A Research Paper: A Comparison of Face2Face and Online Learning Environments

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# A Comparison: Face-to-Face and Online Leaning

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## Abstract

This research focused on the differences in student achievement between traditional face-to-face learning and online learning. The academic subject addressed in the study was physical science. Findings from the study were overall similar, however three significant differences favored the face-to-face learning environment. A statistical analysis employed the End of Course Test for physical science. In the state of Georgia, physical science is a required course at the high school level. The participants are all high school students learning the same subject in one of the two learning environments.

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# A Comparison of Student Achievement: Online and Face-to-Face Learning

## Introduction

This study was a comparison between traditional face-to-face learning and online learning. The goal of the comparison was to determine possible differences and similarities in student achievement between the two learning environments. The academic subject addressed in this study was physical science. The findings resulted from comparing student achievement assessed by the End of Course Test for physical science. In the state of Georgia, physical science is a required course at the high school level. The participants were all high school students who had completed the same subject in one of the two learning environments.

To earn a high school diploma, considered to be of college prep status, Georgia students complete and pass a physical science course, along with the physical science End of Course Test (EOCT). In 2008-2009 of the 73,000 students tested, 67% passed (37% *pass* and 30 % *pass plus*). In all 34,400 African American students that took the physical science EOCT, 55%  passed (38 % *pass* and 17% *pass plus*).

According to a county school system's Web site, the student population of a north central Georgia county, for this study, was largely 70% African American, 12% Hispanic and 11% White.  Nine of the county's high schools had students enrolled in the county's online program. Students that opted to take classes online paid a few hundred dollars to

enroll. The online option resolved some scheduling conflicts and at times provided curriculum that was not available at some schools.

With the state and national educational leadership concerned that increasing student achievement in math and science is needed to maintain global competitiveness, some see online classes as a necessary tool (Roblyer, 2009). Online classes are available through WAN (wide area network) technology that provides local areas access to the World Wide Web. This nationally connected infrastructure is in place across Georgia making online classes possible for public school students.

## Introduction to Literature Review

Online learning is referred to using several terms: online learning, web based learning, Web based instruction, Web based training, Internet-based training, distributed learning, and even referred to as off-site nomadic learning (Khan, 2005). Online curriculum is widely integrated into the construct of higher education. Online academia has also increased for the secondary grade levels, with middle school online class participation in the *not so distant* future following the path of high school participation (Khan, 2005).

The National Center for Education Statistics reported in 2004-2005 that 506,950 public school students from both high and middle schools were enrolled in online courses (Roblyer, 2009). Khan (2005) reported that research evaluating instructional approaches for online learning was limited.

This study examined current literature that compared student achievement between online and face-to-face courses. The reports were retrieved from database

searches online. The databases included Eric from EBSCO Host, and ProQuest. Google searches also retrieved studies from state and federal departments of education in the US and US education foundations. The searches produced 50 studies that targeted the comparison topic, however only 15 studies were reflected on here. Reports were selected based on their common definition of online characteristics, curriculum content, and geographic significance. The data came from several US states, such as Pennsylvania, Indiana, and Florida. An effort to include data from foreign counties is evident here also, with two studies from Australia, and one study from Romania. Due to the global interest in online technology and science content, the majority of these selected studies were chosen because their content reported on student achievement in science and math curriculum.

*Theory of Online Learning*

Nichols (2003) stated that "technology is pedagogically neutral," and that online learning was a term that described education through Web participation. Nichols also stated that Web leaning did not require face-to-face contact. In the education community eLearning was viewed as an adequate descriptive term that defined Web participation and use of Web-based technology tools, Web distributed, and Web capability for the purpose of education. E-Learning was isolated from or partly combined with face-to-face instruction. Depending on the college or university, the distinction between purely online and partly online was not consistent. (Nichols, 2003).

The technology components were reported as important in the definitions of terms. It was also reported that pedagogy strategies built the framework that provided purposeful education; eLearning enabled unique individual learning that fits within the

existing paradigms of face-to-face pedagogical practices. (Nichols, 2003 & Gregor, 2002).

Learning approaches using Information and Communication Technologies (ICT) provided many opportunities for constructivist teaching (Oliver, 2002). The ICT settings enabled learning to be related to context and practices unlike the conventional lesson planning approaches (Oliver, 2002). Bodies of research indicated that constructivism theory is a suitable philosophy for online learning environments, ensuring the "learning among learners" (Koohang, 2009). Education based on cognitive theory and implemented using online tools allowed prior learning experiences to scaffold the learning experience further. Constructivism is regarded as a path to identify environmental relationships and variables that impact the means to build on student learning (Koohang, 2009). The constructive learning theory framed by Dewey, Piaget and Vigotsky and further discussed by Hein (1991) referred to the idea that learners construct knowledge by themselves.

*Rationale for the Study*

The global need for highly skilled graduates with knowledge of science and math prompted some to support the union of online learning to the traditional education model. The purpose of the literature review was to explore the two learning environments and student achievement. The reviewed literature was limited to largely science subjects. The literature was divided into four sections titled performance results: similarities, positives for online, positives for face-to-face and related variables.

*Performance Results: Similarities*

Researchers examining psychology class assignments completed by 32 graduate students and 59 undergraduates found "no difference in quality of work between the

online section and the face-to-face section" (Dell, 2010). These students, 14 graduate online, 13 undergraduate online, 18 graduates face-to-face and 46 undergraduate face to face, were selected randomly. The selection process assigned random numbers for identification purposes. Using course assignments, researchers identified data by their assigned numbered format. The coded format was unknown by the instructor prior to the analysis. The assignments were graded on knowledge of theories and constructs, this data along with an analysis of short stories, review journal articles and/or described observations of the learning process, and answers to essay questions on final exams were statistically weighted and compared.

Franklin (2001) had similar research results when the researcher compared real dissection techniques with online dissections. The findings suggested little achievement differences between the two types of instructions. In a required class, the lessons were based on the learning of organ structure and organ functions, and these lessons emphasized the use of live animal lab dissection practices. The lessons were known to have the highest disapproval rating because of the involvement of live and dead animals (Franklin, 2001).

The study measured the perceived effectiveness of "real" and "virtual" dissections in a first-year biology course. Students' exam results were compared by this research, and the findings offered support for online uses as a sensitive alternative learning tool. The data was collected from 400 students, randomly from a cohort of 800 first year biology students. A combination of qualitative and quantitative surveying and focus discussion groups were implemented during the introductory and final stages of the course (Franklin, 2001).

Brownstein, Brownstein, & Gerlowski (2008) stated in a comparative assessment, “no significant” differences were indicated in online learning and that of face to face. This sample of data originated from a required MBA course, which was instructed online and face to face by the same instructor. The performance of the 26 online students and 27 face to face students was identically assessed. Writing assignments and final exam grades were compared. The statistically evaluated MBA course work supported the use of the online environment (Brownstein et al., 2008)

Cavanaugh, Gillian, Kromrey, Hess, Blomeyer (2001), using a meta-analysis, also indicated that online learning was equal to academic achievement of traditional instruction for K-12 levels. These researchers stated that the US Department of Education should assume the leadership role and organize national online practices and recommendations. This comparison analysis, studied between 1999 and 2004, of 116 effect sizes from 14 web-delivered distance education programs, supported a recommendation for leadership to act at the national level. Researchers suggested that the leadership of education act at the national level. The researchers suggested that leadership organizations like the North American Council on Online Learning to be part of a leadership effort (Cavanaugh et al., 2001).

*Performance Results: More Positive for Online*

In Sydney, Australia, a research conducted to compare the study of online learning and traditional learning examined student attitudes and performance and the results indicated scores that were not equivalent (Suanpang, 2004). The results indicated online students had a “more positive attitude”, a “greater ability” for problem solving, and a greater sense for the course subject’s worth, while traditional students viewed the

course as “more difficult.” Two sample groups were pooled, 101 participants formed the online group, and there were 109 traditional face to face participants in the second group (Suanpang, 2004).

The statistical analysis used measurements of sub-scales for measuring positive and negative feelings concerning the course subject. *Cognitive competence* was indicated by measuring content knowledge and skills. Scores also measured *relevance* and subject worth. A score for *easiness* indicated how difficult the class was perceived. The survey responses were evaluated and converted to a percentage scale (Suanpang, 2004).

Research to address the effectiveness of online learning versus face-to-face was revisited after a decade of data collection that reflected K-12 learners (Mean, 2009). The comparison of online and traditional instruction indicated better performance “on average” of online students. The overall results of this meta-analysis originated from nearly 1000 systematically researched studies and confirmed some claims that online learning is more “acceptable” by learners than that of face to face (Mean, 2009).

A state university study in Minnesota during the fall of 2009 compared “outcomes achieved” in an online marketing principles class to “outcomes achieved” in the same class in a face-to-face environment (Smith & Stephens, 2010). The results of this statistical analysis of grades from three classes, two traditional with 67 students and one online class with 24 students, indicated some differences in results. The mean score for final class exams was 61.43 for the face-to-face students, and the mean score was 73.92 for the online students. These researchers concluded that demographics may provide a clue as to why the online students performed better in this study and that further research was needed (Smith & Stephens, 2010).

*Performance Results: More Positive for Face-to-Face*

This study addressed this research question: "Is there a difference in student academic indicators between taking a course face-to-face and taking a course as distance education" (Urtel, 2009)? The research indicated that there were differences in student academic performances. The face-to-face students earned a grade of 3.16/4.00 and the distance education students earned a grade of 2.28/4.00 (Urtel, 2009).

Employing a statistical analysis, Urtel (2009), assessed the course work from 269 university students enrolled in a distance education section and 116 enrolled in the face-to-face section. The results indicated a statistically significant difference in final grades. The most notable trend was the disproportionate rate of students classified as freshmen. 65% of first year students earned grades of *D*, *F*, and *W* when taking an online class. The sample collection methods for this data analysis were identical for both face-to-face and distance education. This research analysis weighted course grades, and the end of semester course evaluations. The grade point averages were computed on a 4.0 scale but a grade of *W* (student did not complete class) for grades were not factored into the evaluations and had no impact on computations (Urtel, 2009).

*Performance Results: Environmental Impact and Variables:*

Tutunea, Rus, &Toader (2009) implemented a study at "Babeş-Bolyai" University of Cluj-Napoca and composed a correlative statistical analysis. The Romanian study had several key objectives: to support an increase in the use of Internet services, promote development of a knowledge-based economy, promote research and innovations, and accelerate the development of an information society. The results indicated that students with better basic computer and Internet skills preferred online learning methods, and

concluded that the younger distance learning students have more information technology abilities. 45% of participants were characterized as *high-Internet skilled* users, 39% were labeled with medium-Internet skills, and 16% were categorized with low-Internet skills. The study also concluded that 55% of the participants would prefer a mix of both environments, a combination of online and face-to-face (Tutunea, 2009).

This data also suggested that students with previous instructional technology (IT) experience prefer online learning methods. The majority of the distance learning students did not have previous experiences in online learning. Students that manifested the highest reticence at the beginning of the online classes were also the most active persons on the platform. They communicated more questions and launched discussions. The researchers concluded that this initial attitude of reticence was considered an "attitude as being normal" and supported a need for traditional instruction. These students needed additional "explanations" and a mixture of online with traditional instructional help for a better learning experience. The researchers further concluded that it may be necessary to consider other methods that are beyond a comparison of exam grades in order to determine the advantages of online learning (Tutunea, et al., 2009).

Daymont and Blau (2008) performed a meta-analysis of a state university population in the eastern area of the US. This analysis compared final grades, and the average final grade for online students was 2.76, and the average final grade for traditional students was a score of 2.51. The grades were derived from course quizzes and discussion forums of business major students, and non-business majors, enrolled in a required undergraduate management course. Two classes were online and five classes were traditional (Daymont et al., 2008). This research also showed that the average quiz

score for online students was 80.4 and for traditional students the average quiz score was 77.45. The sample population was more female, 59 percent. Researchers concluded that online students were not likely freshman and had higher cumulative GPA's (Daymont et al., 2008). A synthesis of five Meta-analyses on K12 online learning education presented variances in research factors, such as student and teaching characteristics, course design, teacher preparation, technology, and administrative services (NACOL, 2007). This research was an effort to determine whether K-12 distance education fostered a comparative learning experience similar to that of traditional classroom learning. Technology approaches that provided simulations and tutoring feedback indicated an increase in online student performance and that online students valued frequent and timely responses to their questions, with teacher feedback the most valued aspect of online courses (NACOL, 2007).

The analysis indicated that the better teaching practices provided collaborative communication tools for groups and one-on-one discussions. The report claimed that teachers with professional development for online facilitation have a positive effect in online and classroom-based instructions. Elements such as administrative and technical support services for mentoring and on-site support staff may contribute to positive outcomes in the online learning process (ibid,).

*Summary*

The review of research here indicated that online learning had an accepted role in education. There were concerns that a national concerted effort was needed to better direct online pedagogy practices, and that the growth of K12 online programs needed to

be better supported. Support for online policies did not appear to be a major concern in the general community and therefore not at the attention of policy makers. Whether or not online learning experiences are equal to traditional face-to-face learning experiences was not conclusive in research.

It is evident that additional technological training is needed for teachers and student populations as virtual classrooms become the norm for most grade levels. Additional research-based data is needed to address situational implications such as demographics and content practices. Online learning credibility may be further enhanced with research that uses methodology that accounts for diverse learning factors, such as English Learners and students with economic limitations. Comparisons in this review of literature mostly used course grades to reflect on student outcomes.

Beyond the scope of this review, additional concerns presented included: the need for technology in under-developed and under-funded educational systems, cheating, authenticity of online participation, and the role of the online facilitator. These factors along with language barriers and content pedagogy factors are related to this topic and in need of additional research.

## Purpose of the Study:

The purpose of this comparison study was to identify student achievement differences and similarities of face-to-face and online learning environments. The study examined student achievement in the four content domains of physical science. The four domains are Chemistry: *Atomic and Nuclear Theory, and Periodic Table*, Chemistry:

*Chemical Reactions and Properties of Matter*, Physics: *Energy, Force, and Motion*, Physics: *Waves, Electricity, and Magnetism*. Research between face-to-face and online learning for K-12 is limited, and thus limits the advancement of online pedagogy.

## Research Questions:

The following research questions were addressed:

Will the findings of this study indicate online students achieve higher test scores than face-to-face students?

Are there differences in achievement among the physical science content domains?

Physical Science course content domains:

Chemistry: Atomic and Nuclear Theory, and Periodic Table

Chemistry: Chemical Reactions, and Properties of Matter

Physics: Energy, Force, and Motion

Physics: Waves, Electricity, and Magnetism

## Importance of the Study

This investigation of student achievement in the online environment and the comparison to that of student achievement in the traditional face-to-face environment was necessary for the purpose of bringing more understanding of online educational services. Online learning is now a part of the public school model, and research on K-12 student achievement online is limited. The growth of online learning is rapid and more adequate support of its effectiveness is warranted. The apparent primary advantages of student participation online are geographic matters. There are concerns that social economic

matters could be resolved by access to effective instructors and quality content curriculum that may be available online, yet not available in less fortunate, or economical disadvantaged, face-to-face learning environments.

Additional research that assesses online learning is needed to support the decisions of policy makers attempting to solidify standards for online pedagogy and online curricula. Face-to-face traditional classes are not being totally replaced by online classes; however school systems in need of content experts in math and science see the beneficial factors associated with online learning as a means to provide more students with expert teachers. Knowing what hindrances (or null impact) and advantages are associated with the online environment will be of value for the education community and society at large.

The online learning environment is now an option in the education model. Web tools have enabled an exchange of information and communication in a virtual place and time. A virtual classroom is not physically accessed. The physical classroom with face-to-face communication is defined as a physical room visited at an appropriate time in order to participate in the learning process (Khan, 2006). Web tools such as chat rooms, discussion boards and email are valued for providing both synchronous and asynchronous communication and information (Watkins, Leigh, & Triner, 2003).

## Definition of terms

eLearning – course content using the Internet, network, or a stand-alone computer, and has electronic delivery methods such as internet-based learning delivery packages,

CD-ROM, online video conferencing, websites or email/messaging (Nichols, 2003).

ECOT – An End Of Course Test is a standards-based assessment, this test measures how well students are mastering specific skills as defined by the state of Georgia.

Face-to-face – Instructions provided by teachers to learners, together in the same physical space and moment in time are referred to as face-to-face (Khan, 2006).

Internet – The Internet is a global network that connects millions of computers and Exchanges transmitted digital data.

Online – An online connection to the Internet, and/or a computer connected to a network is referred to as online.

Virtual classroom – The virtual classroom is a learning environment that exists solely in the form of digital content that is stored, accessed, and exchanged through networked computers and information systems (Watkins, 2003).

Web site - A site of pages located on the World Wide Web is called a Web site. Each site contains a homepage that is the first page of many pages linked together.

Web page – A Web page is an digital document on the World Wide Web, commonly called a page, and is identified by a unique URL (Uniform Resource Locator).

Web tools – Web tools are communication methods such as: chat rooms, discussion boards and email messages. These tools provide synchronous and asynchronous communication (Watkins, Leigh, & Triner, 2003).

# Methodology:

## *Research Design*

The study, a quantitative analysis, compared student academic achievement in physical science, in two learning environments. The End of Course Test scores (EOCT) for physical science served as the unit of measurement for student achievement. The physical science course was offered online and face-to-face. The study compared the EOCT physical science scores of the students that participated online to the scores of the students that participated face-to-face. In additional to the overall tests, the subject domains scores of physical science were also compared. These domains were Chemistry: Atomic and Nuclear Theory, and Periodic Table, Chemistry: Chemical Reactions, and Properties of Matter, Physics: Energy, Force, and Motion, and Physics: Waves, Electricity, and Magnetism.

## *Participants*

Participants were from a north central Georgia county. Students, a total of 1,112, from 9 high schools composed the two student groups. The groups were based on participation in physical science (a required core course) either online (a group of 42 students) or face-to-face (a group of 1082 students). In addition to having completed a physical science course, selected students took and scored on the physical science EOCT.

## *Data Sources and Collection*

The data of this study were obtained from a county research department. The on-online participant poplation determined the online sample size of the first group. The face-to-face participants composed the second group. The second group was composed of all the students from the same nine high schools that took physical science in face-to-face classes. The EOCT assessment scores, according to the county's Web site, have a reliable and credible history. The EOCT is administered after completion of the physical science class. The test score is averaged into the class grade with a weight of 15% of the final course grade. A student must score a grade of 70 or above to pass the course and earn credit toward graduation. Test scores are ranked as: scores below 400 - "Does Not Meet Expectations;" scores from 400 to 449 - "Meets Expectations;" and scores at/or above 450 - "Exceeds Expectations." To be graded "Meets Expectations" a student must apply knowledge and skills learned in domains of physical and chemical properties of matter, identify molecular chemistry, and distinguish between the types of forces, energy, and waves.

*Reliability, of Instrument*

The EOCT was administered after completion of the physical science class. The test score was averaged into the class grade as a weight at 15% of the final course grade. According to the county's Web site, the EOCT tests provided scores that reflected student achievement levels and were based on internal consistency measures; using Kuder-Richardson 20 (KR-20). The KR-20 has a high reliability range of .08 to low .90 ranges. The state of Georgia considers this instrument reliable for measuring student achievement levels in the four domains of physical science content.

*Validity, of Instruction*

According to the Georgia Department of Education (www.doe.k12.ga.us) the EOCT is aligned with the Georgia curriculum standards and is an assessment of specific content knowledge. The assessment is used to identify student strengths and weaknesses in subject content areas, and indicates effectiveness of classroom instruction at the school and county levels.

*Data Analysis*

Student achievement, as interpreted by the EOCT (End of Course Test) scores, was analyzed by using independent-samples t-tests to determine significant differences in mean EOCT scores. The EOCT scaled scores are defined: below 400 - *Does Not Meet Expectations*, 400 to 449 - *Meets Expectations*, and scores at/or above 450 - *Exceeds Expectations*. The Physical Science EOCT was composed of four domains with each having a raw score value: Chemistry: Atomic and Nuclear Theory, and Periodic Table, with a raw score of 15, Chemistry: Chemical Reactions, and Properties of Matter, raw score of 12, Physics: Energy, Force, and Motion, a raw score of 13, and Physics: Waves, Electricity, and Magnetism, had a raw score of 10. Significant differences in achievement between students taught on-line and students taught face-to-face were indicated at a $p<.05$ level of significance.

# Findings

## *Quantitative Data Analysis*

This quantitative analysis compared student achievement in a Physical Science course between the two learning environment groups, face-to-face and online. The findings indicated that overall there was not a significant difference in student achievement. EOCT scaled scores are ranked as: below 400 - *Does Not Meet Expectations*, 400 to 449 - *Meets Expectations*, and scores at/or above 450 - *Exceeds Expectations.* T-tests showed that the mean EOCT score in physical science for the face-to-face group was 412.95. The online physical science group had a mean EOCT score of 395.88. These mean scaled scores/results of the two groups were not significantly different ($p>.05$). However, the mean EOCT score for face-to-face students of 412.94, ranked at *Meets Expectations* (400 to 449). The mean EOCT score of 395.88 for online ranked below 400, *Does Not Meet Expectations* and interpreted as below the benchmark for learning (see Table 1).

Table 1

*Descriptive Statistics –Means of Physical Science End of Course Test (EOCT)*

| Descriptor | Face-to-Face | Online |
|---|---|---|
| 9th | 385 | 393 |
| 10th | 418 | 375 |
| 11th | 408 | 400 |
| 12th | 427 | 408 |
| All grades combined | 413 | 396 |

Further examination of EOCT scores of each grade level (9th, 10th, 11th, and 12th) did indicate significant differences between the two groups. The additional independent-samples t-tests also revealed a pattern in student achievement (see Table 1). The mean scores for the face-to-face 10th, 11th and 12th grade levels were above a score of 400. These findings suggested differences in the subject domains at each grade level were possible.

At the 9th grade level, additional statistical analysis of the four domains revealed the study's first significant difference in student achievement. The domain, physics (*energy*), reflected higher student achievement. This physics domain has a raw score maximum of 12. The online 9th grade group scored a mean of 7.0 while the face-to-face 9th grade group scored a mean of 6.67, a significant difference of $p<.014$. The differences in three of the remaining four domains were not significant. In the domain of physics (waves), the 9th grade online group's mean score was 6.33, and the 9th grade face-to-face group's mean score was 6.53. In the two chemistry domains the mean scores for the 9th grade online group were 7.67 and 6.67. The two chemistry domains mean scores for the 9th grade face-to-face group were 6.96 and 6.30 (see Tables 2 and 3).

Table 2

*Descriptive Statistics – 9th Grade, Means of Physical Science EOCT Domains*

| Descriptor | Face-to-Face | Online | Domain Value |
|---|---|---|---|
| Chemistry (atomic) | 6.96 | 7.67 | 15 |
| Chemistry (reactions) | 6.30 | 6.67 | 13 |

| | | | |
|---|---|---|---|
| Physics (energy) | 6.65 | 7.00 | 12 |
| Physics (waves) | 6.53 | 6.33 | 10 |

Table 3

*Descriptive Statistics – Independent Samples t-Test for 9th Grade Level*

| Descriptor | F | Sig | t | df | Sig. (2-tailed) | Mean Dif. | Std. Error Dif. |
|---|---|---|---|---|---|---|---|
| Equal Variance Assumed Chemistry (atomic) | 1.165 | .282 | -.415 | 167 | .679 | -.70884 | 1.70786 |
| Equal Variance Assumed Chemistry (reactions) | 1.824 | .179 | -.230 | 167 | .818 | -.37149 | 1.61354 |
| Equal Variance Assumed Physics (energy) | 6.106 | .014 | -.219 | 167 | .679 | -.34940 | 1.70786 |
| Equal Variance Assumed Physics (waves) | .302 | .583 | .125 | 167 | .901 | -.19679 | 1.57583 |

The mean EOCT scaled scores for the 10th grade face-to-face group was 418 (and ranked at the "Meet Expectations" level, 400-449). The 10th grade online group had a mean EOCT score of 375 (ranked at "Does Not Meet Expectations"). These two scores were not significantly different; however the mean score for the online group was below the 400 minimum score needed to rank as "Meets Expectations". These findings suggested the additional analyses of the four domains at the 10th grade level may reveal some significant differences in student achievement. The t-test results from the domain of Chemistry (atomic) indicated a second significant difference in student achievement and the two learning environments. This chemistry domain had a raw score maximum of 15,

and the 10th grade online group scored a mean of 6.37. The 10th grade face-to-face group scored a mean of 8.99. This significant difference of $p < .036$ between the two groups indicated higher achievement by the face to face group in chemistry (see table 4 and 5). The mean scores for the four domains at the 10th grade level did indicate a pattern. The chemistry (reactions) domain means score for face-to-face was 8.14, and the mean score for online was 5.10. The mean score for the two physics domains were face-to-face 8.30 and 8.40, and online 6.54 and 6.0 (see Table 4).

Table 4

*Descriptive Statistics – 10th Grade, Means of Physical Science EOCT Domains*

| Descriptor | Face-to-Face | Online | Domain Value |
|---|---|---|---|
| Chemistry (atomic) | 8.99 | 6.36 | 15 |
| Chemistry (reactions) | 8.14 | 5.09 | 13 |
| Physics (energy) | 8.29 | 6.55 | 12 |
| Physics (waves) | 8.38 | 6.00 | 10 |

Table 5

*Descriptive Statistics – Independent Samples t-Test for 10th Grade Level*

| Descriptor | F | Sig | t | df | Sig. (2-tailed) | Mean Dif. | Std. Error Dif. |
|---|---|---|---|---|---|---|---|
| Equal Variance Assumed Chemistry (atomic) | 4.406 | .036 | 2.900 | 732 | .004 | 2.62392 | .90482 |
| Equal Variance Assumed Chemistry (reactions) | 2.832 | .093 | 3.339 | 732 | .001 | 3.04602 | .91238 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Equal Variance Assumed Physics (energy) | .342 | .559 | 1.990 | 732 | .047 | 1.74777 | .97846 |
| Equal Variance Assumed Physics (waves) | 1.165 | .281 | 2.633 | 732 | .901 | -.19679 | 1.57583 |

The mean EOCT scaled scores for the 11th grade face-to-face group was 408.4 (ranked at the *Meet Expectations*: 400-449). The 11th grade online group had a mean EOCT score of 399.7 (ranked *Meets Expectations*). These two scores were not significantly different; however the mean score for the online group was at the 400, the minimum score needed to rank at *Meets Expectations*. Using the t-test for additional analysis of both student groups' data indicated a third significant deference in student achievement. Physics (waves): the 11th grade face-to-face group scored was 7.76 and the online group scored 7.50 (a significant difference of $p < .046$, see Table 6). The data reflecting the remaining three domains at the 11th grade level did not indicate a pattern.

Table 6

*Descriptive Statistics – 11th Grade, Means of Physical Science EOCT Domains*

| Descriptor | Face-to-Face | Online | Domain Value (maximum) |
|---|---|---|---|
| Chemistry (atomic) | 8.54 | 9.17 | 15 |
| Chemistry (reactions) | 7.70 | 6.17 | 13 |
| Physics (energy) | 7.64 | 6.75 | 12 |
| Physics (waves) | 7.76 | 7.50 | 10 |

Table 7

*Descriptive Statistics – Independent Samples t-Test for 11th Grade Level*

| Descriptor | F | Sig | t | df | Sig. (2-tailed) | Mean Dif. | Std. Error Dif. |
|---|---|---|---|---|---|---|---|
| Equal Variance Assumed Chemistry (atomic) | .233 | .60 | -.716 | 121 | .475 | -.62613 | .87313 |
| Equal Variance Assumed Chemistry (reactions) | .582 | .447 | 1.711 | 121 | .090 | 1.52703 | .89228 |
| Equal Variance Assumed Physics (energy) | 1.393 | .240 | 1.084 | 121 | .280 | .88964 | .82035 |
| Equal Variance Assumed Physics (waves) | 4.046 | .046 | .318 | 121 | .751 | .25676 | .80703 |

Additional analysis of both student groups for 12th grade did not indicate any significant differences in student achievement between the two groups; however the mean scores for the four domains at the 12th grade level indicated a pattern. The data reflecting all four domains at the 12th grade level showed the face-to-face group scored higher. This pattern was true for two grade levels, 12th and 10th (see Table 8).

Table 8

*Descriptive Statistics – Means of Physical Science EOCT Domains*

| Descriptor | 9th grade | 10th grade | 11th grade | 12th grade |
|---|---|---|---|---|
| Chemistry (atomic) | | | | |
| Face-to-Face | 6.96 | 8.99 | 8.54 | 9.64 |
| Online | 7.67 | 6.36 | 9.17 | 8.53 |
| Chemistry (reactions) | | | | |

| | | | | |
|---|---|---|---|---|
| Face-to-Face | 6.30 | 8.14 | 7.70 | 8.75 |
| Online | 6.67 | 5.10 | 6.17 | 6.80 |
| Physics (energy) | | | | |
| Face-to-Face | 6.65 | 8.30 | 7.64 | 8.62 |
| Online | 7.00 | 6.55 | 6.75 | 8.67 |
| Physics (waves) | | | | |
| Face-to-Face | 6.53 | 8.38 | 7.76 | 8.42 |
| Online | 6.33 | 6.00 | 7.50 | 7.60 |

*Discussion and Implications*

These findings indicated both learning environments, face-to-face and online, had similar student achievement overall. It is important to note that the overall statistical values reside close to the minimum benchmark for academic achievement (see Table 1). The additional analysis at each grade level of each domain indicated face-to-face learning as the environment with higher student achievement in three significant instances. These analyses of the four grade levels also indicated a pattern for 10$^{th}$, and 12$^{th}$ grade levels that favored student achievement for the face-to-face learning environment. The online group for the 9$^{th}$ and 10$^{th}$ grade levels did not display a pattern. Although in one instance, there was a significant difference at the 9$^{th}$ grade level (indicated higher student achievement) by the online group, it is important to note that the 9$^{th}$ grade online group had few (only three) participants. However, the 10$^{th}$ grade online group was a much larger group.

Several concerns regarding variables, such as motivation of the students to take online classes, online cost, and instructional technology (IT) experience of the students, were not addressed in this study. As online learning expands, these concerns warrant additional research for the purpose of projecting student achievement online. It is

possible some students attended online classes because of scheduling conflicts and others because of personal preference to online instructions. It is also possible some students were required to repeat physical science in order to receive credit. The additional cost to register for online courses is likely a concern for some students, and could be a deterrent for other students, along with limitation in technology accessibility and limited IT experience. These factors could result in online classes not being considered by some students as a feasible option.

## Conclusion

These finding suggested online learning was not advisable for ninth grade level students. EOCT mean scores below 400 by both groups indicated gains are needed in both learning environments. An approach that can assess student instructional technology (IT) skills at the 10$^{th}$ and 11$^{th}$ grade prior to online participation training might also be needed to support adequate online participation. Courses that offer exposure and preparation prior to high school years may also be an option. Beyond the ninth grade level, this study supported face-to-face learning as the leading environment for higher student achievement.

The most similar student achievement occurred in the domain of Physics (energy) at the 12$^{th}$ grade level. It is also interesting to note the comparison groups that were furthest apart in student achievement was at the 10$^{th}$ grade level in the domain of Physics (Wave). These results suggested more research is needed to determine how the difficulty of advanced course work impacts student achievement and the online learning environment. Assessments that can determine these strengths and weaknesses may enhance online pedagogy and elevate implementation of online learning strategies. It is

evident here that the online learning environment will require meticulous innovations to equal that of the face-to-face environment. The role and impact of facilitators in the online learning environment is beyond the scope of this paper and also in need of research.

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