INVESTIGATING BLENDED LEARNING IN THE HIGH SCHOOL SCIENCE CLASSROOM

An Abstract of a Thesis

Submitted

in Partial Fulfillment

of the Requirements for the Degree

Master of Arts in Science Education

Holly Cassandra Hinkhouse

University of Northern Iowa

August, 2013

ABSTRACT

Blended learning combines the best practices of online learning with face-to-face learning and some research has shown it to have positive benefits for students at the post-secondary level. However, few studies have reported the use of blended learning in the high school setting.

This study used quantitative methods to measure student attitudes and learning of science content in both a treatment and control group consisting of 9th grade Physical Science classes. Students in the treatment group experienced one semester of blended learning by using online science modules to supplement their in-class learning while the control group continued to have only face-to-face instruction. The findings show no significant change in student attitudes about science and also no significant difference between the groups on a posttest measuring science knowledge. However, the treatment group exposed to the blended learning approach did show significant growth in science content knowledge from pretest to posttest while the growth by the control group was not significant.

Students in the treatment group were also interviewed to gather their opinions of the blended learning experience. Responses show students were engaged by the online simulations and self-paced content but participants also suggested ways to make the blended learning experience more beneficial for student learning. These implications for instruction and the design of blended learning are discussed.

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CHAPTER 1

INTRODUCTION

Online learning is one of the fastest growing trends in education and while institutions of higher learning were quick to implement online courses, the trend is now proceeding rapidly in K-12 school systems. As of late 2010, opportunities for online learning were available to K-12 students in 48 states with an estimated 1.5 million students taking one or more online courses (Means, Toyama, Murphy, Bakia, & Jones, 2010; Watson, Murin, Vashaw, Gemin, & Rapp, 2010; Wicks, 2010).

The enhanced accessibility and capabilities of the Internet have created limitless possibilities for designing, developing and implementing innovative teaching methods. A wide variety of studies have shown online learning to be at least as effective, and often times more effective, than traditional, face-to-face classes. However, research has shown the greatest improvement in student learning occurs when online courses also involve some in-class learning (Means et al., 2010). This “blended learning” approach combines the best pedagogical practices of an online learning community with the interaction of traditional, face-to-face learning. Most blended conditions include additional learning time and instructional elements not possible when courses are strictly online or in-class.

The effects of blended learning have been researched at the post-secondary level and most studies have displayed positive benefits for students in the form of achievement, attitudes, and/or community building. However, only a handful of studies have been reported for the use of blended learning in the high school setting.

The purpose of this research was to measure, analyze, and compare student achievement and opinions of blended learning in an Iowa 9th grade Physical Science classroom. This study used both quantitative and qualitative research methods to compare the achievement and opinions of students in a blended learning environment to those of students in a traditional classroom.

The findings of this research are of interest to educators, policymakers, and stakeholders because student achievement of state standards is of utmost importance. A recent report on the status of education in the state of Iowa emphasizes the importance of technology and skills necessary to prepare students for the 21st Century workforce. In the current age of innovation, Iowa will only regain its superior educational outcomes if learning environments encourage students to take command of and envision higher purposes for technological advances (Pennington & Chadwick, 2011).

Iowa's science education standards focus not only on content but also on the processes of scientific inquiry. While an online curriculum can help students to learn the content, understanding the concepts of inquiry requires hands-on experimentation and collaboration. Therefore, it is predicted that compared to traditional learning the blended learning approach will lead to increased content knowledge and understanding of science skills. Implementing an interactive, standards-based, online curriculum with the blended learning approach will allow more time for meaningful scientific inquiry in the classroom setting as compared to traditional, face-to-face instruction.

CHAPTER 2

REVIEW OF THE LITERATURE

Defining Blended Learning

Blended learning has been discussed and researched for more than ten years but educators still perceive and define this approach in a variety of ways. Clark (2006) contends that blended learning has always been the norm for learners because natural learning takes place through a variety of different encounters. However, for instructional design, blended learning is not about the learning but rather about the teaching. Blended courses have been defined to include both face-to-face and online teaching where 30-79% of the content is delivered online (Allen, Seaman, & Garrett, 2007). Blended learning goes beyond classroom technology integration because students are expected to learn through online content delivery while having some element of control over their own learning time, place, path, and/or pace (Staker, 2011).

The goal of blended courses is to combine the best features of in-class learning with the best features of online learning to deliver a valuable educational experience to students (Gilbert & Flores-Zambada, 2011). However, the combination of learning modalities goes beyond layering or repetition because true blended learning requires a meaningful integration of the face-to-face and online learning experiences (Garrison & Kanuka, 2004).

The blended learning that was implemented in this study follows the descriptions presented in a 2008 report for the North American Council for Online Learning (Watson, 2008). Blended learning is an interactive, student-centered approach that integrates engaging online content with the best features of classroom interaction. This approach also personalizes student learning and includes several forms of assessment for students and instructor. Most of the published research about blended learning does not align with this definition because the studies have not emphasized the use of best pedagogical practices for both the online and in-class learning.

Designing the Blend

Blended learning is not just about finding the right mix of technologies or simply increasing student access to content in a new medium. It is inherently about rethinking and redesigning the teaching and learning relationship (Garrison & Kanuka, 2004). When implementing a blended approach, it is important to go beyond using technology to replicate or multiply traditional classroom instruction. For successful blended courses, a complete redesign of teaching methods is required to create meaningful and engaging integration between in-class and online learning. Some researchers and educators contend the benefits of blended learning are not the result of technology but rather the instructors' reflection and redesign of pedagogical practices in light of new instructional and media choices (Aycock, Garnham, & Kaleta, 2002).

Unfortunately, at the university level, many courses are defined as being "blended" without any redesign or evaluation of pedagogy. Courses receive the blended label simply because a portion of previously existing classroom learning is replaced with some form of online learning (Bliuc, Goodyear, & Ellis, 2007). The majority of research related to blended approaches comes from this type of university course and therefore does not truly fall under the current definition of blended learning.

Blended classroom environments vary based on student characteristics, learning goals, instructor preferences, and online resources. Some courses may evenly blend the online and in-class components while other courses demand more of one approach. However, all blended designs aim to maximize the benefits of both instructional approaches according to the unique needs of learners (Osguthorpe & Graham, 2003).

While no two blended courses are identical, several design principles can be implemented to foster student success. First of all, the online portal and activities should be gradually introduced to students while in the classroom so they become comfortable using the technology to achieve learning targets (Duhaney, 2004). The online course management system must be user-friendly, facilitate discussion to build a community of learners, and also have a good mechanism for communicating expectations and providing feedback (Babb, Stewart, & Johnson, 2010). Lastly, teachers must also have a presence in the online environment to manage, focus, and facilitate meaningful learning experiences (Garrison & Kanuka, 2004).

Osguthorpe and Graham (2003) identified six specific goals for educators designing a blended learning environment.

- Pedagogy must be rich and redesigned to improve student learning.
- Access to knowledge should be increased using online portals and a variety of online resources.
- Social interaction is vital during both face-to-face and online learning so instructors must facilitate meaningful discussions of content.
- Personal agency, or self-directed learning, should also be required of students so they can make choices related to their own learning.

- Cost effectiveness can be analyzed and is relevant for some institutions looking to increase class sizes.
- Ease of revision should be considered so the online environment can be easily changed and duplicated.

For the study presented here, blended learning consisted of an online science curriculum integrated with daily in-class activities. Students had personal laptops to access the online component that included content, interactive simulations, formative assessments, and discussion. Unlike many courses, this blended learning design did not reduce the amount of time students spent in their high school science class but online presentations of the content allowed for more student-centered learning in the classroom and less teacher-centered instruction.

Student Achievement and Blended Learning

A wide variety of research studies have found the blended learning approach to have positive effects on student achievement while other studies have noted student success to be equivalent to traditional instruction (Chen & Jones, 2007). Although the structure of blended courses reported in research studies varies greatly, the possible benefits are widely documented and relevant to all areas of education. The majority of research related to blended learning has taken place at the post-secondary level but some studies have found this approach to be beneficial for high school students.

In a university human anatomy course (n=134), blended learning was found to be more effective than traditional teaching because students earned higher grades and were more successful at passing an exam on the first attempt (Pereira et al., 2007). Computer programming was also taught using blended learning (n=600) and not only resulted in marked improvements in pass rates, but also more positive student evaluations (Boyle, Bradley, Chalk, Jones, & Pickard, 2003).

Students also earned higher grades and higher scores on the final examination in a study comparing achievement in an undergraduate accounting course (n=206). In the blended class, students actually earned lower grades on the midterm exam that required deep understanding of individual topics. However, the final exam required students to demonstrate a breadth of understanding of all topics and their interrelationship. The blended learning students performed an average of 5% better on the final exam and therefore earned a higher overall grade (Dowling, Godfrey, & Gyles, 2003).

At the high school level, studies have shown blended learning to result in students scoring significantly higher on a posttest compared to those experiencing only traditional, face-to-face instruction. In a study by Chandra and Watters (2012), students in the treatment group utilized a teacher-created website to supplement their in-class learning of physics while the control group did not use the website (n=80). An assessment instrument showed the treatment group to have a significant increase in physics knowledge from pretest to posttest while the control did not. A similar study by Yapici and Akbayin (2012) compared high school biology classes and results indicated significant increases from pretest to posttest for the blended learning group, but not the control group (n=107).

Many blended learning approaches focus on the use of online discussion forums and a study of several business courses (n=217) measured the connection between student achievement and the level of discussion participation. Both the number of postings and the number of different forums in which a student posted were used to measure participation levels. The study showed this measure of participation could be used to accurately predict student grades on multiple-choice tests and this prediction was more accurate than any other factor such as age, gender, type of class, or even previous grades of students. Therefore, increased participation in online discussion was found to result in a better understanding of the content (Hwang & Arbaugh, 2009). In a separate study (n=99), online discussions were also found to improve student performance on learning outcomes related to knowledge and analysis in the field of Management Information Systems (Webb, Gill, & Poe, 2005).

Blended learning has also been shown to improve student performance of real-world tasks. Beginning in 1999, Thompson Learning conducted a two-year research study where 128 learners from industry and higher education were trained to use Microsoft Excel. After the training, students were asked to perform three tasks on Excel as if they were doing them at their actual jobs. The group trained using a blended approach performed these real-world tasks with 30 percent more accuracy and also 41 percent faster than those who received only online training (Kiser, 2002).

Student Perceptions of Blended Learning

Research studies related to blended learning have measured not only student achievement but also student perceptions of the course design and execution. Most studies show students to be more satisfied with the blended environment compared to face-to-face and online learning.

Students prefer the reduction in lectures and the focus on group collaboration that is common in most blended environments. Students enjoyed learning from each other, and working in groups also proved to be a powerful incentive for students to stay on track with their assignments (Twigg, 2003). When in-class learning is designed for active participation and discussion, rather than lecture, students indicate a higher rating of satisfaction with the course (Melton, Graf, & Chopak-Foss, 2009).

The online portion of blended learning allows students to learn content in their own time, organize themselves for self-directed learning, and then reflect on the meaning of their learning. Students reported that this positively enhanced their overall learning experience when they were engaged and stimulated by the ideas and processes included in the online module (Bliuc et al., 2007).

A comparative study of traditional classroom, blended, and fully online learning has shown that students in blended courses feel a stronger sense of community with their classmates and professor compared to other students (Rovai & Jordan, 2004). Educators are realizing the importance of creating a learning environment to encourage the student interaction and dialogue that is essential for the development of cognitive growth and critical thinking skills (Babb et al., 2010). Garrison and Kanuka (2004) contend that effective blended learning can facilitate the creation of a community of inquiry. Using multiple forms of communication, blended learning allows communities to exchange dialogue, debate, negotiation and agreement. This sense of community can then provide a stabilizing and cohesive effect to balance the limitless information available on the Internet.

Instructor Perceptions of Blended Learning

Research related to instructor opinions of blended learning is consistent with the research showing blended learning to enhance student learning and engagement. While instructors report positive experiences with the blended model, they also agree designing blended courses required more time, effort, and technology skills than traditional courses. However, instructors said they would do it all over again because the blended design resulted in increased interaction, learning, and performance of their students (Garnham & Kaleta, 2002).

Instructors also reported increased communication and discussion for both student-student and student-instructor interactions with the blended course. Due to the increased communication, instructors also observed higher levels of feedback, reflection, and accountability for students. With those observations, instructors were able to raise their expectations for students in the blended courses (Toth, Amrein-Beardsley, & Foulger, 2010).

Student-Centered Instruction

The online component of blended learning allows students to be more independent in structuring their learning. Most educators see this as a positive, more learner-centered approach that is sensitive to the real needs of learners (Clark, 2006). With blended learning designed to create communities of inquiry, teachers focus less on delivering instruction and more about active learning through collaboration and social construction of understanding (Rovai & Jordan, 2004). Instructors can behave as a coach, facilitator, and a cheerleader as students are guided to become leaders of their own success (Gilbert & Flores-Zambada, 2011).

In 1999, ten American universities began a Program in Course Redesign with support from the Pew Charitable Trust grant. Professors were selected to redesign their instructional approaches using technology with the intent of improving learning outcomes and achieving cost savings. All ten projects used technology to shift away from in-class lecture and towards more active forms of student-centered learning. Learning became less dependent on conveying words and more focused on student reading, exploring and problem solving. As a result, five of the ten projects reported improved learning outcomes and seven of the projects measured positive changes in course completion/retention rates (Twigg, 2003).

In this study, pedagogical practices emphasized student-centered learning in both the online and classroom environments. Online course content could allow more time for open-ended scientific inquiry in the classroom and several studies have shown inquiry learning to positively influence student attitudes and achievement in science content and process skills (Anderson, 2002; Marx et al., 2004).

Summary and Shortcomings of Existing Literature

Blended learning, which integrates online and in-class instruction, can be defined and designed in a variety of ways. When the blended learning utilizes best pedagogical practices, research has indicated positive effects for student achievement, attitudes, and/or community building. However, much of the research does not analyze courses where best practices are implemented. The research has also been quite limited to higher education with very few studies reported for K-12 learners. Therefore, more research is needed on the outcomes of blended learning in the high school setting.

In terms of achievement, students in blended courses often earn higher grades than those in traditional online or face-to-face courses. However, the study conducted and presented here did not compare achievement using grades because the treatment and control groups often had assignments and projects with different point values. Therefore, scores on a pretest and posttest of science skills were used to analyze student achievement.

CHAPTER 3

METHODS

Research Questions

Due to the gap in literature for blended learning in a high school setting, the two research questions guiding this study were: (1) How does blended learning affect student attitudes and understanding of science skills and content in a 9^{th} grade Physical Science class? (2) What are student opinions of the blended learning environment?

Online Curriculum

The online science curriculum implemented with the treatment group was purchased from the Florida Virtual School (FLVS). In 1997, the Florida Department of Education awarded two Florida school districts a grant to co-develop the online high school now called FLVS. This was the nation's first statewide, Internet-based, public school and it has grown to currently offer more than 120 online courses. In 2011-2012 it served over 148,000 students in Florida along with other learners around the world.

The Physical Science curriculum was purchased by the state of Iowa in 2011 and was edited to fit Iowa science standards and other statewide learning initiatives. Students in the treatment group of this study experienced only face-to-face instruction for the first semester but then used this online curriculum during the second semester of Physical Science. The online component included written science content, interactive simulations, formative assessments, and discussion boards. Students in the treatment group used this online curriculum in addition to their in-class learning while the control group learned similar content using a traditional textbook and more teacher-led instruction.

Instruction

Classroom instruction for Physical Science utilized many strategies and tools in both the treatment and control groups. All students experienced a wide variety of in-class learning activities that aimed to create a student-centered environment. During class, science content was taught using videos, teacher demonstrations, laboratory experiments, student projects, and written practice. Homework was infrequently assigned and students completed most of their work during class. All students used laptops provided by the school district to access online tools, complete projects, and communicate through email. Student learning in both groups was assessed using in-class quizzes and chapter tests.

While the instructor did not focus on lecture as the main tool to convey information, the use of lecture was more frequent in the control group as new content was introduced to students. In contrast, students in the treatment group were introduced to the content by completing the online modules. When these modules were completed outside of class it not only increased the amount of time students spent learning science but also provided the treatment group with more time during class for discussion and activities. While the in-class activities were mostly similar for both groups of students, more time was available for clarification of the content in the blended learning setting of the treatment group.

Population

Invitations asking students to participate in the research study were sent to parents/guardians of all 48 students in the 9th grade at Riverside High School in Oakland, Iowa. This group of students consisted of 26 girls and 22 boys from 14-16 years of age. The population was 92% Caucasian, 4% Hispanic, 2% African-American, and 2% Asian and also had 43% of students qualifying for free and reduced lunch rates. This student population was chosen because of its access to the researcher and the statewide electronic curriculum initiative for 9th grade Physical Science. Students were informed that participation would not alter their classroom experience and they were simply given the option of consenting to the use of their data in the study.

This population of students was randomly scheduled into three separate classes of Physical Science with the researcher being the instructor of all three sections. For this study, two sections were considered the treatment group and used the online science curriculum as an integral part of learning and instruction. The remaining section served as a control and did not use the online curriculum.

Measures

Items from assessments created by Anton Lawson and the Arizona Collaborative for Excellence in the Preparation of Teachers were used to quantitatively measure student achievement of physical science skills and concepts. The Lawson tests were designed to measure student attitudes, skills, and knowledge in the areas of math and science. Student attitudes about science and the nature of science are assessed with questions using a Likert-scale while content knowledge and skills are measured with multiple-choice questions. The assessment questions were compiled from other resources (i.e., International Association for the Evaluation of Education Achievement, 1998; Lawson, 1995; National Center for Education Statistics, 1998) and the questions for the specific disciplines of biology, chemistry, physics, and mathematics were then each divided into three equivalent forms (Adamson et al., 2003).

For this study of physical science achievement, only the content areas of chemistry and physics were assessed. The assessment for this study consisted of questions from Lawson's Chemistry Attitudes, Skills, and Knowledge Survey (CASKS) Form 3 and Lawson's Physics Attitudes, Skills, and Knowledge Survey (PASKS) Form 1. These questions were compiled by the researcher to create the assessment instrument Physical Science Attitudes, Skills, and Knowledge Survey (PSASKS). Questions in the instrument address content related to the scientific method, chemical reactions, density, gravity, and forces. Student achievement in this study was measured using the same Lawson PSASKS assessment as a pretest and a posttest in the treatment and control groups (Appendix A).

The edited assessment used in this study was piloted in a biology class composed of students who were enrolled in Physical Science the previous year. Student responses were analyzed for internal consistency and reliability using Cronbach's alpha (Cronbach, 1951). Scores on this pilot test were analyzed to have a Cronbach's alpha coefficient of 0.614 which is lower than the standard benchmark of 0.70. However, studies by Adamson et al. (2003) and Coletta and Phillips (2005) have shown the original Lawson tests to be valid assessment instruments. Therefore, the questions compiled from the Lawson tests were used in this study to assess student understanding of science.

To address the second research question, student opinions of blended learning were qualitatively assessed using semi-structured interviews at the conclusion of the study. Interviews included, but were not limited to, the following questions:

- How does this semester of Physical Science, with the online learning, compare to the first semester of science?
- How do you think the online environment affected your learning?
- What did you enjoy most about the online environment?
- What was difficult about the online environment?
- What could be changed about the online modules to make them more useful for students?
- What would motivate you to work on the online modules outside of class?
- What other comments do you have about science or the online learning?

The researcher/instructor also recorded field notes related to the execution of the online curriculum. These Instructor Reflection notes were not shared with student participants but provided a qualitative measure of instructor opinions and observations as blended learning was implemented in the classroom.

Data Collection

All Physical Science students were given the edited Lawson test in January, prior to the implementation of blended learning, and again in May. The school principal administered the test in the science classroom and participation and performance did not influence student grades.

A retired teacher who was certified to collect data from human participants conducted the semi-structured interviews with students. Midterm grades were used to classify students in the treatment group as high-achieving, average-achieving, and low-achieving. The interviewer was given the list of approximately 35 students in the treatment group and randomly selected two students from each achievement level to invite for interviews. Students were not required to participate in the interviews and did not receive any incentive for being interviewed.

All methods and procedures for data collection and analysis were approved by the University of Northern Iowa Institutional Review Board (Appendix B).

Data Analysis

Data from the edited Lawson test was statistically analyzed for differences in the pretest and posttest scores of the treatment and control groups. Multiple-choice questions had only one correct answer so students earned one point for a correct answer and zero points for any other answer. Average scores on the test were compared for differences using a *t*-test. An average value for student responses on each of the Likert-scale questions about science attitudes were computed and also statistically analyzed for differences using a Wilcoxon Signed-Ranks test. For the purposes of this study, a significance was set at p=.05 and effect size was calculated using Cohen's *d* (Cohen, 1992).

Interviews with students in the treatment group were recorded and transcribed by a third party. Once the semester ended and student grades were submitted, the researcher inductively analyzed the interview transcripts and used Grounded Theory (Glaser & Strauss, 1967; Taber, 2000) to find trends in student responses.

CHAPTER 4

RESULTS

Participants

From the population of 48 high school students invited to participate in this study, 28 students consented to have their data used in the research study. In the control group, 15 students gave consent along with 13 students from the treatment group. Students did not receive any incentive for participation. For the purposes of confidentiality and anonymity, no demographic information was recorded for the group of consenting participants.

Student Attitudes about Science

Students were asked to indicate their level of agreement with six statements about science and the nature of science on both the pretest and posttest (Appendix A). The mean responses to each question on the pretest and posttest were compared within the treatment group and control group. The Wilcoxon signed-rank test was used to analyze the Likert-scale responses because this test is appropriate for small sample sizes and data on an interval scale. The test found no significant difference in the Likert-scale responses for either the Control Group (Table 1) or the Treatment Group (Table 2).

Table 1: Wilcoxon Signed-Ranks Test for Control Group Attitudes about Science

Question	Control Group (n=15)			
	Pretest Mean	Posttest Mean	Z	Asymp. Sig. (two-tailed)
#1: I am good at science.	3.67	3.73	-0.38	.71
#2: Science is useful for everyday problems.	4.13	4.13	-0.18	.86
#3: Hypotheses/theories cannot be proved to be true beyond any doubt.	2.33	2.87	-1.59	.11
#4: To test a hypothesis, one needs a prediction.	4.13	3.67	-0.79	.43
#5: The primary goal of modern science is to discover facts about nature.	2.87	2.60	-0.86	.39
#6: Coming up with hypotheses requires creative thinking.	3.80	3.80	0.00	1.00

Table 2: Wilcoxon Signed-Ranks Test for Treatment Group Attitudes about Science

Question	Treatment Group (n=13)			
	Pretest Mean	Posttest Mean	Z	Asymp. Sig. (two-tailed)
#1: I am good at science.	3.85	4.00	-1.00	.32
#2: Science is useful for everyday problems.	3.77	3.92	-0.52	.60
#3: Hypotheses/theories cannot be proved to be true beyond any doubt.	2.92	2.38	-1.13	.26
#4: To test a hypothesis, one needs a prediction.	3.85	4.08	-0.74	.46
#5: The primary goal of modern science is to discover facts about nature.	2.77	2.62	-0.63	.53
#6: Coming up with hypotheses requires creative thinking.	4.15	3.69	-1.61	.11

The analysis found no significant difference from pretest to posttest. This indicates student attitudes about science and the nature of science were not significantly changed by either instructional method.

Student Understanding of Science

Student understanding of science content was measured using 22 multiple-choice questions on a pretest (Appendix A). As measured by an Independent Samples *t*-test, there is no significant difference (p=.601) between the mean pretest scores of the control group and the treatment group (Table 3). Therefore, at the beginning of the study, the two groups were considered equivalent.

Table 3: Pretest Mean Scores

	n	Pretest Mean	*p*
Control Group	15	9.467	.601
Treatment Group	13	8.769	

At the conclusion of the study, both groups of students were given a posttest (Appendix A) to measure growth in their understanding of science. A *t*-test comparison of pretest and posttest scores shows there was no difference between the mean pretest and posttest scores for the control group (t(14)=-1.90, p=.08) (Table 4) but the difference was significant for the treatment group (t(12)=-3.93, p=.002) (Table 5).

Table 4: Paired Samples *t*-test Showing Control Group Growth (n=15)

Control	Mean	Standard Deviation	Standard Error Mean	T	Df	*p*	*d*
Pretest	9.47	3.36	0.87	-1.895	14	.08	0.38
Posttest	10.93	4.40	1.14				

Table 5: Paired Samples *t*-test Showing Treatment Group Growth (n=13)

Treatment	Mean	Standard Deviation	Standard Error Mean	T	Df	*p*	*d*
Pretest	8.77	3.61	1.00	-3.93	12	.002	0.58
Posttest	11.23	4.92	1.36				

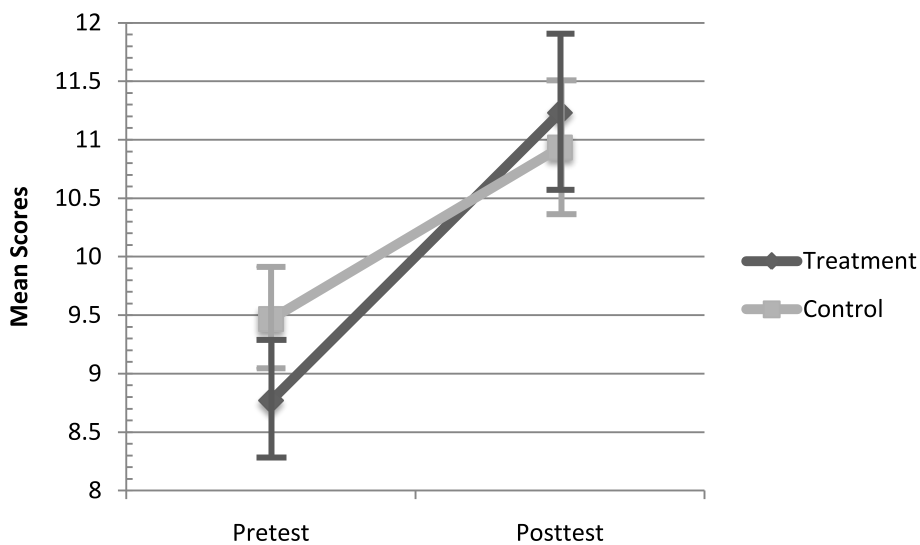
The growth from pretest to posttest was significant for the treatment group but a *t*-test comparison of posttest scores shows there is no significant difference (p=.867) between the control and treatment groups at the conclusion of the study (Table 6).

Table 6: Posttest Mean Scores

	n	Posttest Mean	*p*
Control Group	15	10.933	.867
Treatment Group	13	11.231	

Statistical analysis shows the control and treatment groups to be equivalent at both the beginning and end of the study. However, from pretest to posttest, only the growth of the treatment group was measured to be statistically significant (p=.002) with a moderately large effect size (d=0.58). Figure 1 further illustrates this growth within the treatment group and the error bars represent standard errors.

Figure 1: Comparison of Growth in Control Group and Treatment Group



Further analysis with a *t*-test shows significant growth on only four of the individual assessment questions. Table 7 and Table 8 indicate the percent of correct answers and statistical analysis for both groups of students on the pretest and posttest. The calculations of Cohen's *d* illustrate large effect sizes each time a significant difference in student scores was noted.

Table 7: Control Group Percent Correct on Pretest and Posttest Questions

Question and Topic	Control Group (n=15)			
	Pretest %	Posttest %	*p*	*d*
#19: Density	46.7	86.7	.028*	0.78
#23: Frame of Reference	53.3	33.3	.271	0.39
#24: Force on Charged Particles	33.3	46.7	.499	0.27
#28: Action and Reaction Forces	13.3	53.3	.009*	1.14

Table 8: Treatment Group Percent Correct on Pretest and Posttest Questions

Question and Topic	Treatment Group (n=13)			
	Pretest %	Posttest %	*p*	*d*
#19: Density	53.8	61.5	.721	0.15
#23: Frame of Reference	15.4	46.2	.04*	0.82
#24: Force on Charged Particles	23.1	53.8	.04*	0.70
#28: Action and Reaction Forces	23.1	76.9	.012*	1.23

The four questions showing significant growth from pretest to posttest assessed a variety of science topics. The most significant growth for both the control and treatment group was on the same question about Newton’s Third Law of Action and Reaction Forces.

Overall, data analysis of pretest and posttest scores indicates no significant difference between the control and treatment groups before or after the study. However, the treatment group did display significant growth from pretest to posttest but only three individual questions indicated this growth while the control group only showed significant growth on two questions.

Student Opinions of Blended Learning

Interview Participants

A total of six students from the treatment group were interviewed about their blended learning experience. Consenting participants were invited for interviews via email and interviews were scheduled until two participants from each of the achievement groups (high, average, and low) consented to an interview. Students had been divided into achievement groups using their first semester science grades but no other demographic information was used to classify students (Table 9). The names assigned to interview participants are pseudonyms that were randomly assigned and do not contain any identifiers of the participants, not even gender.

Table 9: Interview Participants

<table>
<tr><th>Participant</th><th>Pseudonym</th><th>Achievement Group</th></tr>
<tr><td>H12</td><td>Alan</td><td rowspan="2">High-achieving</td></tr>
<tr><td>C22</td><td>Ann</td></tr>
<tr><td>H14</td><td>Brandy</td><td rowspan="2">Average-achieving</td></tr>
<tr><td>H13</td><td>Ben</td></tr>
<tr><td>C27</td><td>Cassie</td><td rowspan="2">Low-achieving</td></tr>
<tr><td>C18</td><td>Chad</td></tr>
</table>

Interview Process

Private student interviews were conducted at the school in the guidance counselor's office. Participants were informed the interviews would be audio-recorded for transcription and their identities would not be revealed to the researcher. Interviews were conducted by the research assistant and, upon completion; the audio recordings were transcribed by an outside source.

Interviews were semi-structured with seven main questions and allowed for necessary follow-up questions. All interview questions were aimed to gather data for the second research question: What are student opinions of the blended learning environment?

Instructor Reflections

At the conclusion of the blended learning experience, the instructor typed reflections about her ideas, observations, and struggles while implementing the new learning approach with her students. These typed reflections were organized into categories and were then used to examine and clarify the interview participants' opinions of blended learning.

Document Analysis

Student responses to the interview questions were organized into a data table and analyzed for trends among students and/or achievement levels. Student ideas and opinions of blended learning were then cross-referenced to the Instructor Reflections document to expand on the opinions presented by interview participants. This process provided a more holistic analysis of the entire learning environment.

The discussion of the results will focus on the main ideas presented by student interview responses and their relationship to instructor reflections. First, the discussion will show how students compared face-to-face instruction to the blended learning environment. Then, it will focus on the students' perceived benefits of blended learning. Finally, ideas for improving blended learning will be presented.

How Does Direct Instruction Compare to Blended Learning?

There are many ways to deliver instruction in a high school science classroom. Students experienced direct, face-to-face instruction with a learning cycle approach during the first semester of science but then blended learning was implemented with the treatment group during the second semester.

Student Comparison of Instruction

Students were asked to compare the two semesters of science and most students noted the shift away from direct instruction. Of the interview participants, three preferred teacher-led instruction (italicized), two participants felt they benefitted more from having the resources online, and one did not indicate a preference (Table 10).

Table 10: Comparison of Direct Instruction to Blended Learning

Question	ALAN	ANN	BRANDY	BEN	CASSIE	CHAD
How does this semester of Physical Science of the online learning compare to first semester of science?	*I liked first semester more because it was easier, because she actually taught us more.*	*I think it was better for us to like, learn with a teacher*	*First semester I felt was easier, because we talked about more.*	It was a little bit easier because we had all of our resources directly in front of us with our laptops.	I like it, cause it's easier. Online. I have more time reading it rather than just listening to the teacher.	Good.

Students in the high-achieving group, Alan and Ann, were more vocal about their preference of direct instruction. However, they had differing opinions when asked if the transition to blended learning affected their learning. Alan simply said, “Not really.” Ann actually described how she was distracted during the blended learning experience. “There is a lot of things on the Internet to distract you from learning, but when you’re off the computer, there’s not a lot of things to distract you away from the teacher talking to you.” While Ben stated his preference for the online learning, he also noted the possible distractions on the Internet. “Just like normally on the Internet, sites to go to that are just more interesting and fun, instead of what we were supposed to be doing. So [the instructor] would make sure we would get all our stuff done before we would go to anything like that.”

Distractions were also mentioned as a problem in the Instructor Reflections. “While websites like facebook and YouTube were blocked on the students’ computers, they quickly found unblocked game websites that caused frequent distractions during class.” During the first semester of direct instruction this would not have been an issue because the students did not yet have their own, personal laptops during class.

Student Motivation for Online Learning

One of the goals of the blended learning approach is to have students learn about the content outside of class and then be prepared for more authentic activities during class. This required students to be motivated to learn new content on their own, rather than just doing homework about content presented in class.

The instructor noted student motivation as one of her biggest challenges while trying to implement blended learning:

> For blended learning to work, students must spend time learning the material outside of class. I would assign a Moodle lesson to the students but they would come to school the next day without doing it or saying they did not understand anything about it. I was constantly struggling to find ways to motivate students to learn on their own. Since they were only freshmen, none of the students had taken an online class yet and had no experience with self-paced learning.

When interview participants were asked what would motivate them to learn science outside of class, they were unsure (Table 11). Most students indicated the need for some reward such as extra credit or being exempt from a test.

Table 11: Motivating Students to Complete Work

Question	ALAN	ANN	BRANDY	BEN	CASSIE	CHAD
What would motivate you to work online modules outside of class?	Not having to take certain tests. Not really anything specific.	Maybe something, like, if you do this, then you'll get a reward for it maybe. Like if you work on this outside of school.	I'm not sure. Um, I don't know. Extra credit maybe.	Getting good grades because my parents would always ride me every time if I have bad grades.	Just that the teacher, I don't know, the teacher is telling me to go work on it, I guess.	Mm I don't know.

What are the Perceived Benefits of Blended Learning?

Blended Learning was used in the classroom in order to utilize student laptops and it also aimed to improve student learning of the science content. During interviews, students were asked about ways they enjoyed and benefitted from the availability of the online science content.

Access to Science Resources

The school gave all high school students their own personal laptop to use both during school and at home. With access to the Internet, all of the online science content was available to students at any time without requiring them to carry a textbook.

The online content was similar to a traditional textbook but could be accessed from the student computers. Ben mentioned, "It was a little bit easier because we had all of our resources directly in front of us with our laptops…that made it so we had class time of actually learning instead, than just trying to find everything." Ben went on to mention learning outside of class, "We could access at home so it was not just learning in class, we could learn at home, too."

Self-Paced Learning

The availability of online science content and resources allowed students to work at their own pace, both in and out of the classroom. While each student did have a copy of the actual science textbook, it was used infrequently during instruction and was rarely needed to complete homework. Students seldom carried the science textbook with them but had their laptops at all times. Interview participants of all ability-levels viewed this constant access to online content as beneficial for self-paced learning, clarification of the content, and getting caught up after absences.

Alan, a high-achieving student, felt he benefitted from being able to work through the content on his own. "Once I got done, I didn't have to wait for other people, I could just do whatever I wanted." This was also helpful for struggling students like Cassie who needed more time to process the content. "I have more time reading it rather than just listening to the teacher."

Both Ann and Ben discussed their ability to clarify the science content by re-visiting the online lessons. While Ann preferred direct instruction and Ben enjoyed the online environment, they did agree the online content motivated them to go back and improve their understanding of the content. Ann stated, "You could go back to a different chapter and go and read over the subject again. But with the teacher, if they're saying something, you really can't go back unless you have your book."

Ben also stated the online content helped him to get back on track with the content after an absence from school.

> If you missed a day, you just had to ask what you went over. You just had to find it on the page and go over what they did…It made everything a lot lighter, made packing up after class a lot easier too, just had to pack up the laptop and zip up the case and you were ready to go…If I got stuck, I would just go back to the top of the page and read back through, just to make sure I understand it all. She'd send us an email with the directions. I'd go back to that email a few times so I'd know exactly what I was doing.

Students viewed the online modules as beneficial for staying on track with the content even though it contained the same type of information as their science textbook.

The main difference was the constant access to the modules and the teacher-to-student communication about the assigned lessons.

Online Videos and Simulations

Along with reading paragraphs about the science content, students could view short video clips embedded within the online modules. In addition, game simulations with instant feedback were often used to introduce or review concepts. During the interview process, every student referred to the usefulness of these videos and games.

Students from each achievement level mentioned how the videos and games were what they enjoyed most about the online environment. Ann said, "There was like games you could play to help you learn a subject. So that was a lot easier to understand things." Brandy also said the games were her favorite part and Cassie stated they helped her to review the content, "You got to practice a little bit and the games would be on there to help you." Cassie went on to explain that these activities provided instant feedback about right and wrong answers. "It would have you go back and look up the information, then get the right answer."

When asked about the activities and games, Ben specifically described a simulation that helped him. "There were lots of visuals and games to it. There are a few videos. There was one where you had to choose how fast you were going down a hill and what was covering the hill and see how far you would go off the end of it. I thought that was pretty fun." Interactive simulations that allow students to make choices and instantly see the results are not possible in a traditional textbook and are therefore perceived to be a benefit of the online environment.

How Could the Blended Learning Environment be Improved?

Blending Online and In-Class Instruction

Students experienced both face-to-face instruction and online instruction over the course of the year. Alan and Ann both proposed a better balance of these two teaching methods to improve the learning experience. When asked what could be changed to make the online learning more useful for students, Alan proposed to "incorporate both online and just actual teaching" while Ann would have preferred to "have a huge class discussion or go into groups and discuss what you learned."

The Instructor Reflections also indicated the need for a better blend of in-class and online learning:

> The original goal of blended learning was for students to spend time learning the content outside of class and then to focus on questions, discussions, and activities during class time. However, lack of student motivation and a confusing module design resulted in assigning the online learning to be done during class. Therefore, there was not a good balance of online content and in-class activities.

The initial design of the blended learning was to have students learn content outside of class in order to utilize class time for more activities and experiments. However, the data indicates an effective balance of these learning methods was not accomplished.

Changing Online Module Layout

The online modules were purchased from the Florida Virtual Schools and were placed into a Moodle format by the State of Iowa. Instructors were told to edit the modules as little as possible in an effort to gain information about the usefulness of the original design.

Both students and the instructor suggested changes to improve student learning. Ben mentioned, “Some of it was a little bit confusing to me…how to navigate through the pages.” The science content was organized into a central dashboard but then within each module there were multiple lessons and within each lesson there were at least three pages of content and activities.

Student difficulty in navigating the online content was also mentioned in the Instructor Reflections:

> [Students] struggled to navigate within Moodle because its layout was unfamiliar and not easily personalized. I frequently had to direct individual students to the correct link within Moodle, even if they had been given both written and oral instructions.

Reduction of Required Reading

Each science lesson contained a short introduction to the main ideas followed by several paragraphs of science content. The online lessons were similar to the format of a traditional textbook. Brandy indicated the most difficult part for her was the large amount of reading, “I still think it was a lot of reading, like a lot to comprehend.”

The Instructor Reflections also mentioned the students’ struggle to learn from simply reading content online. “The modules used mostly text to present concepts and very few students actually understood or even remembered what they had read.”
The focus on text was especially difficult for students with lower reading-ability levels. The instructor notes how she attempted to overcome this problem:

> Several students in the special education program struggled to go through an online lesson without having it read to them by a para-educator. Therefore, I began recording myself reading the content aloud and inserting the audio file into the lesson. This was an incredibly time consuming process. While this was designed to help struggling readers, other students took advantage of this option and chose to simply listen to the lesson while playing a separate game on their computer. This did not result in effective learning of the science content.

The results of the quantitative and qualitative data help to address the research questions and expand on trends noted in the existing literature about blended learning. Further analysis of the results and relevance to science teaching are the focus of the discussion section.

CHAPTER 5

DISCUSSION

This study compared face-to-face instruction with blended learning by collecting data about student opinions, attitudes, and understanding of science skills and content. The data supported much of what was found in the literature and also described specific factors affecting the blended learning experience for both the students and the instructor.

Student Attitudes about Science

Student attitudes about science and the nature of science were measured using six statements on a pretest and posttest. Using a Likert-scale, students indicated their level of agreement with each statement at the beginning and end of the study. Data analysis showed no statistical difference in the pretest and posttest responses for the treatment or control groups. This indicates student attitudes and opinions related to the nature of science remained unchanged.

This study lasted only four months and while the treatment group did experience a shift in teaching style the actual instructor remained the same. The science content presented during the study was related to chemistry and physics and did not specifically discuss scientific processes or the role of science. Therefore, it is not surprising that student attitudes about science were unchanged. This finding supports research which indicated explicit and reflective instruction about the nature of science, and not just inquiry learning, is required to alter student conceptions about the nature of science (Khishfe & Abd-El-Khalick, 2002).

Student Understanding of Science

A modified version of the Lawson Assessments was used to measure student understanding of the scientific method, chemistry, and physics. Analysis of student scores on the pretest and posttest displayed significant growth within the treatment group (p=.002) but not in the control group (p=.079).

These quantitative results are congruent with current literature reporting increased student achievement in blended courses compared to exclusively face-to-face instruction. The majority of research related to blended learning has been at the post-secondary level and studies have indicated higher grades and increased pass rates for students in blended learning courses. For this study, grades were not used to compare achievement but the assessment tool measured student understanding of a breadth of science topics and processes. These results are further supported by a research study where the final exam measured student understanding of many topics and their interrelationship, students in the blended learning class earned higher scores (Dowling et al., 2003).

Further analysis of student responses to the pretest and posttest indicates significant growth on only four of the 22 multiple choice questions. These four questions addressed a variety of topics in the areas of chemistry and physics but not the scientific method. Table 12 summarizes where significant growth was observed on these four questions.

Table 12: Significant Growth on Pretest and Posttest Questions

Question and Topic	Significant Growth	
	Control Group	Treatment Group
#19: Density	Yes	No
#23: Frame of Reference	No	Yes
#24: Force on Charged Particles	No	Yes
#28: Action and Reaction Forces	Yes	Yes

Question #28 was the only assessment item displaying significant growth for both the control and treatment groups. This specific question covers the topic of Newton's Third Law of Action and Reaction Forces. The instructor specifically recalls reinforcing student understanding of this concept using the same in-class learning prompt for both groups. Therefore, with identical instruction, significant growth for both groups is a valid result.

The treatment group displayed significant growth on questions #23 and 24 while the control group did not. Both of these questions assessed topics discussed during the course of the research study: frame of reference and force on charged particles. The online modules included more information about these topics than what was discussed with the control group. The more focused inclusion of these topics in the online instruction resulted in significant growth for only the treatment group.

The final question showing significant growth from pretest to posttest was related to the topic of density. The control group alone displayed growth but this topic was not addressed during the time of the research study so it is not clear why this growth was observed. The instructor led more discussions and lectures with the control group and could have referenced the idea of density when helping students to understand the difference between the force of weight and the measurement of mass. When comparing weight and mass, students sometimes confuse the concepts of mass and density so the instructor may have clarified student understandings of density during class discussions. However, density was not an explicit part of the online content about weight and mass and the instructor led fewer discussions about the content with the treatment group. This could explain why the treatment group did not display significant growth on the topic.

Both the control and treatment group displayed an increase in mean scores from the pretest to the posttest of science skills and knowledge. However, statistically comparing these mean scores indicated the growth was significant for only the treatment group. The assessment instrument contained 22 multiple choice questions and significant growth was unique to the treatment group on only two questions. Both of these questions were related to physics content that was included in the online modules but not the in-class teaching of the control group. Therefore, the significant growth on those questions by the treatment group appears to be a reflection of the time spent on those topics in the online module rather than the actual implementation of blended learning.

The purpose of blended learning was to increase student knowledge of both science content and process skills by allowing more time for student-centered learning in the classroom. While the treatment group did show significant growth on questions related to physics content, there was not significant growth from pretest to posttest on any of the six questions related to science processes. The implementation of blended learning in this study did not meet the goal of increasing science process knowledge but student interviews provided insight on how to improve the blended learning environment.

Student Opinions of Blended Learning

Student opinions of the blended learning experience were gathered by interviewing six students in the treatment group. Analysis of interview transcripts indicated students have varied opinions and preferences when comparing blended learning to more traditional, face-to-face instruction. However, common themes about student learning within a blended design did emerge across the interviews. Students preferred the access to self-paced content in the online modules even though they were not motivated to complete the assigned modules. Students also suggested ways to improve the blended learning design and experience.

Student Learning Preferences

Students from the treatment group were categorized into high, average, and low achievement groups and two students from each group were selected for interviews. In these interviews, students were asked to compare their experiences with blended learning during the second semester of science with the more traditional, face-to-face instruction they received first semester. Of the six interview participants, three indicated a preference for more teacher-led instruction, two felt they benefited more from the use of online modules, and one gave no opinion (Table 13). There was no clear trend in learning preferences but both of the high-achieving students favored direct instruction from the teacher while neither of the low-achieving students indicated this preference. This possible link between student achievement levels and instructional design preferences should be further investigated because it appears to go against much of the research on learning preferences. Many studies have found high-achieving and gifted students prefer to work alone (Dunn, 1984; French, Walker, & Shore, 2011). In this study, completing the online modules provided the opportunity for students to work independently but the high-achieving students did not prefer this learning method. However, with such a small sample size, no clear conclusion can be made from this data and a study by Burns, Johnson, and Gable (1998) found differences in learning preferences within an achievement group could be as great as differences between achievement groups.

Table 13: Student Learning Preferences

Achievement Group	Pseudonym	Learning Preference	
		Teacher-Led	Online Modules
High-achieving	Alan	X	
	Ann	X	
Average-achieving	Brandy	X	
	Ben		X
Low-achieving	Cassie		X
	Chad	No preference given	

<u>Access to Online Science Resources</u>

Although not every student preferred using the online modules, the benefits of having the science content available online were discussed during every interview. More specifically, students indicated both self-paced learning and interactive simulations were helpful in the online environment.

Interview participants noted the convenience of having all the science content organized within the modules and available on their laptops. While the content was organized in a similar fashion in their science textbook, students rarely used the book over the course of the school year. Since students had their laptops at all times they also had access to the science content any time they accessed the Internet. This allowed students to learn at their own pace both in and out of class by simply following the teacher prompts for online assignments. The blended learning research of Bliuc et al. (2007) reported students benefitted from the self-paced online learning portion and this study supports that finding.

Interactive games and simulations were the primary online resource students said helped them to learn and these would not be possible in a traditional textbook. Research by Thomas and Milligan (2004) indicates the use of interactive, challenging, task-based online simulations encourages students to take a more active role in their learning. The games and simulations used in this study provided instant feedback and were often used to introduce or review concepts. Research has shown immediate feedback from online simulations to be an effective form of self-assessment which engages students in their learning (Nicol & Milligan, 2006). During interviews, students from each achievement level mentioned how these interactive games helped them to learn and were also their favorite part of the online modules.

Student Motivation for Online Learning

One goal of blended learning is for students to independently learn about content through online modules. Osguthorpe and Graham (2003) included this focus on self-directed learning as one of the six specific goals for designing a blended learning environment. Completion of the online tasks outside of class would then allow for more authentic learning and discussion to take place in class.

During interviews for this study, students indicated a lack of motivation to actually complete the modules and desired some type of reward or extra credit for learning on their own. In an effort to help students become more comfortable completing the online tasks, they were given time during class to work but frequent distractions such as online games were noted. These distractions and lack of motivation resulted in the need to re-teach concepts during class rather than focusing on discussion, scientific inquiry, and authentic learning activities.

Research studies related to student motivation are often framed within the constructs of self-regulated learning (SRL), which has been widely researched in the fields of education and psychology. Dembo and Eaton (2000) view academic SRL as "the ability of students to control the factors or conditions affecting their learning" (p. 474). Motivation is a key dimension for SRL but unfortunately most adolescents believe they must depend on their teachers and parents for motivation. For teachers to increase intrinsic student motivation and reduce distractions they must provide timely feedback and actively help students to set goals as they maintain positive beliefs in their academic abilities. If teachers create an environment focused on developing the skills of self-regulation it can lead to greater academic achievement (Dembo & Eaton, 2000).

In terms of pedagogy, motivation can also be enhanced by focusing on mastery goals for student learning rather than just performance goals. Mastery-oriented classrooms and assessments motivate students by helping them to believe the learning outcome will depend on their effort. Students are also given a measure of control as their abilities and interests determine either the learning process or product (Ames, 1992).

A recent study from a vocational school in Taiwan examined the effects of self-regulated blended learning for students in a software application course (n=177). The strategies of SRL were purposefully incorporated when the blended approach was implemented with the treatment group. At the end of the course, students took a software certification exam and the pass rate was significantly higher in the treatment group than the control group. Student course evaluations also reported the online activities and SRL techniques to be helpful when learning the content (Shen, Lee, & Tsai, 2011).

In this study, the instructor did not focus on setting goals with students but the online modules would have been more aligned with the notion of performance goals rather than mastery. The execution of blended learning in this study also did not focus on student interests or varied ability levels. Considering these conditions and the research on SRL, it is not surprising that students lacked motivation and were frequently distracted.

The research related to student motivation and the data from this study indicate future implementations of blended learning should explicitly teach students the skills of self-regulated learning and also allow for student control of learning related to their interests.

Improving Blended Learning

Students in the treatment group of this study experienced one semester of traditional, teacher-directed science instruction and one semester where laptops were utilized for a blended learning environment. This provided students with the unique opportunity to reflect on their science learning from two different perspectives. During interviews, students provided ideas for improving the blended learning experience.

To improve student learning, the high-achieving interview participants recommended a better blend of in-class and online learning. They suggested more class discussion of the online learning along with some teacher-led instruction. This was the original intent of blended learning, but the proposed blend of instructional strategies was impaired due to a deficit in student motivation. Students did not complete the online modules outside of class and therefore more class time was used for completing, rather than discussing, the online modules.

When designing blended learning, Babb et al. (2010) indicated the need for a user-friendly online learning management system. In this study, the students and instructor all indicated the need for changes in the online module design. Both the layout of the content and the large amount of required reading were described as problematic for students. The online component used in this study was purchased by the State of Iowa and the instructor had limited options for editing or personalizing it. Students struggled to navigate through the multiple pages of content and were reluctant to complete all of the reading presented in the modules. These factors severely hindered the effectiveness of the online learning.

Limitations and Future Work

As with all research, this study is not without its weaknesses and limitations. As noted by Aycock et al. (2002), blended learning is not truly about the learning but is actually about the teaching. Research studies have shown successful blended courses require a complete redesign of teaching methods to integrate in-class and online learning. Unfortunately, that did not happen in this study. Due to the nature of this study in a small high school setting, the treatment and control groups could not have totally divergent paths. To minimize the risks associated with human participant research, both the instructional timelines and assessments had to remain parallel for the two groups. This, along with the premade online modules, limited the options for redesigning the teaching methods.

In this study, student science abilities were assessed using instruments compiled by Anton Lawson. The science questions focused on the topics of chemistry and physics but some questions addressed content that was not specifically taught during the time of this research study. While the Lawson tests have been used in many studies, the tests were not tailored to assess the specific learning goals expected of students over the course of this study. The decision was made to use whole sections of the Lawson tests, rather than individual questions, in an effort to retain their previously measured validity and reliability. This discord between assessment questions and course content could have limited the effectiveness of the instrument used to measure student understanding of the science content.

The online modules used in this study were limited in their use of research-based teaching practices. Within the modules, large amounts of text were used to present the majority of the content. Videos, simulations, and diagrams were occasionally included but overall the modules were similar to a traditional textbook. Students were reluctant to participate in any of the other online features such as discussion boards, links to additional resources, and formative assessments. The goal of blended learning is to utilize the best teaching practices in both the classroom and the online environment but that was not achieved and likely limited the scope of this study.

While the blended learning was not as pedagogically rich as intended, this study does provide topics for future research. In this study, the mid-year transition to blended learning and the need to remain lockstep with the control group may have confounded the results. A yearlong study would be more effective for comparing student achievement, especially if the treatment and control groups are able to have disparate timelines and assessments.

The use of purchased online modules and low student motivation also appear to have influenced the outcomes of this research. The researcher would like to investigate a possible relationship between these two factors. A study could compare the level of student engagement in the online learning with the amount of instructor control of module design.

Implications for Instruction

The findings from this study have implications for designing both online course content and blended learning. For more effective online learning, instructors must be directly involved in the creation of online content and resources for their students. As teachers design and edit the online layout they can also differentiate for learning styles and abilities by providing a wide variety of learning tools. The online lessons must provide more than just reading material for the students and teachers should be able to edit the content in accordance with student needs.

Students were not motivated or engaged by the online modules but students using the modules did display more growth on the assessment instrument than those who experienced only face-to-face instruction. This implies student learning was not adversely affected by the use of the online curriculum even though it was not designed with the best methods for online learning. More research should be conducted to determine if a better online module design would result in even more growth in student learning.

To enhance both student learning and engagement, the design of online modules should especially capitalize on the use of simulations and games with instant feedback. Interviews with students indicated those were the most effective components of the online content and many research studies have shown online simulations to encourage student learning. While teachers may not be able to design their own simulations, many are already available online and could be added as links within the course content.

This research indicates the need for blended learning classrooms to focus on teaching the skills of self-regulated learning. For the ideal blended learning experience, students must be motivated to work outside of class. While some students are intrinsically motivated to learn and complete assignments, others will need more encouragement to meet the goal of independent learning. Student motivation could be increased if the blended learning allows for some student control of content, relates to their interests, and focuses on mastering the content.

The use of technology in the classroom continues to grow and holds limitless possibilities for improving student learning. Blended learning has the potential to expand avenues for learning by combining the best practices of in-class instruction with the most useful online resources. More research is needed to understand how to best design and implement this new foundation for learning.

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APPENDIX A

PHYSICAL SCIENCE ATTITUDES, SKILLS, AND KNOWLEDGE SURVEY (PSASKS)

Directions to Students:
Please respond to the following items by marking the best answer on your answer sheet. Do not write on this survey. Scratch paper will be provided on request. Please respond on the accompanying sheet. If you do not understand what is being asked in an item please ask the survey administrator for clarification. Calculators not permitted.

Arizona Collaborative for Excellence in the Preparation of Teachers
Supported by the National Science Foundation under Grant DUE-0084434 September, 2000

Use the following key to indicate to what degree you agree with items 1 – 6.

5 = strongly agree
4 = agree
3 = don't know
2 = disagree
1 = strongly disagree

1. I am good at science.
   On your answer sheet, explain your answer.

2. Science is useful for everyday problems.
   On your answer sheet, explain your answer.

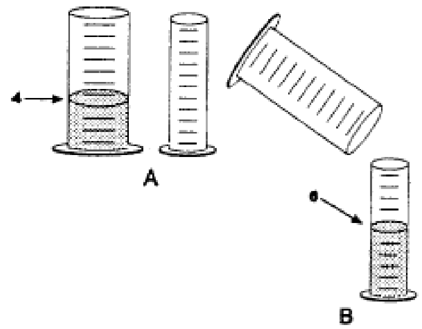
3. Hypotheses/theories cannot be proved to be true beyond any doubt.

4. To test a hypothesis, one needs a prediction.

5. The primary goal of modern science is to discover facts about nature.

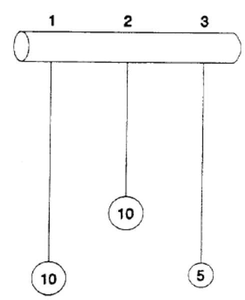
6. Coming up with hypotheses requires creative thinking.

7. To the right are drawings of a wide and a narrow cylinder. The cylinders have equally spaced marks on them. Water is poured into the wide cylinder up to the 4th mark (see A). This water rises to the 6th mark when poured into the narrow cylinder (see B). Both cylinders are emptied, and water is poured into the narrow cylinder up to the 11th mark. How high would this water rise if it were poured into the empty wide cylinder?
    a. to about 7 ½
    b. to about 9
    c. to about 8
    d. to about 7 1/3
    e. none of these answers is correct



8. because
    a. the ratios must stay the same.
    b. one must actually pour the water and observe to find out.
    c. the answer cannot be determined with the information given.
    d. it was 2 less before so it will be 2 less again.
    e. you subtract 2 from the wide for every 3 from the narrow.

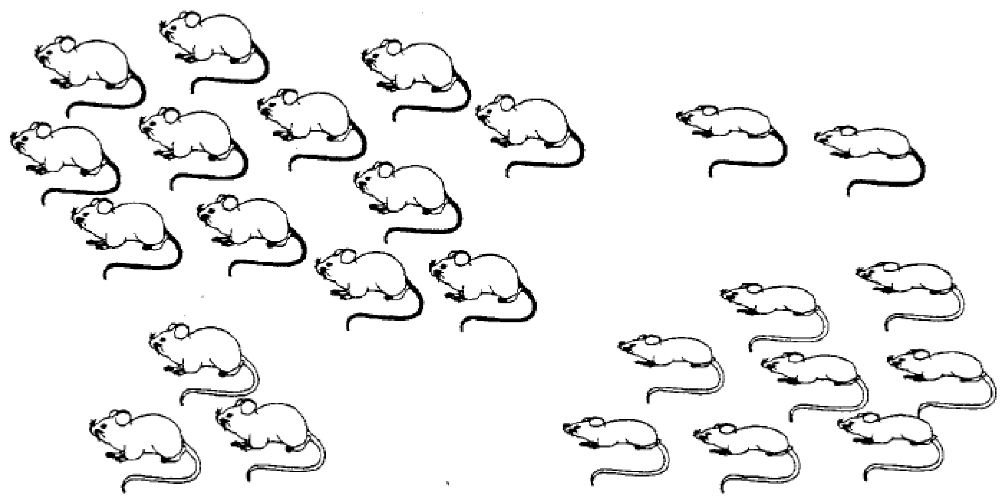
9. At the right are drawings of three strings hanging from a bar. The three strings have metal weights attached to their ends. String 1 and String 3 are the same length. String 2 is shorter. A 10 unit weight is attached to the end of String 1. A 10 unit weight is also attached to the end of String 2. A 5 unit weight is attached to the end of String 3. The strings (and attached weights) can be swung back and forth and the time it takes to make a swing can be timed.



    Suppose you want to find out whether the length of the string has an effect on the time it takes to swing back and forth. Which strings would you use to find out?
    a. only one string
    b. all three strings
    c. 2 and 3
    d. 1 and 3
    e. 1 and 2

10. because
    a. you must use the longest strings.
    b. you must compare strings with both light and heavy weights.
    c. only the lengths differ.
    d. to make all possible comparisons.
    e. the weights differ.

11. Farmer Brown was observing the mice that live in his field. He discovered that all of them were either fat or thin. Also, all of them had either black tails or white tails. This made him wonder if there might be a link between the size of the mice and the color of their tails. So he captured all of the mice in one part of his field and observed them. Below are the mice that he captured.



Do you think there is a link between the size of the mice and the color of their tails?

a. appears to be a link
b. appears not to be a link
c. cannot make a reasonable guess

12. because

a. there are some of each kind of mouse.
b. there may be a genetic link between mouse size and tail color.
c. there were not enough mice captured.
d. most of the fat mice have black tails while most of the thin mice have white tails.
e. as the mice grew fatter, their tails became darker.

13. Below is a list of properties of a sample of solid sulfur:
    i. Brittle, crystalline solid
    ii. Melting point of 1130 °C
    iii. Yellow color
    iv. Combines with oxygen to form sulfur dioxide

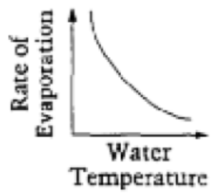
    Which, if any, of these properties would be the same for one single atom of sulfur obtained from the sample?
    a. i and ii only
    b. iii and iv only
    c. iv only
    d. All of these properties would be the same
    e. None of these properties would be the same

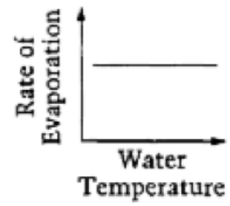
14. Iron combines with oxygen and water from the air to form rust. If an iron nail were allowed to turn entirely to rust, the rust should weigh:
    a. less than the nail it came from.
    b. the same as the nail it came from.
    c. more than the nail it came from.
    d. it is impossible to predict.

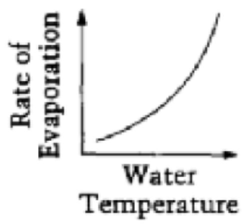
15. because
    a. rusting makes the nail lighter.
    b. rust contains iron and oxygen.
    c. the nail flakes away.
    d. the iron from the nail is destroyed.
    e. the flaky rust weighs less than iron

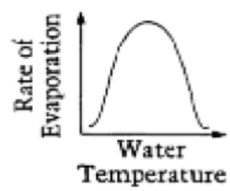
16. In an experiment, 12.0 grams of solid carbon reacted with oxygen gas to form 44.0 grams of carbon dioxide gas. How many grams of oxygen reacted with the carbon?
    a. 12.0 grams
    b. 32.0 grams
    c. 44.0 grams
    d. 56.0 grams

17. Which of the following graphs shows how the rate of evaporation changes with changes in water temperature?

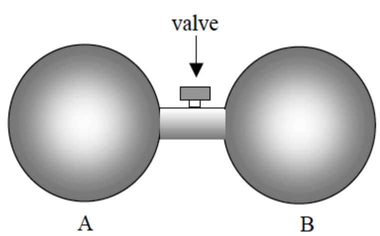
a. 

b. 

c. 

d. 

18. Two bulbs of equal volumes contain a gas.



The gas pressure is equal in both bulbs. Bulb 'B' is heated to a temperature of 100°C while Bulb 'A' remains at room temperature. During the heating the valve is open. After heating, the valve is closed and the system is allowed to cool. What happens?

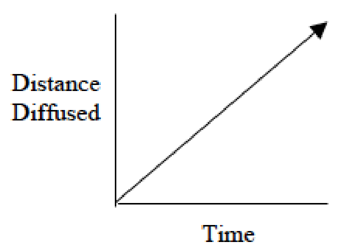
a. Bulb 'B' will have more molecules than Bulb 'A'.
b. Bulb 'A' will have more molecules than Bulb 'B'.
c. Bulb 'B' will have greater pressure than Bulb 'A'.
d. Bulb 'A' and Bulb 'B' will possess equal pressures.

Use the following data when answering item 19.

Chemical	Density (g/ml)	Chemical	Density (g/ml)
Magnesium	1.74	Water	1.00
Aluminum	2.70	Carbon Tetrachloride	1.59
Lead	11.3	Mercury	13.6
Iron	7.87	Gasoline	0.68
Gold	19.3	Ethyl Alcohol	0.79

19. Water, gasoline, mercury, and carbon tetrachloride are poured into a graduated cylinder. A sample of magnesium is then dropped into the cylinder. Where would you most likely find the magnesium?
    a. beneath the water, above the carbon tetrachloride
    b. beneath the carbon tetrachloride, above the mercury
    c. beneath the water, above the mercury
    d. beneath the mercury

Use the following graph when answering item 20.



20. A drop of food coloring is added to water at room temperature. The diffusion rate of the food coloring is depicted by the graph above. The following experiments were conducted to investigate the diffusion rates under different conditions.

    Procedure 1: A drop of food coloring was added to warm water.

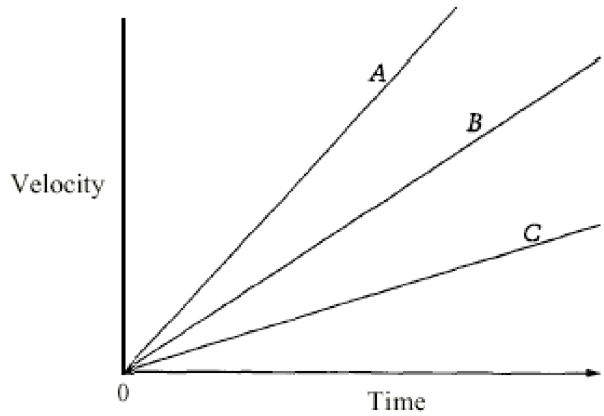
    Procedure 2: A drop of food coloring is added to cold water.

    Procedure 3: A drop of food coloring is added to salt water.

    Procedure 4: Heated food coloring is added to room temperature water.

    Which procedure(s) would slow the diffusion rate?
    a. Procedure 1 and Procedure 4
    b. Procedure 1, Procedure 3, and Procedure 4
    c. Procedure 2, Procedure 3, and Procedure 4
    d. Procedure 2 and Procedure 3

Questions 21 – 22 refer to the following information:



A graph of velocity as a function of time when the same net force is applied to three different objects (A, B, and C) is shown above.

21. Which object has the greatest acceleration?
    a. A
    b. B
    c. C
    d. They all have the same acceleration

22. Which object has the greatest mass?
    a. A
    b. B
    c. C
    d. They all have the same mass

23. A woman traveling in a train watches a train on an adjacent track go past her window. The time the other train takes to completely pass her depends on all of the following except:
    a. the speed of the train on which the woman is traveling.
    b. the speed of the other train.
    c. the length of the train on which the woman is traveling.
    d. whether the trains are traveling in the same direction or in opposite directions.

24. Two electrically charged particles held close to each other are released. As they move, the force on each particle increases. Therefore, the particles have
    a. the same sign.
    b. opposite signs.
    c. not enough information given.

25. When a small volume of water is boiled, a large volume of steam is produced because:
    a. the molecules are further apart in steam than in water.
    b. water molecules expand when heated.
    c. the change from water to steam causes the number of molecules to increase.
    d. atmospheric pressure works more on water molecules than on steam molecules.
    e. water molecules repel each other when heated.

26. Two metal balls are the same size but one weighs twice as much as the other. The balls are dropped from the roof of a single story building at the same instant in time. The time it takes the balls to reach the ground will be:
    a. about half as long for the heavier ball as for the lighter one.
    b. about half as long for the lighter ball as for the heavier one.
    c. about the same for both balls.
    d. considerably less for the heavier ball, but not necessarily half as long.
    e. considerably less for the lighter ball, but not necessarily half as long.

27. A stone dropped from the roof of a single story building to the surface of the Earth:
    a. reaches a maximum speed soon after release and then falls at a constant speed thereafter.
    b. speeds up as it falls because the gravitational attraction gets considerably stronger as the stone gets closer to the Earth.
    c. speeds up because of an almost constant force of gravity acting upon it.
    d. falls because of the natural tendency of all objects to rest on the surface of the Earth.
    e. falls because of the combined effects of the force of gravity pushing it downward and the force of the air pushing it downward.

28. A large truck collides head-on with a small compact car. During the collision:
    a. the truck exerts a greater amount of force on the car than the car exerts on the truck.
    b. the car exerts a greater amount of force on the truck than the truck exerts on the car.
    c. neither exerts a force on the other, the car gets smashed simply because it gets in the way of the truck.
    d. the truck exerts a force on the car but the car does not exert a force on the truck.
    e. the truck exerts the same amount of force on the car as the car exerts on the truck.

APPENDIX B

IRB APPLICATION

University of Northern Iowa
Standard Application for Human Participants Review

Note: Before completing application, investigators must consult guidance at: http://www.uni.edu/osp/irb Always check website to download current forms.

All items must be completed and the form must be typed or printed electronically. Submit 2 hard copies to the Human Participants Review Committee, Office of Sponsored Programs, 213 East Bartlett, mail code 0394

Title of proposal: **Investigating Blended Learning in the High School Science Classroom**

Name of (PI) Principal Investigator(s): **Holly Hinkhouse**

PI Status: ☐ Faculty ☐ Undergraduate Student ☒ Graduate Student ☐ Staff ☐ Non-UNI

Project Type: ☐ Faculty/Staff Research ☒ Thesis/Dissertation ☐ Other-specify:

PI Department:	**Science Education**	PI Phone:	**(712) 369-1881**	PI Email:	**hollych83@hotmail.com**
PI Address:	**508 Walnut St. Oakland IA 51560**				
Faculty Advisor Mail Code:	**281 MSH**	Advisor Phone:	**(319) 273-3296**	Advisor Email:	**dawn.delcarlo@uni.edu**
Source of Funding:	**None**				
Project dates: Beginning	January 9, 2012	Through	May 25, 2012		

All key personnel and Advisor (if applicable) must be listed and must complete IRB training/certification in Human Participants Protections. Attach a copy of the certificate, if not already on file *in the IRB office*.

Principal Investigator	Holly Hinkhouse	Certificate Attached	☐	On File ☒
Faculty Advisor	Dawn Del Carlo	Certificate Attached	☐	On File ☒
Other Key Personnel:	Veva Larson	Certificate Attached	☐	On File ☒

SIGNATURES: The undersigned acknowledge that: 1. this application represents an Accurate and complete description of the proposed research; 2. the research will be conducted in compliance with the recommendations of and only after approval has been received the UNI IRB. The PI is responsible for reporting any adverse events or problems to the IRB, for requesting prior IRB approval for modifications, and for requesting continuing review and approval.

Principal Investigator:	Holly Hinkhouse		
	TYPED NAME	SIGNATURE	DATE
Faculty Advisor (required for all student projects):	Dawn Del Carlo		
	TYPED NAME	SIGNATURE	DATE

Committee Use Only

EXEMPT FROM CONTINUING REVIEW ☐ EXPEDITED APPROVAL ☐

FULL BOARD APPROVAL ☐

REVIEW COMMITTEE SIGNATURE ________________________________ DATE __________

Period of approval: ____________ Effective through ____________

____

A. PURPOSE OF RESEARCH.

Explain 1) why this research is important and what the primary purposes are, 2) what question(s) or hypotheses this activity is designed to answer, and 3) whether and how the results will be used or disseminated to others.

1) The enhanced accessibility and capabilities of the Internet have created limitless possibilities for designing, developing and implementing innovative teaching methods. A wide variety of studies have shown online learning to be at least as effective, and often times more effective, than traditional, face-to-face classes. However, research has shown the greatest improvement in student learning occurs when online courses also involve some in-class learning. This “blended learning” approach combines the best pedagogical practices of an online learning community with the interaction of traditional, face-to-face learning. Most blended conditions include additional learning time and instructional elements not possible when courses are strictly online or in-class.

The effects of blended learning have been researched at the post-secondary level and most studies have displayed positive benefits for students in the form of achievement, attitudes, and/or community building. However, only a handful of studies have been reported for the use of blended learning in the high school setting.

The purpose of this research is to measure, analyze, and compare student achievement and opinions of blended learning in an Iowa 9^{th} grade Physical Science classroom. This study will use both quantitative and qualitative research methods to compare the achievement and opinions of students in a blended learning environment to those of students in a traditional classroom.

2) The two research questions guiding this study are: 1) How does blended learning affect student attitudes and understanding of science skills and content in a 9^{th} grade Physical Science class? 2) What are student opinions of the blended learning environment?

3) The findings of this research will be of interest to educators, policymakers, and stakeholders because student achievement of state standards is of utmost importance. Results of student achievement and student opinions will be shared with other educators implementing a blended learning approach. Results may also be published in a peer-reviewed journal and will be used to fulfill the thesis requirement for the MA in Science Education.

B. RESEARCH PROCEDURES INVOLVED.

Provide a step-by-step description of all study procedures (e.g., where and how these procedures will take place, presentation of materials, description of activity required, topic of questionnaire or interview). Provide this information for each phase of the study (pilot, screening, intervention and follow-up). <u>Attach</u> questionnaires, interview questions/topic areas, scales, and/or examples of materials to be presented to participants.

Invitation:

In December 2011, an invitation asking students to participate in the research study will be read to all 49 students enrolled in Physical Science at Riverside High School in Oakland, Iowa. The high school principal will read the invitation script (see Appendix A) and will give students a consent form. Students will ask a parent/guardian to read and sign the form. All students will return the consent form to the school secretary.

This population of students is randomly scheduled into three separate classes of Physical Science with the researcher being the instructor of all three sections. For this study, two sections will be considered the treatment group and will use the online science curriculum as an integral part of learning and instruction. The remaining section will serve as a control and will not use the online curriculum. The use of the online modules will be a regular part of instruction for all students in the treatment group even if a student chose to not have his/her data included in the research project.

Pre/Post-test:

In this study, items from assessments created by Anton Lawson and the Arizona Collaborative for Excellence in the Preparation of Teachers will be used to quantitatively measure student achievement of physical science skills and concepts. The Lawson tests were designed to measure student attitudes, skills, and knowledge in the areas of math and science. Student attitudes about science and the nature of science are assessed with questions using a Likert-scale while content knowledge and skills are measured with multiple-choice questions. The assessment questions were compiled from other resources (i.e., International Association for the Evaluation of Education Achievement, 1998; National Center for Education Statistics, 1998) and the questions for the specific disciplines of biology, chemistry, physics, and mathematics were then each divided into three equivalent forms.

For this study of physical science achievement, only the content areas of chemistry and physics will be assessed. The assessment for this study (see Appendix B) will consist of questions from Lawson's Chemistry Attitudes, Skills, and Knowledge Survey (CASKS) Form 3 and Lawson's Physics Attitudes, Skills, and Knowledge Survey (PASKS) Form 1. Questions from these assessments address main ideas such as the scientific method, chemical reactions, density, and gravity.

Student achievement will be measured with both a pretest and a posttest in the treatment and control groups. All Physical Science students will be given the edited Lawson test in January 2012, prior to the implementation of blended learning, and again in May 2012. The school principal will administer the test in the science classroom and participation and performance will not influence student grades.

Interviews:

To address the second research question, student opinions of blended learning will be qualitatively assessed using semi-structured interviews at the conclusion of the semester in May 2012. A retired teacher, who is not the participants' science teacher, will conduct the interviews. Midterm grades will be used to classify students in the treatment group as high-achieving, average-achieving, and low-achieving. The interviewer will be given the list of students in the treatment group and will randomly select two students from each achievement level to invite for interviews (see Appendix C). The interviewer will send an invitation letter to the students' school email addresses and will ask them to send an email response about whether or not they would like to schedule an interview. Students will not be required to participate in the interviews and will not receive any incentive for being interviewed. Once the semester has ended and student grades are submitted, interviews will be recorded for transcription and inductively analyzed.

Interviews will include, but not be limited to, the following questions:

- How does this semester of Physical Science, with the online learning, compare to the first semester of science?

- How do you think communication with your teacher changed from first semester to second semester?
- How did your activities in class change once you began using online learning?
- How did the amount of work required of you change, both in and out of class, once you started using online learning? How did your desire to complete that work change?
- How do you think the online environment affected your learning?
- What did you enjoy most about the online environment?
- What was difficult about the online environment?

C. DECEPTION.

If any deception or withholding of complete information is required for this activity: a) explain why this is necessary and b) explain if, how, when, and by whom participants will be debriefed. Attach debriefing script.

Deception will not be used in this research.

D. PARTICIPANTS.

1. Approximately how many participants will you need to **complete** this study?

   Number: 25 Age Range(s): 13-16

2. What characteristics (inclusion criteria) must participants have to be in this study? (Answer for each participant group, if different.)

   Must be enrolled in Physical Science at Riverside High School in Oakland, Iowa.

3. Describe how you will recruit your participants and who will be directly involved in the recruitment. Key personnel directly responsible for recruitment and collection of data must complete human participant protection training. Attach all recruiting advertisements, flyers, contact letters, telephone contact protocols, web site template, PSPM description, etc. that you will use to recruit participants. If you plan to contact them verbally, in person or over the telephone, you must provide a script of what will be said.

Note: Recruitment materials, whether written or oral, should include at least: a) purpose of the research; b) general description of what the research will entail; and c) your contact information if individuals are interested in participating in the research.

Possible participants are limited to the Riverside High School Physical Science students. These students will be invited to participate in the research study by the school principal, Mr. David Gute, during class in December 2011. Mr. Gute will read a script (see Appendix A) to inform students about the study and will then give each student a parental consent form.

4. How will you protect participants' privacy during recruitment? Note: This question does not pertain to the confidentiality of the data; rather it relates to protecting privacy in the recruitment process when recruitment may involve risks to potential participants. Individual and indirect methods of contacting potential participants assist in protecting privacy.

The researcher will ask potential participants to return a parent/guardian permission form indicating whether or not the student will be participating in the study. Forms will be returned to the school secretary and kept in a secure filing cabinet. To protect privacy, all students will be required to return the forms even if they choose not to participate in the study.

5. Explain what steps you will take during the recruitment process to minimize potential undue influence, coercion, or the appearance of coercion. What is your relationship to the potential participants? If participants are employees, students, clients, or patients of the PI or any key personnel, please describe how undue influence or coercion will be mitigated.

The researcher is also the science teacher of the potential participants and therefore will not introduce the research project. To minimize coercion, the high school principal, rather than the researcher, will read a prepared script (see Appendix A) to inform students about the research project. This script will explain the research project to students and invite them to participate if they so choose. The formal consent forms will then be given to students by the principal. All students will be asked to return consent forms to the school office personnel and the forms will indicate the students' consent or non-consent. The researcher will be made aware when all forms have been returned but will not know who has chosen to participate in the research until the conclusion of the study.

6. Will you give compensation or reimbursement to participants in the form of gifts, payments, services without charge, or course credit? If course credit is provided, please provide a listing of the research alternatives and the amount of credit given for participation and alternatives.

☒ No ☐ Yes If yes, explain:

7. Where will the study procedures be carried out? If any procedures occur off-campus, who is involved in conducting that research? Attach copies of IRB approvals or letters of cooperation from non-UNI research sites if procedures will be carried out elsewhere.

(Letters of cooperation are required from all schools where data collection will take place, including Price Lab School.)

☐ On campus ☒ Off campus ☐ Both on- and off-campus

8. Do offsite research collaborators involved in participant recruitment or data collection have human participants protections training? Note: Individuals serving as a "conduit" for the researcher (i.e., reading a recruitment script developed by the researcher and not in a supervisory or evaluative role with participants) are not considered key personnel and human participants training is not required.

☐ No ☒ Yes ☐ Don't know ☐ Not applicable

E. RISKS AND BENEFITS.

1. All research carries some social, economic, psychological, or physical risk. Describe the nature and degree of risk of possible injury, stress, discomfort, invasion of privacy, and other side effects from all study procedures, activities, and devices (standard and experimental), interviews and questionnaires. Include psychosocial, emotional and political risks as well as physical risks.

This study is of very low risk to participants. There is no risk of injury for participants. Possible stress may occur when students take the pretest and posttest. There is minimal risk of invasion of privacy because participant identification will be removed and replaced with codes. There are no foreseeable physical risks to participants.

Physical Science students will all learn the same content but the treatment group will learn using online modules while the control group will continue the traditional in-class learning. The online modules will be a regular part of instruction regardless of student consent but students may choose whether or not to have their pretest and posttest data included in the data analysis. Therefore, some students may experience stress or anxiety due to the teaching method used in their particular section of Physical Science. However, teaching methods are at the discretion of the instructor and the data collected during this research project should not increase a student's stress or anxiety.

2. Explain what steps you will take to minimize risks of harm and to protect participants' confidentiality, rights and welfare. (If you will include protected groups of participants which include minors, fetuses in utero, prisoners, pregnant women, or cognitively impaired or economically or educationally disadvantaged participants, please identify the group(s) and answer this question for each group.)

All students are minors and have the right to not participate in this study. All participant information will be coded for privacy. A research assistant who is not associated with the class or students will use codes to protect the information of all participants and will not inform the researcher (and teacher of the participants) of these codes.

3. Study procedures often have the potential to lead to the unintended discovery of a participant's personal medical, psychological, and/or psycho-social conditions that could be considered to be a risk for that participant. Examples might include disease, genetic predispositions, suicidal behavior, substance use difficulties, interpersonal problems, legal problems or other private information. How will you handle such discoveries in a sensitive way if they occur?

Given the nature of the study, it is unlikely these issues would arise. However, if a participant does encounter these issues they would be allowed to exit the study and would be directed to the appropriate resources for help (i.e. school guidance counselor, parent, etc.).

4. Describe the anticipated benefits of this research for individual participants. If none, state "None."

It is hypothesized that compared to traditional learning the blended learning approach will lead to increased achievement of science standards by implementing an interactive, standards-based, online curriculum which will allow more time for meaningful scientific inquiry in the classroom setting.

5. Describe the anticipated benefits of this research for the field or society, and explain how the benefits outweigh the risks.

Iowa's science education standards focus not only on content but also on the processes of scientific inquiry. While an online curriculum can help students to learn the content, understanding the concepts of inquiry requires hands-on experimentation and collaboration. This research will measure student achievement and opinions of a blended learning approach in the high school science classroom. Potential risk to participants is very low and both the researcher and participants will benefit from learning how to navigate a partially-online learning environment.\

F. CONFIDENTIALITY OF RESEARCH DATA.

1. Will you record any participant identifiers? (Direct personal identifiers include information such as name, address, telephone number, social security number, identification number, medical record number, license number, photographs, biometric information, etc. Indirect personal identifiers include information such as race, gender, age, zip code, IP address, major, etc.)

☒ No ☐ Yes If yes, explain a) why recording identifiers is necessary and b) what methods you will use to maintain confidentiality of the data (e.g., separating the identifiers from the other data; assigning a code number to each participant to which only the research team has access; encrypting the data files; use of passwords and firewalls, and/or destroying tapes after transcription is complete and using pseudonyms.) Also explain, c) who will have access to the research data other than members of the research team, (e.g., sponsors, advisers, government agencies) and d) how long you intend to keep the data.

2. After data collection is complete, will you retain a link between study code numbers and direct identifiers?

☒ No ☐ Yes If yes, explain why this is necessary and for how long you will keep this link.

3. Do you anticipate using any data (information, interview data, etc.) from this study for other studies in the future?

☒ No ☐ Yes If yes, explain and include this information in the consent form.

G. ADDITIONAL INFORMATION.

1. Will you access participants' medical, academic, or other personal records for screening purposes or data collection during this study? Note: A record means any information recorded in any way, including handwritten, print, computer media, video or audio tape, film, photographs, microfilm, or microfiche that is directly related to a participant.

   ☒ No ☐ Yes. If yes, specify types of records, what information you will take from the records and how you will use them. **Permission for such access must be included in the consent form**.

2. Will you make sound or video recordings or photographs of study participants?

   ☐ No ☒ Yes. If yes, explain what type of recordings you will make, how long you will keep them, and if anyone other than the members of the research team will be able to see them. **A statement regarding the utilization of photographs or recordings must be included in the consent information.**

   Interviews with participants will be audio recorded for transcription. These recordings will be saved only until they have been transcribed by a research assistant. Therefore, audio recordings will be destroyed within one month of the completion of the study.

H. CONSENT FORMS/PROCESS (Check all that apply.)

☒ **Written Consent** - Attach a copy of all consent and assent forms.

☐ **Oral Consent** - Provide a) justification for not obtaining written consent, and b) a script for seeking oral consent and/or assent.

☐ **Elements of Consent Provided via Letter or Electronic Display** – Provide a) justification for not obtaining written consent, and b) the text for the letter of consent or the electronic display.)

☐ **Waiver of Consent** Provide a written justification of waiver of consent process. Note that waiver of consent is extremely rare and would only be granted if the consent process itself posed a greater risk to participants than did participation in the research.

Parent or Guardian Consent Form for Research Involving a Minor

Title of Project: Investigating Blended Learning in the High School Science Classroom
Researcher: Holly Hinkhouse, Riverside Science Teacher

Invitation to Participate: Your permission is being sought to have your child participate in this research study conducted through the University of Northern Iowa. Please read the following information carefully before you decide whether or not to give your permission.

Purpose of the Research: The purpose of this research is to measure, analyze, and compare student achievement and opinions of blended learning in a 9th grade Physical Science classroom. This “blended learning” approach combines the best practices of an online learning community with the interaction of traditional, face-to-face learning.

Procedure:
To gain an understanding of the effects of blended learning, some Physical Science students will begin to learn science content using state-approved online modules. All students will learn the same content but some will use the online modules while others do not. Students will be asked to complete a pretest in January 2012 and a posttest in May 2012. Students will complete these multiple choice tests during class but the results will not influence student grades.

In May 2012, several students will be invited for interviews where a retired teacher will ask questions about the blended learning experience. The interviewer (a retired Riverside teacher) will randomly select participants with different levels of achievement to invite for interviews. These invitations will be sent to the students’ school email addresses and students will be asked to reply about whether or not they would like to schedule an interview. The identity of the interviewed students will be kept confidential from the researcher (science teacher). Interviews will be optional, scheduled at the students’ convenience, will last no more than 30 minutes, and will be audio recorded for accurate transcription. The interviews can take place in the high school guidance counselor’s office or the Oakland Library.

At the conclusion of the study, the tests and interviews of the research participants will be analyzed. Only data from the consenting participants will be submitted for analysis. For the duration of the study, identifying information (such as names) will be removed from collected information, a code number will be assigned, and upon completion of the study, all tests and audio recordings will be destroyed.

Incentives/Benefits: There are no incentives or guaranteed benefits for participants.

Discomfort/Risks: This study is of very low risk to participants. Possible stress may occur when students complete the pretest and posttest. Participants may feel some stress when asked to explain their answers during interviews but the interviews are optional.

Confidentiality: Information containing any student identification will be kept confidential. The summarized findings of this research may be published but will contain no identifying information of participants.

Voluntary Participation: Student participation is completely voluntary. Participants are free to withdraw from participation at any time.

Time Duration of Research Study: The study will begin in January 2012 and will conclude in May 2012.

Questions: If you have questions regarding the research please direct them to Dr. Dawn Del Carlo at (319)273-3296 in the Department of Chemistry and Biochemistry, University of Northern Iowa. You may also contact the UNI Office of Sponsored Programs at (319)273-3217. If you would like to contact me directly, please call me at Riverside High School at (712)482-6464.

Sincerely,
Holly Hinkhouse
Riverside Science Teacher
UNI Graduate Student

Parent or Guardian Consent Form for Research Involving a Minor

Sign the left column to indicate your consent OR sign the right column to indicate non-consent. Return form to the high school office.

Consent for Participation	Non-Consent for Participation
I am fully aware of the nature and extent of my child's participation in this project as stated above. I hereby agree to allow my son/daughter's pre/post-test data to be used for this research project and I agree to allow my student to possibly participate in an optional interview if they so choose.	I am fully aware of the nature and extent of this project as stated above. I have chosen to **not** allow my son/daughter to participate in this project.
______________________________ (Signature of parent/guardian)	______________________________ (Signature of parent/guardian)
______________________________ (Printed name of parent/guardian)	______________________________ (Printed name of parent/guardian)
______________________________ (Printed name of Student)	______________________________ (Printed name of Student)
Date: ___________________________	Date: ___________________________

Consent Form for
Research Involving a Minor

Title of Project: Investigating Blended Learning in the High School Science Classroom
Researcher: Holly Hinkhouse, Riverside Science Teacher

I, ____, have been told that one of my parents or guardians may give his/her permission for me to participate in a project about using online resources in my science class.

I have been told that I will complete a pretest and a posttest in my science class and that if I chose to participate in the research study then my test data can be analyzed for my science teacher's project. And, if I choose to participate, I know that I might be invited for an optional interview about my learning in science class. Participants with different levels of achievement will be randomly selected for individual interviews. The interview would be with a retired Riverside teacher and I could choose whether or not to schedule an interview. I also know that, no matter what, my identity will be kept confidential.

I understand that my participation is voluntary and will not be rewarded in any way. I have been told that I can stop participating in this project at any time. If I choose to stop or decide that I don't want to participate in this project at all, nothing bad will happen to me. My grade will not be affected in any way.

Sign the left column to indicate your consent OR sign the right column to indicate non-consent. Return form to the high school office.

Consent for Participation	Non-Consent for Participation
I am fully aware of the nature and extent of this project as stated above. I hereby agree to allow my data to be used for this research project.	I am fully aware of the nature and extent of this project as stated above. I have chosen to **not** participate in this project.
____________________ (Signature of Student)	____________________ (Signature of Student)
____________________ (Printed name of Student)	____________________ (Printed name of Student)
Date: ____________________	Date: ____________________