VIRTUAL SCIENCE INSTRUCTIONAL STRATEGIES: A SET OF ACTUAL PRACTICES AS PERCEIVED BY SECONDARY SCIENCE EDUCATORS

by

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This dissertation was prepared under the direction of the candidate's dissertation advisor, Dr. Valerie Bryan, Department of Educational Leadership, and has been approved by the members of her supervisory committee. It was submitted to the faculty of the College of Education and was accepted in partial fulfillment of the requirements for the degree of Doctor of Education.

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ABSTRACT

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The purpose of this proposed research study was to identify actual teaching practices/instructional strategies for online science courses. The identification of these teaching practices/instructional strategies could be used to compile a set of teaching practices/instructional strategies for virtual high school and online academy science instructors. This study could assist online science instructors by determining which teaching practices/instructional strategies were preferred for the online teaching environment.

The literature reviewed the role of online and face-to-face instructional strategies, then discussed and elaborated on the science instructional strategies used by teachers, specifically at the secondary level. The current literature did not reflect an integration of these areas of study. Therefore, the connectedness of these two types of instructional

strategies and the creation of a set of preferred instructional practices for online science instruction was deemed necessary.

For the purpose of this study, the researcher designed a survey for face-to-face and online teachers to identify preferred teaching practices, instructional strategies, and types of technology used when teaching high school science students. The survey also requested demographic data information from the faculty members, including years of experience, subject(s) taught, and whether the teacher taught in a traditional classroom or online, to determine if any of those elements affect differences in faculty perceptions with regard to the questions under investigation.

The findings from the current study added to the literature by demonstrating the differences and the similarities that exist between online and face-to-face instruction. Both forms of instruction tend to rely on student-centered approaches to teaching. There were many skills that were similar in that both types of instructors tend to focus on implementing the scientific method. The primary difference is the use of technology tools that were used by online instructors. Online instructors tend to rely on more technological tools such as virtual labs. A list of preferred instructional practices was generated from the qualitative responses to the open-ended questions. Research concerned with this line of inquiry should continue in order to enhance both theory and practice in regard to online instruction.

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CHAPTER 1

INTRODUCTION

Throughout the past 30 years, the interest in distance education has grown tremendously. There are many ways to define distance education. Keegan (1996) characterizes distance education through several descriptions which include "the quasi-permanent separation of teacher and learner throughout the length of the learning process; the use of technical media (i.e., print, audio, video or computer)" (p. 50). With the recent development of better technologies and the need for more accessible classes, there has been an increase in enrollment of online courses.

Although there has been a significant amount of research conducted on online interaction between students and faculty, there is very little known about the level of learning and what factors are most influential in learning outcomes (Beaudoin, 2002). Motiwalla and Tello (2000) report that a number of studies compare levels of learner outcomes through their final grades or compare course outcomes between distance learners and students who are in conventional classrooms. Moreover, Motiwalla and Tello state that learning objectives need to be set and measured in order to determine the effectiveness of Web-based courses. These learning objectives are usually set by the course instructor, the curriculum, and the institution and are measured in two different ways: student achievement and student perception.

Since online learning is more student-centered than traditional learning, there are several factors to consider for the likelihood of students completing an online course successfully. According to Moore and Kearsley (1996), these include “intent to complete,” “early submission,” and “completion of other courses” (p. 164).

Establishing a sense of community in an online course is yet another factor which may increase student participation (Hricko, 2002). Students can provide web biographies and photos in order to gain a feeling for who their classmates are in the course (Hricko). More recently, the use of wikis and blogs in addition to discussion board postings have helped students feel more connected to their classmates and instructor.

Distance education, online learning, and Web-based courses have been a part of higher education for many years now. However, a recent shift toward online courses has occurred at the high school level. Many students are seeking online alternatives to courses which are either unavailable to them at their local institution or they are seeking to make up missing credits. An interesting aspect to consider is how effective these online courses are at the secondary level. Furthermore, can a subject like science be taught effectively online? Can the traditional lab component of a science course be offered in the online environment? Can learners in an online secondary science class gain the full spectrum of knowledge and experience which typically comes from a traditional secondary science course with hands-on experimentation? Do secondary science teachers that teach face-to-face and those that teach online share common views as to what the preferred instructional practices are and how the subject matter can best be delivered?

All in all, there is no magical formula for how to conduct an online class nor is there any one set of best practices for a specific course. Instructors must develop their own course outline and materials. It is then up to each instructor to determine which practices work best for his or her students.

Statement of the Problem

Since online instruction is a relatively new concept in the field of science, a set of best practices specifically for online science instruction has not been identified. A greater challenge arises when trying to create a set of best practices for online secondary school instruction. The concept of a virtual high school is young and still being developed and improved. Furthermore, online academies are now included as a part of the curriculum in several school districts in the United States. Enrollment in virtual schools and online academies is vastly increasing. Therefore, it is important to define best teaching practices for this type of learning environment. Currently, the research in this specific area is lacking. Since so few references are available, it is necessary to research the relevant literature in the areas of online instruction and science instruction to determine if what works effectively in one arena is effective in the other arena.

In doing so, stakeholders in public education and decision-makers, like principals and superintendents could use this information to help guide which courses to offer at their schools. This information could also assist school superintendents in determining what types of courses should be offered to students and the best methods of instruction for faculty to use for those courses.

Purpose of the Study

The purpose of this proposed research study was to identify actual teaching practices/instructional strategies for online science courses. The identification of these teaching practices/instructional strategies may be used to compile a set of teaching practices/instructional strategies for virtual high school and online academy science instructors. This study may assist online science instructors by determining which teaching practices/instructional strategies are preferred for the online teaching environment.

This proposed study asked the following:

1. What are the actual teaching practices/instructional strategies for science courses taught by face-to-face secondary science instructors?
2. What are the actual teaching practices/instructional strategies for science courses taught by online secondary science instructors?
3. Do differences in actual teaching practices/instructional strategies exist between face-to-face science instructors and online science instructors?
4. What types of technology usage in the classroom is preferred for delivering instruction in a secondary science course taught by a face-to-face science instructor?
5. What types of technology usage in the classroom is preferred for delivering instruction in a secondary science course taught by an online science instructor?
6. Do differences exist in types of technology usage between face-to-face science instructors and online science instructors?
7. What is the relationship among actual teaching practices/ instructional strategies, technology usage, and demographics (years of experience, subject taught, and their role as a traditional classroom teacher or an online teacher) of face-to-face science instructors and online science instructors?

8. What practices are preferred by both face-to-face and online secondary science instructors for the following:
    a. To identify and address science concept misconceptions?
    b. To address student questions?
    c. As a face-to-face best practice for science instruction?
    d. As an online best practice for science instruction?

The survey in this research requested demographic data information from the faculty members, including years of experience, subject(s) taught, and whether they were traditional classroom teachers or online teachers to determine if any of those elements showed unique differences in their perceptions when they considered the questions under investigation. Previous studies have shown that differences do exist regarding teachers' views or perceptions based on some of the demographics under investigation.

> How educators select their teaching strategies and implement techniques is a function of their beliefs and values regarding the methods and can be modified to fit within the unique belief system of the educator. The manner in which any method, whether lecture or game, discovery-based learning or discussion is used within a learning event is the choice of the educator and should be a reflection of his or her philosophy. (Heimlich & Norland, 2002, p. 20)

Due to the influence of these beliefs, teachers often preferred strategies may change between generations or age cohorts due to their own exposure to different learning and teaching environments. For example, a teacher who is 50 years old and has been in the classroom for 25 years may have a different set of preferred learning and teaching strategies than a 22 year old who is entering the classroom for the first time in his or her career.

Significance of the Study

This proposed study added to the existing knowledge base of educational leadership through the exploration of unchartered territory in the use of best teaching practices and instructional strategies for science instruction. This study provided input to educational leaders in science instruction regarding their presentation of the curriculum. Exploring and documenting what professionals do when it comes to their own practice in the workplace is important for any organizational leader's mission to make his or her organization the best it can be. Significance of such a study included the potential benefits to organizations in which quality science teachers were employed and improvement of curriculum and instruction. The use of an effective online environment for science may also increase the variety of course offerings for students and increased accessibility for students at a distance, homebound, and place bound. The use of an effective online environment for science may improve student test scores. Identifying preferred teaching practices/instructional strategies in secondary science programs, whether face-to-face or online, may improve the communication and collaboration of science teachers within a department and an organization and the curriculum of that organization.

Definition of Terms

Asynchronous is "instruction in which interaction between sender and receiver does not take place simultaneously, usually referring to offline and sequential communication" (Barclay, 2001, p. 171).

Best instructional/teaching practices or best instructional strategies are defined as "a superior method or an innovative process that contributes to improved performance" in instruction and/or teaching (Spencer & Johnston, 2003, p. 19) or a superior method in which "a science teacher uses materials, media, setting, and behaviors to create a learning environment that fosters desirable outcomes" (Fraser & Walberg, 1995, p. 70). In this study, those teaching practices/instructional strategies identified as *preferred* by the teachers under investigation were viewed as *best instructional/teaching practices* or *best instructional strategies.*

Effectiveness for the purpose of this study is defined by frequency of use of a particular teaching practice/instructional strategy by secondary science instructors.

E-learning is "Technology-supported learning" (Barclay, 2001, p. 6). E-learning, is this study, refers to planned teaching experiences that use varied technologies to reach learners at a distance where the students rarely, if ever, attend face-to-face for on-campus access to educational facilities, because they study on-line. E-learning and online learning in this study will be used interchangeably.

Generation Zs are defined as those students who were born between 1990 and 2001.

Georgia Virtual School is described by the following statement**:**

On May 4, 2005, Governor Sonny Perdue signed the Georgia Virtual School bill, O.C.G.A. 20-2-31, into law establishing the first official state virtual school. Broadcast live by Georgia Public Broadcasting from Winder Barrow High School over the Internet, Governor Purdue signed the bill and answered questions about its creation in a face-to-face class of AP government students and to 18 other classes and public libraries across the state of Georgia via the Internet video stream and a virtual chat room.

> Like the previous e-Learning program, the Georgia Virtual School program offers a wide-variety of courses to Georgia high school students. However, the Georgia Virtual School program serves public, private, and home school students and has expanded its course offerings to over 78 unique core curriculum, AP, and elective courses, including SAT Preparation, with 198 course variations, each meeting QCC/GPS or College Board standards. These classes are offered in both block and semester formats on various schedules to meet the differing course offering and scheduling needs of local school districts. (Cox, 2007, p. 4)

Henry County Online Academy online learning is described by the following statement:

> Online learning opportunities provide students with flexibility to address coursework needed to complete graduation requirements. Students cannot participate in an online course that is offered and can be scheduled at their school. Situations that merit online learning may include:
>
> 1. Scheduling conflicts,
> 2. Recovery credit for courses not adequately completed,
> 3. Plans to complete graduation requirements at a faster pace,
> 4. Participation in enrichment courses,
> 5. Completion of the requirements for the College Prep Diploma with Distinction,
> 6. Hospital/homebound situations. (Henry County Schools, 2007)

Homebound or place bound students are defined as those whose injuries or illness are beyond the scope of being able to complete homework assignments independently. A teacher is assigned to serve as the student's liaison between the student and his or her teachers. This assigned teacher also acts as a tutor who comes to the student's home.

Millennials are described by the following statement**:**

> Demographers differ on just what ages they include in this next generation. Some include those born since 1980; others start with 1982 and go to about 2000. Most researchers have focused on the "first-wave" millennials—those roughly ages 16 to 25. Although there is no one set of traits that everyone shares, research has suggested some commonalities in areas ranging from home life and education to workplace behavior and leisure-time interests (Jayson, 2006)

Online course is described by Watson and Ryan (2006) as "Education in which instruction and content are delivered primarily via the Internet. Online learning is a form of distance learning" (p. 134). Teaching practices and instructional strategies may be offered in synchronous and asynchronous modes in conjunction with, and without, a teacher and/or fellow students.

Secondary science is science taught at the secondary level, which can include grades 6 to 12 or 7 to 12. Secondary science may include: general science, biology, chemistry and/or physics.

Synchronous is "communication or instruction in which interaction between sender and receiver takes place simultaneously. Instructor directed" (Barclay, 2001, p. 173).

Technology of use in this study is defined as those instructional practices that require a technological device such as a tape recorder, a computer, a software program, a video, a CD-ROM or DVD, or an active website.

Traditional high school is a facility in which instruction is delivered primarily face-to-face.

Virtual refers to existing or occurring online.

Virtual dissections are various stages of dissection that allows students to dissect specimens using computer software and a mouse to demonstrate what a hands-on dissection would be like. Virtual dissections generally require computer aided instruction (computer and specialized software or CD-ROM or DVD) and frequently internet access.

Virtual lab is a lab that can be conducted or simulated on a computer. This can be used as a supplement to laboratory exercises or in lieu of a laboratory exercise. Using multimedia products, and generally access to the Internet or an Intranet, students are educated about science and technology. In select cases students can change or modify the results and or the events of the lab and/or experiment through the choices made by the student. A sample of virtual labs available for the secondary science classroom (McGraw-Hill Online Learning Center, 2001).

Web-based course is described by the following statement**,** "Web-based courses are those in which the majority of instruction occurs online or via the Internet, synchronously or asynchronously, when student and instructor are not in the same place" (University of Wisconsin Green Bay, 2000)**.** Web-based courses are distinguished from online courses as those in which the instruction is mostly delivered online, but not entirely. Online courses are those in which the instruction is delivered completely online.

Role of the Researcher

The researcher has been a full-time instructor teaching high school science courses including biology and honors biology. The researcher, a lead teacher for the biology strand, is responsible for the overview of the biology course, course materials and assessments at a secondary school in the state of Georgia. In this role and previous roles in other school settings over a period of seven years, the researcher has observed the lack of consistent practices among secondary science teachers in several settings. The researcher has also observed the impact that a lack of best or preferred practices for both a face-to-face and an online environment has had on the varying levels of student achievement in said courses.

Delimitations

Only published articles and dissertations involving the planning and organization processes of online instruction and science instruction were included in the literature review on best teaching practices. Research was limited to publication in the past 12 years with a few “classics” in the field represented in the literature review.

The focus of the literature review may not be as relevant in the future. Due to the advances in technology, the best online teaching practices noted for both the face-to-face and the online environment may become less significant or dated in the future.

Limitations of the Study

Several articles and research studies have been published about instructional technology. However, the number of publications specifically related to virtual science instruction for secondary educators is limited. Many of the studies report instructional strategies in the online environment, but do not specifically address instructional strategies for virtual science environments. Generalizations about best instructional practices from related fields may be necessary to establish a good baseline of best instructional practices and may not be as relevant as practices from the specific science field.

The participants invited to respond to the survey were limited to providers of science instruction in secondary schools to which the researcher had access and who were willing to accept the invitation and who completed the survey. The actual number of faculty involved in the study in the various categories of review may have also impacted the results. Larger numbers of faculty reporting may have yielded different results. Participants responding to the survey based their responses on their experiences and knowledge of online science instructional strategies within their organizations. This self-reporting process was limited to their perception of the practices being utilized. Participants' responses may have been influenced by what the expected views are in their current organizations or by the standards of practice they have been exposed.

Chapter Summary

Lack of current studies in this area of research have prevented the compilation of a consistent agreement on a set of preferred practices in virtual science instructional practices. A recent shift toward online courses has been occurring at the high school level. Many students are seeking alternatives to courses which are either unavailable to them at their local institution, are seeking to make up missing credits, or are unavailable due to conditions such as being homebound due to illness or other factors. With the convenience of taking such courses in the comfort of their own home, many students are turning toward online courses. Due to the nature of high school science courses, it may be difficult for instructors to decide which practices would be best in order to teach these students in a virtual environment.

Currently, in Henry County, Georgia, each instructor must develop their own course outline and materials based upon state standards. It is then up to that instructor to determine which practices work best for his or her students. There is no specific guidance in this process. The instructors use strategies that have shown to be the most effective with their students in the past. However, such strategies may only be beneficial in the traditional classroom.

The goal of this study was to examine different studies in the fields of online instructional strategies and science instructional strategies in order to identify a common set of preferred instructional practices for secondary science instruction that was appropriate and desired for both the online and the face-to-face environments. This chapter included an introduction to the research problem, a description of the purpose of the study, a discussion of the significance of the research, and definitions of terms related to research regarding determinants of academic performance. The second chapter of this study continues with a comprehensive review of the literature on current online instructional strategies and science instructional strategies.

Chapter 3 introduces the methodology of the study including the instruments utilized and the data collection methods and procedures. Chapter 4 will highlight the findings. Chapter 5 will address the impact of the conclusions and make recommendations for future research based on this study.

CHAPTER 2

LITERATURE REVIEW

The extensive literature related to online instructional strategies and science instructional strategies was identified through a comprehensive review of books, dissertation abstracts, dissertations, documents and journals. This chapter reviewed online learning as a form of distance education and the need for alternative forms of education. Furthermore, this chapter reviewed the role of online learning and instructional strategies; then discussed and elaborated on the science instructional strategies used by teachers, specifically at the secondary level. The current literature did not reflect an integration of these areas of study.

This chapter also discusses the connectedness of these two types of instructional strategies and the creation of a set of preferred instructional practices (identified by practitioners as *best practices*) for online science instruction. Since online instruction is a relatively new concept in the field of science, it has become a necessity to identify first what was viewed as *best (preferred) practices* in a traditional science course and then to suggest a set of *best (preferred) practices* specifically for online science instruction. The development of such best practices at the secondary level of education was more challenging due to state standards and testing requirements that must be taken into consideration.

An additional aspect of the literature that was discussed deals with leadership decisions in secondary schools. Specifically, shared decision making and the leadership behavior of principals in secondary schools were addressed. Included in this area of discussion are faculty perceptions and experienced secondary science teachers' pedagogical content knowledge.

Traditional or Teacher-Centered Learning

Traditional teaching strategies typically place the focus of attention on the teacher during class activities. Dale's (1954) learning pyramid states that on average, students who practice by doing retain 75% of the material covered, and those who teach others retain the material at an average of 90%. However, students who experience the teacher-centered lecture classroom retain on average only 5% of the material (Alamo Community College District, 2003). A study done on introductory psychology students showed that students who were exposed to a lecture-based course only knew 8% more than students who had never taken the course (Rickard, Rogers, Ellis, & Beidleman, 1988). This research claims student-centered learning to be superior to teacher-centered learning when looking at student achievement.

Teacher-centered learning activities generally involve low-level cognitive skills, such as note taking and memorizing facts (Najike, McRobbie, & Lucas, 2002). Based on the views of Najike et al. (2002), teacher-centered activities do not promote long-term retention of concepts, instead sacrificing learning for being able to temporarily match answers with questions. As posited by these researchers, in addition to low-level cognitive skills, product questions rely completely on memory, not mastery. Product questions have short one- to two-word answers, or can be answered with a simple yes or no (Reinhart, 2000). These types of questions are the exact opposite of the higher-level cognitive questions presented during student-centered learning. Staff development may not be meeting the needs of those teachers who are struggling to shift the locus of control to the students and more to a student-centered model. However, the four-step model presented by Cantor is an easy method to work with the students to shift the locus of control and get away from a teacher-centered learning environment (Cantor, 2001). This student-centered model contains many of the elements of andragogy posed by Knowles (Knowles, Holton, & Swanson, 1998).

Four-Step Model of the Locus of Control

Studies have shown an increase in externality of the locus of control (Twenge, Zhang, & Im, 2004). Traditional teaching strategies have not been successful in assisting students with shifting that locus of control back to the students, which leads to unmotivated students who may not achieve as much in the classroom due to the low-level cognitive skills (Najike et al., 2002). The four-step model of the locus of control is a tool that teachers can use to help implement student-centered activities in the classroom without completely doing away with traditional teaching strategies.

The first step of the model states that the teacher states the concept and demonstrates the concept (Cantor, 2001). This step included teacher-centered learning activities, such as note taking, presenting new information, and class demonstrations. One way to enhance learning and thinking during this step was to use different types of concept maps so students could organize their thoughts (Callison, 2003). Once new ideas and information were introduced the locus of control went through its first shift. In the second step, the student became the teacher, but the teacher was still responsible for explaining the concept, while the student demonstrated the concept (Cantor). During this step the teacher may help organize a concept map, or give a few ideas that will help the students complete the concept map. If it was a hands-on learning activity the teacher would walk the students through the process step by step, stating directions as the students performed the task. The third step began to put the students in control of their learning. During this step, the learner was responsible for explaining and presenting ideas while walking the instructor through the steps (Cantor). The instructor was not allowed to perform any task or action that had not been described or stated by the students. Here the students may have to choose the type of concept map to use, how to fill it in, how to set up equipment for an inquiry exercise, and how to perform the steps necessary to solve the problem presented. Once the fourth step had been reached, the locus of control had been shifted to the students, creating a totally student-centered learning environment. During this step the students were responsible for describing the concepts, as well as demonstrating how to solve the problem presented (Cantor). The teacher took on the role of a facilitator and asked questions to guide the learning and monitored individual progress (Knobloch, 2003).

This model helped shift the locus of control in the classroom from the teacher to the students. It was important to remember that each class of students was different. Keeping that in mind, not all classes may reach the next step of the model at the same time. Some students will need more attention from the teacher and may struggle if the teacher turns to a facilitator too quickly. Others will be ready to explore on their own quickly and the traditional teaching strategies may cause the student to lose curiosity and interest in the concept being studied.

Science Instruction

Hartman and Glasgow (2002) offered over 20 tips for effective science instructional strategies throughout the first chapter of their book. These tips are summarized in the following list:

1. Prior to the lesson, provide students with an overview.
2. Use analogies.
3. Identify misconceptions about science that are presented in the textbook.
4. Assess students' prior knowledge of a topic.
5. Use conceptual models.
6. Address misconceptions and reiterate the correct knowledge.
7. Use a problem-centered approach.
8. Refer to state and national standards for assessing science literacy.
9. Implement peer tutoring.
10. Use concept maps and graphic organizers to aid understanding.
11. Work directly with students frequently.
12. Use a learning cycle approach to move from concrete to abstract concepts.
13. Align teaching practices with students' learning styles.
14. Help students with mental models.
15. Pair students for problem solving.
16. Realistically estimate the time needed for lessons.
17. Employ a variety of strategies to encourage students to ask questions.
18. Vary the type and levels of questions you ask.

19. Focus on the important content in depth so that students can understand and apply their knowledge.
20. Consider the acclimation and time involved for students to shift from receiving knowledge to reflecting on that knowledge.
21. To stimulate student interest, “contextualize” science content.
22. Present the integration of scientific practice into culture and society.
23. Have students role-play concepts.

Fraser and Walberg (1995) provided nine implications for improving science education. These implications are discussed below.

1. Use a variety of instructional techniques. This includes various media, visual aids, and models.
2. Conduct demonstrations. In order to engage student interest, the teacher should use demonstrations in the classroom. Demonstrations also were considered useful when introducing a concept or engaging students in scientific inquiry.
3. Incorporate laboratory work. Providing the students with an opportunity to participate in hands-on activity assists the students with applying the concepts presented in class to a tangible exercise. Labs also appeal to the kinesthetic learners in the classroom.
4. Use alternative instructional methods such as computer simulations. Oftentimes, these are a necessity due to budget constraints for materials. When used appropriately, computer simulations can assist the students who like to use computers and are visual learners to ascertain meaning from the concepts being discussed in the lectures.

5. Students should be evaluated based on work in the classroom and in the laboratory. A part of the grading criteria should include class work and lab work. Many students perform better in lab settings than they do on worksheets.
6. Students should be engaged in small group activities. Small group activities shift the locus of control from the teacher to the students and allow students to teach each other.
7. Organize field trips. Field trips can provide students with real-life exposure to the concepts being explored in the classroom. Students will view field trips as “fun” and may not even realize that they are in fact learning.
8. Distance education can be an effective method for expanding learning opportunities. Many scientific concepts can be explored virtually. Students who are homebound may find it necessary to use the Internet and computer-mediated forms of instruction to earn credit for a course.
9. Be sure the incorporate enough “wait time.” Most teachers fail to provide ample wait time for students to answer questions. Teachers are anxious to share their knowledge and at times forget to wait long enough to allow the students in his or her classroom to think, process, and answer the questions being posed by their teachers.

“Good science teachers are: competent and enthusiastic in their subject knowledge, skilled and rigorous in their classroom management, and understanding and sympathetic to their students’ needs” (Woolnough, 1994, p. 43). Visits to scientific establishments, guest lecturers, demonstrations, and student research projects are also key elements for effective science teaching (Woolnough).

In a study conducted by Lee and Luft (2008, p. 1352), four secondary science teachers were interviewed to identify common elements the seven components of Pedagogical Content Knowledge (PCK). These seven components are as follows: “Knowledge of science, knowledge of goals, knowledge of students, knowledge of curriculum organization, knowledge of teaching, knowledge of assessment, and knowledge of resources.”

Each of the four participants offered slightly different variations within these specific elements, but common ideas were identified. All of the teachers thought that a strong background in science was essential. Their lessons were also linked to instructional goals. “One common goal among all teachers was teaching science to students so that they better understood natural phenomena in everyday life” (Lee & Luft, 2008, p. 1352). Understanding how the students prefer to learn and what their lives were like outside of school was something that all of the participants felt could only be learned through experience. The teachers felt that the curriculum should be organized in a manner that makes connections between science concepts, other subjects, and other bases of knowledge. As far as knowledge of teaching, the teachers felt it was best to link their teaching to the learning goals of their students. Knowledge of assessment allows the teachers to make decisions about the effectiveness of their teaching and to know what to assess and how to do it. The final component that the teachers spoke about was knowledge of resources. This knowledge allowed for them to bring the scientific world outside of the classroom into their classrooms.

Online Learning

Due to the various factors that affect today's students, how we define education and learning is changing in response to what the students need. "The use of distance learning technologies, and more specifically, online distance learning, have both grown out of and enhanced the changes now occurring in the delivery of education" (Palloff & Pratt, 2001, p. 3). Online courses are especially gaining popularity with adult learners. Adult learners may elect to enroll in an online course for several reasons. Many adults prefer the flexibility of taking online courses. However, in recent years, adult learners are not the only ones who are registering for online courses. Many high school students are opting to enroll in online courses either due to the lack of such a course at their institution or in order to make up credits lost.

Prevalence of Online Courses

According to a report published by the National Center for Education Statistics (NCES) of the United States Department of Education (USDE), almost 66% of all higher education institutions offered distance-based or online courses in 2006-2007 (NCES, 2008). Furthermore, distance-delivered or online courses were offered by 89% of public four-year institutions and 97% of public two-year institutions (NCES). Asynchronous computer-based technology courses in higher education, conducted primarily over the Internet rather than video, were the most widely used type of course (NCES). With a majority of the growth in these types of courses, the question of what instructional strategies were most effective for this type of environment began to rise.

Creation of Online Courses

> The planning and design of an on-line course requires us to strike a unique balance between a course that is highly structured and detailed prior to the first day of class, with the need to retain flexibility and spontaneity as it relates to both teaching and learning. (Schweizer, 1999, p. 15)

The online student needs to have a course that is well designed, easy to navigate, and has clear expectations provided. This begins with a thorough, yet concise course description. The next step is to define student outcomes at the program level, the course level, and the unit level. Writing good course outcomes requires the instructor to identify what is expected of the student to demonstrate. One must be sure that the course is organized around the learner and not the teacher (Schweizer).

According to Quilter and Weber (2004), there are three types of benchmarks that should be followed for developing and teaching online. These benchmarks were derived from the benchmarks published by the Institute for Higher Education Policy (IHEP) in April of 2000 (cited in Quilter & Weber). The three identified by Quilter and Weber are the course development benchmarks, the teaching/learning benchmarks, and the course structure benchmarks.

Within the course development benchmarks, learning outcomes should determine the technology to be used and the course design should be one that engages students and requires them to analyze, synthesize, and evaluate. When it comes to teaching and learning, interaction is a must. Not only should students and faculty interact, but students need to interact with one another. This should be facilitated in a variety of ways like voicemail or e-mail. Quilter and Weber (2004) echo other authors' comments when it comes to feedback. Feedback should be constructive and timely. Furthermore, students should receive instruction in effective research methods. The final benchmark, regarding course structure, discussed that students should be advised as to whether or not they possess the necessary skills and commitment for enrolling in an online course and if they have access to the required technology. The establishment of clear expectations and deadlines is reiterated by Quilter and Weber.

Finally, the authors suggest an additional category for benchmarks: the student support category. This benchmark is an essential instructional component where students are trained in securing materials electronically and through library resources. This includes electronic databases and interlibrary loans (Quilter & Weber, 2004).

"The keys to the creation of a learning community and successful facilitation online are simple. They are as follows: *honesty, responsiveness, relevance, respect, openness, and empowerment*" (Palloff & Pratt, 1999, p. 20). According to Palloff and Pratt (2001), online instructors should consider the following:

1. Set up a well-organized site for the course being taught. Online instructors should use a widely accepted program or platform for conducting their courses, like Black Board.
2. Include an area on the course website for reflection on the online learning experience. This can be easily addressed by creating a discussion board or blog designated to topic reflections.
3. Encourage students to share real-life experiences and examples that are pertinent to the material. By allowing students to share real-life examples the instructor is

engaging the students and trying to gain insight as to where everyone is coming from.

4. Refrain from lecturing. Find alternatives to posting lectures or Power Points on the course site. Examples include inquiry-based activities, Internet scavenger hunts, research reports, article summaries about course topics, book reviews, and etcetera.
5. Comment on student postings and ask additional questions, but refrain from being overbearing. Comment constructively on student postings and if you are looking for more substance, then let the student know so in a polite manner. If the student feels like he or she is being attacked, then he or she is more likely to retreat into cyberspace and not participate fully in the class.
6. Be comfortable enough with the technology to assist students with their questions about the online course. You must have a deep enough understanding of how to guide students through basic technological issues. If you are not computer savvy enough to do so you are setting yourself and your students up for frustration. Furthermore, have a contact at technical support on your campus to assist when you are in a bind or out of your element.
7. Play the role of facilitator rather than instructor. Guide the students through the course rather than instruct them. Allow for the course to be student-centered rather than teacher-centered.
8. Have fun. If you are not enjoying what you are doing and having fun to a certain extent, then you may want to ask yourself if teaching in this type of environment is right for you.

Cooper (2000) suggested that an initial class meeting can be beneficial to online students. Cooper (p. 2) pointed out that, “An important and necessary component to successful Web-based instruction is ongoing communication…” This communication involves instructor/student communication, student/instructor communication, and student/student communication. Cooper also advises professors to track student activity throughout the term. Due to the fact that all students learn differently, diverse instructional materials should be used for online courses (Cooper).

“By way of virtual classrooms, emerging technologies make it possible to add back useful affordances such as the onsite classroom’s simultaneous multi-user, visual communication lost in the early translation of learning to online formats” (Downing & Holtz, 2008, p. 161).

Hsu, Hamza, and Alhalabi (1999) offered “10 easy steps” for designing a virtual classroom:

Step 1: Assess the needs and the necessary conditions to satisfy them.

Step 2: Estimate the development cost, effort, and implications.

Step 3: Plan the virtual classroom.

Step 4: Design the virtual classroom.

Step 5: Prepare and distribute contents.

Step 6: Enable communication.

Step 7: Implement online student assessment methods.

Step 8: Implement class management procedures.

Step 9: Set up the system.

Step 10: Maintain and update the virtual classroom. (Hsu, et al., 1999, pp.1-7)

Ohler in Berge and Collins (1995, p. 176) offered six steps for structuring most of the courses he teaches: “…vision, goals, objectives, activities, evaluation, and special considerations.” The course overview and syllabus are based on the six-step model. Four tips are offered by Ohler “(a) Teach students what they need to know; (b) Do not fear people who have more knowledge than you; (c) Do not stick with one particular technology; (d) Have fun (Berge & Collins).

Bischoff (2000) discussed elements of effective online teaching that include being visible, providing timely and consistent feedback that is evaluative and choosing instructional materials carefully. Online visibility means that the instructor should be participating at the same level as the students. Students often feel isolated when they do not see comments posted by their instructor. Visibility provides reassurance to the students that they are truly working with their instructor and classmates in a collaborative fashion. In addition to the visibility aspect of teaching an online course, instructors must provide frequent and consistent feedback to their individual students and to the class as a whole. Giving feedback includes answering student questions, providing suggestions, all of which must be done in a prompt manner. Online materials must be content-driven so that the class remains focused. Online lectures must be written concisely and URLs should always be checked prior to posting them. When it comes to online materials, instructors must post due dates for assignments and tasks. If using a handout, it should be highlighted to keep the students informed of the important pieces of information (Bischoff).

Harasim, Hiltz, Teles, and Turoff (1995) created a checklist for online courses. The authors made the following points (that mirror the works of Knowles (Knowles et al., 1998) regarding andragological principles):

1. Refrain from lecturing.
2. Be clear about class expectations.
3. Do not be so rigid and remember to be patient.
4. Respond to comments.
5. Do not be overbearing.
6. Monitor participation and keep track of those who are falling behind.
7. Set up small groups for assignments.
8. Be a facilitator.
9. Summarize and focus the discussions or assign individual students or small groups to complete this task.
10. Be sure to organize and do your electronic housekeeping.
11. Create rules and standards for communication (good netiquette).
12. Establish clear norms for grading.
13. Purge messages and conferences in stages, allowing members to review and save messages.
14. Be flexible with regards to approaches to the curriculum.

Pedagogies for Online Courses

King (2002) states that there is a pedagogy for online courses which has proved very successful. This pedagogy includes the use of "authentic problem-based, collaborative learning at a distance" (Carr-Chellman, Dyer, & Brennan, 2000, p. 1).

Muirhead (2002) further states that the integration of critical thinking skills must also be incorporated into online courses. Palloff and Pratt (2001) discuss the need for building a community among online learners.

King (2002) found that one such way to build a collaborative community of learners is to enroll a fictitious virtual student in his class named Joe Bag O'Donuts. King informs his class that this student will join in all discussions and participate with all project teams and although King's other students know that Joe is a fictitious student, they must respond to him (King). King has used Joe to get the discussion started and to get other students involved, thus forming a sense of community (King). "Joe plays learner and facilitator in all of the whole class discussions and individual project team discussions" (King, p. 162).

Motiwalla and Tello (2000) point out key features of a Web-based model:

> The asynchronous aspects of the Web-based model support the learners' ability to access course materials at a time and place, which is convenient to them. This simply is not possible in a traditional face-to-face classroom where faculty schedules and administrative demands set the time and location of the courses. The Web-based model, along with other asynchronous models, provides the learner flexibility in accessing course resources and interacting with classmates, the material, and the instructor. The proposed additional benefit of the Web-based model is that it provides structure and motivation for those learners who require it in the form of peer and instructor interaction and feedback. (p. 257)

There are also several more key elements that need to be included in the design of an online course. Online courses must encourage students to think critically and independently. According to Muirhead (2002):

> Teachers will need to develop a class structure and online teaching style that encourages creativity, reflective thinking, and self-directed learning. It is important that teachers enable students to have the freedom to ask questions and take intellectual risks in their written assignments and discussion groups. Teachers can provide valuable guidance by keeping dialogues focused, relevant and probing deeper into issues. This will require moderating discussions and creating a list of key ideas, references and student contributions. Distance educators can pose a diversity of questions to foster reflective comments. (p. 42)

Palloff and Pratt (2001) discuss several key elements for creating a successful cyberspace classroom. These elements include the technology itself (hardware and software), establishing rules and protocols, achieving high rates of participation, developing collaboration, and developing reflection. According to Ko and Rossen (2004, p. 13), “A successful online course often includes challenging assignments that lead to publicly conducted discussions, moderated and guided by you.” Alexander and Boud (2001) also have their own list for enhancing online learning. This list includes creation of an atmosphere for learning that values the learner; dynamic engagement with trials and tribulations; interactivity and awareness; reproduction of rich settings; and peer conversation. Good examples of online learning include online debates and role-playing (Alexander & Boud).

Downing and Holtz (2008) offer several suggestions for best practices and technologies for online science learning. Most strategies used at the college and university level can transfer over to the secondary level of education. Examples of such practices that can be used at either level of education include game simulations for educational purposes, virtual field trips, virtual labs, authentic experiments, use of digital libraries, and online assessments to determine understanding of science material (Downing & Holtz).

A Framework for the Design of Learning Technology

"The framework describes what, in the pedagogical consensus, are three main elements of a learning process - conceptualization, construction, and dialogue" (Mayes, 2001, p. 19). The process of conceptualization is the grasp of an early understanding of a new notion. The construction aspect involves the early understanding being applied to a problem and feedback about the performance will be expanded. The third stage involves real application of the learner's expertise (Mayes).

Student-Centered Learning in Online Courses

In the past in the traditional classroom, the teacher was the center of the classroom and resided as the "sage on stage." In the face-to-face and online classrooms today, this emphasis is less evident and teachers are now being trained to be more facilitative. Due to the nature of online courses, the emphasis of learning shifts from the teacher to the student. In traditional classroom settings, the focus is on the teacher. In online learning the teacher acts more as a facilitator in student learning. Therefore, the students are given more responsibility for their learning. The assignments that are often a part of online courses focus more on students' individual differences, learning styles, and cognitive and metacognitive development than do their traditional counterparts (Daniels & Perry, 2003). When these assignments or activities are introduced into the virtual classroom a learning community is created. This makes learning a shared process between the students and the teacher (Harada, Lum, & Souza, 2003). Students are given more responsibility for their learning, and the teacher may give up some of the control of the learning activities. In an online setting the teacher expects to give up the control and that actually ensures a more meaningful experience for his or her students. The benefits of such an experience include increased student motivation, student engagement, and less stress for the teacher if all students cooperate with the virtual classroom rules and expectations (Harada et al.; Weinberger & McCombs, 2003). Although student-centered learning does not completely do away with the teacher's responsibility, it does shift the role of the teacher as the center of attention in the classroom to that of facilitator. In this role the teacher is one who facilitates learning through frequent interactions, monitoring progress, helping individuals when needed, and asking thought provoking questions that drive learning (Daniels & Perry; Juilfs, 2003).

Facilitation is a powerful approach to learning that creates a different environment from that found in lecture-based, teacher-centered classrooms. This approach is the most common and obvious one in online instruction. Facilitative learning and teaching means that the teacher is a participant in the learning community, and the teacher is a participant in the learning community, and the students expend the most energy in the classroom (Knobloch, 2003). A facilitator creates a learning environment that works toward a common goal through self-reflection, flexibility, higher order questioning, students' interest, and inclusive discussion (Harada et al., 2003; Knobloch). In addition to increasing student participation, engagement, and collaboration, a facilitative environment promotes students to learn better interpersonal skills and the ability to critically address complex issues (Grudens-Schuck, 2003).

A key component to facilitation and student-centered learning is questioning. Encouraging students to formulate their own questions has a positive impact on learning (Callison, 2003). Teachers may begin the questioning by introducing essential questions at the beginning of the lesson. These questions are thought provoking and may require student investigation in order to completely answer (Juilfs, 2003). This can also create an open-question environment in the classroom. This environment will encourage student interactions and can also be used as a type of informal assessment. The quality of students' questions is a good indicator of student performance (Callison). It is important to remember that since individual differences do exist in the classroom students will need varying levels of interaction from the teacher (Tanner, Bottoms, Feagin, & Bearman, 2003). Improving the students' ability to construct workable questions will increase student inquiry projects and other student-centered problem solving activities (Callison).

Student-centered learning environments make it easy for both the students and teacher to succeed. This type of learning environment promotes interpersonal skills among students and increases their self-confidence in learning (Grudens-Schuck, 2003; Weinberg & McCombs, 2003). When the students feel confident they are more easily motivated to learn, which decreases problems. The open-ended questioning environment allows creativity to be expressed by both the facilitator and the learner. One of the challenges to being a facilitator is being flexible and adaptive (Knobloch, 2003). Since each group of students is different the facilitator must be prepared for the various questions that will be asked by curious learners. However, this also works to keep the teacher interested in the virtual discussions since they are an important part of the shared learning process seen in the student-centered environment (Harada et al., 2003).

Leadership Behaviors in Secondary Schools

"The traditional roles of teachers and principals have changed and improved organizational teamwork is fostered by all members of the learning community assuming decision making roles" (Leech & Fulton, 2008, p. 630). Within the past two decades, involving employees and other stakeholders in organizational decision making has increased in popularity. It can be argued that today's schools must be led differently. School "…leaders must rely more on applying elements from research of cultural, transformational, and participatory leadership" (Leech & Fulton, p. 632).

Senge, Kleiner, Roberts, Ross, and Smith (1994) suggested steps for changing public schools. Although he believes that change can occur by using any of the five learning disciplines, it should start with systems thinking. "It is not just a politically neutral vehicle, but a powerful way to involve students in generative learning" (Senge et al., p. 491). Since there is a great deal of political issues that the board of education in a particular county may face, the leverage for reform should come in a small grass-roots effort. Curricular integration is the first step in pushing school reform. Only once the bonds of curriculum fragmentation can be broken, can schools truly make changes. Dialogue also needs to be opened between all stakeholders involved in education. These include parents, bureaucrats, administrators, teachers, students, and government leaders. Senge et al. suggested that each of these steps in promoting school reform be approached incrementally.

In order for a set of best practices in science instruction to actually be used in a particular school system, the importance of changing the current methods of instruction must be recognized. Many stakeholders may resist implementing such a set since it could involve resistance from other groups within education. Administrators may feel that it affects their leadership style by forcing their science teachers to follow a prescribed set of instructional strategies. Teachers may feel that it impedes on their individual teaching styles and preferences.

> School leaders, however, need to understand the learning dynamics within communities of practice and the part they might play to ensure productive learning in the sense that it enhances teachers' belief systems and skills and improves learning outcomes for all students. (Printy, 2008, p. 191)

Preferred Practices for Science Instruction in Online and Face-to-Face Settings

A review of the literature across the field of science teaching in both online/virtual and face-to-face settings included the following themes:

1. Be organized. Organization is crucial for any professional. The teacher who lacks organization will often lack classroom management. This is especially true at the secondary level as teenagers are well aware of which teachers have their acts together and will prey upon those who do not exhibit such.
2. Accommodate different learning styles. Teachers can do this fairly easily in a science classroom by incorporating different instructional strategies. Teachers can use lecture, technology, laboratories, demonstrations, worksheets, small

group activities, discussions, and videos to appeal to the various learning styles present in his or her classroom.

3. Promote collaborative learning. Collaborative learning can be achieved through laboratory activities in which students are working with a partner or in small groups. Collaboration can also be incorporated through mini-lessons in which students teach each other for a specific amount of class time. Students could also quiz each other while preparing for an upcoming exam.
4. Provide an overview of the course and each lesson. An overview of the course is typically provided to the students in the form of a syllabus, which is discussed during the first day of class. As for overviews of each lesson, teachers many choose to use concept maps and graphic organizers in order to guide the students through that particular lesson.
5. Create clear expectations. Teachers must be sure that the classroom expectations are clearly stated and posted in the classroom. Teachers should not bend on these expectations as the students could possibly detect weakness and unfairness.
6. Be available to the students. Teachers should have time set aside before or after school in which they can be available for tutoring. Deciding on a designated day of the week and time can be beneficial to both the students and the teacher.

Scientific Inquiry Continuum

Inquiry is a student-centered learning approach that can be easily implemented into the science classroom. Inquiry promotes the students to question, examine, and investigate topics. This approach not only presents the curriculum to the students, it enables the students to understand the processes and skills necessary to perform science (Krantz & Barrow, 2006). The students' previous experiences in science are probably limited to vocabulary exercises and insufficient practice with investigating. The 5E learning cycle model is beneficial during scientific inquiry. The five steps are engage, explore, explain, elaborate, and evaluate. Implementing this cycle gets the students engaged in the learning and research shows this cycle is compatible with how students learn best (Wilder & Shuttleworth, 2005). The first step is more teacher-centered, but it allows the teacher to assess previous knowledge and to identify misconceptions. The exploring stage is largely student-centered, but the teacher may need to provide varying levels of instruction. The remaining stages extend the learning and allow students to apply their understandings to real-life situations (Townsend & Bunton, 2006).

The 5E learning cycle model and inquiry closely resemble the scientific method. The students move through the process starting with a problem, investigating the problem, and forming a conclusion based on the information gathered. However, the teacher should not assume that all students can perform a full-scale scientific inquiry without being taught how (Wilke & Straits, 2005). The students' understanding should be scientifically accurate using inquiry (Krantz & Barrow, 2006). However, if the student has not been taught how to primarily address each stage of the scientific method, then the learning is only as good as the weakest step in the process (Wilke & Straits). Successful inquiry in the science classroom will allow the students to explore the concepts, explain the concepts, and allow the students to master the concepts for long-term retention (Wilder & Shuttleworth, 2005).

Chapter Summary

This chapter reviewed the literature on online instructional strategies and science instructional strategies. This chapter also reviewed literature on secondary school leadership. The research and theories discussed in this chapter provide a conceptual framework for investigating best practices among educators of traditional and online courses and educators of science courses. In this research several elements were considered.

Student-centered learning versus teacher-centered learning is relatively easy to achieve in an online environment due to the nature of the design of the course. Since the students and instructor are not in a traditional classroom setting, it is to the students' advantage that the instructor acts as a facilitator rather than a lecturer. In the science classroom, this may be more difficult to achieve since most instructors tend to lecture. However, there are many more teaching methods that science teachers can incorporate into the lessons.

Science instructional techniques have traditionally kept the teacher as the center of instruction. Science teachers rely heavily on lecture to disseminate the topics being investigated. Nevertheless, including laboratory exercises and demonstrations are also involved in the science classroom. Inquiry is the main basis of science and teachers can easily shift the locus of control from themselves to their students. The scientific method can be implemented to engage students in the learning process and allow them to become more comfortable with inquiry and investigative skills. These skills promote critical thinking and shift the acquisition of knowledge from rote memorization to mastery of concepts, which will remain in the long-term memory of the students involved in such learning processes.

Another element discussed was online learning. Online learning includes distance education using technologies that are available to a large population regardless of the distance from the host institution. Online learning has gained popularity in recent years due to the flexibility it offers to students. Students are no longer confined to the physical classroom. Instead they can participate in a course virtually.

Creation of online courses involves many factors for instructors to consider when planning their courses. Online instructors need to be organized. Without proper planning, the course may not elicit enough student participation and may fail to be a beneficial experience for all who are involved. Instructors also need to include space on the course site for student discussions and reflections. Instructors may choose to set up a discussion board or blog for the students to reflect on specific topics. Furthermore, online instructors need to respond promptly to student postings and provide constructive criticism. The instructors should also refrain from lecturing and should provide assignments that differentiate the instruction in order to appeal to the various learning styles present among the students.

Pedagogies for online courses are numerous and many researchers have discussed useful and beneficial ideas for instructors to implement into their online curriculum. These suggestions include creating collaborative learning opportunities which are problem-based and realistic. Other researchers suggest creating assignments and activities that engage the learners and cause them to think independently and critically about the questions posed on the course site.

Statistics can support the widespread phenomenon of online learning. According to a national survey conducted by the NCES of the United States Department of Education (USDE), there has been an almost 44% increase in distance-based course offerings in higher education institutions. With such a great increase in these course offerings and the demand for online courses to be offered by higher education institutions, it becomes necessary to determine which type of instructional strategies are most effective for this type of learning environment.

Leadership decisions may affect teachers' use of a set of best practices. Many educators may disagree with the implementation of a prescribed set of instructional strategies that teachers must follow. In order for these strategies to be used effectively, there should be an agreement between administrators and teachers as to how they will be used in the classroom.

A framework for technology involves the processes of conceptualization, construction, and dialogue. Challenging assignments should be facilitated by the instructor to engage student learning and promote critical thinking. In addition to these elements, the technology itself must be addressed. The decision as to what type of hardware and software will be implemented in the course design needs to be made prior to the course being established. Instructors must also be comfortable enough with the technology to assist students when they are having difficulties with the technical aspects of the course. Furthermore, the instructors should have a contact for technical support at their institutions in the event that they cannot assist the students with their technological issues. Chapter 3 describes the methodology that was utilized in this study.

CHAPTER 3

METHODOLOGY

This study was designed to identify actual teaching practices and instructional strategies for online science courses. For the purpose of this study, the researcher designed a survey for face-to-face and online teachers to identify preferred teaching practices, instructional strategies, and types of technology used when teaching high school science students. The survey also requested demographic data information from the faculty members, including years of experience, subject(s) taught, and whether the teacher taught in a traditional classroom teacher or online, to determine if any of those elements affect differences in faculty perceptions with regard to the questions under investigation. Previous studies have shown that there are differences in teachers' views based on some of the demographic characteristics under investigation. The remainder of this chapter presents the research design for this study, the population, sampling plan, instrumentation, data collection procedures, and an overview of the data analysis that was conducted for this study

Method

A quantitative comparative descriptive research method was used for this study to address the use of instructional strategies identified for face-to-face science instruction and online science instruction. Data were solicited from individuals through a survey instrument. A letter of support from Mr. Michael Surma, superintendent of Henry County

Schools, was included with the survey and consent letter. The surveys were packaged in envelopes and delivered to the principals at the secondary schools for them to disseminate to the science teachers in each department. The surveys were delivered via courier mail, completed, and returned via courier mail. Paper surveys were used instead of online surveys because of Henry County Schools' restrictions of access to their e-mail pipeline. The participants' anonymity was protected through the use of the consent letter included with the surveys. This precaution ensured that the participants would not experience any anxiety when returning the surveys to the researcher because their responses will not be revealed or tracked by the administration.

The descriptive design was used to create an accurate description of the teaching practices and instructional strategies that are frequently used when teaching high school science students. The quantitative descriptive design provided credibility to the analysis because the results and findings could be replicable for future studies (Marsland, Wilson, Abeyassekera, & Kleih, 2001). This was accomplished by presenting the numbers, percentages, and proportions of participants who respond to each of the questions on the survey instrument. The quantitative research design was appropriate for the proposed study because this allowed the researcher to be able to quantify the results and findings and compare the data with results from other studies in the same or similar fields to determine if the results are consistent.

The comparative design was used in this study because the purpose of the comparative design was to determine whether there was a difference between two independent populations with respect to a continuous dependent variable. For this study, the two independent populations that were compared are teachers who teach online science courses and teachers who teach face-to-face science courses. If a teacher taught online science courses then they were assigned a value of 0, while if the teacher taught face-to-face science courses then they were assigned a value of 1. By doing this, these two groups of teachers could be compared with one another to determine whether there was a difference in the preferred teaching practices/instructional strategies, and types of technology used by these teachers. This was accomplished by combining the item responses provided on the survey instrument so that scores for the teaching practices/ instructional strategies and types of technology used were obtained.

To address the objectives of this study, descriptive statistics and independent samples *t* tests were used. The descriptive statistics used in this study were frequency distributions and measures of central tendency. These provided information about the number of responses and the distribution for each of the questions on the survey instrument. The independent samples *t* test was used to determine whether there was a significant difference between two independent populations with regard to the average scores obtained on a dependent variable.

Research Questions

This study asked the following questions:

1. What are the actual teaching practices/instructional strategies for science courses taught by face-to-face secondary science instructors?
2. What are the actual teaching practices/instructional strategies for science courses taught by online secondary science instructors?
3. Do differences in actual teaching practices/instructional strategies exist between face-to-face science instructors and online science instructors?

4. What types of technology usage in the classroom is preferred for delivering instruction in a secondary science course taught by a face-to-face science instructor?
5. What types of technology usage in the classroom is preferred for delivering instruction in a secondary science course taught by an online science instructor?
6. Do differences exist in types of technology usage between face-to-face science instructors and online science instructors?
7. What is the relationship among actual teaching practices/ instructional strategies, technology usage, and demographics (years of experience, subject taught, and their role as a traditional classroom teacher or an online teacher) of face-to-face science instructors and online science instructors?
8. What practices are preferred by both face-to-face and online secondary science instructors for the following:
    a. To identify and address science concept misconceptions?
    b. To address student questions?
    c. As a face-to-face best practice for science instruction?
    d. As an online best practice for science instruction?

Population

Science teachers from secondary schools in Henry County, Georgia, were asked to participate in the survey. Demographic information of science teachers in Henry County was collected prior to the survey administration. The researcher collected relevant pieces of demographic information about science teachers in Henry County, such as years of experience, subject(s) taught, and the type of instruction (online or face-to-face). These data were collected to compare to the actual demographic information contained in the survey responses.

Nonprobability sampling was used because of the limited accessibility of teachers outside the researcher's school district. For the purpose of the study, a convenience sampling plan was used. The convenience sampling plan was a form of non-probability sampling where the participants were selected as they came along. The reason for choosing the convenience sampling plan was because it has an advantage over a probability sampling method (i.e., random sampling technique). The researcher was able to obtain more observations for the study in a shorter period of time (Cozby, 2001). Similarly, the convenience sampling plan was appropriate for this study since the teachers were not randomly selected from the entire population of teachers within Henry County, Georgia. Rather the teachers were selected based on whether or not they voluntarily chose to participate in the proposed study.

In this study, the researcher asked principals of secondary schools in Henry County, Georgia, to forward copies of the survey to the science teachers on staff. It was expected that each principal would allow the researcher to conduct the study using the teachers within their schools. If a principal refused the request then their school was not included in the study. The researcher sought permission from individual principals, who then forwarded the survey package to their science faculty members. There were approximately 175 secondary science teachers in the Henry County school system.

When calculating the sample size for the study there were three factors that had to be taken into consideration. The first factor was the statistical power of the test. For the purpose of this study, a power of 80% was selected because a power of this magnitude offers adequate opportunity (probability) to reject a null hypothesis that is false in the population (Moore & McCabe, 2006). The second factor was the effect size. For the purpose of this study, a moderate effect size was selected because this would provide evidence of a relationship between the independent and dependent variables without being too strict or too lenient. The final factor that was important was the level of significance. For this study, the level of significance was selected to be equal to 5% because this is most consistently used in studies of this nature.

The minimum sample size also depended on the type of analysis conducted, such that the sample size needed to achieve the .80 power is obtained. For the purpose of this study, an independent samples *t* test was used. In terms of the independent samples *t* test, the sample size also depended on whether the alternative hypothesis was one-sided or two-sided. Based on this information, the minimum sample size that would be required for this study would be 128. This was based on a two-tailed alternative hypothesis.

Survey Instrument

The survey instrument was a modification of existing surveys involving research on instructional strategies. Items that reflected the elements of "actual teaching practices/instructional strategies for online science courses" that have been gleaned from the literature comprised the elements of the survey. The researcher created the survey in Microsoft Word to administer to teachers via the courier mail service in Henry County Schools. The survey requested demographic data information from the faculty members, including years of experience, subject(s) taught, and whether the teacher taught in a traditional classroom teacher or online. It was anticipated that the views of the teachers would be related to factors such as their years of experience, subject taught, and their role as a traditional classroom teacher or an online teacher.

The survey featured a 5-point Likert-type scale: 1 (strongly agree), 2 (agree), 3 (neither agree nor disagree), 4 (disagree), 5 (strongly disagree). The Likert scale measured the perceptions of the teachers as to the *instructional/teaching practices* or *instructional strategies* employed by science teachers in classrooms and online. The questions on the survey were used to measure the perceptions of the teachers in the study.

Perceptions of teachers based on their actual practices were part of Part II and Part V of the survey instrument. Part II was based on a 5-point Likert-type scale that ranged from 1 indicating ‘Strongly Disagree’ to 5 indicating ‘Strongly Agree.’ In total, there were 14 questions that were asked in part II of the survey instrument. Part V was based on a 6-point Likert-type scale that ranged from 1 indicating ‘0 times per week’ to 6 indicating ‘5+ times a week.’ There are 17 questions that were asked in part V of the survey instrument. Role of the teacher was based on Part IV of the survey instrument. Part IV used a 5-point Likert-type scale that ranged from 1 to 5. In total, there were 6 questions that were asked in part IV of the survey instrument. Each of the items on Part II, IV and V were analyzed separately by using Spearman’s rank correlation analyses and Mann-Whitney U tests.

Validity

The validity of the instrument was shown in one way. This was through face validity. The face validity of the instrument was determined by the researcher during the development of the survey instrument, by assuring that the questions asked measured what they were intended to measure. This was done to make sure that the items looked like they measure what they intended to measure.

Reliability

One type of measurement was calculated to illustrate the reliability of this survey instrument. Alpha scores were calculated for each of the constructs that were found. This type of measurement provided evidence that there was reliability between the items on the survey. The resulting reliability for Part II of the survey was .50, while the reliability for Part IV was .48. The reliability for Part V was .76. The reliabilities were calculated using Cronbach’s Alpha coefficients.

Data Collection

Data for this study were obtained by providing the survey instruments to school principals who distributed them among their school’s science teachers. Enough packages were provided to the principals so that they were able to distribute them to all the teachers who met the inclusion criteria in the schools. The participants were given a package that included the survey instrument, a description of the study, an informed consent letter, a letter of support from the superintendent of schools, and a self-addressed envelope to allow the teachers to return the surveys to the researcher. The description of the study provided information on the purpose of the study as well as the contact information of the researcher so that the potential participants could ask questions if necessary. The potential participants were informed of how long it would take them to complete the entire study as well as any other further information necessary for the study.

The participants were aware that if they wished to not finish the study at any point, they could discontinue the study without any subsequent consequences. If the participant chose to participate, then the participant completed the survey instrument for the study. The informed consent letter had no identifying information so that identification of the participants was impossible. If the potential participants chose not to complete the study, then the potential participants were thanked for considering taking part in the study and no further information was collected from them.

The raw data from the survey instruments was imported into a computer spreadsheet (Microsoft Excel®) for future analysis. The information obtained from the participants was imported in such a way that each row received a unique identification number. This identification number was used in order to specify which responses corresponded to which participant in the study. The data were saved on a separate flash drive and stored in a filing cabinet or was stored on a personal computer in which only the researcher had access. This method ensured that the confidentiality of each participant in the study was maintained and that no personal information would accessible to others outside the study. The data were placed in a file to be held for a period of three years, after which the data would be destroyed and deleted from the hard drive.

Data Analysis

Descriptive statistics were used to summarize and compare the responses of face-to-face teachers with those of online teachers and to measure the teaching strategies used by instructors in face-to-face science classrooms and virtual science classrooms. None of the teachers in the sample taught both face-to-face science classrooms and virtual science classrooms. Both online and face-to-face teachers completed the entire survey instrument so that the scores from each component of the survey could be compared with one another.

Table 1

Statistical Analysis Methods Used to Address Research Questions

Research Questions	Analysis
1. What are the actual teaching practices/instructional strategies for science courses taught by face-to-face secondary science instructors?	SPSS-XVI Frequency Distributions
2. What are the actual teaching practices/instructional strategies for science courses taught by online secondary science instructors?	SPSS-XVI Frequency Distributions
3. Do differences in actual teaching practices/instructional strategies exist between face-to-face science instructors and online science instructors? $H_0$1: There are no differences in actual teaching practices/instructional strategies exist between face-to-face science instructors and online science instructors. H_A1: There are differences in actual teaching practices/instructional strategies exist between face-to-face science instructors and online science instructors.	SPSS-XVI Mann-Whitney U-test
4. What types of technology usage in the classroom is preferred for delivering instruction in a secondary science courses taught by a face-to-face science instructor?	SPSS-XVI Frequency Distributions
5. What types of technology usage in the classroom is preferred for delivering instruction in a secondary science courses taught by an online science instructor?	SPSS-XVI Frequency Distributions

(table continues)

Table 1 *(continued)*

Research Questions	Analysis
6. Do differences exist in types of technology usage between face-to-face science instructors and online science instructors? $H_0$2: There are no differences in types of technology usage between face-to-face science instructors and online science instructors. H_A2: There are differences in types of technology usage between face-to-face science instructors and online science instructors.	SPSS-XVI Mann-Whitney U-test
7. What is the relationship among actual teaching practices/ instructional strategies, technology usage, and demographics (years of experience, subject taught, and their role as a traditional classroom teacher or an online teacher) of face-to-face science instructors and online science instructors? $H_0$3: There is no relationship among actual teaching practices/ instructional strategies, technology usage, and demographics (years of experience, subject taught, and their role as a traditional classroom teacher or an online teacher) of face-to-face science instructors and online science instructors. H_A3: There is a relationship among actual teaching practices/ instructional strategies, technology usage, and demographics (years of experience, subject taught, and their role as a traditional classroom teacher or an online teacher) of face-to-face science instructors and online science instructors.	SPSS-XVI Spearman's rank correlation coefficient

(table continues)

Table 1 *(continued)*

Research Questions	Analysis
8. What practices are preferred by both face-to-face and online secondary science instructors for the following: a. To identify and address science concept misconceptions? b. To address student questions? c. As a face-to-face best practice for science instruction? d. As an online best practice for science instruction?	SPSS-XVI Frequency Distributions to determine themes, Cross Comparative Analysis, and Summary of Open-ended Comments

To address the first, second, fourth and fifth research questions, frequency distributions were computed. This included calculating the number of occurrences for each of the responses, as well as the percentage for each of the responses. The number of occurrences was based on the frequency in which the categories of the Likert-type scales were selected by the participants. The frequencies and percentages were computed for both online and face-to-face instructors.

Frequencies and percentages were also computed for the categorical demographic characteristics of the participants. To determine whether there was a relationship between the categorical demographic characteristics and type of instructor (online or face-to-face), chi square tests were conducted. The chi-square tests were used when the variables being assessed were categorical variables. The chi square test indicated whether one level of the demographic variables depended on the type of instructor. The analysis would indicate whether there is a relationship between demographic variable and instructor type.

For research questions three and six, a non-parametric test was used to get around the normality assumption of parametric testing by using ranked or ordered values in the analysis instead of interval or ratio scale of measurement. This is because each of the items on the survey instrument were assessed using the original ordinal Likert-type scale responses. Non-parametric test were used if one or more variables in the data set violated the normality assumption; the non-parametric tests have an advantage of not requiring the assumption of normality or homogeneity of variance; they are also referred to as distribution-free or parameter-free tests. Lastly, a non-parametric test was needed to be used if the number of cases or subjects was small.

Mann-Whitney's U test was used because whereas in other statistical analyses the assumptions of normality have to hold, the Mann-Whitney test does not have to make any such assumptions. Without having to assume the populations in the study come from a normal distribution, the Mann-Whitney test compared two sample populations to see whether they both come from the same population versus whether or not they come from different populations. In the case of the current study this allowed one to determine whether or not online instructors were different from face-to-face instructors when it came to their responses for the Likert-type scale questions on the survey instrument.

This was accomplished by taking the scores for each one of the items used to measure the individuals' perceptions. The scores were then ranked accordingly from smallest to largest with the lowest score being assigned a value of one, the second lowest score being assigned a value of two and so forth. The analysis was then conducted on either the summed rankings from one (i.e., online instructors) group (W_1) or the other (i.e., face-to-face instructors) group (W_2). Here W_1 and W_2 represent the summed scores for each of the groups. Based on these results the test statistic used in the calculation was either

$$U_1 = W_1 - \frac{n_1(n_1 + 1)}{2}$$

or

$$U_2 = W_2 - \frac{n_2(n_2 + 1)}{2}$$

where n_1 was the number of observations in the one (i.e., online instructors) group and n_2 was the number of observations in the other (i.e., face-to-face instructors) group. In general, the smaller of the two scores could be used which was then represented by *U*. If the value obtained from *U* was less than or equal to a critical value then it was concluded that there was a significant difference between the scores of the two populations. The Mann-Whitney U-test was used to compare online to face-to-face teachers with respect to every one of the Likert-type scaled questions provided on the survey instrument.

For research question 7, Spearman’s rank correlation coefficient was used. Spearman’s rank correlation coefficient is a nonparametric version of the correlation coefficient. Instead of correlating the continuous variables with one another the ranked variables are correlated with one another. The coefficient ranges from a – 1 to + 1, with a score of around – 1 indicating that there was a strong negative relationship between the variables and a score of around + 1 indicating there was a strong positive relationship between the variables. If there was a strong negative correlation then this meant that when the ranks of one variable increased the ranks of the other variable decreased while a strong positive correlation then this meant that when the ranks of one variable increased the ranks of the other variable increased as well.

Chapter Summary

Chapter 3 discussed the research methods that were employed in the study, which used a quantitative comparative descriptive research design. Chapter 3 presented information on the data collection process and the statistical analyses, which included descriptive statistics as well as Mann-Whitney U tests. In addition, this chapter presented the research questions, the population and sample size, and a description of the instrumentation that was used. Chapter 4 presents the results of the data analyses for this study.

CHAPTER 4

FINDINGS

The purpose of this study was to present the results of the analyses conducted on the dataset comparing online secondary science instructors with face-to-face secondary science instructors. In order to compare the online instructors with face-to-face instructors several different analyses were conducted. These included frequency distributions, summary statistics, chi-square tests of independence, independent samples *t* test, Spearman's rank correlation, Mann-Whitney U tests, and content analysis. These findings were then divided into four sections. The first section presents the results of the exploratory data analysis. The chi-square tests of independence, Spearman's rank correlation and independent samples *t* test will be presented in the following section comparing those who were an online instructor with those who were a face-to-face instructor in terms of their demographic characteristics. The third section includes the results of the Mann-Whitney U test comparing online instructors with face-to-face instructors in terms of the responses on the survey instrument as well as the Spearman's rank correlation results comparing age, years experience and proficiency with technology with each of the responses on the survey instrument. The final section includes the results of the content analysis. Open-ended questions were addressed using content analysis. This involved reviewing and then coding the responses depending on the common themes among them.

Exploratory Data Analysis

Demographic Characteristics

Tables were produced to illustrate the frequency distributions of the demographic characteristic variables included in the study. This included presenting the number and percentage of occurrences for each of the variables in the study. Fifty-six (88.9%) of the participants were not online instructors, while the remaining 11.1% were online instructors. For the “subjects teaching” and “subjects certified” in variables there were several different responses where only one individual selected a response. For this reason, these variables were reduced to include three different categories each.

For the subjects teaching variable, the groups included those who taught general science (i.e., environmental science, science, social studies, and math), physical sciences (i.e., physics, chemistry and physical science), and biology. As for the subjects certified in variable, the groups included science related courses (i.e., math, physics, chemistry, science, and social science), biology and other (comprising other types of certifications, such as language arts and special education).

Overall, the most frequent course taught by teachers was the general science related courses (44.4%), while the majority of teachers were certified in science related courses (74.6%). For the level of proficiency with technology, the majority of the participants reported themselves as being intermediate (65.1%). These results are presented in Table 2.

Descriptive statistics were produced for the age and number of years experience for the teachers in the study. The summary statistics produced included the minimum and maximum values for the variables, as well as the mean and standard deviations. The minimum age of the teacher was 24 years old, while the maximum age was 62 years old. The average age of the teachers was equal to 38.72 years old (*SD* = 9.39 years). Overall, two individuals did not provide information regarding their age. The minimum number of years experience for the teacher was 1 year, while the maximum age was 32 years. The average number of years experience for the teachers was equal to 11.21 years (*SD* = 8.27 years).

Table 2

Frequency Distribution for Demographic Characteristics of Survey-Part I

Variable	Frequency (N = 63)	Percent
Online Instructor		
No	56	88.9
Yes	7	11.1
Subjects Taught		
Biology	22	34.9
General Science	28	44.4
Physical Science	13	20.6
Subjects Certified In		
Biology	11	17.5
Other	5	7.9
Science	47	74.6
Proficiency with Technology		
Expert	19	30.2
Intermediate	41	65.1
Novice	3	4.8

Tables were produced to illustrate the frequency distributions of the second (Teaching Practices) and fifth (Instructional Strategies) part of the survey included in the study. This included presenting the number and percentage of occurrences for each of the variables in the study. The results for this part of the survey are presented in Table 3.

Table 3

Frequency Distribution for Teaching Practices/Instructional Strategies, Survey-Part II and Part V

Variable	Overall		Face-to-Face		Online	
	Frequency (N = 63)	Percentage	Frequency (N = 56)	Percentage	Frequency (N = 7)	Percentage
Teacher Centered						
SD	3	4.8	3	5.4	0	0.0
D	22	34.9	19	33.9	3	42.9
N	12	19.0	12	21.4	0	0.0
A	18	28.6	15	26.8	3	42.9
SA	8	12.7	7	12.5	1	14.3
Student Centered						
SD	1	1.6	0	0	1	14.3
D	11	17.5	9	16.1	2	28.6
N	11	17.5	10	17.9	1	14.3
A	26	41.3	25	44.6	1	14.3
SA	14	22.2	12	21.4	2	28.6
Printed Notes/Docs for Subject Material						
SD	10	15.9	7	12.5	3	42.9
D	22	34.9	21	37.5	1	14.3
N	7	11.1	7	12.5	0	0
A	17	27.0	16	28.6	1	14.3
SA	7	11.1	5	8.9	2	28.6
Power Point						
SD	10	15.9	10	17.9	0	0
D	24	38.1	24	42.9	0	0

Variable	Overall		Face-to-Face		Online	
	Frequency (N = 63)	Percentage	Frequency (N = 56)	Percentage	Frequency (N = 7)	Percentage
N	8	12.7	7	12.5	1	14.3

(table continues)

Table 3 *(continued)*

Variable	Overall		Face-to-Face		Online	
	Frequency (N = 63)	Percentage	Frequency (N = 56)	Percentage	Frequency (N = 7)	Percentage
A	16	25.4	12	21.4	4	57.1
SA	5	7.9	3	5.4	2	28.6
Intro to concepts through Printed Materials						
SD	7	11.1	4	7.1	3	42.9
D	23	36.5	22	39.3	1	14.3
N	7	11.1	7	12.5	0	0
A	21	33.3	18	32.1	3	42.9
SA	5	7.9	5	8.9	0	0
Intro to concepts through Group Discussion						
SD	4	6.3	4	7.1	0	0
D	18	28.6	16	28.6	2	28.6
N	14	22.2	12	21.4	2	28.6
A	20	31.7	19	33.9	1	14.3
SA	7	11.1	5	8.9	2	28.6
Intro to concepts through Video Demo or in Person						
SD	2	3.2	1	1.8	1	14.3
D	13	20.6	12	21.4	1	14.3
N	14	22.2	14	25.0	0	0
A	29	46.0	24	42.9	5	71.4
SA	2	3.2	2	3.6	0	0
Labs 3x or Less During Semester						
SD	34	54.0	34	60.7	0	0

(table continues)

Table 3 *(continued)*

Variable	Overall		Face-to-Face		Online	
	Frequency (N = 63)	Percentage	Frequency (N = 56)	Percentage	Frequency (N = 7)	Percentage
D	13	20.6	9	16.1	4	57.1
A	7	11.1	6	10.7	1	14.3
SA	8	12.7	6	10.7	2	28.6
Labs Conducted at Least Once/Week						
SD	8	12.7	4	7.1	4	57.1
D	11	17.5	10	17.9	1	14.3
N	4	6.3	4	7.1	0	0
A	23	36.5	21	37.5	2	28.6
SA	17	27.0	17	30.4	0	0
Labs Done in Classroom						
SD	4	6.3	2	3.6	2	28.6
D	2	3.2	0	0	2	28.6
N	1	1.6	1	1.8	0	0
A	25	39.7	22	39.3	3	42.9
SA	31	49.2	31	55.4	0	0
Virtual Labs						
SD	14	22.2	12	21.4	2	28.6
D	15	23.8	14	25.0	1	14.3
N	10	15.9	10	17.9		
A	19	30.2	17	30.4	2	28.6
SA	4	6.3	2	3.6	2	28.6

(table continues)

Table 3 *(continued)*

Variable	Overall		Face-to-Face		Online	
	Frequency (N = 63)	Percentage	Frequency (N = 56)	Percentage	Frequency (N = 7)	Percentage
Assess Prior Knowledge on Every Test						
SD	1	1.6	1	1.8	0	0
D	8	12.7	8	14.3	0	0
N	4	6.3	4	7.1	0	0
A	29	46.0	23	41.1	6	85.7
SA	21	33.3	20	35.7	1	14.3
Use Videos and DVDs						
SD	2	3.2	2	3.6	0	0
D	3	4.8	3	5.4	0	0
N	5	7.9	4	7.1	1	14.3
A	37	58.7	33	58.9	4	57.1
SA	16	25.4	14	25.0	2	28.6
Teaching Activities Aligned to GPS						
A	17	27.0	15	26.8	2	28.6
SA	46	73.0	41	73.2	5	71.4
Audio Files as Teaching Tools						
0	32	50.8	31	55.4	1	14.3
1	11	17.5	10	17.9	1	14.3
2	7	11.1	6	10.7	1	14.3
3	8	12.7	4	7.1	4	57.1
4	2	3.2	2	3.6	0	0
5+	2	3.2	2	3.6	0	0

(table continues)

Table 3 *(continued)*

Variable	Overall		Face-to-Face		Online	
	Frequency (N = 63)	Percentage	Frequency (N = 56)	Percentage	Frequency (N = 7)	Percentage
Physical Model as Teaching Tools						
0	2	3.2	0	0	2	28.6
1	16	25.4	16	28.6	0	0
2	17	27.0	15	26.8	2	28.6
3	15	23.8	12	21.4	3	42.9
4	8	12.7	8	14.3	0	0
5+	4	6.3	4	7.1	0	0
Analogies to Relate Science Concepts to Real Life Situations						
1	1	1.6	0	0	1	14.3
2	4	6.3	4	7.1	0	0
3	14	22.2	12	21.4	2	28.6
4	14	22.2	14	25.0	0	0
5+	29	46.0	25	44.6	4	57.1
Conceptual Models as Teaching Tools						
0	1	1.6	0	0	1	14.3
1	5	7.9	5	8.9	0	0
2	12	19.0	11	19.6	1	14.3
3	21	33.3	17	30.4	4	57.1
4	15	23.8	15	26.8	0	0
5+	8	12.7	7	12.5	1	14.3
Peer Tutoring						
1	15	23.8	14	25.0	1	14.3

(table continues)

Table 3 *(continued)*

Variable	Overall		Face-to-Face		Online	
	Frequency (N = 63)	Percentage	Frequency (N = 56)	Percentage	Frequency (N = 7)	Percentage
2	11	17.5	9	16.1	2	28.6
3	10	15.9	10	17.9	0	0
4	17	27.0	15	26.8	2	28.6
5+	9	14.3	7	12.5	2	28.6
Graphic Models as Part of my Teaching Strategy						
0	2	3.2	2	3.6	0	0
1	3	4.8	2	3.6	1	14.3
2	15	23.8	13	23.2	2	28.6
3	14	22.2	12	21.4	2	28.6
4	16	25.4	15	26.8	1	14.3
5+	11	17.5	10	17.9	1	14.3
Work Directly with Students						
0	2	3.2	0	0	2	28.6
2	2	3.2	2	3.6	0	0
3	10	15.9	9	16.1	1	14.3
4	11	17.5	9	16.1	2	28.6
5+	37	58.7	35	62.5	2	28.6
Help Students Create Mental Models						
1	2	3.2	1	1.8	1	14.3
2	3	4.8	2	3.6	1	14.3
3	15	23.8	12	21.4	3	42.9
4	15	23.8	14	25.0	1	14.3
5+	27	42.9	26	46.4	1	14.3

(table continues)

Table 3 *(continued)*

Variable	Overall		Face-to-Face		Online	
	Frequency (N = 63)	Percentage	Frequency (N = 56)	Percentage	Frequency (N = 7)	Percentage
Engage Students in Role Play						
0	21	33.3	17	30.4	4	57.1
1	18	28.6	16	28.6	2	28.6
2	9	14.3	9	16.1	0	0
3	7	11.1	7	12.5	0	0
4	6	9.5	5	8.9	1	14.3
5+	1	1.6	1	1.8	0	0
Students Engage in Computer Simulations						
0	21	33.3	20	35.7	1	14.3
1	22	34.9	22	39.3	0	0
2	6	9.5	6	10.7	0	0
3	9	14.3	7	12.5	2	28.6
4	2	3.2	0	0	2	28.6
5+	2	3.2	0	0	2	28.6
Take Students on Field Trips						
0	47	74.6	40	71.4	7	100.0
1	9	14.3	9	16.1	0	0
2	2	3.2	2	3.6	0	0
3	1	1.6	1	1.8	0	0
4	1	1.6	1	1.8	0	0
5+	1	1.6	1	1.8	0	0

(table continues)

Table 3 *(continued)*

Variable	Overall		Face-to-Face		Online	
	Frequency (N = 63)	Percentage	Frequency (N = 56)	Percentage	Frequency (N = 7)	Percentage
Provide Students with Real Life Examples						
2	6	9.5	5	8.9	1	14.3
3	15	23.8	10	17.9	5	71.4
4	13	20.6	13	23.2	0	0
5+	28	44.4	27	48.2	1	14.3
Provide Constructive Feedback to Students						
1	1	1.6	1	1.8	0	0
2	7	11.1	7	12.5	0	0
3	24	38.1	20	35.7	4	57.1
4	9	14.3	6	10.7	3	42.9
5+	21	33.3	21	37.5	0	0
Available to Students Outside of Class						
0	4	6.3	3	5.4	1	14.3
1	4	6.3	4	7.1	0	0
2	6	9.5	5	8.9	1	14.3
3	10	15.9	10	17.9	0	0
4	12	19.0	11	19.6	1	14.3
5+	26	41.3	22	39.3	4	57.1

(table continues)

Table 3 *(continued)*

Variable	Overall		Face-to-Face		Online	
	Frequency (N = 63)	Percentage	Frequency (N = 56)	Percentage	Frequency (N = 7)	Percentage
Use Rubrics for Student Assignments						
0	1	1.6	1	1.8	0	0
1	16	25.4	14	25.0	2	28.6
2	12	19.0	10	17.9	2	28.6
3	6	9.5	5	8.9	1	14.3
4	10	15.9	8	14.3	2	28.6
5+	16	25.4	16	28.6	0	0
Require Students to Access my Course Website						
0	32	50.8	32	57.1	0	0
1	7	11.1	7	12.5	0	0
2	3	4.8	2	3.6	1	14.3
3	5	7.9	3	5.4	2	28.6
4	2	3.2	1	1.8	1	14.3
5+	12	19.0	9	16.1	3	42.9
My Students Use Curriculum Related Software or Programs						
0	19	30.2	19	33.9	0	0
1	19	30.2	19	33.9	0	0
2	10	15.9	9	16.1	1	14.3
3	5	7.9	2	3.6	3	42.9
4	4	6.3	3	5.4	1	14.3
5+	5	7.9	3	5.4	2	28.6

Tables were produced to illustrate the frequency distributions of the fourth (Teacher Self-Profile) part of the survey included in the study. This included presenting the number and percentage of occurrences for each of the variables in the study. The results for this part of the survey are presented in Table 4.

Table 4

Frequency Distribution for Teacher Self-Profile, Survey-Part IV

Variable	Overall		Face-to-Face		Online	
	Frequency (N = 63)	Percentage	Frequency (N = 56)	Percentage	Frequency (N = 7)	Percentage
Current Role as Science Teacher						
1	33	52.4	33	58.9	0	0
2	15	23.8	14	25.0	1	14.3
3	10	15.9	7	12.5	3	42.9
4	2	3.2	1	1.8	1	14.3
5	2	3.2	0	0	2	28.6
Instructor or Facilitator						
1	6	9.5	5	8.9	1	14.3
2	8	12.7	8	14.3	0	0
3	26	41.3	22	39.3	4	57.1
4	19	30.2	17	30.4	2	28.6
5	4	6.3	4	7.1	0	0
Current Approach to Problem Solving						
1	3	4.8	2	3.6	1	14.3
2	6	9.5	4	7.1	2	28.6
3	22	34.9	21	37.5	1	14.3
4	27	42.9	24	42.9	3	42.9
5	5	7.9	5	8.9	0	0

(table continues)

Table 4 *(continued)*

Variable	Overall		Face-to-Face		Online	
	Frequency (N = 63)	Percentage	Frequency (N = 56)	Percentage	Frequency (N = 7)	Percentage
Clear Norms for Grading						
1	1	1.6	1	1.8	0	0
2	2	3.2	2	3.6	0	0
3	9	14.3	8	14.3	1	14.3
4	25	39.7	24	42.9	1	14.3
5	26	41.3	21	37.5	5	71.4
Clear Assignment Expectations						
1	2	3.2	2	3.6	0	0
2	2	3.2	2	3.6	0	0
3	24	38.1	21	37.5	3	42.9
4	34	54.0	30	53.6	4	57.1
5	1	1.6	1	1.8	0	0
Wait Time for Oral Response						
3	11	17.5	9	16.1	2	28.6
4	17	27.0	16	28.6	1	14.3
5	33	52.4	31	55.4	2	28.6

Mean Rankings for Survey Items

In addition to the frequency distributions presented in the above tables, means and standard deviations were calculated for each of the questions included on the different parts of the survey instrument. To determine which item had the highest mean, the items were ranked according to mean value. This was done for the overall scores on the items. Subsequently, the mean rank for the online and face-to-face teachers was also calculated. The results for mean ranks of the different parts of the study are presented in Table 5.

Table 5

Mean Ranks for Teaching Practices/Instructional Strategies, Survey-Part II and Part V and Teacher Self-Profile, Survey-Part IV

	Overall		Online			Face-to-Face		
	M	SD	M	SD	Rank	M	SD	Rank
Part II and Part V								
Teaching activities aligned to GPS	4.73	0.45	4.71	0.49	1	4.73	0.45	1
Work directly with students	4.24	1.17	3.00	2.16	19	4.40	0.89	3
Labs done in classroom	4.22	1.08	2.57	1.40	24	4.43	0.85	2
Analogies to relate science concepts to real life situations	4.06	1.05	3.86	1.57	5	4.09	0.99	6
Provide students with real-life examples	4.02	1.05	3.14	0.90	18	4.13	1.02	4
Help students with creating mental models, images or associations they can visualize	4.00	1.09	3.00	1.29	20	4.13	1.00	5
Use videos & DVDs	3.98	0.91	4.14	0.69	4	3.96	0.93	7
Assess prior knowledge on every test	3.97	1.03	4.14	0.38	3	3.95	1.09	8
Provide constructive feedback to students	3.68	1.11	3.43	0.53	11	3.71	1.17	10
Student centered	3.65	1.06	3.14	1.57	15	3.71	0.99	9
Available to students outside of class	3.61	1.57	3.71	1.98	7	3.60	1.53	12
Labs conducted at least once/week	3.48	1.39	2.00	1.41	28	3.66	1.28	11
Intro of concepts via demo video or in person	3.27	0.95	3.29	1.25	13	3.26	0.92	13
Graphic models as part of my teaching strategies	3.18	1.31	2.86	1.35	21	3.22	1.31	14
Intro of concepts by group discussion	3.13	1.14	3.43	1.27	9	3.09	1.13	16

(table continues)

Table 5 *(continued)*

	Overall		Online			Face-to-Face		
	M	SD	M	SD	Rank	M	SD	Rank
Conceptual models as teaching tool	3.10	1.20	2.71	1.50	23	3.15	1.16	15
Teacher centered	3.10	1.16	3.29	1.25	12	3.07	1.16	17
Use rubrics for student assignments	2.92	1.63	2.43	1.27	26	2.98	1.67	18
Intro of new concepts through printed materials	2.90	1.21	2.43	1.51	25	2.96	1.17	19
Peer tutoring (where students pair up to explain to one another)	2.90	1.42	3.29	1.60	14	2.85	1.41	20
Printed notes/docs for subject material	2.83	1.30	2.71	1.89	22	2.84	1.23	21
Virtual labs	2.74	1.29	3.14	1.77	17	2.69	1.23	22
Power Point	2.71	1.24	4.14	0.69	2	2.54	1.17	23
Physical models as teaching tool	2.37	1.27	1.86	1.35	29	2.44	1.26	24
Labs 3 x or less during semester	2.06	1.48	3.14	1.46	16	1.93	1.44	25
Require students to access my course website	1.57	2.02	3.86	1.21	6	1.28	1.92	27
My students use curriculum related software or programs	1.53	1.55	3.57	1.13	8	1.27	1.41	28
Engage students in role play	1.39	1.40	0.86	1.46	30	1.45	1.39	26
Students engage in computer simulations	1.27	1.33	3.43	1.72	10	1.00	1.00	29
Audio files as teaching tool	1.08	1.41	2.14	1.21	27	0.95	1.38	30
Take students on field trips	0.41	0.97	0.00	0.00	31	0.46	1.02	31

(table continues)

Table 5 *(continued)*

	Overall		Online			Face-to-Face		
	M	SD	M	SD	Rank	M	SD	Rank
Part IV								
Wait time for oral response (1 sec through 5 sec)	4.36	0.78	4.00	1.00	2	4.39	0.76	1
Clear norms for grading (somewhat clear vs. very clear)	4.16	0.90	4.57	0.79	1	4.11	0.91	2
Clear assignment expectations (somewhat clear vs. very clear)	3.48	0.74	3.57	0.53	4	3.46	0.76	3
Current approach to problem solving (Teacher driven vs. student)	3.40	0.94	2.86	1.21	6	3.46	0.89	4
Instructor or facilitator (Ins vs. Fac)	3.11	1.03	3.00	1.00	5	3.13	1.05	5
Current role as a science teacher (F2F vs. Online)	1.79	1.04	3.57	1.13	3	1.56	0.79	6
Technology Related Questions								
Use videos & DVDs	3.98	0.91	4.14	0.69	1	3.96	0.93	1
Intro of concepts via demo video or in person	3.27	0.95	3.29	1.25	6	3.26	0.92	2
Virtual labs	2.74	1.29	3.14	1.77	7	2.69	1.23	3
Power Point	2.71	1.24	4.14	0.69	2	2.54	1.17	4
Require students to access my course website	1.57	2.02	3.86	1.21	3	1.28	1.92	5
My students use curriculum related software or programs	1.53	1.55	3.57	1.13	4	1.27	1.41	6
Students engage in computer simulations	1.27	1.33	3.43	1.72	5	1.00	1.00	7
Audio files as teaching tool	1.08	1.41	2.14	1.21	8	0.95	1.38	8

Spearman's Rank Correlation for Age, Years Teaching and Proficiency With Technology

To determine whether there was a significant correlation between the age of the instructor, the number of years teaching and the proficiency with technology, Spearman's rank correlation coefficients were calculated. The analysis was conducted to address research question seven. There was a significant negative correlation with the age of the instructor and the level of proficiency with technology, $r = -.41$, $p < .01$. This indicated that when the age increased the proficiency with technology decreased. There was a significant negative correlation with the number of years teaching experience of the instructor and the level of proficiency with technology, $r = -.32$, $p = .01$. This indicated that when the number of years teaching experience increased the proficiency with technology decreased. These results are presented in Table 6.

Table 6

Spearman's Rank Correlation for Age, Years Teaching and Proficiency With Technology

	Age	Years of Teaching	Proficiency with Technology
Age	1.00	.76**	-.41**
Years of Teaching		1.00	-.32*
Proficiency with Technology			1.00

Note. ** $p < .01$ two-tailed and * $p < .05$ two-tailed

Comparing Online Versus Face-to-Face Demographic Characteristics

Chi Square Test

To compare online instructors with face-to-face instructors for the subjects taught, subjects qualified to teach and the level of proficiency with technology, a chi square test was conducted. There was a significant relationship between whether the teacher was an online instructor or a face-to-face instructor when it came to the subjects taught, $\chi^2(2) = 6.75$, $p = .03$. There was a significant difference in the expected and observed frequencies for online and face-to-face teachers.

There was not a significant relationship between whether the teacher was an online instructor or a face-to-face instructor when it came to the subjects the teacher was certified in, $\chi2(2) = 3.86$, $p = .15$. There was a significant relationship between whether the teacher was an online instructor or a face-to-face instructor when it came to the proficiency in technology, $\chi^2(2) = 6.44$, $p = .04$. There was a significant difference in the expected and observed frequencies for online and face-to-face teachers. These resulting contingency tables are presented in Table 7.

Table 7

Contingency Table for Demographic Comparisons Between Face-to-Face and Online Instructors

	Online Instructor	
	No	Yes
Subject Teaching		
Biology	17	5
General Science	28	0
Physical Science	11	2
Subject Certified In		
Biology	8	3
Other	5	0
Science	43	4

(table continues)

Table 7 *(continued)*

	Online Instructor	
	No	Yes
Proficiency with Technology		
Expert	14	5
Intermediate	39	2
Novice	3	0

Independent Sample t Test

To compare the online instructors with face-to-face instructors with respect to their age and number of years teaching experience, an independent samples *t* test was conducted. Independent samples *t* test was used to determine whether there was a significant difference between two group means. The average age for online instructors was equal to 31.14 years (*SD* = 4.85 years), while the average age for face-to-face instructors was equal to 39.70 years (*SD* = 9.41 years). There was a significant difference between the ages of online and face-to-face instructors, t(12.95) = 3.83, $p < .01$. The degrees of freedom equal to 12.95 because the variances were assumed to not be equal, based on the results of the Levene's test for equality of variances, F(1, 59) = 4.45, $p = .04$. On average, face-to-face teachers were 8.56 years older than online instructors.

The average number of years experience for online instructors was equal to 5.71 years (*SD* = 4.35 years), while the average number of years experience for face-to-face instructors was equal to 11.89 years (*SD* = 8.41 years). There was not a significant difference between the number of years experience of online and face-to-face instructors, t(61) = 1.90, $p = .06$. The results of the Levene's test for equality of variances was not significant, F(1, 61) = 2.48, *p* = .12. The results of the independent samples *t* test are presented in Table 8.

Table 8

Means, Standard Deviations and Independent Samples t Test *Results for Age and Years of Teaching for Face-to-Face Versus Online Instructors*

	Online Instructor	N	M	SD	t(df)	p
Age	No	54	39.70	9.41	t(12.95) = 3.83	< .01
	Yes	7	31.14	4.85		
Years of Teaching	No	56	11.89	8.41	t(61) = 1.90	.06
	Yes	7	5.71	4.35		

Spearman's Rank Correlation for Online Instructors

To determine whether there was a significant correlation between the age of the instructor, the number of years teaching and the proficiency with technology, Spearman's rank correlation coefficients were calculated. These results are presented in Table 9. There was not a significant correlation between the age of the instructor and the level of proficiency with technology, *r* = .63, *p* = .13. This indicated that when the age increased the proficiency with technology did not significantly change.

There was a significant positive correlation with the number of years teaching experience of the instructor and the level of proficiency with technology, *r* = .81, *p* = .03. This indicated that when the number of years teaching experience increased the proficiency with technology increased as well.

Table 9

Spearman's Rank Correlation for Online Instructors Relative to Age, Years of Teaching and Proficiency with Technology

	Age	Years of Teaching	Proficiency with Technology
Age	1.00	.91**	.63
Years of Teaching		1.00	-.81*
Proficiency with Technology			1.00

Note. ** $p < .01$ two-tailed and * $p < .05$ two-tailed

Spearman's Rank Correlation for Face-to-Face Instructors

To determine whether there was a significant correlation between the age of the instructor, the number of years teaching and the proficiency with technology, Spearman's rank correlation coefficients were calculated. There was a significant negative correlation with the age of the instructor and the level of proficiency with technology, $r = -.41$, $p < .01$. This indicated that when the age of the instructor increased the proficiency with technology decreased.

There was a significant negative correlation with the number of years teaching experience of the instructor and the level of proficiency with technology, $r = -.35$, $p = .01$. This indicated that when the number of years teaching experience increased the proficiency with technology decreased. These results are presented in Table 10.

Table 10

Spearman's Rank Correlation for Face-to-Face Instructors Relative to Age, Years of Teaching and Proficiency With Technology

	Age	Years of Teaching	Proficiency with Technology
Age	1.00	.74**	-.41**
Years of Teaching		1.00	-.35**
Proficiency with Technology			1.00

Note. ** $p < .01$ two-tailed

Online Versus Face-to-Face Instructors Survey Responses

Mann-Whitney U Test – Part II and Part V

To determine whether there was a difference between online and face-to-face instructors in terms of the responses provided on the survey instrument, a Mann-Whitney U test was conducted. The Mann-Whitney U test is a nonparametric version of the independent samples *t* test, such that the assumption of normality is not required. The Mann-Whitney U test is appropriate when the variables being compared are ordinal level variables. There was not a significant difference between online and face-to-face instructors when it comes to the scores received on the teacher centered question, $Z = -.42$, $p = .69$. There was a significant difference between online and face-to-face instructors when it comes to the scores received on the Power Point question, $Z = -3.16$, $p < .01$. In fact, online instructors had significantly higher scores for the Power Point question when compared to face-to-face instructors. The results for the remaining questions are presented in Table 11.

To compare online and face-to-face instructors, Mann-Whitney U *t* tests were conducted for every item on the survey instrument. There was not a significant difference between online and face-to-face instructors when it comes to the scores received on the physical models as teaching tools question, $Z = -.79$, $p = .46$. There was a significant difference between online and face-to-face instructors when it comes to the scores received on the audio files as teaching tools question, $Z = -2.38$, $p = .03$. In fact, online instructors had significantly higher scores for the audio files as teaching tools question when compared to face-to-face instructors. The results for the remaining questions are presented in Table 11.

Table 11

Mann-Whitney U Test Results – Teaching Practices/Instructional Strategies, Survey- Part II and V

	Online Instructor	N	Mean Rank	Z	p
Teacher centered	No	56	31.67	-.42	.69
	Yes	7	34.64		
Student centered	No	56	32.74	-.95	.37
	Yes	7	26.07		
Printed notes/docs for subject material	No	56	32.32	-.41	.71
	Yes	7	29.43		
Power Point	No	56	29.53	-3.16	< .01
	Yes	7	51.79		
Intro of new concepts through printed materials	No	56	32.88	-1.12	.30
	Yes	7	25.00		
Intro of concepts by group discussion	No	56	31.49	-.65	.54
	Yes	7	36.07		

(table continues)

Table 11 *(continued)*

	Online Instructor	N	Mean Rank	Z	p
Intro of concepts via demo video or in person	No	53	30.18	-.42	.70
	Yes	7	32.93		
Labs 3 x or less during semester	No	55	29.47	-2.74	.01
	Yes	7	47.43		
Labs conducted at least once/week	No	56	34.18	-2.78	< .01
	Yes	7	14.57		
Labs done in classroom	No	56	34.64	-3.58	< .01
	Yes	7	10.86		
Virtual labs	No	55	30.85	-.81	.45
	Yes	7	36.57		
Assess prior knowledge on every test	No	56	32.05	-.07	.56
	Yes	7	31.57		
Use videos & DVDs	No	56	31.80	-.27	.82
	Yes	7	33.57		
Teaching activities aligned to GPS	No	56	32.06	-.10	.92
	Yes	7	31.50		
Audio files as teaching tool	No	55	29.70	-.238	.03
	Yes	7	45.64		
Physical models as teaching tool	No	55	32.13	-.79	.46
	Yes	7	26.57		
Analogies to relate science concepts to real life situations	No	55	31.55	-.06	.97
	Yes	7	31.14		

(table continues)

Table 11 *(continued)*

	Online Instructor	N	Mean Rank	Z	p
Conceptual models as teaching tool	No	55	32.09	-.75	.49
	Yes	7	26.86		
Peer tutoring (where students pair up to explain to one another)	No	55	30.85	-.81	.45
	Yes	7	36.57		
Graphic models as part of my teaching strategies	No	54	31.62	-.76	.48
	Yes	7	26.21		
Work directly with students	No	55	32.95	-2.02	.08
	Yes	7	20.07		
Help students with creating mental models, images or associations they can visualize	No	55	33.30	-2.34	.03
	Yes	7	17.36		
Engage students in role play	No	55	32.54	-1.31	.21
	Yes	7	23.36		
Students engage in computer simulations	No	55	28.95	-3.27	< .01
	Yes	7	51.57		

(table continues)

Table 11 *(continued)*

	Online Instructor	N	Mean Rank	Z	p
Take students on field trips	No	54	31.91	-1.51	.28
	Yes	7	24.00		
Provide students with real-life examples	No	55	33.29	-2.33	.03
	Yes	7	17.43		
Provide constructive feedback to students	No	55	32.00	-.65	.56
	Yes	7	27.57		
Available to students outside of class	No	55	31.10	-.51	.63
	Yes	7	34.64		
Use rubrics for student assignments	No	54	31.69	-.87	.40
	Yes	7	25.64		
Require students to access my course website	No	54	28.61	-3.17	< .01
	Yes	7	49.43		
My students use curriculum related software or programs	No	55	28.75	-3.48	< .01
	Yes	7	53.14		

Note. No represents that the teacher was not an online instructor; Yes represents that the teacher was an online teacher.

Mann-Whitney U Test – Part IV

To determine whether there was a difference between online and face-to-face instructors in terms of the responses provided on the survey instrument, a Mann-Whitney U test was conducted. The Mann-Whitney U test is appropriate when the variables being compared are ordinal level variables. There was not a significant difference between online and face-to-face instructors when it comes to the scores received on the instructor or facilitator question, $Z = -.24$, $p = .82$. There was a significant difference between online and face-to-face instructors when it comes to the scores received on the current role of teacher question, $Z = -3.99$, $p < .01$. In fact, online instructors had significantly higher scores for the current role of teacher question when compared to face-to-face instructors. The results for the remaining questions are presented in Table 12.

Table 12

Mann-Whitney U Test Results – Teachers Self-Profile, Survey-Part IV

	Instructor	N	Mean Rank	Z	p
Current role as a science teacher (F2F vs. Online)	No Yes	55 7	28.53 54.86	-3.98	<.01
Instructor or facilitator (Ins vs. Fac)	No Yes	56 7	32.19 30.50	-.24	.82
Current approach to problem solving (Teacher driven vs. student)	No Yes	56 7	32.96 24.36	-1.25	.25
Clear norms for grading (somewhat clear vs. very clear)	No Yes	56 7	30.90 40.79	-1.45	.18
Clear assignment expectations (somewhat clear vs. very clear)	No Yes	56 7	31.87 33.07	-.19	.87
Wait time for oral response (1 sec through 5 sec)	No Yes	56 5	31.59 24.40	-.96	.40

Spearman's Correlation Between Age, Teaching Years, Proficiency and Part II – Overall

To determine whether there was a significant correlation between the age of the instructor, the number of years teaching, the proficiency with technology and the Part II of the survey, Spearman's rank correlation coefficients were calculated. The results are presented in Table 13.

Spearman's Correlation Between Age, Teaching Years, Proficiency and Part IV– Overall

To determine whether there was a significant correlation between the age of the instructor, the number of years teaching, the proficiency with technology and the Part IV of the survey, Spearman's rank correlation coefficients were calculated. The results are presented in Table 14.

Spearman's Correlation Between Age, Teaching Years, Proficiency and Part V– Overall

To determine whether there was a significant correlation between the age of the instructor, the number of years teaching, the proficiency with technology and the Part IV of the survey, Spearman's rank correlation coefficients were calculated. The results are presented in Table 15.

Table 13

Spearman's Correlation Between Age, Teaching Years, Proficiency and Part II – Overall

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1.Age	1	.762**	-.413**	0.005	0.042	-0.017	-.293*	0.034	-0.004	-0.078	-0.004	0.047	0.096	-0.114	-0.024	-0.118	-0.068
2.Years of Teaching		1	-.315*	-0.034	0.053	-0.129	-.291*	0.042	-0.136	-0.117	-0.026	0.033	0.097	-0.023	0.041	-0.092	0.048
3.Proficiency with Technology			1	0.073	0.073	-0.157	0.239	-0.029	-0.059	-0.075	0.212	-.343**	-.491**	0.097	-0.033	0.002	0.019
4.Teacher centered				1	-.684**	.299*	0.081	.334**	-0.124	-0.072	0.186	-0.158	-0.014	-0.094	0.049	-0.017	0.202
5.Student centered					1	-0.146	0.019	-0.108	.273*	0.125	-0.213	.260*	0.102	0.085	0.101	0.102	0.034
6.Printed notes/docs for subject material						1	-0.077	.661**	0.026	0.064	-0.041	0.007	0.159	-0.208	0.064	0.184	0.105
7.Power Point							1	-0.142	0.035	-0.032	0.103	-0.162	-0.162	0.088	-0.057	0.069	-0.221
8.Intro of new concepts through printed materials								1	-0.006	-0.116	0.039	0	0.117	-.254*	0.026	0.03	0.006
9.Intro of concepts by group discussion									1	0.192	-0.056	0.149	0.165	0.03	.326**	0.163	0.033
10.Intro of concepts via demo video or in person										1	-0.238	-0.022	0.112	0.016	0.044	.255*	0.005
11.Labs 3 x or less during semester											1	-.561**	-.435**	-0.035	-0.144	0.008	0.014
12.Labs conducted at least once/week												1	.536**	-0.09	0.181	-0.074	0.14
13.Labs done in classroom													1	-0.195	.293*	0.091	.289*
14.Virtual labs														1	0.174	-0.184	-0.008
15.Assess prior knowledge on every test															1	0.11	0.133
16.Use videos & DVDs																1	0.095
17.Teaching activities aligned to GPS																	1

Note. ** $p < .01$ two-tailed and * $p < .05$ two-tailed

Table 14

Spearman's Correlation Between Age, Teaching Years, Proficiency and Part IV– Overall

	1	2	3	4	5	6	7	8	9
1.Age	1	.762**	-.413**	-0.06	-0.026	-0.169	-0.103	-0.237	0.147
2.Years of Teaching		1	-.315*	-0.016	0.015	-0.09	-0.025	-0.048	0.158
3. Proficiency with Technology			1	0.137	-0.026	0.125	-0.141	0.025	-0.025
4.Current role as a science teacher (F2F vs. Online)				1	0.051	-0.211	0.123	-0.1	-.329*
5.Instructor or facilitator (Ins vs. Fac)					1	.591**	-0.03	-0.065	0.14
6.Current approach to problem solving (Teacher driven vs. student)						1	-0.045	0.043	0.035
7.Clear norms for grading (somewhat clear vs. very clear)							1	.622**	0.136
8.Clear assignment expectations (somewhat clear vs. very clear)								1	0.201
9.Wait time for oral response (1 sec through 5 sec)									1

Table 15

Spearman's Correlation Between Age, Teaching Years, Proficiency and Part V– Overall

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1.Age	1	.762**	-.413**	0	0.027	-.315*	-0.165	-0.084	-0.137	-0.188	-0.086	-0.136	-0.127	0.069	-0.108	0.028	-0.014	0.04	-0.119	0.059
2.Years of Teaching		1	-.315*	-0.005	0.152	-0.248	-0.025	-0.024	0.017	-0.195	0.028	-0.096	0.053	0.155	-0.045	0.04	0.003	0.093	-0.041	0.206
3. Proficiency with Technology			1	-0.059	-.273*	0.01	-0.104	0.045	0.069	-0.04	-0.085	-0.074	0.168	-0.139	-0.17	-0.185	0.043	-0.207	.256*	0.048
4.Audio files as teaching tool				1	0.213	0.127	0.109	0.109	0.008	0	0.044	0.175	.400**	0.202	0.018	0.076	0.039	0.017	0.201	.417**
5.Physical models as teaching tool					1	.315*	.520**	0.206	.361**	.280*	.348**	.537**	0.061	.450**	.355**	.429**	.368**	0.238	-0.195	0.075
6.Analogies to relate science concepts to real life situations						1	.569**	-0.043	-0.123	0.218	.547**	.366**	0.031	0.166	.576**	.279*	0.15	0.083	-0.071	0.047
7.Conceptual models as teaching tool							1	0.191	0.128	.265*	.374**	.495**	0.067	.310*	.488**	.278*	.437**	0.131	-0.05	-0.015
8.Peer tutoring (where students pair up to explain to one another)								1	.256*	.254*	0.032	.309*	0.075	0.133	-0.018	0.046	0.056	0.149	0.058	0.052
9.Graphic models as part of my teaching strategies									1	0.147	0.167	.361**	0.193	0.082	0.045	-0.057	-0.046	0.246	-0.13	-0.062
10.Work directly with students										1	.344**	0.22	-0.035	0.154	.379**	.359**	.321*	0.216	-0.176	-0.109
11.Help students with creating mental models, images or associations they can visualize											1	.360**	0.012	0.248	.671**	.364**	0.121	0.21	-0.206	-0.064
12.Engage students in role play												1	-0.125	.279*	.358**	.255*	0.2	0.118	-0.087	-0.099
13.Students engage in computer simulations													1	0.218	-0.028	0.05	0.044	0.166	.363**	.618**

(table continues)

Table 15 *(continued)*

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
14.Take students on field trips														1	0.251	.299*	0.207	.295*	0.019	0.109
15.Provide students with real-life examples															1	.521**	0.22	0.18	-0.2	-0.003
16.Provide constructive feedback to students																1	.353**	.372**	-0.024	-0.038
17.Available to students outside of class																	1	.417**	0.209	0.096
18.Use rubrics for student assignments																		1	0.049	0.113
19.Require students to access my course website																			1	.405**
20.My students use curriculum related software or programs																				1

Spearman's Correlation Between Age, Teaching Years, Proficiency and Part II – Face-to-Face

To determine whether there was a significant correlation between the age of the instructor, the number of years teaching, the proficiency with technology and the Part II of the survey, Spearman's rank correlation coefficients were calculated. The results are presented in Table 16.

Spearman's Correlation Between Age, Teaching Years, Proficiency and Part IV– Face-to-Face

To determine whether there was a significant correlation between the age of the instructor, the number of years teaching, the proficiency with technology and the Part IV of the survey, Spearman's rank correlation coefficients were calculated. The results are presented in Table 17.

Spearman's Correlation Between Age, Teaching Years, Proficiency and Part V– Face-to-Face

To determine whether there was a significant correlation between the age of the instructor, the number of years teaching, the proficiency with technology and the Part IV of the survey, Spearman's rank correlation coefficients were calculated. The results are presented in Table 16.

Table 16

Spearman's Correlation Between Age, Teaching Years, Proficiency and Part II – Face-to-Face

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1.Age	1	.740**	-.409**	0.036	-0.037	-0.005	-0.197	0.035	0.053	-0.022	0.093	-0.028	-0.032	-0.149	-0.041	-0.096	-0.164
2.Years of Teaching		1	-.351**	-0.017	-0.022	-0.117	-0.225	0.016	-0.084	-0.091	0.047	0.01	0.021	-0.096	0.032	-0.043	0.009
3.Proficiency with Technology			1	0.049	0.123	-0.044	0.169	0.052	-0.023	-0.053	0.095	-0.19	-.388**	-0.016	-0.053	0.083	-0.008
4.Teacher centered				1	-.639**	.429**	0.03	.407**	-0.122	0.012	0.156	-0.147	0.026	-0.08	0.018	0.006	.285*
5.Student centered					1	-0.234	0.146	-0.172	.327*	0.036	-0.165	.284*	0.055	0.024	0.149	0.115	-0.026
6.Printed notes/docs for subject material						1	-0.085	.660**	0	-0.046	0.004	-0.125	0.118	-0.139	0.108	0.081	0.183
7.Power Point							1	-0.116	0.024	-0.053	-0.046	-0.038	0.015	0.078	-0.071	0.04	-0.23
8.Intro of new concepts through printed materials								1	0.056	-0.25	0.128	-0.102	0.03	-0.261	0.059	-0.021	0.115
9.Intro of concepts by group discussion									1	0.186	-0.074	0.162	0.232	0.074	.366**	0.115	0.04
10.Intro of concepts via demo video or in person										1	-0.227	-0.057	0.113	0.013	0.099	0.205	0.067
11.Labs 3 x or less during semester											1	-.493**	-.323*	-0.087	-0.18	0.032	-0.014
12.Labs conducted at least once/week												1	.436**	0.007	0.22	-0.156	0.218
13.Labs done in classroom													1	-0.169	.356**	0.083	.404**
14.Virtual labs														1	0.163	-0.183	-0.052
15.Assess prior knowledge on every test															1	0.124	0.129
16.Use videos & DVDs																1	0.15
17.Teaching activities aligned to GPS																	1

Note. ** $p < .01$ two-tailed and * $p < .05$ two-tailed

Table 17

Spearman's Correlation Between Age, Teaching Years, Proficiency and Part IV– Face-to-Face

	1	2	3	4	5	6	7	8	9
1.Age	1	.740**	-.409**	0.114	-0.004	-0.252	-0.035	-.268*	0.128
2.Years of Teaching		1	-.351**	0.123	0.025	-0.19	0.083	-0.021	0.166
3. Proficiency with Technology			1	-0.06	-0.032	0.169	-0.184	0.018	0.007
4.Current role as a science teacher (F2F vs. Online)				1	0.092	-0.169	0.032	-0.13	-.312*
5.Instructor or facilitator (Ins vs. Fac)					1	.572**	0.019	-0.049	0.154
6.Current approach to problem solving (Teacher driven vs. student)						1	0.078	0.13	0.062
7.Clear norms for grading (somewhat clear vs. very clear)							1	.620**	0.104
8.Clear assignment expectations (somewhat clear vs. very clear)								1	0.128
9.Wait time for oral response (1 sec through 5 sec)									1

Note. ** $p < .01$ two-tailed and * $p < .05$ two-tailed

Table 18

Spearman's Correlation Between Age, Teaching Years, Proficiency and Part V– Face-to-Face

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1.Age	1	.740**	-.409**	0.179	-0.004	-.311*	-0.204	-0.081	-0.245	-0.27	-0.151	-0.204	-0.018	0.007	-0.197	0.006	-0.022	0.035	-0.025	0.232
2.Years of Teaching		1	-.351**	0.142	0.144	-0.231	-0.039	0.012	-0.094	-0.24	-0.016	-0.118	0.153	0.112	-0.118	0.023	0.026	0.102	0.061	.396**
3. Proficiency with Technology			1	-0.144	-0.259	0.089	-0.079	0.031	0.057	0.178	0.069	0.037	-0.035	-0.087	-0.024	-0.183	0.008	-0.203	0.164	-0.079
4.Audio files as teaching tool				1	.285*	0.071	0.129	0.08	0.123	0.07	0.121	0.208	.360**	.287*	0.105	0.101	0.04	0.026	0.09	.301*
5.Physical models as teaching tool					1	.270*	.478**	0.169	.376**	0.22	.336*	.520**	0.2	.465**	.343*	.482**	.363**	.293*	-0.155	0.127
6.Analogies to relate science concepts to real life situations						1	.560**	-0.073	-0.102	0.148	.559**	.325*	0.103	0.181	.615**	.294*	0.182	0.072	-0.05	0.045
7.Conceptual models as teaching tool							1	0.147	0.139	0.241	.362**	.491**	0.155	.311*	.514**	.311*	.435**	0.131	0.008	0.011
8.Peer tutoring (where students pair up to explain to one another)								1	.338*	.315*	0.105	.306*	0.126	0.173	0.053	0.119	-0.083	0.237	0.016	-0.031
9.Graphic models as part of my teaching strategies									1	0.183	0.177	.429**	.271*	0.068	0.027	-0.069	-0.028	.300*	-0.07	0.012
10.Work directly with students										1	0.234	0.148	0.183	0.119	.304*	.375**	.408**	0.227	-0.075	-0.018
11.Help students with creating mental models, images or associations they can visualize											1	.358**	0.16	0.217	.604**	.349**	0.216	0.148	-0.069	0.074
12.Engage students in role play												1	0.052	.270*	.371**	.279*	0.193	0.134	-0.025	-0.061
13.Students engage in computer simulations													1	.367**	0.098	0.071	0.086	0.207	0.258	.587**

(table continues)

Table 18 *(continued)*

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
14.Take students on field trips														1	0.206	.293*	0.238	.287*	0.112	0.226
15.Provide students with real-life examples															1	.523**	.340*	0.125	-0.069	0.149
16.Provide constructive feedback to students																1	.449**	.355**	0.018	0.006
17.Available to students outside of class																	1	.513**	0.199	0.041
18.Use rubrics for student assignments																		1	0.114	0.195
19.Require students to access my course website																			1	0.247
20.My students use curriculum related software or programs																				1

Note. ** $p < .01$ two-tailed and * $p < .05$ two-tailed

Spearman's Correlation Between Age, Teaching Years, Proficiency and Part II – Online

To determine whether there was a significant correlation between the age of the instructor, the number of years teaching, the proficiency with technology and the Part II of the survey, Spearman's rank correlation coefficients were calculated. The results are presented in Table 19.

Spearman's Correlation Between Age, Teaching Years, Proficiency and Part IV– Online

To determine whether there was a significant correlation between the age of the instructor, the number of years teaching, the proficiency with technology and the Part IV of the survey, Spearman's rank correlation coefficients were calculated. The results are presented in Table 20.

Spearman's Correlation Between Age, Teaching Years, Proficiency and Part V– Online

To determine whether there was a significant correlation between the age of the instructor, the number of years teaching, the proficiency with technology and the Part IV of the survey, Spearman's rank correlation coefficients were calculated. The results are presented in Table 19.

Table 19

Spearman's Correlation Between Age, Teaching Years, Proficiency and Part II – Online

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1.Age	1	.909**	0.632	-0.193	0.273	-0.487	-0.219	-0.386	-0.349	-0.356	0.618	-.837*	-0.718	0.606	0.408	-0.478	.791*
2.Years of Teaching		1	.805*	-0.02	0.222	-0.553	-0.162	-0.196	-0.495	-0.295	0.548	-.862*	-0.645	0.701	0.416	-0.558	0.483
3.Proficiency with Technology			1	0.171	0.081	-.828*	-0.353	-0.342	-0.569	-0.394	0.529	-.882**	-0.669	0.569	0.258	-.882**	0.3
4.Teacher centered				1	-.943**	-0.344	0.732	-0.167	-0.159	-0.722	0.473	-0.065	-0.327	-0.04	0.661	-0.237	-0.342
5.Student centered					1	0.2	-.801*	0.236	-0.019	0.748	-0.477	-0.081	0.298	0.243	-0.624	0.091	0.242
6.Printed notes/docs for subject material						1	0.271	.768*	0.125	0.653	-0.564	.835*	.812*	-0.51	-0.428	.835*	-0.414
7.Power Point							1	0.215	-0.01	-0.422	0.3	0.3	-0.011	-0.256	0.569	0.322	-0.353
8.Intro of new concepts through printed materials								1	-0.317	0.674	-0.473	0.559	0.735	-0.317	-0.441	0.473	-0.683
9.Intro of concepts by group discussion									1	0.16	-0.42	0.317	0.175	-0.132	-0.105	0.481	0
10.Intro of concepts via demo video or in person										1	-.870*	0.522	.825*	-0.114	-.764*	0.547	-0.394
11.Labs 3 x or less during semester											1	-0.7	-.896**	0.051	0.569	-0.678	0.529
12.Labs conducted at least once/week												1	.885**	-0.522	-0.342	.833*	-0.617
13.Labs done in classroom													1	-0.291	-0.54	.769*	-0.669
14.Virtual labs														1	0.525	-0.174	0.325
15.Assess prior knowledge on every test															1	-0.114	0.258
16.Use videos & DVDs																1	-0.353
17.Teaching activities aligned to GPS																	1

Note. ** p < .01 two-tailed and * p < .05 two-tailed

Table 20

Spearman's Correlation Between Age, Teaching Years, Proficiency and Part IV– Online

	1	2	3	4	5	6	7	8	9
1.Age	1	.909**	0.632	0.112	-0.319	-0.019	-0.579	-0.144	0
2.Years of Teaching		1	.805*	0.2	-0.142	0.21	-0.59	-0.22	-0.162
3. Proficiency with Technology			1	0.331	0.176	0.249	-0.394	0.091	0
4.Current role as a science teacher (F2F vs. Online)				1	-0.511	-0.5	0.327	0.151	-0.707
5.Instructor or facilitator (Ins vs. Fac)					1	.814*	-0.422	-0.242	0
6.Current approach to problem solving (Teacher driven vs. student)						1	-0.653	-0.605	-0.177
7.Clear norms for grading (somewhat clear vs. very clear)							1	0.72	0.53
8.Clear assignment expectations (somewhat clear vs. very clear)								1	.913*
9.Wait time for oral response (1 sec through 5 sec)									1

Note. ** $p < .01$ two-tailed and * $p < .05$ two-tailed

Table 21

Spearman's Correlation Between Age, Teaching Years, Proficiency and Part V– Online

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
1.Age	1	.909**	0.632	-.808*	0.132	-0.598	-0.177	0.11	0.673	-0.569	-0.63	-0.299	-0.239	-0.401	-0.433	0.256	-0.698	0.187	-0.505
2.Years of Teaching		1	.805*	-.772*	0.029	-0.517	-0.13	-0.15	.824*	-0.598	-0.415	-0.396	-0.009	-0.272	-0.147	0.04	-0.402	-0.019	-0.743
3. Proficiency with Technology			1	-0.523	-0.251	-0.529	-0.174	-0.163	0.483	-.813*	-0.492	-0.265	0.081	-0.592	-0.091	0.087	0	0.166	-0.58
4.Audio files as teaching tool				1	0.25	.857*	0.576	0.284	-0.522	0.516	0.593	0.692	-0.132	0.369	0.159	0	0.425	-0.217	0.361
5.Physical models as teaching tool					1	0.538	.834*	0.728	0.269	0.583	0.392	0.569	-.816*	0.283	-0.535	0.594	-0.573	-0.416	0.089
6.Analogies to relate science concepts to real life situations						1	0.725	0.215	-0.061	0.706	.806*	0.7	-0.215	0.671	0.242	-0.099	0.184	-0.438	0.031
7.Conceptual models as teaching tool							1	0.628	0.07	0.506	0.593	0.56	-0.557	0.369	-0.319	0.457	-0.081	-0.65	0.072
8.Peer tutoring (where students pair up to explain to one another)								1	-0.262	0.217	-0.114	0.584	-.896**	-0.275	-.890**	.911**	-0.538	0	0.519

(table continues)

Table 21 *(continued)*

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
9.Graphic models as part of my teaching strategies									1	-0.14	0.057	-0.152	-0.028	0.204	0.147	-0.201	-0.393	-0.219	-.867*
10.Work directly with students										1	.800*	0.399	-0.292	0.687	0.074	0.051	-0.028	-0.452	0.385
11.Help students with creating mental models, images or associations they can visualize											1	0.248	0.076	.832*	0.449	-0.266	0.4	-0.738	-0.019
12.Engage students in role play												1	-0.676	0	-0.242	0.363	-0.215	0.188	0.219
13.Students engage in computer simulations													1	0.275	.816*	-.861*	0.708	-0.115	-0.337
14.Provide students with real-life examples														1	0.54	-0.516	0.206	-0.7	-0.21

(table continues)

Table 21 *(continued)*

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
15.Provide constructive feedback to students															1	-.956**	0.668	-0.151	-0.454
16.Available to students outside of class																1	-0.516	0.062	0.516
17.Use rubrics for student assignments																	1	-0.269	0.029
18.Require students to access my course website																		1	0.157
19.My students use curriculum related software or programs																			1

Note. ** $p < .01$ two-tailed and * $p < .05$ two-tailed

Themes From Open-Ended Interviews

Part of the teacher interview consisted of open-ended questions that allowed each teacher to respond freely. Each of their responses was recorded and transcribed. Their answers were analyzed to identify the common themes.

Theme One: The Ways in Which Teachers Identify and Address Science Misconceptions

Theme One was identified as the ways in which teachers identify and address science misconceptions. Many teachers identified using more than one approach in the classroom. This suggests that these teachers were open to using multiple methods and were not aligned with a specific approach when working with students as each provided examples of various ways in which they identified and addressed science misconceptions. Based on the information provided, information was grouped according to the seven methods that were most commonly used. Table 22 summarizes the invariant constituents. It should be noted that interview responses were based on 62 participant responses, as 1 participant did not provide information on this topic.

Table 22

Identifying and Addressing Science Misconceptions

Invariant Constituents	# of participants to offer this experience	% of participants to offer this experience
Discussion	23	37%
Demonstrations	20	32%
Questions	16	25%
Quizzes	15	24%
Homework	8	13%
Small group projects	5	8%

Table 22 illustrates that the most common method of identifying and addressing science misconceptions is through discussion. 37% (n=23) of the teachers reported using some form of discussion in the classroom. This method allows for the discussion to be either student directed or teacher led. Student directed discussion allows for the student to lead the way in discussion and promotes an open discussion and dialogue. In contrast, teacher led discussion allows for the teacher to be the primary facilitator of the discussion and to promote those topics which he/she deems as most important and/or relevant. There were many different ways that teachers reported using discussion. For example, one of the teachers indicated using "familiar examples or known examples" to assist students in developing a clearer understanding. Another teacher described invoking "responses from students to reveal their prior knowledge about it or make statements or common beliefs that they get to agree or disagree."

The second most common method was demonstrations. 32% (n=20) of the teachers indicated using demonstrations to help address and correct science misconceptions. Many of the teachers reported using "scientific experiments to show students how to find correct answers to questions." It was common for teachers to report using KWL charts in their demonstrations. Other common approaches included the use of videos and using other forms of digital media.

The third most common method was the use of questions. 26% (n=16) of the teachers reported using questions to identify and address science misconceptions. There were many different ways that questions were used and presented. For example, one of the teachers uses questions to "diagnose students' misconceptions" and does so by "asking open-ended questions and truly listening to students' ideas." Other teachers ask questions to "highlight" misconceptions.

The fourth most common method was the use of quizzes. 25% (n=15) of the teachers reported using quizzes in order to identify and address science misconceptions. Many of the teachers indicated that they give pre-tests prior to presenting any of the material in order to establish a baseline or to determine what the initial conception of the topic may be. Others use tests to evaluate student knowledge acquisition after a topic has been presented in order to assess whether students understand the material.

The fifth most common method was the use of homework. 13% (n=8) of the teachers used some type of homework to assist in identifying and addressing science misconceptions. Some teachers give "performance assessment" assignments. Another teacher monitors knowledge acquisition by performing "homework checks."

The last method for identifying and addressing science misconceptions was through the use of small group projects. 8% (n=5) of the teachers use small groups in their classroom practices. Some of the small group activities include having students engage in a group project. Other activities include having students work on research within small groups.

Theme Two: Strategies for Handling Students' Questions

Theme Two was identified as the strategies that teachers use to handle students' questions. Many teachers identified using more than one strategy in the classroom. Based on the information provided, information was grouped according to the six strategies that were most commonly used. Table 23 summarizes the invariant constituents. It should be noted that interview responses were based on 59 participant responses as 3 participants did not provide information on this topic and 1 participant indicated that they did not understand the question.

Table 23

Strategies for Handling Students' Questions

Invariant Constituents	# of participants to offer this experience	% of participants to offer this experience
Using Other Students	19	32%
Type of Question	15	25%
In-class Discussion	14	24%
Use of Technology	5	8%
One-to-One	4	7%
Parking Lot	4	7%

The most common strategy that was employed by the teachers in regard to handling student questions was using other students. 32% (n=19) of the teachers indicated using other students as a strategy. Many of the teachers reported using other students to "answer other students' questions." Other teachers indicated pairing students together and engaging in "reciprocal teaching." Others described the use of "pair-share."

The next most common strategy focused on what types of questions were used. 25% (n=15) of the teachers indicated that the type of question used was an important strategy. For example, many teachers described using open-ended questions for some purposes and using other more close-ended questions for other purposes. Some teachers reported using Socratic questioning. Many of the teachers described or gave examples of the ways in which they phrase questions.

The third most common strategy for questions was in-class discussion. 24% (n=14) of the teachers reported using in-class discussion as a way to handle student questions. For example, one of the teachers described having students “brainstorm questions that cannot be answered yes/no” and then having a “game show type activity to encourage asking and answering questions.” Many of the teachers reported using class time before and after to provide an arena for students to ask questions.

The last three commonly reported strategies for handling students’ questions were using digital technology, answering questions on a one-to-one basis, and using the parking lot. 8% (n=5) of the teachers reported using digital technology for answering questions. Examples of this included the use of e-mail and other web based programs to answer questions. 7% (n=4) of the teachers described the ways in which they handle questions on a one-to-one basis. Lastly, 7% (n=4) of the teachers indicated using the parking lot method as a strategy for handling students’ questions.

Theme Three: Practices for Face-to-Face Science Instruction

Theme Three was identified as the best practices for face to face science instruction. The most frequently cited practice for face to face science instruction was hands on activity. It is important to clarify that hands on activity is constitutes a separate category than labs. 60% (n=36) of the teachers reported that the best practice for face to face science instruction would be to use some form of hands on activity. There was a wealth of examples provided regarding hands on activities that could be practiced. Many made reference to students “learning by doing.” Others described how hands on activities provide an opportunity for “experiential discovery of scientific principles, skills, and theories.” Hands on activities also provide an opportunity for “simulated learning.” Table 24 summarizes the invariant constituents. It should be noted that interview responses were based on 60 participant responses, as 3 participants did not provide information on this topic.

Table 24

Practices for Face-to-Face Science Instruction

Invariant Constituents	# of participants to offer this experience	% of participants to offer this experience
Hands on Activities	36	60%
Labs	14	23%
Use of Technology	9	15%

The second most frequently cited activity was traditional lab activities. 23% (n=14) of the teachers reported the importance of lab activities. Lastly, 15% (n=9) of the teachers indicated that the use of technology was a helpful practice in teaching science. Some of the examples of technology included playing “clips from the Internet” and “virtual labs.”

Theme Four: Best Practices for Online Instructors

Theme Four was identified as the best practices for online science instruction. However, many of the teachers surveyed did not contribute towards the development of this theme. Many did not answer interview questions related to this topic. Specifically, 31% (n=20) of the teachers did not provide information regarding the best practices for online instruction. The majority of the teachers who did not respond either left the questions blanked or indicated that they did not have experience in online instruction. As such, the analysis was conducted with 43 teachers. Based on the information provided, information was grouped according to the three practices that were most commonly described. Table 25 summarizes the invariant constituents.

Table 25

Practices for Online Science Instruction

Invariant Constituents	# of participants to offer this experience	% of participants to offer this experience
Virtual Labs	14	33%
Instruction Quality	13	30%
Tests	4	9%

Table 25 illustrates that the most frequently reported practice for online instruction was virtual labs. 33% (n=14) of the teachers reported the benefits of using a virtual lab in online science instruction. Many reported that virtual labs can be similar to physical labs. Teachers indicated the ways in which they used and manipulated virtual labs. The second most reported practice was related to the quality of the instructions given. 30% (n=13) of the teachers described the importance of providing quality online instruction. There was a variety of ways in which they described these practices. For example, one teacher indicated “since I am not there to physically explain it, it is best for them to get their answers through practice and repetition.” Another teacher described how instruction should be comprised of “detailed explanations and examples since the face to face component is much less.”

Lastly, 9% (n=4) of the teachers indicated that tests should be considered the best practice for online science instruction. They described how tests can be used to assess whether students are acquiring the knowledge provided. In addition, they can be comprised of similar material that is provided in a physical classroom.

Conclusion

Chapter 4 provided the results from the data analysis. Chapter 5 will discuss the findings in detail as well as describing the implications, limitations, and recommendations for future research.

CHAPTER 5

SUMMARY, CONCLUSIONS, RECOMMENDATIONS, IMPLICATIONS

Summary

Purpose

Due to the recent shift toward online learning in secondary education, many questions have arisen regarding the best ways to teach in this type of environment. An increasing number of students are turning to alternative means of instruction for various reasons, such as scheduling conflicts, credit recovery, or hospital/homebound situations (Henry County Schools, 2007).

A common reason for participating in online instruction is to make up high school credits. These credits may be missing due to student failure or lack of availability at the student's home institution. Based on this trend toward online learning at the high school level, teachers must begin to ponder which teaching practices and instructional strategies are best suited for this type of learning environment. However, online instruction in science presents a unique concern for science teachers due to the lab component of their courses. There are many questions that researchers concerned with this line of inquiry are asking. Some of these questions include: Can the traditional lab component of a science course be offered in the online environment? Can learners in an online secondary science class gain the full spectrum of knowledge and experience, which typically comes from a traditional secondary science course with hands-on experimentation? Do secondary science teachers that teach face-to-face and those that teach online share common views as to what the preferred instructional practices are and how the subject matter can best be delivered? The current study was designed to begin to provide research regarding these important questions.

Although research and information on online secondary science teaching practices/instructional strategies is emerging, it was important to identify a set of teaching practices and instructional strategies for virtual high school and online academy science instructors. By doing so, online science instructors may determine which online teaching practices and instructional strategies are preferred and to modify their practices accordingly when teaching in this environment. The purpose of the current study was to identify actual teaching practices/instructional strategies for online science courses.

The current study was governed by the following questions:

1. What are the actual teaching practices/instructional strategies for science courses taught by face-to-face secondary science instructors?
2. What are the actual teaching practices/instructional strategies for science courses taught by online secondary science instructors?
3. Do differences in actual teaching practices/instructional strategies exist between face-to-face science instructors and online science instructors?
4. What types of technology usage in the classroom is preferred for delivering instruction in a secondary science course taught by a face-to-face science instructor?

5. What types of technology usage in the classroom is preferred for delivering instruction in a secondary science course taught by an online science instructor?
6. Do differences exist in types of technology usage between face-to-face science instructors and online science instructors?
7. What is the relationship among actual teaching practices/instructional strategies, technology usage, and demographics (years of experience, subject taught, and their role as a traditional classroom teacher or an online teacher) of face-to-face science instructors and online science instructors?
8. What practices are preferred by both face-to-face and online secondary science instructors for the following:
    a. To identify and address science concept misconceptions?
    b. To address student questions?
    c. As a face-to-face best practice for science instruction?
    d. As an online best practice for science instruction?

Methodology

A quantitative comparative descriptive research method was used for this study to address the use of instructional strategies identified for face-to-face science instruction and online science instruction. Data were solicited from individuals through a survey instrument accompanied by a consent letter assuring confidentiality and the support of the superintendent of Henry County Schools. The surveys were packaged in envelopes and delivered to the principals at the secondary schools for dissemination to the science teachers at their schools. The teachers then returned the surveys via courier mail. Paper surveys were used instead of online surveys because of Henry County Schools' restrictions of access to their e-mail pipeline and for the inclusion of non-online science instructors in the study.

The descriptive design was used to create an accurate description of the teaching practices and instructional strategies that were effective when teaching high school science students. The quantitative descriptive design provided credibility to the analysis because the results and findings could be replicable for future studies (Marsland et al., 2001). This was accomplished by presenting the numbers, percentages, and proportions of participants who responded to each of the questions on the survey instrument.

The comparative design was used in this study because the purpose of the comparative design was to determine whether there was a difference between two independent populations with respect to a continuous dependent variable. For this study, the two independent populations that were compared were teachers who taught online science courses and teachers who taught face-to-face science courses. The two groups of teachers were compared with one another to determine whether there was a difference in the actual teaching practices/ instructional strategies, and types of technology used by these teachers by combining the item responses provided on the survey instrument so that scores for the teaching practices/instructional strategies and types of technology used were obtained.

To address the objectives of this study, descriptive statistics and independent samples *t* tests were used. The descriptive statistics used in this study were frequency distributions and measures of central tendency. These provided information about the number of responses and the distribution for each of the questions on the survey instrument. The independent samples *t* test was used to determine whether there was a significant difference between two independent populations with regard to the average scores obtained on a dependent variable.

Conclusions

Demographic Characteristics

The participants in this study were a group of secondary science teachers in a suburban school district located in the southeastern U.S. Of the 175 participants who were contacted, 63 participants completed the survey representing a 36% return rate for the study.

On average, participants were 38.72 years old (*SD* = 9.39 years). The range of experience for teachers ranged from 1 year to 32 years. The average number of years of experience for the teachers was 11.21 years (*SD* = 8.27 years). Fifty-six (88.9%) of the participants were not online instructors, and seven (11.1%) were online instructors. Overall, the most frequent course taught by teachers was the general science related courses (44.4%), while the majority of teachers were certified in science related courses (74.6%). For the level of proficiency with technology, the majority of the participants reported themselves as being intermediate (65.1%).

The average age for online instructors was equal to 31.14 years (*SD* = 4.85 years), while the average age for face-to-face instructors was equal to 39.70 years (*SD* = 9.41 years). The average number of years experience for online instructors was equal to 5.71

years (*SD* = 4.35 years), while the average number of years experience for face-to-face instructors was equal to 11.89 years (*SD* = 8.41 years).

Research Question 1

What are the actual teaching practices/instructional strategies for science courses taught by face-to-face secondary science instructors?

Face-to-face instructors were much more likely to take their students on field trips. Face-to-face instructors were more likely to engage in role play with their students than online instructors. Face-to-face instructors tended to have labs occur in the classroom at least once per week. Face-to-face instructors favored a student-centered approach to teaching.

Seventeen face-to-face instructors taught biology, 28 taught general science, and 11 taught physical science. Eight were certified in biology, 5 were certified in a category unrelated to science, and 43 were certified in science. Regarding proficiency with technology, 14 of the face-to-face instructors reported themselves as experts, 39 reported themselves as intermediates, and 3 reported themselves as novices.

Research Question 2

What are the actual teaching practices/instructional strategies for science courses taught by online secondary science instructors?

Online instructors were much more likely to require their students to access their course website. In addition, online instructors were much more likely than face-to-face instructors to use curriculum related software or programs. Online instructors engaged in simulated role play and used graphic models to assist in teaching. Online instructors made use of virtual labs in their teaching practices whereas face-to-face instructors did not.

Online instructors favored a student-centered approach to teaching. Five out of the seven online instructors taught biology and none of the online instructors taught general science. Two of the seven online instructors taught physical science. Three of the online instructors were certified in biology and were not certified in the other category. Four of the online instructors were certified in science. In regard to proficiency with technology, five of the online instructors reported themselves as technology experts, two reported themselves as intermediates, and none reported themselves as novices.

Research Question 3

Do differences in actual teaching practices/instructional strategies exist between face-to-face science instructors and online science instructors?

There was a significant difference between online and face-to-face instructors when it comes to the scores received on the PowerPoint question. Online instructors tended to use PowerPoint presentations more frequently than face-to-face instructors. In addition, there was a significant difference between online and face-to-face instructors in regard to the current role of the teacher. Online instructors had significantly higher scores for the current role of teacher being facilitative and student-directed when compared to face-to-face instructors.

Research Question 4

What types of technology usage in the classroom is preferred for delivering instruction in a secondary science courses taught by a face-to-face science instructor?

There was not a significant difference between online and face-to-face instructors when it comes to the scores received on the physical models as teaching tools. There was a significant difference between online and face-to-face instructors on the scores received on use of the audio files as teaching tools; online instructors had significantly higher scores for the use of audio files as teaching tools when compared to face-to-face instructors. Face-to-face instructors did not use audio files as frequently in their instructions and tended to rely on other teaching tools such as lectures and exams.

Research Question 5

What types of technology usage in the classroom is preferred for delivering instruction in a secondary science courses taught by an online science instructor?

There was not a significant difference between online and face-to-face instructors relative to the scores received on the physical models as teaching tools. There was a significant difference between online and face-to-face instructors relative to the use of audio files as teaching tools. Online instructors had significantly higher scores for the use of audio files as a teaching tool when compared to face-to-face instructors as noted earlier.

Research Question 6

Do differences exist in types of technology usage between face-to-face science instructors and online science instructors?

There was a significant relationship between whether the teacher was an online instructor or a face-to-face instructor when it came to the subjects taught. There was a significant difference in the expected and observed frequencies for online and face-to-face teachers. There was not a significant relationship between whether the teacher was an online instructor or a face-to-face instructor when it came to the subjects the teacher was certified in. There was a significant relationship between whether the teacher was an online instructor or a face-to-face instructor when it came to the proficiency in technology. Online instructors tended to be more proficient in technology. There was a significant difference in the expected and observed frequencies for online and face-to-face teachers regarding technology usage.

Research Question 7

What is the relationship among actual teaching practices/ instructional strategies, technology usage, and demographics (years of experience, subject taught, and their role as a traditional classroom teacher or an online teacher) of face-to-face science instructors and online science instructors?

The analysis revealed that there was a significant negative correlation with the age of the instructor and the level of proficiency with technology. This indicated that when the age of the teacher increased then the proficiency with technology decreased. There was also a significant negative correlation with the number of years of teaching experience of the instructor and the level of proficiency with technology. This indicated that when the number of years of teaching experience increased then the proficiency with technology decreased.

Research Question 8

What practices are preferred by both face-to-face and online secondary science instructors?

Responses from the instructors most frequently cited methods used to identify and address science concept misconceptions was discussion. The most common strategy that was employed by the teachers in regard to handling student questions was using other students. The most frequently cited practice for face-to-face science instruction was hands-on activity. The most frequently reported practice for online instruction was virtual labs. A list of preferred instructional practices was generated from the qualitative responses to the open-ended questions.

Implications

The literature reviewed discussed online instructional strategies and science instructional strategies. Since the current literature did not discuss an integration of these two areas, it became necessary to marry these two types of instructional strategies and to create a set of preferred instructional practices (identified by practitioners as *best practices*) for online science instruction. Since online instruction is a relatively new concept in the field of science, it has become a necessity to identify first what was viewed as *best (preferred) practices* in a traditional science course and then to suggest a set of *best (preferred) practices* specifically for online science instruction. The development of such best practices at the secondary level of education was more challenging due to state standards and testing requirements that must be taken into consideration.

The literature also discussed leadership decisions in secondary schools. Within the past two decades, involving employees and other stakeholders in organizational decision making has increased in popularity. It can be argued that today's schools must be led differently. School "…leaders must rely more on applying elements from research of cultural, transformational, and participatory leadership" (Leech & Fulton, p. 632).

Due to the design of online courses, student-centered learning versus teacher-centered learning is relatively easy to achieve in that particular environment. Because the students and instructor in a non-traditional setting, the instructor can act more easily as a facilitator rather than lecturer. In the science classroom, this may be more difficult to achieve since many instructors deliver their material via lecture. Still, there are many more teaching methods that science teachers can incorporate into the lessons.

Science teaching practices have traditionally kept the teacher as the "sage on the stage." Depending on the science course, teachers may rely heavily on lecture to disseminate the topics being investigated. However, including laboratory exercises and demonstrations are also involved in the science classroom. Since inquiry is the main basis of science, teachers can easily shift the locus of control from themselves to their students. Furthermore, the scientific method can be implemented to engage students in the learning process and allow them to become more comfortable with inquiry and investigative skills. These skills often promote critical thinking and shift the acquisition of knowledge from rote memorization to mastery of concepts, which will remain in the long-term memory of the students involved in such learning processes.

Limitations

The current study was limited by several limitations. The current study had a relatively low return rate. Of the 175 invitations to complete the survey, only 63 individuals (a 36% return rate) returned the survey and only 7 of those returns were from online instructors. This may have exerted an influence on the results. It may be that those participants who responded to the survey had an interest in the subject matter. It may be that they had strong opinions or feelings regarding the topic and as such, this may have motivated them to participate. This should be considered when interpreting the findings from the current study.

The low return rate and specifically the low number of online faculty created sparse cells for statistical runs and may have compromised the generalizability of the study. The small resulting frequencies in the chi square values were due to the low response rate. This small number has an effect when divvying up the subjects taught and the subjects certified in for comparisons between face-to-face instructors and online instructors. A higher return rate would have provided a more accurate portrayal of the questions under review.

An additional limitation to the study may have been the effect of multiple hypothesis testing on the actual alpha. The multiple comparisons made in this study may have contributed to errors in inferences. The examination of age, teaching years, and proficiency with technology showed several associations that were statistically significant at the 0.05 level. Since a set of statistical inferences was considered simultaneously, the hypothesis tests may have incorrectly rejected the null hypotheses.

A further limitation to the study may have also been influenced by social desirability. Teachers are influenced in making choices on surveys that they feel are appropriate or desired in their classrooms. There has been a shift in the county where teachers are encouraged to utilize a more student-centered approach to teaching, which may have influenced the responses of face-to-face teachers portraying their teaching style as more facilitative. There are always questions regarding the impact of the environment when survey research is involved.

The criteria used for participation by the teachers to teach in the online environment versus the face-to-face environment were influenced by the availability of fiscal resources and those who volunteered for these online positions. The scope of this study did not address the role of the selection process for the various instructors or their motivations for serving in an online versus a face-to-face environment.

Recommendations for Future Research

The findings from the current study added to the literature by demonstrating the differences as well as the similarities that exist between online and face-to-face instruction. Both forms of instruction tend to rely on student-centered approaches to teaching. There are many skills that are similar in that both tend to focus on implementing the scientific method. The primary difference was the use of technology tools that are used by online instructors. Online instructors tended to rely on more technological tools such as virtual labs. Research concerned with this line of inquiry should continue in order to inform both theory and practice in regard to online instruction.

In addition, this study was limited by the relatively low return rate. Future studies should seek to employ measures that will increase the return rate. It may be beneficial to offer a form of thank you token for participating in order to increase returns. Increasing returns may lead to a more heterogeneous sample and decrease some of the other motivations for participation that may have an impact on the results. The use of an online method of data collection such as Snap.com or SurveyMonkey may also improve the return rate as more instructors become use to these forms of assessments.

There has been a recent shift toward online courses that has occurred at the high school level. Many students are seeking online alternatives to courses which are either unavailable to them at their local institution or they are seeking to make up missing credits. The findings from the current study have shown that science can be taught effectively online as noted by the instructors. In addition, the traditional lab components of a science course can be offered in the online environment in the form of virtual labs and that this is common practice in this environment. Online instructors employ similar methods and teaching strategies as face-to-face instructors that allows students in the online environment to gain access to the full spectrum of knowledge and experience that is offered in traditional classrooms.

Future studies should address the students' motivation and rationale for studying in the online versus the face-to-face environment. Specific questions could focus on the students' preferences for the instructional environment and whether the decision is based on life situations, like being homebound or the need to complete missing credits, or a preference for the particular instructional environment. Do the nature of the students' learning styles, other behavioral characteristics, or knowledge and comfort with technologies impact their selection of a particular learning environment? Follow-up studies need to address the preferences of the teachers and the students for the different classroom models.

Additional studies could also review the state standards for secondary science instruction in order to see if the current standards take into account the actual and preferred practices of the secondary science instructors in this study. This review could suggest additional training opportunities to meet the needs of both the online and the face-to-face secondary science instructors.

“More important than the curriculum is the question of the methods of teaching and the spirit in which the teaching is given” (Russell, 2006, p. 181).Without the creation of a set of preferred instructional practices (identified by practitioners as *best practices*) for online science instruction, the quality of instruction may suffer. It is especially useful to have such a set available to new teachers. For those new to teaching this compilation can reduce the stress of determining which instructional practices to employ in their classrooms.

APPENDIX A

Approvals to Conduct Research

HENRY
COUNTY
SCHOOLS

October 23, 2008

Ms. Tammy Gillette
Luella High School
Henry County Schools

Dear Ms. Gillette:

Your request to conduct research in our school system as part of the Doctorate of Education in Educational Leadership program at Florida Atlantic University has been reviewed. Specifically, consideration was given to the description of your research project, proposed population, survey instruments, and timeline.

It is my understanding that you plan to identify effective teaching practices and instructional strategies for the virtual high school and on-line science courses. You may use the Henry County courier service to distribute and collect your surveys. No names will be identified in the study. Please note that all information obtained for this study must be completely voluntary and anonymous. Pseudonyms for students, schools, and this system must be used in all written reports.

After considering all of the information submitted, it appears that your research request meets the requirements of Henry County Board of Education policy KEBA-R, Solicitation of Information. I am, therefore, approving your request to conduct the research in our school system as described in your proposal. I hope that your research project goes well and that the information you obtain will be beneficial to you and the students of Henry County Schools.

Sincerely,

Michael Surma,
Superintendent

Copy: Marian Tillotson

33 North Zack Hinton Parkway
McDonough, Georgia 30253
Phone: 770-957-6547 * Fax: 770-957-0301

FAU
FLORIDA ATLANTIC UNIVERSITY

Division of Research
Institutional Review Board
777 Glades Road
Boca Raton, FL 33431
Tel: 561.297.0777
Fax: 561.297.2319
www.fau.edu/research/rcs

MEMORANDUM

DATE: January 8, 2009

TO: Valerie Bryan,
Tammy Gillette,
Educational Leadership

FROM: Nancy Aaron Jones, Chair

RE: H08-337 "Virtual Science Instructional Strategies: A Set of Best Practices as Perceived by Secondary Science Educators"

The Institutional Review Board (IRB) has reviewed the above protocol. The Committee determined that the procedures described in the above protocol are **exempt** from federal regulations.

It is now your responsibility to keep the IRB informed of any substantive change in your procedures and if you encounter any problems of a human subjects' nature.

Please do not hesitate to contact either myself (6-8632) or Elisa Gaucher (7-2318) with any questions.

NJ:ceg

IRB Consent Letter for Survey on Virtual Science Instructional Strategies: A Set of Best Practices for Secondary Educators

The purpose of this proposed research study is to identify effective teaching practices and instructional strategies for online science courses. The identification of these teaching practices and instructional strategies may be used to compile a set of teaching practices and instructional strategies for virtual high school and online academy science instructors. This study may assist online science instructors by determining which teaching practices and instructional strategies are most effective for the online teaching environment.

You, as participant in this study, are encouraged to complete a printed survey regarding current teaching strategies used by science teachers. The survey should take you no more than 20 minutes to complete. The survey will be delivered via the district courier mail service to the principal of each school. Upon completion of this survey, you will place the completed survey in the appropriately labeled envelope, which will be returned via courier mail to Luella High School. The survey has been approved by the superintendent, Michael Surma, as a means to possibly improve instructional practices.

There is minimal risk involved in participating in this study. The risk involved in participating in this study is no more than what the participant would encounter in normal daily activities.

The benefits for your participating in the study are that you and other respondents are contributing to the creation of a set of best practices for virtual science instruction that may also aid face-to-face science instruction. This set of best practices can then be used to assist beginning science teachers. There is no penalty for choosing not to participate in this study. Although there is no compensation for participation, it would be greatly appreciated by the researcher, the Henry County Board of Education, and the discipline involved.

The results will be identified anonymously. The results will not be released in such a way as the participants' identities can be traced. The investigators and their committee members will be the only ones who will have access to the data. Your return of this completed instrument/survey indicates that you are aware of the value of this research and the assurance of anonymity in this research.

For related problems or questions regarding your rights as a subject, the Office of Sponsored Research at Florida Atlantic University can be contacted at (561) 297-0777. For other questions about the study, you should call or e-mail the principal investigators, Tammy J. Gillette at (954)536-1980 or tgillette@henry.k12.ga.us and Dr. Valerie Bryan at (561)799-8639 or bryan@fau.edu.

APPENDIX B

Survey

Research Survey for Henry County Schools

The purpose of this proposed research study is to identify effective teaching practices and instructional strategies for online science courses. The responses you provide to this study will be kept anonymous. Please read the IRB Consent Letter for additional information regarding the anonymity of your responses. Your support of this research may help to improve instructional practices for online science courses.

Part I

Instructions: *Please indicate your responses for Part I by responding on the space provided.*

What is your age? ______

How many years of teaching have you completed (end of school year)? ________

Are you an online instructor? _______

What subject do you teach? ______________

What subject(s) are you certified to teach?__________________________________

How would you describe your level of proficiency with technology? Please use Expert, Intermediate, or Novice. ____________________

Part II

Instructions: *Please indicate your responses for Part II by indicating SA for Strongly Agree, A for Agree, N for Neither agree nor disagree, D for Disagree, and SD for Strongly Disagree on the line provided.*

_________ Most days I use a teacher-centered approach to instruction.

_________ Most days I use a student-centered approach to instruction.

__________ My main method of delivering subject content is by lecture via notes and documents in print.

__________ My main method of delivering subject content is using Power Point.

__________ My main method of introducing new concepts is by lecture via notes and documents in print.

__________ My main method of introducing new concepts is by discussion in groups.

__________ My main method of introducing new concepts is demonstration by video or in person. The “in person” part is a separate question from video.

__________ My students conduct laboratory experiments three times or less throughout a semester.

__________ My students conduct laboratory experiments at least once per week.

__________ My students conduct laboratory experiments in the classroom.

__________ My students conduct laboratory experiments at school through virtual labs.

__________ I assess prior knowledge on every test.

__________ I use videos and/or DVDs as a teaching tool.

__________ My teaching activities are aligned to the Georgia Performance Standards.

Part III

Instructions: *Please indicate your responses for Part III by responding in the space provided below each question.*

How do you identify and address science concept misconceptions?

What variety of strategies do you employ for student questions?

What can you suggest as a best practice for face-to-face science instruction?

What can you suggest as a best practice for online science instruction?

Part IV

Instructions: *Please indicate your responses for Part IV by circling the number indicate which number you agree with on the sliding scale.*

On a sliding scale please classify your current role as a science teacher on the following scale:

1. Totally face-to-face science instructor	5. Totally online science instructor

1	2	3	4	5

On a sliding scale please classify if you see yourself more as an instructor or as a facilitator in your courses?

1. Instructor 5. Facilitator

1 2 3 4 5

On a sliding scale please classify your current approach to problem solving.

1. Teacher driven 5. Student driven

1 2 3 4

On a sliding scale please classify how would you assess yourself in establishing clear norms for grading?

1. Somewhat clear 5. Very Clear

1 2 3 4 5

On a sliding scale please classify how you would assess yourself in establishing clear assignment expectations.

1. Somewhat clear 5. Very Clear

1 2 3 4 5

On a sliding scale please classify how long you wait for students to respond to oral assessment questions on the following sliding scale:

1. One second 5. Five seconds

1	2	3	4	5

Part V

Instructions: *Please indicate your responses for Part V by circling the number to indicate the rate of the frequency using the scale of 0 to 5+ for number of times per week.*

	Number of Times Per Week
I use audio files as a teaching tool.	*0 1 2 3 4 5+*
I use physical models as a teaching tool.	*0 1 2 3 4 5+*
I use analogies to relate science concepts to real life situations as a teaching tool.	*0 1 2 3 4 5+*
I use conceptual models as a teaching tool.	*0 1 2 3 4 5+*
I implement peer tutoring, situations in which students pair up and explain concepts to one another, as part of my teaching strategies.	*0 1 2 3 4 5+*
I use graphic models as part of my teaching strategies.	*0 1 2 3 4 5+*
I work directly with students.	*0 1 2 3 4 5+*
I help students with creating mental models, images or associations that they can visualize in their minds.	*0 1 2 3 4 5+*
I engage students in role play.	*0 1 2 3 4 5+*
My students engage in computer simulations.	*0 1 2 3 4 5+*
I take my students on field trips.	*0 1 2 3 4 5+*
I provide my students with real-life examples.	*0 1 2 3 4 5+*
I provide constructive feedback to my students.	*0 1 2 3 4 5+*

I am available to my students outside of class. *0 1 2 3 4 5+*

I use rubrics for student assignments. *0 1 2 3 4 5+*

I require my students to access my course website. *0 1 2 3 4 5+*

My students use curriculum related software or programs. *0 1 2 3 4 5+*

Instructions for returning survey: Upon completion of this survey, you will place the completed survey in the appropriately labeled envelope. You will return the envelope to the main office at your school so that it will be returned via courier mail to Tammy Gillette at Luella High School.

If you need to contact the researcher, please do so at (954)536-1980 or tgillette@henry.k12.ga.us.

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