really benefited immensely from that. We all did. The conferences are always great. You meet people who [are a] like-minded, magnanimous, spirited, engaged, [group of] instructors who recognize the power of HG Wells' comment that civilization is a race between education and catastrophe. It's always wonderful to go to those workshops where you meet people who are going to pat you on the back for trying to do a better job with your teaching. Because you don't always get that from the institution where you're at. And then, of course, the support and feedback from people like Kipp [Herreid] and the folks at the Center [for case study teaching]. I've been very lucky to have both a personal friend and a colleague in Louise Mead [Education Director at The BEACON Center for the Study of Evolution in Action], given her background and focus on effective science teaching. Yeah, so [networking is] really important.

Structural description. Mark is very passionate about scientific literacy. It quickly becomes obvious during a conversation with Mark that he cares about addressing the misconceptions that students have regarding what he calls "pseudoscience nonsense." He and three colleagues designed a course that uses case studies in the attempt to overcome student misunderstandings. Fortunately for him, when he was in the process of designing this experimental course, the success of the course was at the centerpiece of the reaccreditation for the institution. So, he had full support and received resources from his administration. The course was a success and the team published their findings. He admires how case studies are a much better way to teach at-risk students. He firmly believes that case study teaching is a better way to teach non-majors, who tend to be the group more susceptible to pseudoscience nonsense. Mark would like to see more people exposed to the literature evidence showing the success of case study teaching with the hope of changing their minds that case studies are a better way to improve the critical-thinking skills of their students. However, Mark is realistic about the fact that evidence may not always make a difference. He wants those who are not ready to make a change to their teaching to understand that active learning is not being forced upon them, but at the same time is ready to offer support and encouragement for those who are interested.

Dr. Aaron Wade

Biographical information. Aaron Wade has taught for almost 40 years and is currently a professor of biology and associate dean at a public research university. He has also held academic positions at three other public research universities where he was at dean at both. During the times he was a dean, he either did not teach or only taught an honors course. Now, he is back to teaching introductory biology using case studies. He has attended the case study conference.

> **Textural description.** [Prior to using case study teaching, my teaching strategy] was pretty much standard, traditional lecture with extremely large classes. I had no choice [but] multiple-choice questions on the exams. Occasionally I would do short answer or draw a picture in my non-majors biology class, but then trying to grade almost 500 of those is a killer. [I also] went to the Institute at the University of Delaware's extensive clearinghouse of problem-based learning exercises, PBL, which is sort of in the sciences I think. It's sort of the progenitor to the current use of case studies. PBL is a pretty demanding technique. It really takes a lot of time and effort to learn how to do it. I think [it takes] more effort than it does to do a case. I [also] did some think-pair-share kind of things back then. I would ask questions, [but] it's hard to get people to raise their hand in front of 500 other people. So that didn't work so well. But one of the things I did then, in human biology…the non-majors course [was], we talked about pretty personal kinds of things. And so I would leave a box at the back of the room, near the two exits, and tell people, "If you've got a question, I understand that you're not going to raise your hand and ask questions, especially when we're

talking about sex and all kinds of other stuff." So, I leave a box at the back of the room and say, "Write your question on a piece of paper and throw it in the box as you leave and I'll do my best to answer it." I almost always had a number of pieces of paper in those boxes. So I would start each class by reading the questions and then trying to answer it. And sometimes [there were] three or four questions [in the box]. So that's one way of trying to be interactive in kind of a pre-digital age. The other thing I would do is try to make it relevant to their everyday life. The non-majors course was called human biology. We basically covered basic biology topics. And it was a non-lab course, which meant the students were taking it to satisfy part of their general college science requirement. So, there are 500 students in there, who are convinced, they hate science, and they're only in there because they have to be and, "What does this got to do with me anyway?" I kind of took that as a challenge; I needed to make this as relevant as I can and show them that they need to understand these kinds of topics. So, depending on what we were covering that day, I would try to start class with something out of *that* [emphasis added] day's newspaper or maybe that week's Newsweek. I don't care what the topic is, you can *always* [emphasis added] find something that's in the current news that's relevant. So, I would show them this article and say, "Now look, this is what we're talking about today. You can't read this article and understand what it's talking about unless you understand the topic that we're talking about in this class today." I don't know if that works, you know, [but] I think it helped a little. Certainly, I tried to be as engaging and making it as relevant as possible.

[My initial exposure to case study teaching was when] I met Kipp [Herreid]. I also worked on a project called the virtual cell animation collection. Kipp [Herreid] was starting into a project where they were trying to incorporate videos into case studies. So, he invited me to come and work with them because they didn't have anybody who was really doing animation. That's what led to my attendance at the conference and that was just when I was getting back into the classroom [due to being a dean and out of the classroom for 15 years]. [That was] my introduction to case studies. I was at the [workshop] in the summer and the [workshop] in the fall. So, with my experience with PBL, it was sort of a natural. I understood the philosophy behind it. I learned an awful lot about the cases themselves and how to build them by being involved in those conferences. But that was really my introduction. I didn't actually *try* [emphasis added] one in class until after I had taught the part of those courses on animations.

I think it's the overwhelming evidence that's out there [that influenced my decision to implement case study teaching] about how active learning is a more effective means of teaching. Combined with, I don't want to use the word "failure" but [the] success rates in these big introductory classes are not good in the sciences. Anytime you have a D or F or withdrawal rate of 25-40%, how do you call that success? I mean, that's just not good. I think it was a combination of those two things [that influenced my decision to use case studies]. [I got that information] from the literature [and] going to conferences. I was keeping up with the education literature some; enough to see the big articles. But not at the level I needed to be [in order] to start treating this as my research, which now…this *is* my research area. I was a plant cell biologist. That was my laboratory research, and [I was] doing the virtual cell work on the side. When I moved to [the institution where I was going to be a new dean, I had to give up the lab work. So, I did keep up my virtual cell work and that kept me at least up with parts of the literature. But when I moved to [my current institution], I really made an effort. I said, "I've got to catch up with the state of the art in this area." So I went to lots of conferences that first year; anything that had education or STEM [Science, Technology, Engineering, and Mathematics] in the title. I didn't necessarily go to all of them, but I went to a lot of conferences to try to catch up. I spent a lot of time reading the literature and tried to at least catch up with the last ten years of literature. So, it was a combination of going to conferences and networking with people and reading the literature. [After I attended the summer and fall case study workshops, I used a case for the first time] the following spring.

[The initial challenge for me was] that I hadn't taught a course like that in 15 years. So, as I started preparing to go back into the class for the first time in 15 years, I realized that my lecture notes were 15 years old and my technology was non-existent. I didn't have anything in PowerPoint. PowerPoint didn't *exist* [emphasis added] the last time I taught. I knew that the biology itself hadn't changed, not really. I mean at the intro level…other than maybe genomics and bioinformatics and things like that. There's not anything fundamentally different about intro biology from 15 years ago and now. I think the practices in class had changed a lot. The students, I think are a different generation [plus] I had the technology challenge in front of me. I know how to use PowerPoint, had used it all the time, but not in the classroom. I didn't have any of it in place ready to use in class. Then there's flipping. I was intrigued with the idea of trying to flip a class and had read enough to know that if you dive into something like flipping classrooms or case studies, you know, re-do the whole course all at once. I had a sort of unique opportunity of having not taught that class in 15 years; I was in a way starting over again. So, I had the opportunity to introduce things like case studies and flipping, at least sections of the course. I went into that first fall, that first course that I taught thinking, okay, I'll do two or three case studies and I'll flip two or three sections of the course. Well, that lasted less than a week. I got in there and I don't have any of this ready to go. I'm lucky if I keep up a week ahead of where I am in the class, just in preparing for what I've got to do in this class next week. So, I anticipated some problems, but I didn't anticipate what I was up against. Really, I had to just completely re-do my plan on the fly that first semester. I ended up doing two case studies. I used a lot of the virtual cell animation, and then one of the case studies I used came out of the University of Buffalo, the National Center, you know the Case Study Teaching in Science summer workshop. So the summer workshop was a smaller number of instructors who were there to try to actually write new case studies that incorporated videos and animations to them. So, one of the ones that came out of that was using one of the virtual animations and it was on mitosis, sort of a murder mystery kind of case study. That was actually the first one I used and it went over really well. The students loved it; they said, "Do more of these, we like that." I feel like I engaged in this topic in [more of] a way [than having students] just seeing it and hearing it in lecture. I was really encouraged and thought, okay, that went well; I'll try a couple more. So the next one I picked was [also] out of the [case collection] from Buffalo. The next one was on molecular genetics, presenting a couple of the classic experiments that were done. Well, it crashed and burned for me. I don't know what it was. It may have been toward the end of the semester, but you could see [the students] rolling their eyes as I would go through each part of it. I had to basically just pull them from one part of it to the next. They were totally disengaged [and] they thought it was stupid. It was very strange and disconcerting. I didn't quite know what to do. I didn't do a third one. We were pretty much out of time anyway. That was sort of a mixed bag that first time. I've used [the mitosis murder mystery case] twice since then and all three times I've used it, it's gone over very well. The students really like it. So anyway, I guess I've had some mixed results [both] encouraging and disconcerting. [But] yeah, I will continue to use them. It's a matter of continuing to look at new cases and try to pick a few more that are likely to work and start incorporating those and use them and try them. I think that's what you have to do. You've got to ease into them.

[What makes case study teaching advantageous is] the student engagement! It's active. They *have* [emphasis added] to engage with it. You're not lecturing. You might be giving mini-lectures, you might be explaining something for a few minutes, but it is not a lecture. And basically, if they don't participate and actively engage in it, then they're just sitting there doing nothing. I think if forces them to think about that topic in a completely different way. They have to use their knowledge or gain some knowledge about that topic in order to address whatever the case is setting up for them, which they do not have to do in a standard lecture. It's not only engaging and active, it's working in a group. And anytime you are working in a group like that, you're being challenged by the other people. It's just a very different way of engaging with the topic than with straight lecture and trying to write down notes.

I experienced [observing others using case studies] in both the summer and the fall [workshops]. It wasn't uncommon for [the people in] those sessions to be actually doing cases themselves. So, I experienced [it] essentially [from] a student perspective [with] Kipp [Herreid] and other people doing cases. I hadn't ever actually taught one myself before doing it [at the conference]. Other than those experiences, I had never observed somebody, that's for sure. [As far as resources go to help other instructors feel better informed about the benefits of case studies] there's a certain background familiarity with the literature that I think needs to be put out there. I think by and large, if you don't already know about case studies and active learning, then most instructors who are first being exposed to it need to be convinced, first of all that this *is* a better way of addressing instruction and learning. And second, what the evidence is…that it *is* [emphasis added] better. Once you get into it, it's pretty clear, as scientists, I think that most people who are exposed to the literature realize very quickly, whoa, this is overwhelming! This isn't even close! It's pretty dramatic. You don't find many cases in science where the evidence is as clear as it is…[and] what's out there; that this is a much better way of doing things. And I think it kind of shocks people when they first become aware of exactly how good it is. [Alleviating the reluctance] is multi-layered and very deep. It's culture. You don't change culture easily or quickly. It's the whole reward system, which at least at research universities, the reward system is 95% on being rewarded for the research you do, not the teaching that you do. And in fact, being an innovator in teaching can actually hurt you and faculty members know that. The assistant professor know that. They know what's going to get them tenure and it's not doing active learning or case studies or you know, something new and innovative in their teaching.

[My communication about case study teaching with others has been through] a group here that I organized when I got on campus that involves learning and pedagogy. It's about all of the active learning and engagement, and flipping classrooms, and any other methods. We meet every other week over lunch. I started it focusing kind of on the STEM disciplines because that's what my job is, but very quickly it was clear that the interest was much broader than that and it quickly just opened up to the whole university. We've been doing it for three years now and over that three year period, we've done a combination of helping each other learn the literature. So, picking a topic and kind of digging into the background, you know, [the] literature and then the current state [of the art]. We often will take a section that we're doing, a topic that we've decided to study…like a faculty learning community [does]. Then we'll try to take the next step, which is, "Alright, now how do we take what we just learned about this and actually start to implement it in our classes?" So, we'll spend a couple of sessions developing ideas of how we could actual build units or modules or applications of what we just talked about in class and report those back to the group. And then we try to get other people to go out there and try them…actually test them out. So, it's a pretty nice combination of getting the literature, getting yourself up to the state of the art and then trying to take the action step of actually implementing it in your classroom. It's been a really interesting and engaging way to do it. We've got everything from graduate students [and] post-docs, to assistant, associate, and full professors. So, one of the things we did there was one on case studies and I was surprised at how many people across campus actually use them, especially outside of science. You know, they were asking students to read this and then apply what you know about how you approach history to try to analyze what's going on here. Well in my view, that's essentially a case study. Trying to implement it at the intro level is a different thing. It's a lot harder [and] I'm not even sure, looking at the junior-senior-level biology course at most large state institutions and you know, those classes can be well over one hundred students; I mean, with some pretty detailed topics that you cover in cell biology. Especially if you are in an auditorium with the seats bolted down facing the front. It's just the obstacles [that] you have to overcome are pretty difficult. And if you are going to do case studies, they've got to be able to circle up and you know, talk to each other. If you're in an auditorium, it's really hard to do that. So, you know, there's a problem…physically. How do you get yourself into a teaching space where you can actually even do this? On this campus, there are very few spaces like that.

[My participation in professional development includes things such as] NSF funded research collaborative networks. So I got involved in a number of these research collaborative networks, and there's one on case studies too. I got involved in the one on case studies and the one on faculty development in biology. In biology, there's the response to the *Vision and Change* and [also] PULSE [Partnership for Undergraduate Life Sciences Education]. PULSE is a specific group, I think they're funded by NSF [National Science Foundation] or maybe HHMI [Howard Hughes Medical Institute], [but] they try to implement the ideas behind the *Vision and Change* document and get more departments [involved]. So their whole point is that [the] individual, that's good, but to really make change, you've got to change the whole department at a time. I've been to a couple of PULSE conferences and been [to] a number of conferences where they were [people from PULSE were giving presentations]. AAC&U has their annual STEM conference. AAC&U stands for the American Association for Colleges and Universities. They have a whole series of conferences every year, but about the last four or five years, they've had a STEM conference every year. Then there's CIRTL [Center for the Integration of Research, Teaching, and Learning]. It's a group of research-one institutions that are trying to get active learning and evidence-based practices more widely accepted. So, it's essentially attacking all of those cultural problems I was talking about a few minutes ago. Another one is the science of learning and pedagogical innovation. So, we're working on a national network and we decided that what was really needed was some type of repository of good active-learning activities and exercises. And not just a list of websites [where] you can go look at stuff because that can get overwhelming really quick. It's kind of like looking at the case study collection. What we were looking for was something on the order of a wiki thing, where the users actually give input and reviews and comments that are constantly being updated by other people who are using it on a real-time basis so [that it is] searchable. But broader than just case studies; all kinds of [things].

I'm coming at this [with regards to networking] in a very different way. I really got involved with the kind of national leadership component of working with this and then have worked my way back into teaching as opposed to the typical path, [which] would be more in the other direction. So, it's sort of a unique position I find myself in. And a little scary too. Oh my goodness, getting back into the classroom…I have always loved teaching, you know, that's why I'm a professor. And that didn't go away in the 15 years of being a dean. What I found was, I still like this, I want to do it more, and I want to work on how to do it better. So that part of it I think is sort of the inspirational instructor part that has to be there. You know, the people who are willing to put in the time and effort to learn how to do these active-learning methods have to have some passion for teaching. Otherwise, they're not going to do it or they're only going to do a little bit of it, which is okay; that's fine. A little bit is better than nothing. What I hope is that the little bit will lead to a realization that, wow, this does actually work better and maybe I ought to do a little bit more. The networking part helps in that, again, back to the cultural change. That's on the ground, department[al] cultural change, which is not easy to do, and it really helps to get ideas from other people around the country who are doing the same kinds of things to try to make those same kinds of changes happen. You get lots of good ideas. They may or may not work for you. You know, it's something else to think about and I think that's the value of networking. You're sort of back to the idea that, "I don't want to reinvent the wheel." Why should I go make the same mistakes they've already made? If I find what they've been doing, then I can start from where *they* left off, which saves a whole lot of time and effort and heartache. The problem is finding those things. So, that's been part of *my* [emphasis added] approach to this. I want to make it easy.

Structural description. Aaron was in a unique position when he was introduced to case study teaching. He had been a dean for 15 years and was getting back to the classroom to teach an introductory biology course. He was going to have to re-do his course anyway to add the current technology. He laughed about the fact that PowerPoint was not available back in his early days of teaching. So, he went in with grandiose plans to incorporate case studies and also flip some of the sections of his course. He said that lasted for about half of a week; keeping up with each week was overwhelming enough. On the bright side, the first case study he used went over very well. It was a case study that came out of the summer workshop he attended where they write cases. His students loved it and wanted more. Unfortunately, the second case study "crashed and burned" as he put it. So he did not incorporate a third case. He has not given up though. He continues to look for new cases to try. He will be diligent about finding the right cases, because he made the effort to find newspaper articles for his students back in his earlier years of teaching in order to make the course material relevant. Aaron realized how much active learning has become a part of instruction and learning during the 15 years he was a dean. He looked back through 10 years of literature to try and get caught up. He went to conferences with the same focus in mind. When he became a dean, Aaron had given up the plant cell biology research that he did in his own lab. Now that he is getting back to regular professor kinds of things, the overwhelming evidence showing that active learning is a better way to teach has led him to become an education researcher. I think he would shout it from the rooftops if he could that teaching in a way that engages students is more effective than lecturing. To help spread the word, he is involved with groups that focus on active learning practices. He is part of a group that does this in his current department and he is also involved with a research collaborative network. This is a national network of professors who are focusing on cultural change, not just at the individual level, but at the departmental level.

Dr. Cathy Welsh

Biographical information. Cathy Welsh is a full-time associate professor who currently teaches at a state-funded, public community college. She started teaching in 1999 and has held positions at a four-year university and also a four-year private college for ten years before moving into her current position. She teaches an introductory biology course for majors and an online, non-majors general biology course that includes a hands-on lab that the students do at home. She uses case studies in her face-to-face majors' course and in her topic-based online course. She has attended the case study conference.

Textural description. [Prior to using case study teaching, my teaching strategy was] pretty traditional. [I would] go chapter by chapter through the book. And a lot of that was dictated by where I was and what we were expected to cover. There was a bit of oversight in terms of how we were teaching and what we were teaching [at a previous institution]. Where I am now, we have certain learning objectives and we can meet those in any way we want. [My initial exposure to case study teaching came from] another faculty member who was talking about this. I always used examples in my teaching and then get the students to apply some stuff to those examples or understand the applications of the examples. But taking that next step to bringing a case study for [the students] to work with, another teacher demonstrated that as sort of a, "Hey, this is what I am doing in my teaching." Then, because I was the botany person, and [this other teacher] was more developmental, animal biology, [I was asked to] help come up with some scenarios [involving botany] and things like that. And it was kind of fun! I thought, "Why aren't I doing this?" That was my initial exposure to it.

[In addition to learning about it from another person] I looked at some of the *CBE – Life Sciences* articles. There was a teaching [article in *CBE*] that had case study examples. I generally looked through there just to get teaching ideas anyway and so all of a sudden I had that *search* [emphasis added] image for case study stuff and paying more attention to that. Actually, the Ecological Society of America, not in their main journal, but in their other publications, would have an article that talked about how to use one of their primary literature articles in your classroom. And I just started seeing [case studies] in a lot more places. [Regarding evidence], I'm a scientist; I want to see hard numbers. Anecdotally, if the students are engaged in the classroom, they're going to retain more. So, that's what I'm looking for. When I see students doing *this* [emphasis added] versus students applying what they've learned, that to me is sort of my first-hand evidence [that influenced my decision to use case studies].

The big [challenge] for me is assessment. To me that's a big thing. There's a big range in terms of how much guidance you're giving the students versus not. And there's a lot of terminology in there, like problem-based learning. So, the more student-driven the case study or activity that we're doing, the harder I find it to really create a good kind of assessment for what they've learned. I'm presenting it to [the students] in a different format [so] I'm not going to go back and just use my general questions that I would use if I was going straight through because, presumably, they should be learning the content, but they should be learning how to *apply* [emphasis added] it in a different way. I have done some reading on the introvert-extrovert personality type in the classroom. On the one hand, I think maybe the ones who are quieter in the group are really the introverts and they really are processing and learning the material. But if they're getting assessed as a group in terms of what they're turning in, then the extroverts kind of rule the day. I did [look for information in the literature] but it was also on the bigger context of assessing group work in general. Assessing student-driven [work], like project-based learning, it comes back to content versus skills that they've picked up and it's so much easier to assess the content than it is to assess the other aspects of it. Then I go questioning myself. Do I really need to assess the other aspects or it that just a benefit they're getting that they're going to take forward in their education?

[After my initial exposure to case study teaching] I tried one out pretty quickly. [Cases are] kind of mixed in [throughout my course] and it's usually toward a later part of the semester because we're starting with students, especially at the community college [level, who are] really deficient in background information and so we're starting with a lot of fundamental stuff. [But] yeah, it was pretty quick. I was pretty excited about the whole idea. I had tried them before I [went] to the [case study] conference [at Buffalo], which is sort of what drove me. In fact, I went to the [case study] conference with two other people and one was somebody who teaches almost exclusively by this method in our department. She's a really good resource person in our department to go to. This other person [and I] were sort of like, we've tried it a little bit, [and] we want to do more of it.

I really think [what makes case study teaching advantageous for me is] the student engagement, especially with our more "at-risk" students. I think that for a lot of students, putting the content on a framework that helps them make connections between the different facts they are learning a little bit [easier]. You can always refer back to [a] case study. One of the main ones that I've [used] has to do with diabetes and [also] some of the cancer-related ones. The students [remember an] aunt [who] has diabetes and so they can relate to it. To me [that] is one of the biggest advantages. I mean it's the bewildering number of facts that they're expected to learn in intro bio, and in a story, it helps them remember a little bit better.

I haven't [had the opportunity to observe another person use case study teaching] in the classroom, but it is one of those things I kept meaning to do. [Instead] I would just stop by [a colleague's] office and [ask], "When you've done something like this, what did you [do or] what do I need to do to make it work?" It was more of that kind of information rather than direct observation. [But] to see it in action [would] absolutely [be a good way of seeing the effectiveness of case study teaching]. I've meant to look to see if anybody's posted any YouTube videos of their classroom teaching [showing] a case study in action so if you don't have somebody on your campus to go watch, then you could observe a whole series of classes where they followed through on a case study.

Convincing people to do it [is critical] because it takes a lot of work. And it's a little bit of a leap of faith to do it as well because you just lose so much control over the classroom whenever [the students] are working on things. You have to be quiet instead of standing up there and talking the whole time. But actually seeing data [from a study where] one instructor [teaches] a class in a traditional lecture and another class with case studies, [where the results of the] exam [shows some] differences [would help others feel better informed about the benefits of case study teaching]. Seeing data like that would be good, but I also think that just hearing from other instructors, just word of mouth, is probably pretty effective.

[My communication about case study teaching to others primarily involves] word of mouth. I haven't done any formal presentations [but] I am on the Buffalo case study [list where] they send out emails saying when new case studies [are posted]. I'll pass that along to the rest of the department. I do look at the "comments" section on the case studies. Sometimes people actually write back comments and it's one of those things on my list. I should really post some comments of what I've done or what I've changed. [My participation in professional development regarding case study teaching involves] the Buffalo one [plus] I've been going to [other] meeting for years and years. I end up going to the teaching sessions that they've had there. Just recently I went to an HHMI BioInteracitve workshop, a regional workshop that was really interesting. We don't have much money to go to conferences at our school. So, if they're nearby and free, I go to them. The community college biology teachers [in our state] have a little get together, a statewide STEM conference that has teaching sessions in it that I go to. And, we've had on-campus things [where] people [who] are working with this stuff [share what they're doing]. [Networking] is a big part of it. Just the conversations about it, having other people say, "Have you tried this one in your classroom?" "Does it work or have you seen this one?" Those kinds of networking conversations are really useful. Now what I haven't participated in is if there's any sort of online, broader network of people doing case studies and sort of supporting each other. I'm just talking about people that I know personally.

I would say that, just in terms of using case studies, I think it's really hard to find one that exactly matches what an individual wants to be doing in the classroom or that's at the right level. So, that to me is also probably a little bit of a barrier to some people using them. [Other people] will read and they'll go, "Oh, this is really interesting, but it doesn't cover this, this, or this." Or, "I really want to focus on this other part and this has all of this extra stuff." A lot of people aren't willing to put the extra work into modifying it. I think that a lot of the earlier case studies that were put in the Buffalo [case study collection] are really at a lower level, especially with the story sophistication. I've noticed that as new [cases] come out, they're a little more "upper level" [and] a little more detailed and they require a little more background. I wouldn't even think to work through them. But the scenarios, they're a little bit more realistic or sophisticated.

Structural description. There are a few things that challenges Cathy's use of case study teaching; however, she maintains a positive attitude about it. What seems to give Cathy trouble is assessing the learning with case studies. Being a scientist, Cathy is torn between assessing the massive amount of content that is associated with introductory biology versus the application of that content in different contexts. She turns to the literature looking for research studies that show empirical data reporting the difference in learning outcomes between traditional lectures and case studies. Even with the assessment challenge, she has a very positive attitude about case study teaching. She can see anecdotally that her students are more engaged and that they retain more. She was introduced to case study teaching through a fellow colleague who would ask her for scenario ideas that involve botany since that is her specialty. She saw how much fun her colleague was having with case study teaching and wondered why she was not doing this. So, due to the enthusiasm that her colleague provided, Cathy became convinced and tried a case study shortly thereafter. She really loves the idea of case studies helping the students who attend the community college where she teaches because many of them are what she calls "at-risk" students who have deficient backgrounds in the basic fundamentals of science. So she feels that she needs to give her students those fundamentals first before using a case study. How relatable case studies are to her students is something that Cathy explained with excitement in her voice. She can use a case study that has to do with diabetes, for example, and a student can relate that to a family member, which just makes the information within that case study more powerful. Cathy enjoys the camaraderie that networking with other case study colleagues has given her. At science conferences, she finds herself attending the teaching sessions and she is beginning to attend more conferences based on active learning practices. Cathy understands what it takes to convince other people to get involved with case study teaching. Due to her acquired enthusiasm, it seems that she will be a great resource for future case study faculty.

Dr. Keith Williamson

Biographical information. Keith Williamson is a professor of biology at a community college offering associates degrees as well as a transfer program for students to earn credits for transfer to other colleges. He has been teaching full time for eight years at this same institution. He uses case studies in both of the courses he teaches, which includes a first-semester introductory general biology to non-majors and also a conservation biology course that has no prerequisites to first year students.

> **Textural description.** [Prior to using case study teaching, my teaching strategy was] mostly a traditional lecture; lecture and exams. I would do a little bit of small group work. [My initial exposure to case study teaching came from] other faculty members using it. Plus, I had started reading about [case studies] in different journal articles…articles in different publications about the use [of case studies]. It seemed interesting and a better methodology. I guess I read a sort of mixture [of research and practitioner papers]. Probably more practitioner articles, but I do remember seeing a couple of research articles. I don't remember exactly what they were, but it was sort of showing that there was more high-level learning taking place.
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> [Challenges] with any case study [is] trying to make it applicable to your students or [make it] fit the way you teach. So, I knew that that was going to take some work. And then [there is] resistance from students that are expecting to come in and just have you lecture to them. So, I knew that there would be a little bit of resistance there until they got used to them. The initial outlay of time was certainly something to be considered. [So] when I really started out, most of the time I would find sort of a case study that had already been done and then just modify it for my use, rather than starting from scratch. That helped reduce the time [challenge].
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> [I made the decision to implement case study teaching] pretty much right away. I had been thinking I needed more activities in my classes and this seemed a good way. I would say it was probably a year [before actually using a case study

in my classroom]. I needed to sort of wait through a summer before I was ready to put [in] the time to get it all together and ready to use in my class. As soon as I talked to people [though], heard that they were using them and enjoying them, I knew I was going to go ahead and do it. It was just a matter of having the time to find appropriate ones and get them modified for my use.

[Case study teaching is more advantageous than what I was using before because] to me it's a way of getting the students engaged in the material more than simply sit there and listen to me talk about it. And it also involves small group work, which is again, always a better thing to do [and to] get the students involved with one another as well. I think those are all important things, especially in a science class unless you're talking about [student involvement] in the lab itself. So, I thought those were all good points for using case studies.

I would say that [I found the benefits of case study teaching to be obvious] fairly quickly. Usually the first case study in the class is a little rough because the students have to sort of change their minds [and you have to] get them used to it. Then, the next couple [of cases] go pretty smoothly and the students are much more engaged and willing to put in the effort.

[I have not watched a colleague teach a class using case studies]; it's not one of those things you think about asking a colleague, you know, do you mind if I come and sit in and watch how you do this. But it would have been a good strategy to have used, had I thought of it. I also think that going to the [case study] conference [in Buffalo] is a really good place to at least sort of see some demos of how to do different types of case studies…actually see it done by somebody else would be great. I think that having the case study library as a resource is a great thing to have with all of the teaching notes and all of that is great. And, having sort of a forum would probably be nice. [People] could sort of share what they're doing …things that they've done, that have or haven't worked, or a place where they tweaked certain cases would be quite helpful.

As the coordinator for the first semester bio for non-majors, I've created a resource page. Most of the faculty members [at our community college] are adjuncts and so, I've tried to populate that [resource page] with case studies. I've also offered some workshops to show how to use case studies. I don't know how many of them are actually using case studies, but I've tried to give them the resources so that they could. Unfortunately, [I have not participated in other professional development workshops outside of the Case Study Conference], our travel budget is practically non-existent. I was lucky to get to [go to] that one. [I first learned about the Case Study Conference from] other faculty members that had been using case studies more than I had and [a fellow colleague] found out that we could get money for it. So, the three of us from [our community college] went.

> I think [networking] is reinforced [by] my using case studies and just sort of realizing that this is a good tool. It's used by quite a few people. The students are starting to get a bit more used to it and not being quite as resistant [as] that initial resistance. I think that certainly some of our earlier faculty sort of look at [those faculty who use case studies] like, "What are you trying?" Now [case studies] are becoming a lot more accepted and folks are talking about different cases that they've used and how they [have] modified different cases. I think it's becoming much more of a common practice rather than an outlier. Hearing about [case study teaching] and hearing about where some resources [are] would make that transition easier. It would have been great [if I had been to] that conference *before* [emphasis added] I sort of even got involved in [case study teaching]. It would have made it even easier to make that initial jump.

Structural description. It seems that Keith was easily convinced that case study teaching is a more effective methodology for getting his first year students engaged in the material. Conversations with other faculty revealed to Keith that case studies can be fun. His initial challenge was the time it would take to find the appropriate cases and modify them according to his teaching style. Even though he had made the decision to use case studies, it took him about a year to get the cases lined up to use in his class. The second challenge that Keith encountered was resistance from the students. Actually, he anticipated that there would be resistance, but he believed that over time the students would get used to case studies. Keith was not deterred and proceeded with the implementation of case studies. While the first case study was as he anticipated, a little rough, he reported that over time the students began to become more engaged and put some effort into them. Keith's belief in the benefit of case study teaching inspired him to offer workshops to other instructors at the community college where he teaches. He also created a resource page and has filled it with case study ideas to help the many adjuncts who teach at his institution. Keith has noticed that case studies are becoming more and more accepted as a teaching methodology. The more people that get involved with case study teaching, the more infectious it seems to be. He asserts that hearing about case studies from colleagues and going to the case study conference would make the initial jump into case study teaching easier for those who are at the beginning of their case study journey.

Textural-Structural Synthesis: The Essence of the Experience

The following synthesis describes the essence of the experience of the phenomenon of the innovation evaluation process that case study faculty go through following initial exposure to case study teaching. It explains how the essential structural elements underlie the various manifestations of the experience. This textural-structural synthesis represents the essence as manifested in the participants' experiences, as seen from the perspective of an individual researcher as a result of an intuitive and reflective study of the phenomenon (Moustakas, 1994).

Significant statements. During the phenomenological reduction phase that generates the textural descriptions, statements are given equal value and delimited for redundancy (Moustakas, 1994). These are the statements used to generate the textural descriptions. What follows are some of the verbatim significant statements that were identified as horizons:

- "The fact that my colleague told me to go and hear Herreid really made a big difference." (Anne)
- "I heard that they were using them and enjoying them." (Keith)
- "I also think that just hearing from other instructors, just word of mouth, is probably pretty effective." (Cathy)
- "I came away convinced that cases were important and right after I took the workshop, I decided to try to teach a case." (Evan)
- "I tried one out pretty quickly." (Cathy)
- "And it was convincing to me that that's a way you could definitely go." (Anne)
- "It would have been a good strategy to have used, had I thought of it." (Keith)

- "It was instructive to see novices like me present their first case study to this group of honors students." (Mark)
- "Having a demonstration where he actually made us do the case was really what was convincing." (Anne)
- "There's a certain background familiarity with the literature that I think needs to be put out there." (Aaron)
- "I had started reading about case studied in different journal articles." (Keith)
- "I think showing them the data or just a quote with data in." (Kendra)
- "It's a matter of continuing to look at new cases and try to pick a few more that are likely to work and start incorporating those and use them and try them." (Aaron)
- "Faculty need to recognize that it's not being forced upon them." (Mark)
- "I tend to take a case and use it differently than it was intended." (Kendra)
- "It's a way of getting the students engaged in the material." (Keith)
- "I think if forces them to think about that topic in a completely different way." (Aaron)
- "In a story, it helps them remember a little bit better." (Cathy)
- "There was more high-level learning taking place." (Keith)
- "They have to use their knowledge or gain some knowledge about that topic in order to address whatever the case is setting up for them, which they do not have to do in a standard lecture." (Aaron)
- "I came to realize that cases can substantially improve students' retention of the material." (Evan)
- "Those kinds of networking conversations were really useful." (Cathy)
- "It's something else to think about and I think that's the value of networking." (Aaron)
- "That kind of collegiality, that kind of networking, in retrospect, I really benefited immensely from that." (Mark)
- "On a very informal level, I am always happy to talk about cases and encourage people who are interested." (Evan)
- "My use of case studies comes up in department meetings and it comes up in discussions in the hall." (Kendra)
- "I'll pass that along to the rest of the department." (Cathy)

Meaning units. Statement such as these were then grouped together into themes or meaning units. Once all of the significant statements were organized into meaning units, I made note of how many participants made a statement that was categorized into a meaning unit. There were nine meaning units that included statements by five or more participants. Only two meaning units included statements by four participants and the rest of the meaning units included statements by only three participants. Due to the spread of these numbers, I have chosen to report the nine meaning units shared by five or more participants in Table 1. The significant statements listed above will be repeated below to provide examples for each meaning unit.

Table 1

Organization of Significant Statements into Themes or Meaning Units.

Themes/Meaning Units	Corresponding Significant Statement
Initiated by Colleagues	"The fact that my colleague told me to go and hear Herreid really made a big difference." (Anne)
	"I heard that they were using them and enjoying them." (Keith)
	"I also think that just hearing from other instructors, just word of mouth, is probably pretty effective." (Cathy)
Quickly Convinced	"I came away convinced that cases were important and right after I took the workshop, I decided to try to teach a case." (Evan)
	"I tried one out pretty quickly." (Cathy)
	"And it was convincing to me that that's a way you could definitely go." (Anne)
Observations are Beneficial	"It would have been a good strategy to have used, had I thought of it." (Keith)
	"It was instructive to see novices like me present their first case study to this group of honors students." (Mark)
	"Having a demonstration where he actually made us do the case was really what was convincing." (Anne)

Influenced by Literature	"There's a certain background familiarity with the literature that I think needs to be put out there." (Aaron) "I had started reading about case studies in different journal articles." (Keith) "I think showing them the data or just a quote with data in." (Kendra)
Adaptable and Flexible	"It's a matter of continuing to look at new cases and try to pick a few more that are likely to work and start incorporating those and use them and try them." (Aaron) "Faculty need to recognize that it's not being forced upon them." (Mark) "I tend to take a case and use it differently than it was intended." (Kendra)
Promotes Relevancy	"It's a way of getting the students engaged in the material." (Keith) "I think if forces them to think about that topic in a completely different way." (Aaron) "In a story, it helps them remember a little bit better." (Cathy)
Increases Competencies	"There was more high-level learning taking place." (Keith) "They have to use their knowledge or gain some knowledge about that topic in order to address whatever the case is setting up for them, which they do not have to do in a standard lecture." (Aaron) "I came to realize that cases can substantially improve students' retention of the material." (Evan)

Effect of Networking	“Those kinds of networking conversations were really useful.” (Cathy) “It's something else to think about and I think that's the value of networking.” (Aaron) “That kind of collegiality, that kind of networking, in retrospect, I really benefited immensely from that.” (Mark)
Continued Communication	“On a very informal level, I am always happy to talk about cases and encourage people who are interested.” (Evan) “My use of case studies comes up in department meetings and it comes up in discussions in the hall.” (Kendra) “I'll pass that along to the rest of the department.” (Cathy)

Note. These representative significant statements were used to generate the themes or meaning units.

The breakdown of each meaning unit and how they are shared among the participants is shown in Table. 2.

Table 2

Shared Meaning Units by Participant

	Kendra	Anne	Evan	Mark	Aaron	Cathy	Keith
Initiated by Colleagues	x	x		x		x	x
Quickly convinced		x	x		x	x	x
Observations are Beneficial	x	x		x	x	x	x
Influenced by Literature	x	x			x	x	x
Adaptable and Flexible	x			x	x	x	x
Promotes Relevancy	x	x	x	x	x	x	x
Increases Competencies	x		x	x	x	x	x
Effect of Networking	x			x	x	x	x
Continued Communication	x	x	x	x	x	x	

Note. The nine meaning units shared by five or more of the participants.

The synthesis. The essence of the experience of the phenomenon of the innovation-evaluation process for these case study faculty primarily involves the opinion of their colleagues. If conversations with other advocates for case study teaching was not involved in their initial exposure to case study teaching, conversations have certainly become a permanent part of their teaching environment. Obviously each participant was convinced after their initial exposure to case study teaching that it was a better teaching methodology than what they were using before, but for most of them, they were convinced rather quickly. Ultimately, this study revealed nine structural elements that constitute the essence of the experience of the phenomenon: initiated by colleagues, quickly convinced, observations are beneficial, influenced by literature, adaptable and flexible, promotes relevancy, increases competencies, effect of networking, and continued communication. Next are the detailed descriptions of these meaning units shared by and essential to the participants' experiences of the phenomenon.

Initiated by colleagues. For the participants, the experience of the phenomenon is closely related to how they came to know about case study teaching. Diffusion of Innovation (DOI) Theory (Rogers, 1995) is the process by which an innovation is communicated through certain channels over time among members of a social system (see Figure 3 in Chapter 2). Communication is pivotal for innovation evaluation because of the information conveyed during communication among peers and other groups. Communication channels can also be broken down into either mass media (e.g., journals, internet) or interpersonal channels (e.g., face-to-face exchange of information). The knowledge step of the innovation-decision process begins here. It is at the knowledge step that the potential adopters seek information about the innovation (Rogers, 1995). Five of the seven participants specifically said that they learned about case study teaching from a colleague, which is indicative of interpersonal channels. Experiences include directly approaching the participant, “the fact that my colleague told me to go and to hear Herreid really made a difference” (Anne) or indirectly through casual conversation, “a member of our team had been using case studies and convinced us of their possible utility” (Mark), “another faculty member was talking about this” (Cathy), “heard that they were using [case studies] and enjoying them” (Keith). For many, they learned about the case study conference from a colleague and were encouraged to go, “one of my colleagues went to the Buffalo workshop…we had a pretty long conversation about it” (Kendra). The other two participants said their initial exposure to case study teaching came from going to the case study conference, and did not directly say in the interview who told them about the conference (I suspect that someone told them about it rather than them finding the conference on their own).

For the participants in this study, subjective communication by peers who had already adopted the innovation tended to be what influenced further evaluation. The evaluation typically came by means of attending the case study conference. The time of the year that initial exposure occurred in relation to the time of year that the conference was held influenced how soon after initial exposure the participants first *used* a case study not when the participants made the *decision* to use case studies. For example, there were participants who learned about case study teaching because a fellow colleague knew the conference was coming up and they attended the conference within a short period of time from their initial exposure, “learned about a week long workshop in teaching cases at Buffalo. I just went first of all because it was free and secondly, it was something to impress my dean with" (Evan). Some participants had to wait for the conference to come around and in the meantime, they experimented with case study teaching, "It would have been great [if I had been to] that conference before I sort of even got involved…would have made it even easier" (Keith). All of the participants attended the case study conference in some capacity. The differences among them involve the timing of the conference in relation to their initial exposure. However, even though some of them may have had a substantial waiting period, nevertheless, the decision to implement case studies came almost immediately.

Quickly convinced. As previously addressed, the conference may have contributed to a deeper understanding of case study teaching, but the decision to implement case studies typically came quickly after initial exposure, "I was convinced right away after my [initial] exposure to [case study teaching]" (Anne), "I made the decision to implement case study teaching pretty much right away" (Keith), "I tried one out pretty quickly" (Cathy). Those who were able to attend the conference closer to their initial exposure had similar experiences, "right after I took the workshop, I decided to try to teach a case" (Evan). One participant had to wait between the conference and implementation due to the timing of the semester, "I used a case for the first time the following spring [after the conference]" (Aaron).

Rogers (1995) classified adopter categories in terms of "innovativeness" based on how fast or slow the potential adopter proceeds through the innovation-decision process (see Figure 2 in Chapter 2). The adopter categories include the *innovators* who are willing to take on risks and try new things, *early adopters* who utilize information that carries the innovation forward, *early majority* who deliberate longer before embracing the innovation, *late majority* who remove uncertainty only when most of their peers have adopted the innovation, and *laggards* who are suspicious of innovations. According to how quickly the participants made the decision to implement case study teaching, regardless of when they were first able to use a case study for the first time in their class, they fall into the innovator or early adopter categories.

Observations are beneficial. Observability, one of the perceived characteristics coinciding with the persuasion step of the innovation-decision process, is the degree to which the results of an innovation are visible to others (Rogers, 1995). Participants make evaluations about the phenomenon based on the level at which the results of case study teaching are visible enough to stimulate peer discussion. It is through the observability of others' use of case study teaching that helped with the persuasion of a favorable opinion of the innovation (Rogers, 1995). Because all of the participants attended the case study conference, they all had the opportunity to observe a case study in action. Outside of the case study conference, however, few had the opportunity to observe a colleague use case study teaching. Some thought about it, "it is one of those things I kept meaning to do" (Cathy), some had not thought about it but realized the value in it, "it would have been a good strategy…had I thought of it" (Keith), some thought it would be a good resource to help convince others, "people can talk to you about it all day, but [to] actually see it done [would help someone feel better informed]" (Aaron). Several talked about the benefit they received through the observations made at the case study conference, "having a demonstration where [Herreid] actually made us do the case was really what was convincing" (Anne). One participant actually sat in a classroom and watched some of her colleagues as they taught using case studies, "it actually gave me a little bit more confidence to see other people struggle…there's always improvement" (Kendra). Almost all of the participants said that seeing a case study in action was very persuasive in helping them with their decision to implement case study teaching. Observability has the tendency to result in the potential adopter requesting more information (Zhang, Wen, Li, Fu, & Cui, 2010). Some of the participants sought more information by turning to the literature for research that looked specifically at case study teaching.

Influenced by literature. An important objective of this study is to determine the experiences the participants had regarding their evidence-seeking practices about case study teaching. Some of the participants were already familiar with the literature showing the outcomes of using active learning practices and case studies in particular. Some participants received some journals in their field of science that included a section on teaching practices and they would stay informed that way, "there has been all kinds of those numbers [regarding data about case study teaching] in *CBE – Life Science*…that comes to my in-box" (Anne), "there was a teaching [article in *CBE – Life Sciences*] that had case study examples" (Cathy). Some casually perused the literature to see if they could find new activities to do in their courses, "I was keeping up with the education literature some…enough to see the big articles" (Aaron), "what kind of information is out there, what kind of data, what are people reporting?" (Kendra). What the participants mostly agreed upon, however, was that they believe the education literature is a great source to help others who are not convinced of the benefits of case studies, "I think showing them the data or just a quote with data in it [will help]"

(Kendra), “there is a certain background familiarity with the literature that I think needs to be put out there” (Aaron), “actually seeing data…would help others feel better informed” (Cathy).

In their study, Andrews and Lemons (2015) reported that the desire to make changes to teaching styles is less influenced by empirical evidence but rather by personal reasons, such as, the dislike of lecture, the compatibility of case study teaching with their personality and teaching style, and the opportunity to interact with students. The participants in this study show similar findings. However, even though the number of participants is too low to make any generalizations, it seems that empirical evidence (data from studies looking at case study teaching outcomes) plays a bigger role than expected. Not only do the participants in this study take the time to look at the literature for themselves, they believe it is a resource that could be beneficial in helping other faculty who may be reluctant or undecided, “need to be convinced, first of all that it is a better way of addressing instruction and learning, and second, what the evidence [shows]” (Aaron), “sometimes the evidence is sufficient for people who are scientists to change their mind” (Mark), “if they’re hard core scientists, they like data” (Kendra). It is more believable, as Andrews and Lemons (2015) showed, that personal reasons can override empirical evidence. Personal reasons were also revealed by the participants in this study in addition to the influence of the literature previously described.

Adaptable and flexible. Among the experiences that the participants in this study have regarding the essence of the phenomenon, the adaptability and flexibility that case studies provide are important factors that make case study teaching so beneficial. The perceived attribute, relative advantage, from the persuasion step of the innovation-decision process (Rogers, 1995) can be explained here. This shared meaning unit had such a strong influence on the participants that they felt that this information needs to be conveyed to potential adopters of case study teaching (i.e., persuasion). It is in this category that many of their personal reasons for using case studies can be found. For several participants, being able to alter the cases to fit their needs is very useful, "find a case study that had already been done and then just modify it for my use" (Keith), "I tend to take a case and use it differently than it was intended" (Kendra). Like Andrews and Lemons (2015) showed, being able to adapt case studies to meet your personal teaching style is definitely a personal reason in favor of case study teaching. Another way that the participants experience the flexibility of case studies is through how well they help students with conceptual understanding, "I might just take part of a case and just take the story and talk about the concept" (Kendra). Some case studies can also be used multiple times, "get three or four really good case studies that are multi-topic…bringing them up again and again in a different light" (Kendra), "you can always refer back to [a] case study" (Cathy).

Promotes relevancy. The essence of the phenomenon can be closely tied to this shared meaning unit. When the participants described their experiences regarding making the material relevant to their students, this is where they became excited. As the participants described what makes case study teaching more advantageous than how they before taught, the engagement that the students have with the material aligned with the way the case study story makes the information more meaningful. Therefore, I am including increased engagement under the shared meaning unit "promotes relevancy" rather than "increases competencies" coming next, where it may seem more appropriate. All seven participants could see a difference in their students, even if anecdotally, with regards to how case studies link the content with conceptual understanding, “it is a way of getting the students engaged in the material” (Keith), “the students are more engaged” (Mark), “student engagement, it forces [the students] to think about the topic in a completely different way” (Aaron), “if a student gets emotionally invested they are more likely to remember” (Evan), “so they can relate to it and to me [that] is one of the biggest advantages” (Cathy). For a few of the participants, they liked how case study teaching allows students to see science as a process, “by giving them personal scenarios, you give them a chance to see how the science was done” (Anne), “this is real important stuff to make sure these guys are getting [it], that science is doable, understandable, exciting, and something to talk about outside of class” (Kendra), “increases their willingness to tackle [what] a lot of the lay public struggles with” (Mark). Two participants, Mark and Cathy, also pointed out the importance that case study teaching has with connecting at-risk students with scientific concepts. So, listening to the participants describe the importance of relevancy, it became obvious that this constitutes a personal reason why some faculty embrace case study teaching.

Increases competency. Participants tend to find validation in their experiences with case study teaching through the observations of various competencies that improve among their students. These competencies include, “more high-level learning” (Keith), “learning had improved” (Kendra), “students improve their critical-thinking skills, i.e., reasoning skills” (Mark), “cases strongly increase long-term retention” (Evan), “use their [existing] knowledge or gain some knowledge about the topic” (Aaron), “they’re going to retain more" (Cathy). While these competencies are things that can be measured, the participants saw anecdotal evidence that their students were making improvements in these areas. This is another way that relative advantage persuaded them that case study teaching is perceived to be more effective than previous instructional practices.

Effect of networking. The experience of the phenomenon is also closely related to networking. The participants described the effect that networking has had on their use of case studies. It seemed to bring a sense of togetherness to the essence of their experience. The overall effect was positive, "that kind of collegiality, that kind of networking…in retrospect…I really benefited immensely from that" (Mark), "those kinds of networking conversations are really useful" (Cathy), "that is the value of networking" (Aaron), "I think networking is reinforced by my using case studies" (Keith), "networking has had a pretty positive effect" (Kendra). Networking fits into both the communication channels and the social system of DOI Theory, making it influential in the evaluation of an innovation, which seems to fit nicely with the experiences of these participants.

Continued communication. Earlier, I discussed the role that communication with colleagues had on the participants' initial exposure to case study teaching. It only seems fitting that we come full circle back to communication as the last shared meaning unit. Like communication played a role at the beginning of their journey with case study teaching, it continues, as they are now the ones introducing others to this innovative teaching strategy. Even the two participants who did not specifically say that they learned about case study teaching from colleagues (Evan and Aaron) described how they continue with the dissemination of information about case study teaching to others, "I am always happy to talk about [cases] and encourage people who are interested" (Evan), "my communication about case study teaching to others has been through a group here that I organized when I got to campus that involves learning and pedagogy" (Aaron). Like Aaron, for many of the participants, they are involved in groups in their departments or their campus where they are able to share the value of case study teaching with their peers, "my use of case studies comes up in department meetings and it comes up in discussions in the hall" (Kendra), "I'll pass that along to the rest of the department" (Cathy). Then there are those casual conversations where the participants take the opportunity to share, "it comes up in conversation kind of spontaneously… people talk about it at lunch or something" (Kendra), "talking up cases" (Mark).

Summary

The goal of this study was to investigate the phenomenon of innovation evaluation, the information seeking process that case study faculty undergo after their initial exposure to deciding to use case study teaching. The results obtained through the experiences that the participants had with the phenomenon can be used to answer the three research questions:

1. What are the communication channels in which case study faculty use to learn about case study teaching and how much time did it take for them to make the decision to implement case studies in their classroom?
2. What are the information seeking processes that case study faculty use to evaluate the innovative teaching approach, case study teaching, and how did

that innovation evaluation influence their decision to implement and adopt case studies in their classroom?

3. What resources are critical for college biology instructors to receive in order to feel more informed about their decision to use case study teaching?

To answer research question one (RQ1), the data show that communication is extremely important to the phenomenon. Rogers (1995) stated that communication channels create awareness of the innovation that may promote a potential adopter to seek additional information about how well the innovation works. The participants in this study were primarily influenced by the subjective opinions of their peers who have already adopted case study teaching. Communication channels involve the information that is *conveyed* during discussions either as mass media or interpersonal channels. Five of the seven participants used interpersonal channels as their initial exposure to case study teaching. Another five participants, though not exactly the same five just mentioned, said that they did use mass media, both journals and internet. However, mass media was not the source of the initial exposure. Instead they used mass communication to add to their knowledge about case study teaching.

The time element for RQ1 is simple. Again, five of the participants said they made the decision to implement case study teaching almost immediately after their initial exposure. One of the participants, Kendra, believed that she was already doing something very similar to case study teaching but did not call it that, which makes it difficult to determine her timeframe. The other participant, Mark, heard about it as a possibility for the new course he was designing. It was a term that he heard for a period of time before really understanding case study teaching. So, ultimately, his decision came much later after his initial exposure (i.e., hearing the term "case study teaching"). However, once he attended the workshop and was introduced to the elements of case study teaching, his decision came quickly. Subjective opinions communicated by colleagues (interpersonal channels) who have already adopted case study teaching are what the participants used to evaluate the innovation. It also took very little time for the participants to make the decision to implement case study teaching after their initial exposure putting them in the innovator or early adopter categories.

To answer research question two (RQ2), the data come from several places. Most often the participants obtained their information from fellow colleagues. Word of mouth was instrumental for the participants to make the decision to implement case study teaching. Because all of the participants had attended the case study conference, either the fall workshop where they learned more about case study teaching and different ways to use it or the summer workshop where they learned how to write a case study, observability played an essential role for them. Six of the seven participants believe that seeing a case study in action would be a great way to influence others about the benefits of case study teaching. Relative advantage, a perceived attribute of the persuasion step, also played a role in their information seeking processes. Many of the participants mentioned how their own anecdotal evidence was useful in helping with their decision to implement and adopt case study teaching. For these participants, especially the ones who attempted to use case studies before they attended the case study conference, they observed how this teaching strategy improved their students' engagement and retention of the material. Other things that influenced the participants' decision to implement and adopt case study teaching were finding the data reported in the literature and observing another person use a case study (even if that only occurred at the case study conference). It seems that trialability, one of the perceived attributes of the persuasion step of the innovation-decision model, could also be included as being involved with innovation evaluation. Rogers (1995) described trialability as the degree to which with the innovation can be experimented on a limited basis. One participant in particular, Aaron, said that when he attempted his first case it went very well, but when he attempted his second case, it “crashed and burned.” While this did not deter him from continuing to use case studies, it did make him pause to think about what went wrong. This may mean that he wanted to continue trying to make case studies work, hence trialabiltiy. I presume that others also tried it to see how it worked before making the decision to make it a permanent part of their course.

To answer RQ2, the information seeking processes that the participants used to evaluate case study teaching included: asking fellow colleagues, making note of the anecdotal evidence in their own classrooms, finding research articles reporting the outcomes from case study teaching, observing a case study in action, and just giving it a try to see how it works out. These information seeking processes all had an influence on their decision either by increasing their knowledge (knowing) or influencing them with a perceived attribute such as relative advantage, observability, or trialability (feeling).

The list of resources that the participants provided to answer research question three (RQ3) is important because some of the participants had opportunities to experience the resources they suggested and some of them did not but wished they had. These resources include: being familiar with the literature and the evidence; talking with colleagues and having a network of colleagues to turn to; having the opportunity to observe a case study; utilizing textbooks that contain case studies; going to science meetings, especially the case study conference; and accessing the case study collection.

Chapter 5: Discussion

Introduction

More and more college biology instructors are implementing case study teaching in their introductory biology courses; yet, there is little detail in the literature that describes how they evaluated case study teaching as an innovative teaching strategy. If moving away from lecturing as the primary teaching method to more active-learning teaching practices is important for the widespread transformation of undergraduate biology education (Bonwell & Eison, 1991; Freeman et al., 2014; National Research Council [NRC], 1997), then it seems important to understand the factors that influenced college biology college professors who have chosen to make this change. Case study teaching, a form of problem-based learning (PBL), encompasses many of the skills and competencies that documents such as *Vision and Change in Undergraduate Biology Education: A Call to Action – Final Report* (American Association for the Advancement of Science [AAAS], 2011) believe are necessary for students to function in today's society, such as critical thinking (Chaplin, 2009; Noblitt, Vance, & DePloy Smith, 2010), communication (Noblitt et al., 2010), collaboration and decision-making (Dabbagh & Dass, 2013), and conceptual learning (Herreid, 1994a). Even with the evidence that case study teaching does improve competencies such as these, lecturing continues to prevail as the dominant teaching method in undergraduate biology courses (Knight & Wood, 2005; Walker, Cotner, Baepler, & Decker, 2008). In order for case study teaching to become successful in more undergraduate biology courses, college biology instructors must be open to the disposition of change (McPhearson, Gill, Pollack, & Sable, 2008). To persuade more college biology instructors that case study teaching is an effective, innovative teaching strategy, we need to find something that motivates change. Perhaps describing what motivated change among those who have embraced case study teaching could make a difference.

The purpose of this study was to identify and describe the information seeking processes used by college biology instructors who actively use case studies in their introductory biology courses (referred to as case study faculty hereafter) and how this evaluation influenced their decision to implement and adopt case study teaching. I conducted a qualitative study with a phenomenological approach (Moustakas, 1994). I conducted exploratory interviews that consisted of semi-structured, open-ended questions (Berg, 2007; Creswell, 2007) with case study faculty who use cases studies in their introductory biology courses. The aim was to understand why and how case study faculty came to know, value, and implement case study teaching with the intention of using this information to help motivate change among college biology instructors who are reluctant or undecided about making a change to their teaching practices.

Diffusion of Innovation (DOI) Theory (Rogers, 1995) explains the process by which an innovation is communicated through certain channels over time among members of a social system. Within DOI Theory, Rogers also described the subjective evaluation of information derived from individuals' personal experiences and perceptions of an innovation called innovation-evaluation information. Innovation-evaluation information (referred to as innovation evaluation hereafter) can be found within different areas of DOI Theory. Both the DOI Theory and innovation evaluation served as the theoretical framework for this study to describe the information seeking processes that case study faculty used to influence their decision to implement and adopt case study teaching as an innovative teaching strategy.

Discussion

This study used a phenomenological approach designed to describe the participants' lived experiences with a concept or phenomenon (Moustakas, 1995). The phenomenon being investigated for this study was the innovation evaluation that college biology instructors went through between their initial exposure to case study teaching and their decision to implement and adopt it. I used exploratory, semi-structured, open-ended interviews that allowed the participants to describe their experience with the phenomenon. The interview questions were designed to answer the following research questions:

1. What are the communication channels in which case study faculty use to learn about case study teaching and how much time did it take for them to make the decision to implement case studies in their classroom?
2. What are the information seeking processes that case study faculty use to evaluate the innovative teaching approach, case study teaching, and how did that innovation evaluation influence their decision to implement and adopt case studies in their classroom?
3. What resources are critical for college biology instructors to receive in order to feel more informed about their decision to use case study teaching?

Phenomenological data analysis involved three main processes: phenomenological reduction, imaginative variation, and synthesis of textural and structural descriptions (Moustakas, 1995). During phenomenological reduction, I transcribed each interview verbatim and each statement was given equal value and considered with respect to its relevance to the phenomenon and research questions. I then eliminated redundant and overlapping statements leaving behind significant statements, called horizons that represented meaningful units of the experience. The horizons were then clustered into themes or meaning units and the outcome was the textural description of the phenomenon. Through imaginative variation, I used the textural descriptions to explain the participants' feelings and thoughts through my perspective as the researcher. My representations of the textural descriptions are called the structural description. The synthesis of the textural and structural descriptions provided an in-depth description of the participants' experiences and essence of the phenomenon (Moustakas, 1995) (see Figure 4 in Chapter 3). Data analysis revealed nine themes or meaning units shared by five or more of the seven participants. These themes were: initiated by colleagues, quickly convinced, observations are beneficial, influenced by literature, adaptable and flexible, promotes relevancy, increases competencies, effect of networking, and continued communication (see Table 1 in Chapter 4). Meaning units will be italicized for emphasis.

The three research questions mentioned previously were designed to determine two things. First, the research questions were designed to determine if DOI Theory and innovation evaluation applies to the phenomenon of this study. Can the participants' information seeking activities constitute being called innovation evaluation as Rogers (1995) described it? Can any of the activities the participants engaged in during their experience with the phenomenon relate to DOI Theory? Second, it was important to determine how and why some college biology instructors came to know, value, and implement case study teaching so that this information could be used to motivate change among college biology instructors who may be reluctant or undecided with regard to changing their teaching practices to a more active-learning approach such as case study teaching.

To show how innovation evaluation relates to DOI Theory and how it framed this study, I will describe the components of DOI Theory giving attention to the areas that directly involve the evaluation of information about an innovation (innovation evaluation) (Rogers, 1995) (see Figure 3 in Chapter 2). Table 3 shows how all of the meaning units identified in Chapter 4 correspond to DOI Theory.

Table 3

Relationship of Meaning Units to DOI Theory and Innovation Evaluation

	Communication Channels		**Time**	**The Innovation**				**Social System**
				Innovation-Decision Process				
					Persuasion			
Meaning Units	Mass Media	Interpersonal Channels	Innovativeness	Knowledge	Relative Advantage	Observability	Trialability	
Initiated by Colleagues		x		x				
Quickly Convinced			x					
Observations are Beneficial				x		x		
Influenced by Literature	x			x				
Adaptable and Flexible					x		x	
Promotes Relevancy					x	x		
Increases Competencies					x	x		
Effect of Networking		x						x
Continued Communication		x						

Note. The four elements of DOI Theory are represented on the top line and then broken down accordingly. Communication channels is broken down into mass media and interpersonal channels, time is broken down to innovativeness, The innovation is broken down into the innovation-decision process, which is further broken down into knowledge and persuasion. Persuasion is further broken down into relative advantage, observability, and trialability. Finally, social system is not broken down but rather stands alone. For each component of DOI Theory, the associated meaning unit is noted.

There are four main elements of DOI Theory: the innovation, the communication channels, time, and the social system. In this study, the innovation (an idea that is perceived as new by an individual or set of individuals), which is case study teaching, was being looked at in retrospect by the participants because it is no longer new. However, at one time it was new to them and this study asks the participants to reflect back to that time. So that the information explaining DOI Theory and innovation evaluation builds upon itself within each section, the four elements will be presented in the order of communication channels, time, the innovation, and then the social system.

The first of the four main elements that I will present is communication channels. This is the information that is conveyed during communication of the innovation among peers and other groups (Rogers, 1995). Information can come in the form of mass media (e.g., journals, internet) or interpersonal channels (e.g., face-to-face exchange of information). Communication aids in the awareness of the innovation that may promote a potential adopter to seek additional information about how well the innovation works. According to Rogers (1995), subjective opinions by peers who have already adopted the innovation tend to be what most people use to evaluate an innovation, which the findings of this study support.

The participants engaged in both forms of communication, which are reading about case study teaching in the literature or on the internet (mass media) and learning about case study teaching from their colleagues (interpersonal channels). The meaning unit associated with mass media is *influenced by literature* ("what kind of information is out there, what kind of data, what are people reporting?" – Kendra) The meaning units associated with interpersonal channels include *initiated by colleagues (*"the fact that my colleague told me to go hear Herreid really made a difference" – Anne), *effect of networking* ("those kinds of networking conversations are really useful" – Cathy) and *continued communication* ("on a very informal level, I am always happy to talk about [cases] and encourage people who are interested" – Evan). Communication channels are also important for the knowledge step of the innovation-decision process (described in the next section with the time element) because once knowledge about the innovation has been obtained, potential adopters tend to seek more information about the innovation. Both mass media ("all of a sudden I had that search image for case study stuff and was paying more attention to that" – Cathy) and interpersonal channels ("A lot of it is pretty informal but it's interesting to me that you can be known as a case study teacher so people will ask you questions" – Kendra) can be a source of knowledge.

The next main element, time, can be associated with innovation evaluation at two different places within DOI Theory. The first is the innovation-decision process, which is made up of five progressive steps involved with making a decision that results in the confirmed adoption of the innovation (see Figure 1 in Chapter 2). The five steps of the innovation-decision process are: (a) knowledge (first exposure to the innovation), (b) persuasion (formation of a favorable or unfavorable opinion about the innovation), (c) decision (choosing to adopt or reject the innovation, (d) implementation (using the innovation), and (e) confirmation (seeking evidence that supports the decision to adopt or reject the innovation) (Rogers, 1995). The second place that the element of time is associated with innovation evaluation involves the innovativeness of the individual, which equates to the readiness and quickness that an individual is likely to adopt an innovation (see Figure 2 in Chapter 2). Rogers classified adopter categories in terms of innovativeness based on how fast or slow the potential adopter proceeds through the innovation-decision process. Therefore, the meaning unit associated with time is *quickly convinced*. The adopter categories include the *innovators* who are willing to take on risks and try new things*, early adopters* who utilize information that carries the innovation forward, *early majority* who deliberate longer before embracing the innovation, *late majority* who remove uncertainty only when most of their peers have adopted the innovation, and *laggards* who are suspicious of innovations. It is difficult to completely distinguish the participants from this study as either innovators or early adopters. They could all be considered innovators because they were willing to try a "new" thing after learning about case study teaching ("I tried one out pretty quickly – Cathy), however, they could also be considered early adopters because they used the information that introduced them to case study teaching and carried the innovation forward ("I came away convinced that cases were important and right after I took the workshop, I decided to try to teach a case" – Evan). For this study, I will categorize them as early adopters because none of them claimed to stumble onto case study teaching as an innovative teaching method on their own without receiving outside information first.

According to Rogers (1995) the knowledge and persuasion steps of the innovation-decision process are where innovation evaluation takes place. As mentioned previously, knowledge can be initiated through communication channels, which makes sense that it would be the first step in the innovation-decision process. This is where the element of time begins. From this point, the innovativeness of an individual is determined by how fast they go from knowledge to *confirmation*. For this study, I was looking at the time it took the participants to go from knowledge to *decision*. Based on the experiences described by the participants, the decision came fairly quickly. Moving from decision to implementation, however, varied among the participants. This was primarily due to where they were in the semester when their knowledge about case study teaching began. So, even though they may have decided to use case study teaching, some took longer to find the appropriate cases to fit their needs. Due to how quickly the participants made their decision to implement case study teaching, for the purposes of this study they fall into the early adopter categories, explained in the previous paragraph. Persuasion involves the formation of a favorable or unfavorable opinion about the innovation. There are other factors involved with the persuasion step that can be better explained in the next section with the innovation element.

The next main element to be described is the innovation itself. There are certain characteristics of the innovation that are perceived by members of a social system that have a tendency to influence the persuasion step of the innovation-decision process (Rogers, 1995). These characteristic, or perceived attributes, include: relative advantage (the degree in which the innovation is perceived to be better than what it supersedes), compatibility (the degree in which the innovation is perceived as being consistent with existing values), complexity (the degree in which the innovation is perceived to be difficult to understand and use), trialability (the degree to which the innovation can be experimented with on a limited basis), and observability (the degree to which the results of an innovation are visible to others) (Rogers, 1995). According to Rogers (1995), relative advantage and observability are the perceived attributes associated with innovation evaluation. Relative advantages are where advantages or disadvantages are evaluated by seeking outside knowledge about the innovation (Schmidt & Brown, 2007). Observability is associated with innovation evaluation because the level at which the results are visible to others can stimulate peer discussion (Rogers, 1995).

Relative advantage and observability did influence the participants' decision to implement case study teaching. Regarding relative advantage, the participants mentioned the meaning units *adaptable and flexible*, *promotes relevancy*, and *increases competency*. *Adaptable and flexible*, a meaning unit shared by five of the seven participants, involved using case studies in a way that fit their teaching styles. For example, some participants use only the story and then lecture over the concepts ("I might just take part of a case and just take the story and talk about the concept" – Kendra). Another way that case studies are adaptable and flexible is that they can be used over and over throughout the semester if necessary ("you can always refer back to [a] case study" – Cathy). The meaning unit *promotes relevancy* was definitely a relative advantage for the participants because they could see a difference in how their students engaged with the material ("they can relate to it and to me [that] is one of the biggest advantages" – Cathy). All seven participants became excited when they described the relevancy that case studies bring to their students. Similarly to *promotes relevancy*, the meaning unit *increases competency* was a relative advantage because six of the seven participant described how case studies increased learning, critical thinking, and retention of the material among their students ("there was more high-level learning taking place" – Evan; "retention is better" – Mark).

Observability, the other perceived attribute of the persuasion step aligned with the meaning unit *observations are beneficial*. Observing others use case studies plus making anecdotal observations about how well case studies engaged their students were very influential for the participants' decision to implement case study teaching ("having a demonstration where he actually mad us do the case was really what was convincing"

– Anne). Six of the seven participants described the benefit of watching someone else present or teach a case study. Observability could also be related to the meaning units *promotes relevancy* and *increases competency,* because the participants would not have been able to report such findings without first making the observations ("I came to realize that cases can substantially improve students' retention of the material" – Evan).

The last main element of DOI Theory is social systems. Similar to communication channels, social systems also involves communication. However, while communication channels involve *what* information is conveyed, social systems involve *where* that information is being or was conveyed. The meaning unit associated most with social systems is *effect of networking*. Communication takes place in different contexts. The size of the social systems ranged from very narrow to very widespread. It ranges from a few people in the department to an entire department ("comes up in department meetings and it comes up in discussion is the hallway" – Kendra) to several departments to an institution to a network of people across many institutions ("a group here that I organized when I got to campus that involves active learning and pedagogy…so I got involved in a number of research collaborative networks, and there's one on case studies too" – Aaron). However widespread the social system was for each of the participants in this study, they all describe the positive influence that networking had on their decision to implement case study teaching. Further, networking had just as much of an impact on their continued use of case studies after the decision to implement case study teaching had been made.

Examining the phenomenon of the information seeking process that influences case study faculty to make the decision to implement case study teaching as an innovative teaching strategy can indeed apply to innovation evaluation as Rogers (1995) described it within DOI Theory. These are the *communication channels* among members of a *social system*, the *knowledge* and *persuasion* steps of the innovation-decision process, which involves the *relative advantages* that case study teaching could bring and the *observability* of their own and others' use and benefit of case study teaching. In addition to relative advantage and observability, I found that trialability, another one of the perceived attributes that influences the persuasion step of the innovation-decision process could be considered for inclusion in innovation evaluation. Rogers (1995) described trialability as the degree to which with the innovation can be experimented on a limited basis. The meaning unit *adaptability and flexibility* would associate the best with trialability. Because the participants continued to make case studies work by either modifying them or trying different cases ("it's a matter of continuing to look at new cases and try to pick a few more that are likely to work and start incorporating those and use them and try them" – Aaron; "I would find sort of a case study that had already been done and then just modify it for my use rather than starting from scratch" – Kevin; "so start by adding a couple of case studies and see how they go" – Mark; "I like the fact that there's a lot there and I can pick and choose how I want to use it" – Kendra), it seems plausible that this falls under the description of trialability. Therefore, there may be more than just the two perceived attributes suggested by Rogers that contribute to innovation evaluation.

Mentioned previously, I stated that it was important to me to determine how and why some biology instructors came to know, value, and implement case study teaching so that this information could be used to motivate change among college biology instructors who may be reluctant or undecided with regard to changing their teaching practices. This study was able to describe how (communication channels and social systems) and why (relative advantage, observability, and trialability) cases study faculty came to know, value, and implement case study teaching. I believe that this information could be used to motivate change. Based on the experiences of the participants in this study, I suggest that spreading the word about case study teaching and providing an opportunity to see a case study in action would be two of the most important ways to motivate change. Furthermore, the participants not only revealed what motivated change for them, they also provided suggestions to help motivate others.

All of the participants talked about the impact that attending the Conference on Case Study Teaching (referred to as case study conference hereafter) presented by the National Center for Case Study Teaching in Science (NCCSTS) had on either their decision to implement or their decision to adopt case study teaching. If the participants were not convinced before they attended this conference, they were definitely convinced afterwards. The case study conference contributed to innovation evaluation for the participants. Before this study began, I was aware of the case study conference but I was not aware that Kipp Herreid had facilitated some smaller versions of the conference/workshop at various institutions outside of the University of Buffalo where the fall conference and summer workshop are held each year. Some of the participants were able to attend one of these smaller venues making it easier for them if they could not make it to the conference in Buffalo. So, one thing that could be used to motivate change is to offer smaller case study workshops at different institutions increasing the availability and opportunity for people to get exposed to case study teaching and taking advantage of the influence that observability can have on the implementation of case study teaching. Other resources suggested by the participants that could help motivate change included: being familiar with the literature and evidence showing the benefit of case study teaching; talking with colleagues and having a network of colleagues to turn to; utilizing textbooks that contain case studies; and accessing the case study collection.

Limitations

During the process of designing the interview questions, it was my intention to ask open-ended questions that would encourage the participants to describe experiences that would include enough information that could be related to DOI Theory, innovation decision, and the research questions. Most of the participants were able to do this. They would go into lengthy stories to answer the open-ended questions and while I did not necessarily need all of their story to answer my questions, the longer the story, the easier it was for me to extract the information that I needed. A few of the participants answered the open-ended questions with "short and sweet" replies, to which I had difficulty prompting them to provide more information. For the most part, these short replies answered the questions but they were lacking in a richness that I was hoping to receive. From one perspective, this is a limitation because the probing questions I asked in order to gather more information improved as more interviews occurred, but, from another perspective, that is the nature of qualitative research. If I could repeat the study, I would try to be more effective at anticipating where probing questions could be used. However, I cannot be definitive that anticipating the need for these probing questions would have made a difference because no two people had the exact same experiences.

The probing questions that prompted more information from one participant may not have worked with another. Still, I would have tried to be more consistent.

Another limitation that I found with the interview protocol was that I designed the questions in a way that only looked at how innovation evaluation fits into DOI Theory according to Rogers (1995). I did not design the questions in a way to determine if innovation evaluation occurred in places within DOI Theory that are different than what Rogers suggested. The findings from this study suggest that there is an additional place that innovation evaluation takes place, at least in the context of case study teaching. This area was trialability, one of the other perceived attributes that influence the persuasion step of the innovation-evaluation process. It was an unexpected result that I found during data analysis. If I could repeat the study, I would design the interview questions to examine the possibility of innovation evaluation in more places than those suggested by Rogers.

Because phenomenological research attempts to understand human behavior through the eyes of the study participants, sometimes the thoroughness of phenomenological research can come under question (Pereira, 2012). To be judged valid, phenomenological research must take into consideration rigorous and appropriate procedures that provide insight in terms of plausibility and perception of the phenomenon. After writing the textural descriptions of the phenomenon, I used those to write the structural descriptions. Each structural description was my personal interpretation of the participants' experience with the phenomenon. In other words, the textural description was written through the eyes of the participant, while the structural description was written through my eyes as the researcher. I had the participants read their own textural description, a form of member checking, to ensure the validity of the research. The e-mail sent to the participants asking them to review their textural description can be found in Appendix C. The participants either agreed with the textural description or asked for some things to be corrected to better represent what they meant. These changes were made as requested. However, I did not send the structural description back to them. One participant asked to see the structural description and I obliged. However, it was not my intention to send the structural descriptions to the participants because they may have wanted to make changes to them. This is my interpretation of their experience, not their interpretation of their experience. Some may find this a limitation, but I wanted to make it clear that this is an appropriate form of data representation in a phenomenological study.

Failure to reach data saturation in a qualitative study can also have a negative impact of the validity of the research. While there is no universal definition for saturation due to the multitude of research designs (Marshall & Rossman, 2011), there are some general guidelines. Some of the general principles or guidelines that researchers tend to agree include no new data and no new themes, which can be reaches with as little as six interviews depending on the sample size of the population (Guest, Bunce, & Johnson, 2006). With this in mind, data saturation has more to do with the depth of the data rather than the number of people used to generate the data (Burmeister & Aitken, 2012). For this study, eleven people returned the informed consent letter. Only eight people followed through with my communication about scheduling the interview. All eight were interviewed; however, during the interview of the eighth person, it became clear that she did not meet the criteria. Her name was given to me by another participant as a potential person to interview. I interviewed her with the assumption that she read the informed consent letter, which included the criteria. The point I want to make here is that even though I could not include her interview in the study, I did notice that her information was very similar to the other participants with regards to her innovation evaluation of case studies. I believe if I had transcribed her interview and analyzed it for significant statements and meaning units, then there may have been little to no new information. This experience served as a saturation point for me.

Finally, I have strong personal reasons for using case studies in my teaching, which made it a challenge not to attach any of my bias during the interviews or the analysis of the data. As Moustakas (1994) suggested, I went through the process of reflexivity by describing my own experiences with the phenomenon, in order to bracket out my views (an epoché) before proceeding with the interviews. I feel confident that I was able to facilitate the participants to describe their experiences without any of my own biases. The experiences described in this study come solely from the voice of the participants.

Recommendation for Future Research

I think that more investigation into the observability attribute with regards to motivating change is necessary. The findings from this study suggest that observing a case study in action had a positive influence on the participants' decision to implement case study teaching, whether the observation came before they attempted their first case study or after they already gave case studies a try. If the focus was only on observability, perhaps a survey could be constructed to learn more about the degree to which observability made an impact on the implementation and adoption of case studies by other college biology instructors. The scope of the study could be broadened by expanding the inclusion criteria to include instructors who teach upper-level courses in addition to introductory courses. Additional understanding about this highly influential perceived attribute could be used to motivate change.

Conclusions

One lesson that I learned from this study was not to assume that theories could be applicable in more ways than originally described. I was able to show that the phenomenon of this study (the innovation evaluation of case study teaching as an innovative teaching strategy by college biology instructors) can be applied to DOI Theory and innovation evaluation as Rogers (1995) suggested, but that it can also be applied in additional ways. There was a deficit in the literature regarding case study faculty being asked to describe the information seeking process that influenced their decision to implement and adopt case study teaching. Therefore, I thought I was filling a void in the literature by including case study teaching as an innovation that fits into DOI Theory and innovation evaluation described by Rogers (1995). What I found was that I am adding to the literature not only by filling this particular void, but also by showing that there are more places within DOI Theory where Rogers suggested that innovation evaluation takes place, such as the perceived attribute trialability.

This study also adds strength to the study by Andrews and Lemons (2015) who reported that personal reasons influenced the positive attitudes of college biology instructors toward the use of case study teaching. Andrews and Lemons reported personal reasons such as disliking lectures, the compatibility of case studies with their personality and teaching style, and the opportunity to interact with students as being reasons case study faculty implemented and adopted case study teaching. These same personal reasons were reported by some of the participants in this study. Andrews and Lemons also modified the innovation-decision process to be more cyclic rather than linear because the participants in their study reported that they continually made small changes over time. This modification fits very well with the findings of this study for two reasons. First, the participants of this study did not necessarily follow a linear progression after their initial exposure to implementation and adoption. Second, the participants in this study also made small changes to the case studies they used by modifying them to fit their needs. Not every participant used that cases studies as they were intended.

Like Andrews and Lemons (2015) modified the innovation-decision process from a linear process to a cyclic one, I would like to change the word *adopt* to *sustain the use of* because to adopt could mean something more permanent. Potential adopters of case study teaching might feel that to adopt they must use case studies as they are written. The participants in this study described how important adaptability and flexibility was for them to modify the case studies to fit their teaching style or needs. To me, modifying the case studies also means sustaining their use. Andrews and Lemons explained how some of their participants started by incorporating one case in a class and either revised or added to that, "cycling through this process indefinitely, demonstrating motivation, dedication, persistence, and resilience" (p. 17). This is what I would call sustained use rather than adoption.

I would use the findings from this to answer the research questions by providing the following statements: (1) knowledge obtained from the literature, internet, and interpersonal communication across small or large social networks of colleagues is what case study faculty have used to learn about case study teaching and it was a quick decision to implement case study teaching in their classroom after their initial exposure; (2) case study faculty used the subjective opinions from colleagues, evidence found in the literature, observations of others using case studies, trial and error, and perceived advantages such as the adaptability and flexibility of case studies, the relevancy of the material to their students, and the increases in competencies among their students that influenced their decision to implement and sustain the use of case study teaching; (3) resources such as evidence in the literature, evidence from fellow colleagues, observing case studies in action, utilizing textbooks containing case studies, going to conferences, and accessing the case study collection are critical for college instructors to receive in order to feel better informed about the benefits of case study teaching.

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Appendix A

IRB Approval Outcome Letter

The UNIVERSITY of OKLAHOMA

Institutional Review Board for the Protection of Human Subjects

Approval of Initial Submission – Expedited Review – AP01

Date: April 21, 2016

IRB#: 6709

Principal Investigator: Wendy Michele Martin

Approval Date: 04/21/2016

Expiration Date: 03/31/2017

Study Title: The Innovation Evaluation Process of Undergraduate Biology Instructors Who Actively Use Case Studies in Their Introductory Biology Courses

Expedited Category: 6 & 7

Collection/Use of PHI: No

On behalf of the Institutional Review Board (IRB), I have reviewed and granted expedited approval of the above-referenced research study. To view the documents approved for this submission, open this study from the *My Studies* option, go to *Submission History*, go to *Completed Submissions* tab and then click the *Details* icon.

As principal investigator of this research study, you are responsible to:

- Conduct the research study in a manner consistent with the requirements of the IRB and federal regulations 45 CFR 46.
- Obtain informed consent and research privacy authorization using the currently approved, stamped forms and retain all original, signed forms, if applicable.
- Request approval from the IRB prior to implementing any/all modifications.
- Promptly report to the IRB any harm experienced by a participant that is both unanticipated and related per IRB policy.
- Maintain accurate and complete study records for evaluation by the HRPP Quality Improvement Program and, if applicable, inspection by regulatory agencies and/or the study sponsor.
- Promptly submit continuing review documents to the IRB upon notification approximately 60 days prior to the expiration date indicated above.
- Submit a final closure report at the completion of the project.

If you have questions about this notification or using iRIS, contact the IRB @ 405-325-8110 or irb@ou.edu.

Cordially,

Lara Mayeux

Lara Mayeux, Ph.D.
Vice Chair, Institutional Review Board

Appendix B

IRB Approved Informed Consent

701-A-1

University of Oklahoma
Institutional Review Board
Informed Consent to Participate in a Research Study

Project Title: The Innovative Evaluation Process of Undergraduate Biology Instructors Who Actively Use Case Studies in Their Introductory Biology Courses
Principal Investigator: Wendy Martin
Department: Instructional Leadership & Academic Curriculum

You are being asked to volunteer for this research study. This study is being conducted at via Skype. You were selected as a possible participant because you are an undergraduate instructor who actively uses case studies in your introductory biology courses and have participated in the Conference for the National Center for Case Study Teaching in Science. Please read this form and ask any questions that you may have before agreeing to take part in this study.

Purpose of the Research Study
The purpose of this study is:

The purpose of the study is to identify and describe the processes that underlie the initial evaluation of an innovation (case study teaching) by case study faculty and how it influenced their decision to implement and adopt case study teaching in their introductory biology courses.

Number of Participants
About 6-7 people will take part in this study.

Procedures
If you agree to be in this study, you will be asked to do the following:

Agree to an interview via Skype.

Length of Participation
The estimated time for each interview is 45 minutes to 1 hour.

This study has the following risks:
There are no risks to the participant.

Benefits of being in the study are
There is no direct benefit to the study participant.

Confidentiality
In published reports, there will be no information included that will make it possible to identify you without your permission. Research records will be stored securely and only approved researchers will have access to the records.

There are organizations that may inspect and/or copy your research records for quality assurance and data analysis. These organizations include the OU Jeannine Rainbolt College of Education and the OU Institutional Review Board.

Compensation
You will not be reimbursed for you time and participation in this study.

Voluntary Nature of the Study
Participation in this study is voluntary. If you withdraw or decline participation, you will not be penalized or lose benefits or services unrelated to the study. If you decide to participate, you may decline to answer any question and may choose to withdraw at any time.

Audio Recording of Study Activities
To assist with accurate recording of participant responses, interviews may be recorded on an audio recording device. You have the right to refuse to allow such recording without penalty. Please select one of the following options.

I consent to audio recording. _____ Yes _____ No.

Contacts and Questions
If you have concerns or complaints about the research, the researcher(s) conducting this study can be contacted at
Wendy Martin: 405-850-7074 or wmmartin@ou.edu

Contact the researcher(s) if you have questions or if you have experienced a research-related injury.

If you have any questions about your rights as a research participant, concerns, or complaints about the research and wish to talk to someone other than individuals on the research team or if you cannot reach the research team, you may contact the University of Oklahoma – Norman Campus Institutional Review Board (OU-NC IRB) at 405-325-8110 or irb@ou.edu.

You will be given a copy of this information to keep for your records. If you are not given a copy of this consent form, please request one.

Statement of Consent

I have read the above information. I have asked questions and have received satisfactory answers. I consent to participate in the study.

Signature Date

Appendix C

E-mail to Request Member Checking

Dr. ________________,

I said that I would send the summarized data from your interview back to you for input. My research is a phenomenological study, so I report the data first as a textural description, then as a structural description. The textural description is the telling of your story using primarily your own words. I fill in the gaps or make clarifications when necessary, which are shown in brackets. Would you please read the textural description of your experiences to make sure that I have captured everything as you tried to describe it or if I need to make any adjustments? Keep in mind that the textural description does not include everything that you said during the interview. It is just the most pertinent information necessary to provide me with what I need to write the structural description and answer the research questions. Also, I have removed any identifiers and will be changing your name to a pseudonym in the dissertation.

What I am asking from you is that you agree with the textural description because (1) it is what I will use to generate the structural description and (2) it will serve as part of the validity of my study. If there is anything that needs to be changed, please let me know.

Again, thank you for doing the interview and I thank you in advance for giving your input on the textural description of your interview.

Wendy Martin