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Computer-Based Instruction as a Form of Differentiated Instruction in a Traditional, Teacher-led, Low-Income, High School Biology Classroom

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by

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ABSTRACT

In 2015 the U.S. continues to struggle with academic achievement in public schools. Average test scores from 15 years olds taking the Program for International Student Assessment placed the U.S. as 38^{th} out of 71 countries (Drew Devlin, 2017). It is common to discuss elimination of the achievement gap as the single most effective way to improve the U.S.'s mediocre standing among the highest scoring countries in the world in primary and secondary student test scores (McGhee,2004; Flemming 2012). In the broadest sense of the term the "achievement gap" refers to the difference in academic success between different groups of students. It is often used to describe the lower performance of underprivileged student populations (National Education Association, 2004). Attempts to understand why this GAP exists and how educators may narrow such GAPs, researchers have identified both large class size and lack of personalized instruction as two conditions that commonly accompany lower academic achieving student populations (Lee and Buxton, 2008).

Although there is a wealth of literature attempting to assess the effect of class size, few studies have defined small and large class sizes. In her research, Sarah Leahy (2006) defines a small class as one containing between 13 and 17 students and a regular class as one containing between 22 and 25. For the purposes of this research, a large classroom is defined as one with over 25 students.

In theory, computer-based instruction (CBI) offers great potential to expand on the concept of personalized instruction. However, there is very little research available that describes how this tool can be used to effectively enhance the classroom learning process. This study examines the impact of providing computer-based instruction (CBI) or teacher-led instruction on students of various achievement levels enrolled in a traditional, high school biology classroom. The High School in which this research as conducted is a Title One (low income) identified school. One hundred and eleven students, from four sections of freshman high school biology, were randomly divided into two learning groups per section. Both groups in each section were taught one 50-minute lesson on cellular biology. One group received the lesson from CBI while the other group from teacher-led instruction. The impact on learning was measured by the change in pre- and post-test scores. All students in each section received the same lesson content which was provided in the same classroom concurrently. Data from 82 students that returned signed parental consent forms and took the pre-test on day one, the lesson on day two, and the post-test on day three, were analyzed in this study.

Results: The twenty students ranked as high academic achievers scored the highest correct answers on pre- and post-tests (mean 7.1 and 9.4 respectively). Improvement in test scores, measured as mean number of additional correct answers on the post-test, for the high achievers was equal whether they received CBI or teacher-led instruction (+1.72 and +1.75 respectively). Twenty-seven middle ranked academic achieving students also showed a statistically equal degree of improvement from each

instructional platform. However, middle students that scored the highest pre-test scores also produced the highest improvement from CBI. The thirty-five low academic achieving students produced the highest improvement in test scores overall from teacher-led instruction and produced a mean negative change in post-test scores from CBI (mean +2.13 and -.68 respectively). Findings from this study suggest that in a classroom setting, higher academic achieving students will learn equally well from CBI or from a teacher while lower achievers benefit more from small group, teacher-led instruction.

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INTRODUCTION

In a quantitative and qualitative analysis of high poverty schools in Illinois that are also high performing, McGhee (2004) identifies a number of characteristics that are consistently associated with these schools: small class size, student engagement, and teacher awareness of individual student learning needs. In his updated review of the literature on class size effect David Peddler (2006) identifies the unique challenges of teaching in large classrooms which have negative effects on academic achievement. Elements associated with negative impacts on learning in large classes include reduced instruction time and greater need for administration, organization, and time spent addressing discipline issues. His research also shows that although student-teacher interactions are directly related to increased academic achievement, especially for lower academic achieving students, as class size increases direct interactions with the teacher decrease. These student-teacher interactions also increase teachers' understanding of individual student needs and their ability to offer more accurate personalized instruction, which tend to be sacrificed in larger classroom settings (Peddler, 2006). The challenge in today's large classrooms, which are more commonly associated with schools that serve low-income student populations and which more negatively affect the disadvantaged student (Blatchford, 2011), is: how can one teacher address the learning needs of every student?

With Peddler's description of the deficits associated with large class sizes in mind, it would only take a few minutes for any visitor in a low income, first year high school biology class with one teacher and over 30 students to notice that student participation in the learning process varies widely. Some students come prepared to learn and participate while others remain disinterested and resistant to participation throughout the class period. Further, within these diverse groups of students, there are high academic achievers who are often left to their own devices as the teacher is stretched too thin to provide them with personalized instruction. At the same time, the low achievers typically need more instruction time to assimilate concepts than one teacher can accommodate and often are further affected by discipline issues and apathy. . The sole instructor in such a large classroom is typically not able to address the varied and individual learning needs of all students. In the end, it appears the traditional classroom teacher ends up providing a one-size-fits-all lesson that targets the middle achievers. The high achievers are bored and do not get the chance to maximize their potential, and the low achievers are lost and learn very little.

The theory behind personalized, or differentiated, instruction is that the instructor knows each student's level of ability and understanding and can customize instruction to meet differing learning needs (Tomlinson, 1998), thus increasing both engagement and retention of content. However, large class size combined with widely diverse ability and preparedness levels, as well as diverse family/home dynamics—all characteristics of the low-income student population—make student engagement less likely to occur and differentiated instruction much more difficult to accomplish (Truscott, 2005).

The concept of differentiated instruction is rooted in Vygotsky's theory of Zone of Proximal Development, which states that student learning is greatest when content or task is slightly more challenging than the student's comfort level. Vygotsky emphasizes that such learning is supported by both teacher instruction and interactions with peers (Vygotsky, 1978). This further clarifies that the ideal learning environment is defined by both differentiated instruction and student engagement. The converse of this often occurs in traditional instruction where there is front-of-room lecture by a teacher. Traditional instruction is typically only effective for the average student in the classroom while the higher achieving students are left unchallenged and unmotivated and the lower achieving students often fail because they are either without the proper prerequisite education or cannot progress at the same pace as the instructor (Konstantinou-Katzi , et al, 2013). This is what is often referred to as teaching to the middle. Compounding the problem is the evidence showing that interactions between teachers and students that lead to heightened teacher awareness of individual needs, is significantly reduced in large, highly heterogeneous classrooms that are characteristic of many low-income schools (Truscott, 2005).

During the recession of the post-Bush era, the U.S. federal system was faced budget shortfalls that led to cutbacks in public school funding. Though 91% of public school costs are handled by state and local governments (US Census, 2009), public schools serving low-income communities rely on federal subsidies to supplement their lower tax base. As such, they were been hardest hit with federal budget cuts and falling employment levels One result of these such cuts in government spending has been reduction of teaching personnel, resulting in larger class sizes. In the U.S., overcrowded classrooms are among a number of conditions consistently associated with low-income schools and lower academic achievement (Morgan, 2012). Research demonstrates that large class size is associated with both reduced student engagement and reduced student-teacher interactions (Blatchford, Bennett & Brown, 2011). Importantly, students from low-income communities suffer the negative effects of large class size more than any other group (WSIPP, 2007). Unfortunately, the large high school class phenomena is not likely to end any time soon considering the address made by Arne Duncan, U.S. Secretary of Education, to the American Enterprise Institute in which he encourages high schools to save money by increasing class size (Duncan, 2010).

Research investigating the effect of class size on student performance is extensive; however, relatively little is based on sound scientific method; that is, research that incorporates true randomization, similarity of observed populations, and consistency of measurement tools. This has resulted in a wealth of contradictory and inconsistent findings within the literature surrounding class size effect. In fact, Gene Glass, a long-time leading researcher in the area of class size effect comments on the base of literature as having “variously been read as supporting larger classes, supporting smaller classes, and supporting nothing but the need for better research” (Glass & Smith, 1979; Chingos, 2011). It certainly seems intuitive that smaller class sizes would lead to improved performance, but one must consider the many variables that can influence results. Examples include homogeneity and academic ability of students in the classes studied, socio-economic status, family and cultural demographics, age and grade level of student population. For example, Catholic high school students, comprised of mostly white students from high socioeconomic communities produce consistently higher test scores even with class sizes significantly larger than those in public schools (Lazear, 1999). In addition to student-centered variables, there are many school-based variables such as school size, subject area and teacher experience and training. With all of the challenges associated with assessment of class size effect, findings from two recent meta-analyses (Glass, 1979; WSIPP, 2007) that looked at 38 studies assessing effect of class size that met strict scientific design criteria, agree that the academic performance of low-income students is negatively affected by increases in class size It is the low-income students who stand to benefit the most from personalized instruction and who also tend to go to schools with the fewest resources and the largest class sizes.

Computer assisted instruction, online learning and computer-assisted learning, are some of many terms used to describe the use of computers to deliver instruction. Although each term may suggest minor differences, for the purpose of this research, the term computer-based instruction (CBI) will be used exclusively. As listed in the literature review below, there are many studies on the potential of CBI to provide personalized instruction to a greater number of students more efficiently than traditional, face-to-face instructor-based instruction (Hannafin & Forshay, 2008). Strengths used to argue for increased use of CBI are the possibility of lower costs, flexible times of use, more flexible locations for access, and the capability to customize curricula, including formative assessment and content focused on individual student needs. On the other hand, although much of the literature supports the conclusion that learning is at least as successful with CBI as with teacher-based instruction, there is a higher than average course failure/withdrawal rate associated with fully online instruction (Wojciechowski & Palmer, 2005). Additionally, CBI can reduce student interaction with teachers and peers, and often lacks an aspect of accountability—both conditions that have shown to decrease academic success (Riffell & Sibley, 2004). While there has been a great deal of enthusiasm around the possibilities of computer-based instruction, there is still little evidence-based data supporting how to successfully integrate this resource into the high school classroom (Grubb, 2011).

Accepting the premise that increased interactions with both the classroom teacher and peers in the classroom is directly correlated with both improved personalized instruction and improved student performance, Blatchford, Bennett and Brown (2011) analyzed the results from a large and comprehensive study done in England and Wales that was intended to assess the value of support staff in the classroom. This study, called the DISS project (deployment and impact of support staff), recorded the systematic observations of 8 students in each of 88 classes from 49 schools, including grades 1, 3, 7 and 10. Class sizes ranged from a low of 15 students to a high of 30 students. The data analyzed recorded frequency of teacher-student interactions and student-to-student interactions during the class times observed in the study. The results confirmed that student interactions with both teacher and peers occurs significantly more often as class size gets smaller. Additionally, when class size was matched with student performance, it was the lower performing students that produced the greatest increases in teacher and peer interactions and the greatest increases in performance as measured by GPA (Blatchford, Bennett & Brown, 2011).

The theory behind smaller learning communities is that student interactions with both teacher and peers, which have been shown to improve personalized instruction and student performance will increase. Project HiPlaces (High Performing Learning Community Assessment) is a longitudinal study spanning more than 3 decades that records pre-identified elements of primary and secondary education such as student demographics, class sizes, student-teacher ratios and academic achievements. The study is not only ongoing, but adds elements to be recorded as they are thought to be valuable in the search for improved instruction. One element is the impact of smaller learning communities on students of all ages and backgrounds. The extensive data from this project supports the value of small learning communities not only in increasing individualized instruction and student engagement, but also in reducing dropout rates and the lower academic achievement levels that are associated with the low-income student population. This data also agrees with the previously mentioned findings that the positive effects of small classroom instruction are greatest for disadvantaged student populations (Felner, Seitsinger, Brand, Burns, & Bolton, 2007). Low-income students and schools serving a higher proportion of low-income students produce the lowest academic achievement results in the U.S. (Morgan, 2012). Due to budgetary constraints, an increasing percentage of classrooms in low-income schools have classes of over 30 students. Because of this, the negative effects of large class size disproportionately affect low-income students (Vanlarr,2016).

The purpose of this study is to investigate whether replicating the characteristics of a small classroom, which have been found to contribute to improved student learning outcomes, can also improve performance in the context of larger classes. Using pre-and post-intervention tests, the study assesses the impact on student performance of creating smaller groups within a large class in a low-income school. These smaller groups were taught using both CBI and teacher-based instruction and the results were compared. This study addresses the following research questions: 1) does the use of teacher-led and computer-based instruction for different learning groups in the same large class improve overall classroom content understanding? 2) Is there a difference in achievement between high academic achieving students, low achieving students and those in the middle when taught by a teacher or by CBI in the same classroom?

Based evidence in the literature of the benefit of both personalized instruction and small group learning as discussed below, the primary hypothesis tested was that high school students in large, low-income science classes would show improved content understanding when receiving instruction in small learning groups that use either computer-based instruction or teacher-led instruction within the same classroom. A second hypothesis is that higher achieving students will have higher post-test scores as compared to lower achieving students when receiving either CBI or teacher-based instruction but lower achieving students will only show higher post-test scores when receiving teacher-based instruction.

A mixed methods design was used to investigate the impact of reducing class size by introducing CBI into large biology classes in a predominately low-income high school. Four large classes were divided in half, with one half receiving CBI and the other half receiving teacher-based instruction. A fifth class, used as a comparator, received no CBI intervention and used teacher-based instruction exclusively. Evidence of instructional effect on student performance was measured across all the classes using student responses on pre-and post-test scores. The students' regular class teacher ranked each student as a high, middle or low academic achiever.

Participants in this study were freshman high school students enrolled in four sections of first year biology during the 2013-2014 school year. The biology program is located at a suburban Title 1 (greater than 60% of student population qualifying for free or reduced lunch) public high school in the Pacific Northwest. One day prior to the intervention, all students took a pre-test, which included 12 questions related to the lesson content. The intervention or independent variable, in this case, the use of CBI in one smaller learning group within a larger class, was applied to one unit of instruction—a 50-minute lesson covering the subject of cellular biology. Students were assigned to learning groups in each of the four investigational sections randomly. The comparator class was not divided and received teacher-based instruction only. All groups received the same instruction content. During instruction, the researcher recorded frequency of student and teacher interactions. One day after the intervention, students completed the same set of 12 questions from the pretest as an end-of-lesson assessment, or posttest. Comparison of pre- and post-test scores were used to measure content understanding and serve as the dependent variable.

LITERATURE REVIEW

Overview of Literature Review

The premise of this study is that although differentiated instruction and student engagement together have been found to improve student academic achievement, large class sizes, which occur more frequently in low-income schools, make these difficult to produce ((Buxton, 2008). This literature review begins by summarizing the characteristics of the student population comprising this study, which is associated with lower academic performance. This section gives a summary of findings regarding the effect of class size on academic achievement. The second section of this review presents research that identifies factors found to be associated with improved achievement in smaller classes. This is followed by a review of several case studies demonstrating how smaller learning groups have increased such achievement-enhancing characteristics. Finally, this literature review concludes by examining a few examples of how computer-based instruction has been integrated into the classroom in different settings to increase the key characteristics of small class size: differentiated instruction, increased student engagement, and increased teacher-student interactions.

The Low-Income Student, Academic Achievement, and Class Size

Based on low achievement of underprivileged students in the sciences, researchers Lee and Buxton (2008) note a corresponding lack of differentiated instruction materials that support the need for new science standards and question of whether differentiated curricula can lead to improved performance. In their own review of the literature, Lee and Buxton describe the demographics of this student population in order to better understand why and how curricula can be made more relevant to them. The authors found that there are a number of common conditions associated with underprivileged students that are also correlated with low academic performance. These students are typically minority, non-English speaking and from families with low socio-economic status. They often have parents with low education levels, single parent households, or are living with relatives or in foster homes. These students are often at risk of pregnancy and incarceration and are haunted by the emotional stress of poverty and insecurity. Family and community cultures place varying levels of value on education and on science specifically and students may have insufficient prior knowledge of the sciences needed to be successful in secondary science courses (Lee & Buxton, 2008). Added to their personal and home life obstacles, students attending low-income schools often have less qualified teachers as a result of lower pay and poor working conditions that include overcrowded classrooms. Low-income schools are frequently lacking in professional development funds for educators, as well as textbooks and hands-on learning materials to facilitate their instruction (Lee & Buxton, 2008). Lee and Buxton go on to review several examples of differentiated learning curricula that improved student achievement in science in the underprivileged student population, which will be considered in the section below on personalized instruction.

Although it seems intuitive that larger class size would negatively affect student performance, the findings from the educational research community, based on a vast accumulation of research, is ambiguous at best (Chingos, 2012). Educational researchers have been preoccupied with the effect of large and small class size since the era of Abraham Lincoln. However, much of this data was produced prior to current rigorous scientific methodology. Beginning in the 1970's, in answer to the inconsistency of data on this subject, a number of researchers re-evaluated the validity of the previous research. Glass and Smith (1979) are two such researchers. In their extensive meta-analysis, a strict criteria of scientific design was applied to all of the literature available on the relationship between class size and academic achievement. The authors identified only 38 studies that met such criteria; only one having the highest quality randomized design (Glass & Smith, 1979). These 38 studies were re-evaluated using advanced methods of analysis and the authors concluded that, when considering well-controlled studies measuring effect of class size, the data clearly supports a positive relationship between small class size and achievement. The researchers also found that class size effects are most apparent in the secondary grades (Glass & Smith, 1979).

Yet if we fast forward nearly 30 years, the same questions about the impact of class size persist. Vanessa L. Wyss, et al. (2007), conducted a study to provide more scientific evidence on the effect of class size on academic performance in the high school sciences. The authors first acknowledged that the extensive literature on the subject of class size is beset with inconsistencies, poor research design, and conflicting conclusions. Further, the authors noted that most of the evidence used to support the efficacy of smaller class size originated from the Tennessee Star Project, which only assessed class size effect on students in elementary grades. In fact, the authors found very little evidence-based data measuring the effect of class size on secondary students (Wyss, et al., 2007). This study asked two questions. The first was: what was the effect of 5 different high school class sizes (ranging from 10 or less to over 30) on teacher practice—the assumption being that better teacher practices, as listed below, would lead to better student performance. The second question asked was: what effect high school class size had on college science grades—the hypothesis being that teachers using better teacher practices would produce more successful college students. Data was collected through subset analysis of a larger body of data from the four year Factors Influencing College Science Success (FICSS) project that surveyed over 8000 college students regarding their high school science experiences. Frequency of teacher practices and class size were analyzed. The five different teacher best practices measured included whole class instruction, individual work, small group work, demonstrations, lecture, and peer tutoring. Although statistically there were only minor differences in performance between any class, regardless of size, classes that incorporated a mix of best practices least often were the classes of 10 or less and classes of over 30. Analysis of high school science class size and college science grades also showed very week correlation (Wyss, et al., 2007). Based on this data, and showing that the contradictions continue, the authors conclude that class size has minimal effect on academic performance.

Another study conducted in Denmark in 2013 documents exactly the opposite finding. This study measures exit exam scores of over 25,000 tenth grade students and correlates them to class size. Denmark enforces a 28-student classroom maximum. The study found that smaller classes produced higher exit scores. Additionally the study found that the nearer classes got to 17 students per class, the more students entered college programs. (Krassel & Heinesen, 2014).

It is common in the medical industry that when faced with negative results of a large set of general data, that the data then be treated to subset analysis. That is, if the treatment does not statistically benefit the whole of the targeted population, there may be smaller groups within the study population that did benefit. Some social scientists have begun to ask whether this might also be true of the class size effect data. In another meta-analysis done by the State of Washington to assess the value of smaller class size in light of pending budget reductions, the authors identified 38 studies that met their own rigorous scientific criteria (WSIPP, 2007). These researchers also applied rigorous statistical analysis to their selected data and their conclusions are similar to those of Glass and Smith, finding that there is some degree of beneficial effect related to smaller class size. It is important to note that in most of the research on class size, class size ranges from a small of 15 students to a large of 30. The Washington State data did suggest that there is greater positive effect for classes of fewer than 20 compared to classes of over 30, but little difference between classes of 30 compared to classes of over 40. The Washington State report also added additional clarity as to what specific populations of students were shown to benefit from smaller class size. Specifically, it showed that students in early elementary grades and low-income students of all ages do significantly benefit from smaller class size (WSIPP, 2007). Although the authors of the Washington State report did conclude that the benefits of small class size to low-income students are significant, especially when combined with the associated low performance of this population, their final recommendations were that the cost would not justify the potential benefits (WSIPP, 2007).

Most of the research on class size effect defines benefit, either explicitly or implicitly, as improved academic achievement. In this era of high stakes testing, if there is the potential to replicate the success factors of the small classroom that contribute to higher academic achievement within a large classroom, it would be particularly useful to identify such factors. What occurs in a small classroom that does not in a large classroom? With this in mind, Blatchford, Bennett and Brown (2011) set out to document student behavior and classroom interactions in large versus small classes. The authors combined state and school-provided data on each of 868 randomly selected participants, including prior academic achievement level, with classroom observations. Students were enrolled in various K-12 classes and various subject areas. Observations documented number of students in class, time of day, subject and grade, and student and teacher activity at time of observation. In this research the authors considered whether student age or prior achievement is affected differently by class size. The observations were separated into reporting of student behavior as either on-task or off task; personal engagement between teacher and pupil; whether the teacher was focused on the whole class or on non-teaching classroom management. The most relevant results specific to secondary students were as follows:

1. With regard to percent of time on-task, class-size had no significant effect on higher academic achievers, but there was a significant reduction in time on-task for the lower achieving students. In fact, with every 5 additional students in any class there was a 20% drop in on-task time with these students.

2. Regarding off-task time, again there was a significant negative effect for lower performing students. There was over twice as much off-task time documented in classes of 30 students compared to classes of 15.

3. There was a highly significant drop in teacher-student interaction for all ages and classes as class size increased. In the secondary classroom, an increase of 5 students reduced teacher-student interactions by 25%. Instead, teacher provided whole class lecture time increased as class size increased.

These results support the three general findings that there is less student engagement, less individualized teacher-student instruction, and increased teacher-provided lecture as class size increases. This study adds additional clarity to the class size effect in that student learning behavior was most negatively affected by larger class size in the lower achieving student population, and conversely, that high achieving students are generally unaffected by class size (Blatchford, Bennett & Brown, 2008). This last point is worth special note. If the goal is to increase overall academic performance, it might make sense to reduce class size by introducing CBI to students who can learn effectively through that method, leaving more room for interaction between teachers and lower performing students This is the underlying rationale for the research question that guides this project.

The data discussed thus far confirms that low-income students are a unique group who are associated with complex, often troubled personal, family and home life conditions, and who are often disproportionately served by underfunded and inadequately resourced public schools that typically produce the lowest academic achievement scores in the sciences in the country. Large class size is a commonly occurring condition that appears to compound the challenges of learning in this population and is typically accompanied by reduced student engagement and individual teacher-student interaction. Due to ongoing budget constraints, as well as the use of the generalized and contradictory data suggesting no negative effects from large classes by the U.S. government (Duncan, 2010), overcrowded classrooms may not be addressed in the near future. The current phenomenon of overcrowded and underfunded high school classrooms serving low-income populations, combined with low science proficiency scores, has created an area of research that is greatly lacking in peer-reviewed evidence as to how educators might better manage large classes for increase learning in the sciences.

Small Learning Groups and Personalized instruction

As we have seen, personalized instruction and student engagement are key aspects of smaller class size that are associated with higher academic achievement and that are less likely to occur in larger classes. Personalization of the school environment is thought to be directly related to improved student learning and is at the core of a great deal of current research on educational reform (Biddle & Berliner, 2002; Carnegie Task Force on the Education of Young Adolescents, 1989; Bill and Melinda Gates Foundation, 2003; National Association of Secondary School Principals, 1996). The following review will examine how smaller learning groups or communities can increase the activities associated with personalized instruction and student engagement and thereby increase student performance.

The Project on High Performance Learning Communities (Project HiPlaces) was founded in 1989 to build a research organization purposed to create an evidentiary base around efforts to improve education. The project connects researchers with practitioners to implement new practices, evaluate efficacy, and redesign or refine for continued improvement. The goal is to identify what works in educational reform (Felner et al., 2008). Although most research on school reform focuses strictly on improving performance, or test scores and curricula, Felner's project includes a third aspect of learning that he calls the "opportunity to learn" (p. 236). Three decades of research from the Project have lead researchers to conclude that it is the personalized instruction that occurs in small learning groups that improves both performance and the environment for learning, which the researchers call the “opportunity to learn” (Felner, Seitsinger, Brand, Burns, & Bolton, 2008). This research includes more than 3000 annual assessments of 26 state data sets combined with analysis of many studies associated with school reform. The project findings identify three conditions that increase in the presence of personalized instruction: connections between students and teachers, connections between peers, and heightened teacher awareness and responsiveness to individual students (Felner, Seitsinge Brand, Burns, & Bolton, 2008). These conditions have been shown to correlate with increased student engagement, motivation and performance. Their research goes on to provide extensive evidence supporting smaller learning groups as a strategy to increase personalization of instruction (Felner, Seitsinger, Brand, Burns, & Bolton, 2008). The first small learning environment interventions in Project HiPlaces were implemented in secondary schools with 80% of the students being from low income, minority background and where dropout rates exceeded 50%. Beneficial results of smaller learning communities include 40 to 50% declines in dropout rates, increased student motivation and positive attitudes towards school and teachers, and decreased rates of student emotional and behavioral difficulties. Although performance trends suggest improvement from small learning communities, a clearer effect has been the reduction in declines in achievement that were found in control/comparison samples (Felner, Seitsinger, Brand, Burns, & Bolton, 2007). Over time the project interventions have included a full range of school communities across various socioeconomic levels and results have been consistent across multiple school levels/ages and conditions. However, the size of the effect of smaller group learning increases in larger schools and schools with a higher percentage of disadvantaged student populations. The authors of Project HiPlace support the value of small learning communities, especially for the disadvantaged student population, as described above, however, they warn that without comprehensive "practical and procedural changes" that involve district-wide attitudes and supports, school wide operational adjustments, and staff retraining, success may be limited (Felner, Seitsinger, Brand, Burns, & Bolton, 2008, p. 251).

Lee and Buxtons' (2008) recommendations about customized science curricula for disadvantaged students were predicated on several case studies assessing the impact of science curricula created for a specific student population. One study assessed the success of teaching science curricula that was contextualized to the students' own environment using real-world examples from their own community. This customized science content was taught over the course of 3 years to over 8000 students and consistently produced higher achievement scores than previous years' classes. A second study applied common biology topics to the food industry, drawing on preexisting interests of the student population as well as availability and cost of food from their own community stores. The contextualized food lessons were taught in 23 courses at 3 different low-income schools. Two schools continued to teach from the traditional text.

The intervention students consistently scored higher in the end-of-lesson tests. The researchers concluded that science education that draws on community-based information leads to the greatest level of understanding, especially for low-income students who may feel disenfranchised from classroom science (Lee & Buxton, 2008).

Computer-Based Instruction in the Classroom

The challenge of providing personalized instruction in a large classroom is a relatively recent concern in secondary education. For the past several decades America’s public school classrooms have functioned under a federal standard that classes remain below 25 students per class. However, because school regulation is primarily a State responsibility with little to no federal authority, high school classes in the U.S. are often as large as of 35 students per instructor. Further, many state class size maximum limits are grade specific and often only limit class sizes in the primary grades (Chen, 2013). As of 2014, 28 states including Oregon and Washington either have no maximum class size regulation or do not enforce them (Students First, 2014). Even California has recently loosened its strict standard of 20 students per class in all grades. The 2004 U.S. Department of Education Report on the results of a 1999 effort to reduce class size and improve learning presents an accurate description of the constantly changing and ambiguous reporting of class size across America (U.S. Department of Education, 2004). Suffice it to say that high school class size in America runs the spectrum from small (less than 20) to 35 students or more.

There are numerous editorials and anecdotal essays supporting the use of CBI as a solution for providing differentiated instruction in the classroom. CBI could offer an overwhelmed single teacher with large classes a tool to aid in meeting individual learning needs (Kulik, 2003). However, there are very few peer-reviewed articles pertaining to the integration of CBI into the classroom. In the following section I will briefly review the general consensus pertaining to the value of CBI and differentiated instruction as well as giving two examples of how CBI has been used to improve student achievement in the classroom.

Cavanaugh et al (2004), recognized the value of technology-based instruction in meeting individual student learning needs in the midst of an explosion of online or computer-based instruction opportunities that have arisen over the past 20 years (Cavanaugh, Gillan, Kromrey, Hess, & Blomeyer, 2004). Their awareness of the potential for CBI was confounded by the fact that there was very little evidence in the literature that confirms the efficacy of CBI, or, more importantly, that identifies factors that affect student learning success with CBI. To this end, Cavenaugh, et al (2004), ran a meta-analysis of the literature published between 1999 and 2004, which produced only 14 studies deemed to meet scientific criteria, criteria that requires controlled, systematic, empirical comparisons as defined by the U.S Department of Education (National Institute for Literacy, 2006). Their initial review of the 14 studies included in their analysis produced 116 different outcomes. The researchers categorized these outcomes into similar 45 groupings, and used hypothesis testing to identify both instructional effect and any factors that were associated with greater CBI success. Based on their analysis, the authors could only conclude that CBI produces equal academic achievement results to traditional classroom learning. From their results they did not identify any student specific factors that were associated with greater online learning success, but they admit that more research is greatly needed (Cavanaugh, Gillan, Kromrey, Hess, & Blomeyer, 2004).

This researcher found, as did Cavanaugh, et al (2004), that most of the literature on effect of CBI is not related to situations where CBI is used within the classroom, but rather in relation to 'distance learning' when a teacher is not present and the instruction can be accessed from any location with internet service, or provided to students as an alternative to teacher based instruction entirely such as in credit recovery programs. Although there is a wealth of evidence showing value in student-to-student and student-teacher interaction, as discussed in the small learnings groups section of this paper, research addressing the question of using CBI within the traditional classroom in order to retain such valuable aspect to instruction, is lacking. However the challenges of providing personalized instruction in a large classroom has been an area of concern when studying college freshman enrolled in introductory science courses, which can have over 100 students in one classroom. Studies have suggested that students in high enrollment science courses do not retain material, maintain motivation, or develop higher order thinking as well as in smaller classes (McKeachie, 1986).

In an effort to combat the recurrent problem of low attendance and poor performance in these large classroom settings, researchers at Michigan State created a hybrid course design, replacing some lecture with online instruction. The intervention was integrated into one three hour, high enrollment introductory biology course whose effectiveness was then compared to the traditional lecture style course (Riffell & Sibley, 2004). The intervention group received online instruction for two 50-minute classes a week and one face-to-face active lecture by the instructor. Active lecture is described as class time including open discussion, in-class short answer assignments and small group activities. The control group received two 50-minute instructor-provided passive lecture classes a week and one active lecture. Rationale for this design was based on data that supports online instruction as at least as effective as in-person teacher-based instruction combined with the fact that computer-based instruction can be more interactive and personalized than basic note taking in a lecture (Riffell & Sibley, 2004). However, there are numerous references in the literature to high attrition rates in online classes, especially in the high school setting. These may be attributable to lack of face-to-face interactions and accountability (Hawkins, et al, 2013). By combining online learning with face-to-face classroom instruction, authors Riffell and Sibley (2004) questioned whether the benefits of both platforms would be provided. This hybrid format was followed for the entire semester in the test class. The efficacy of the intervention was measured using pre- and post-test scores. Test score analysis was performed with 74 students in the traditional course and 55 students from the hybrid course. Post-tests were given at week 14 of the course, but one week before the final. Results from their study showed that college freshman science students, enrolled in large classes, that used a combination of on-line learning and active lecture scored equal to or better than those in large traditional classes that used passive lecture instead of on-line instruction. Further, students who received the hybrid instructional format reported reading their text books twice as often and participated in study groups with peers 50% more often than the control group (Riffell & Sibley, 2004).

In another example of the use of online instruction used with a traditional classroom, and there are not many, researchers from Lehigh University conducted a feasibility study to assess the success of an on-line learning unit on evolution that that they created (Marsteller & Bodzin, 2015). In the midst of the school year at a rural, traditional high school serving a student population of which 30% qualify for free lunch, their computer-based unit was provided to 77 first year biology students. The intervention spanned 12 days and required students to receive their on-line experience in the schools computer lab.

Based on their research of essential elements of the learning process in science, the authors identified key elements that led to improved learning of science concepts which included basic informational text, simulations, analysis, case study, evaluation and social discourse in their on-line curriculum. The on-line instructional program used did incorporate all of the essential elements listed above into its lesson. In this study the students arrived at the computer lab each day, sat at a computer and completed the assigned learning module for that day. Although cumulative post-test scores were significantly higher than pre-test scores, the design did not literally incorporate CBI into a traditional classroom, but instead removed all students from the classroom which limited any interaction with a teacher or peers. Based on post intervention interviews, students felt that they needed additional support from their teacher and that they felt a lack of interaction with teacher and peers (Marsteller & Bodzin, 2015). In the face of such a lack of evidence supporting any actual process for adding CBI to traditional science classrooms, this study attempts to initiate such discourse.

Literature Review Summary

The effect of large class size on the learning performance of students in American public schools has been debated for over 50 years. Research on this topic can be found to correlate large class size to poor performance and research can be found to so that there is no effect. Certainly other factors play into the potential for students to learn in any environment including home life, teacher quality, educational resources and cultural backgrounds to name a few. There does however seem to be agreement that large class size negatively effects two populations of students. They are students in the primary grades, and students from lower income communities.

Elements that have been identified as more conducive to learning in smaller classes, or learning groups, include increased interactions with both teachers and peers. Such increased interactions have been associated with increases in both differentiated instruction for students as well as student engagement. With this in mind, this study questions whether computer based instruction can be used within a class with an average of 30 low-income, high school science students to create smaller learning group and improve learning performance. Further, this study seeks to identify which students learn better from computer based instruction versus teacher based instruction. As technology continues to play a greater role in classroom instruction this study will hopefully lend some additional direction as to how to most effectively manage large classrooms and leverage this valuable tool for greatest success.

METHODOLOGY

Overview

The primary research question driving this research is: what is the effect of adding CBI, as an instructional group, into large high school science classes, in tandem with teacher-led instruction, to create smaller learning groups? A second question is: Can we identify students who are more likely to learn from one instructional method or the other (CBI or teacher-led instruction)? To this end, students were administered a pre-test before receiving a lesson on cellular biology and a post-test after the lesson. Changes in test scores were assessed to determine if providing different instructional options in the same classroom resulted in whole class improvement. Additionally, student's prior academic achievement ranking (as assessed by the classroom teacher) were matched with post-test improvements to identify any correlation between ability and form of instruction received. To measure student performance, defined as the improvement in content understanding, the researcher administered a 12-question multiple-choice assessment (pre-test) prior to instruction and the same set of questions (post-test) after instruction. This study involved 86 students who were enrolled in 4 selected periods of first-year high school biology. In this study, the researcher delivered the teacher-based instruction for all four periods and conducted the observations of teacher-student interactions.

This study uses a mixed methods approach that incorporates both qualitative and quantitative methodology which includes quasi-experimental design elements.

Qualitative data in this study include: ethnographic research or the study of a particular culture or group; grounded theory (Ralph, 2013), or inductive research based on historical data (literature review); and observation (achievement rankings based on teacher observation). Quantitative methods include comparisons of post-test scores between populations using t-test analysis to determine if the differences between populations are due to random chance or to the variable in question. In this study, the null hypotheses, that the intervention had no effect on classroom performance or that there is no difference in achievement between high and low ability students, are statistically determined to be either accepted (true) or rejected (not true). Hypothesis testing, a form of quantitative statistical analysis, is used to compare the raw data—in this case, changes in test scores between compared class groups. This hypothesis testing along with researcher observations will set the stage for recommendations for future study.

In this study students in each class were randomly assigned to receive either teacher-led instruction or CBI. However, because students in each class were pre-assigned to their respective class the researcher can only base comparisons on assumed similarity between classes. Therefore, this element of non-random selection of participants introduces a quasi-experimental component to the research. The study design is a simple pre-and post-test assessment of two similar populations, each receiving a different intervention (Table 1).

Table 1. Study Design

Diagram of Study:

N1 O1 Xc O2

N2 O1 Xt O2

- - - - - - - - - - - - - - - - - -

Where N1 is all of the students who received the CBI, and N2 is all of the students who received teacher-led instruction. O1 is the pre-test, O2 is post-test, Xc is the CBI treatment, and Xt is the teacher-led treatment.

Purpose

The purpose of this study is to assess the value of incorporating computer-based instruction into a large, traditional, teacher-led instructional classroom of 27 students or more, as a way to create smaller learning groups and provide a higher degree of personalized instruction. More specifically, this study assesses whether such an intervention can benefit the low-income student population that has been demonstrated to benefit the most from both smaller class sizes or learning groups and personalized instruction. As such this study:

1. Measures the effectiveness, assessed by pre- and post-test scores, of giving a computer-based lesson to one small group of students in a large classroom setting, while the remaining students received the same lesson through teacher-led instruction.

2. Analyzes the effect that prior academic achievement level, as rated by the teacher (based on GPA), has on individual performance (test scores) between computer-based and teacher-based instruction.

3. Analyzes the effect of gender on performance between the two learning methods (teacher-led and computer-based).

Participants

Participants in this study were students attending a suburban high school that qualifies for Title 1 funding in Washington State. Title 1 funding consists of grant monies from the Federal Government intended to assist low-income students in achieving educational goals. Students are considered low-income if they qualify for free or reduced cost lunch programs. A school that has over 40% of its student body receiving free or reduced cost lunch qualifies for Title 1 funding. Students were selected based on their enrollment in the 9th grade introductory Biology course. Intro to Biology is a required year-long course at this school. In order to participate in this study, students were required to sign and obtain a signed consent form from a parent or guardian, take pre- and post-tests, and attend all three days of the lesson.

The demographics of this student population are 29% minority and 50% eligible for free lunch. The school enrolls approximately a thousand students. Tenth grade science achievement scores show 64% of students passing. On a 1 to 10 scale, with 10 being the rating for the highest performing schools in the state, this school received a rating of 3 for student readiness for career or college (Washington Board of Education, 2013).

As discussed in the literature review, there are a cluster of conditions associated with lower high school academic performance. These include low socio-economic status (Title 1), large class sizes, and high percentage of minority and non-English speaking students. As evidenced by the State Demographics Report, the school used in this research demonstrates all of the above conditions as shown in Table 2. (Washington State Education, 2013)

Table 2. School Demographics (Office of Superintendent of Public Instruction).

Student Count	950-1100
Gender	
Female	49.7%
Male	50.3%
Ethnicity	
American Indian or Alaskan Native	1.1%
Asian	3.0%
Native Hawaiian / Other Pacific Islander	0.5%
Asian or Pacific Islander	3.5%
Black	1.8%
Hispanic	18.1%
White	68.1%
Two or More Races	7.4%
Special Programs	
Free or Reduced-Price Meals	54.4%
Special Education	

Transitional Bilingual Migrant Section 504 Foster Care	13.5% 1.6% 0.0% 1.5% 0.3%
Adjusted 5-year Cohort Graduation Rate (Class of 2012)	66.0%

These student characteristics also define the student population found to benefit the most from personalized instruction (Felner, Seitsinger, Brand, Burns, & Bolton,2008).

A breakdown of the student variables including gender, academic achievement, and instruction method per class is given in Table 3. Achievement rankings were provided by the classroom teacher based on cumulative GPA. The four periods included a total of 103 Biology students. Eighty-six students completed the study. The discrepancy in total numbers is due to either student absences or to lack of signed consent forms.

Table 3. Mix of Pertinent Variables per Class.

	Class size	Gender M/F	High Achievers	Medium Achievers	Low Achievers	CBI Instruction	Teacher Instruction
Period 2	26	12/14	4	14	8	11	11
Period 3	28	15/13	4	13	11	7	8
Period 4	28	14/14	6	15	7	11	12

Period 6	28	16/12	5	14	9	14	12

Treatment

The treatment in this study was the creation of 2 smaller learning groups within four large classes of introductory biology. One small group received a computer-based lesson on cellular biology. The second small group received the same lesson but provided by a teacher. The lesson topic was selected by the regular classroom teacher and the content was provided by Apex Learning Systems. Each of the four sections of biology were divided randomly into two groups as described below. The intention was to have both groups receive their instruction in the same classroom that they use every day. However, the low-income school had limited access to computers and in the end the treatment was done in the school library. The library provided 15 computer stations located at one end of the library and use of a traditional classroom setting on the other end of the library. The library also provided noise-cancelling headphones for computer-based learners.

Instruments

The first requirement for in finding a lesson unit for this study was that it was available as a computer-based curricula. Apex Learning is the leading provider of virtual or online education in the U.S. and was the online curriculum subscribed to by the school district's alternative school for credit recovery. The classroom teacher was given three different lesson topics to choose from that were available on the Apex learning system. She selected Cell Differentiation based on the current unit of curriculum and for the difficulty of the topic. The classroom teacher felt this intervention would add to her future efforts to teach the subject.

The Apex Learning platform provided instructor notes for classroom lecture-style instruction as well as formative assessment multiple-choice questions derived directly from the content. These multiple-choice questions were used for the pre- and post-test questions. The Lesson Content Outline and pre- and post-test assessment questions are were provided by Edmentum, on online learning software company and rights to their content is proprietary.

The purpose of this study is to assess the value of incorporating online learning into a traditional classroom. The hypothesis is that using computer-based instruction with some students in the classroom will create smaller learning groups and increased personalization of instruction for the other students—both of which are associated with improved learning. Using computer-based instruction for students with high online learning aptitude might make it more possible for one teacher to provide smaller learning groups and greater personalization. It was the researcher's original intention to bring computers into the Biology classroom used daily by the students. The largest of the four classes had 28 students, which therefore set a requirement of a minimum of 14 computers for the computer-based instruction groups. However, the limited resources of this low-income school made providing computers in the classroom impossible and consequently the intervention was carried out in the school library. The library provided 15 computer stations located at one end of the library and use of a traditional classroom setting on the other end of the library. The library also provided noise-cancelling headphones for computer-based learners. Although holding the class in the library was not ideal for supporting the premise that students can receive personalized instruction within the traditional classroom setting, the infrastructure at this low-income based school does not yet provide for classroom computers.

Anonymity was maintained by assigning each student a code, which was the only identifier used in this study. Each code included a class period identifier, which allowed for data comparisons between the different classes. All students enrolled in the four biology classes were expected to participate in the intervention including taking pre-and post-tests. However, only data from students who provided signed consent forms was used in this research. Ninety percent of all students, or 126 students submitted signed consent forms.

Procedure

The four sections of Biology to receive the study treatment were all assigned to the same Biology teacher. For the purpose of consistency and comparison of instruction, in all four sections/periods the researcher served as the instructor for this specific lesson. The teacher was in the classroom during the lesson but did not aid in student instruction.

On day one of this study the researcher used 30 minutes of a 50-minute class period to explain to each section/class the purpose of the experiment and the procedure to be followed for the next day when the intervention would take place. The researcher then administered a 12-question multiple-choice pre-test. On day two, students in the four investigational classes were randomly assigned to either computer-based or teacher-based instructional groups upon arrival to class. Half of the students from each class were assigned to computer workstations. These students received a brief handout with directions on how to access the computer-based cell differentiation lesson. These students worked through the computer-based lesson at the computer stations in the back of the classroom using noise-cancelling headphones. The Apex online lesson included opportunities to review areas of content not clearly understood by the student, as well as two formative assessments to identify such areas. The Apex software had built-in encouragements for students to review content not well understood as well as to open enhancements to primary content such as videos and additional text, to further help with understanding.

The remaining students in each of the four periods sat at the front of the classroom and received the same lesson, but given by the instructor/researcher. The Apex online learning system provided the instructor notes and the same illustrations used in the computer-based instruction, which were projected on a whiteboard. All students in both groups were provided a vocabulary worksheet and encouraged to use it for note taking throughout the lesson. On day three, the researcher administered the same set of 12 multiple-choice questions as a post-test.

The independent variable in this study is the effect of smaller learning groups led by either computer-based instruction or teacher-based instruction on academic performance. The dependent variable is the improvement in content understanding, or performance, as measured by pre- and post-test analysis. Lesson content and test questions, derived from the course content, were provided by the Apex Learning System curricula. In addition to overall changes in pre- and post-test scores based on instructional format (teacher-based or computer-based), the study also assessed the impact of gender and prior academic achievement level, as ranked by the class teacher (ranked as high, medium or low) on performance. The teacher based these rankings on cumulative grades to date. Student engagement was assessed based on frequency of student-teacher and peer-to-peer interactions as observed and logged by the researcher. These observations are addressed in the discussion section of this paper.

Instructional Strategy, Instruments, and Confidentiality

The first requirement for in finding a lesson unit for this study was that it was available as a computer-based curricula. The Apex Learning is the leading provider of virtual or online education in the U.S. and was the online curriculum subscribed to by the school district's alternative school for credit recovery. The classroom teacher was given three different lesson topics to choose from that were available on the Apex learning system. She selected Cell Differentiation based on the current unit of curriculum and for the difficulty of the topic. The classroom teacher felt this intervention would add to her future efforts to teach the subject.

The Apex Learning platform provided instructor notes for classroom lecture-style instruction as well as formative assessment multiple-choice questions derived directly from the content. These multiple-choice questions were used for the pre- and post-test questions. [The Lesson Content Outline and pre- and post-test assessment questions are available in Appendices 2 and 3. The Statement of Accreditation of the APEX curricula is available in Appendix 4. The Online Learning Aptitude Survey, as discussed in the literature review, can be seen in Appendix 5.e

The purpose of this study is to assess the value of incorporating online learning into a traditional classroom. The hypothesis is that using computer-based instruction with some students in the classroom, while others gain instruction from the teacher will create smaller learning groups and increased personalization of instruction for all students. It was the researcher's original intention to bring computers into the Biology classroom that is used daily by the students. The largest of the four classes had 28 students, which therefore set a requirement of a minimum of 14 computers for the computer-based instruction groups. However, the limited resources of this low-income school made providing computers in the classroom impossible and consequently the intervention had to be carried out in the school library. The library provided 15 computer stations located at one end of the library and use of a traditional classroom setting on the other end of the library. The library also provided noise-cancelling headphones for computer-based learners. Although holding the class in the library was not ideal for supporting the premise that students can receive personalized instruction within the traditional classroom setting, the infrastructure at this low-income based school does not yet provide for classroom or individual computers.

Anonymity was maintained by assigning each student a code, which was the only identifier used in this study. Each code included a class period identifier, which allowed for data comparisons between the different classes. All students enrolled in the four biology classes were expected to participate in the intervention including taking pre-and post-tests. However, only data from students who provided signed consent forms was used in this research. Ninety percent of all students, or 126 students submitted signed consent forms. A sample consent form can be viewed in Appendix 6. All participants also completed the aptitude survey.

RESULTS

The purpose of this study was to assess the impact of creating smaller learning groups by incorporating CBI into the classroom, thereby increasing personalized instruction in a large teacher-led classroom. A mixed methods t-test design using quantitative data was used to analyze the following three hypotheses:

1) Classes that were split into two learning cohorts, thereby creating smaller, more personalized learning groups, will produce improvement in post-test scores
2) High academic achievers, as identified by classroom teacher, will produce the greatest improvement in content understanding. Further, high academic achievers will perform best in the CBI groups.
3) Low academic achievers, as identified by classroom teacher, will show higher post-test scores in smaller, teacher provided instruction groups.

Data was tabulated to record pre- and post-test scores, test score delta, gender, academic achievement level (as identified by the teacher). Mean differences in pre- and post-test scores were calculated between the following groups: all students who received CBI, all students who received TBI; high, mid and low academic achievers receiving CBI and TBI; male versus females receiving CBI and TBI. T-test analysis was applied to each group to confirm whether the mean difference was due to the treatment (alternative hypothesis), small group learning with one of two instructional modalities, or to random chance (null hypothesis). The PHstat Excel software program was used to determine statistical significance of raw test scores between groups.

Findings with a p-value of less than .05 confirmed rejection of the null hypothesis, or that the measured affect was in fact due to the intervention.

Hypothesis #1. Students receiving the study treatment, either CBI or TBI within smaller learning groups will increase in content understanding, or performance, based on post-test scores. The null hypothesis therefore, is that the treatment did not result in improvement in content understanding or that any improvement was due to chance and not to the intervention. In this study 86 students in 4 sections/periods of Biology, received the intervention, that is, were in classes that were split into two learning groups with one receiving teacher-based instruction and one receiving computer-based instruction. Using the PHstat program, all pre-test scores were tabulated and compared to all post-test scores. Per Table 4, the mean or average number of correct questions for all students on the pre-test was 5.1 out of 12. After the treatment, the average number correct was 5.67. Although this suggests a trend toward improvement in content understanding, after t-test analysis of the pre- and post-test scores using the PHstat program, the p-value was .11, which requires acceptance of the null hypothesis. This means, in answer the hypothesis #1, that students in this study will increase in content understanding when considering all students that received the lesson either from CBI or teacher based instruction, there was no significant improvement in content understanding. Upon further analysis of hypothesis 2, and 3, these results suggest however that specific students did improve in content understanding depending on which instructional method they received.

Table 4. Pooled-Variance t Test for the Difference Between Two Means; that of pre-test scores and post-test scores of all students in study

Data	
Hypothesized Difference	0
Level of Significance	0.05
Population 1 Sample	
Sample Size	86
Sample Mean	5.125
Sample Standard Deviation	1.845722
Population 2 Sample	
Sample Size	86
Sample Mean	5.671233
Sample Standard Deviation	2.29162
Two-Tail Test	
Lower Critical Value	-1.9767
Upper Critical Value	1.9767
p-Value	0.1164
Do not reject the null hypothesis	

(assumes equal population variances)

Hypothesis #2. High academic achievers will show greatest improvement in content understanding based on delta between pre- and post-test scores. They will produce greater scores in CBI groups. There were a total of 11 students from all 4 periods who were ranked as high academic achievers by their teacher. Six received CBI and six received teacher-led instruction. Table 5 shows the test scores and deltas for each of the 12 high academic achievers. Five high achievers received the lesson from teacher based instruction and 6 received the lesson from CBI. Gender was equally divided between groups.

Table 5. Test Scores of High Academic Achievers

identity	pre-test	post-test	CBI y/n	Gender	Ranking	Delta
2x	7	7	n	m	h	0
4l	6	9	n	m	h	3
4u	7	10	n	m	h	3
4x	6	7	n	f	h	1
6q	8	8	n	f	h	0
2b	9	11	y	m	h	2
2f	8	8	y	f	h	0
2i	9	11	y	f	h	2
3n	5	9	y	m	h	4
4n	9	9	y	f	h	0
6j	7	9	y	f	h	2

Table 6 shows that the mean number of correct answers on the pre-test for high academic achievers was 7.4. The mean number of correct answers on their post-tests was 8.9. Figure 7 shows the results from T-test analysis comparing post-test score improvements from pre-test scores of high academic achievers receiving either CBI or teacher-led instruction and confirms that the improvement from 7.4 to 8.9 has a p-value of .0234. This means that the improvement was not due to chance but was due to the intervention (null hypothesis rejected). This set of data is measuring all high academic achievers receiving either instructional format. This suggests that high academic achievers as a group increased in content understanding.

Table 6. Pooled-Variance *t* Test for the Difference Between Mean pre-test and post-test scores of high achievers receiving either CBI or teacher-led instruction
(assumes equal population variances)

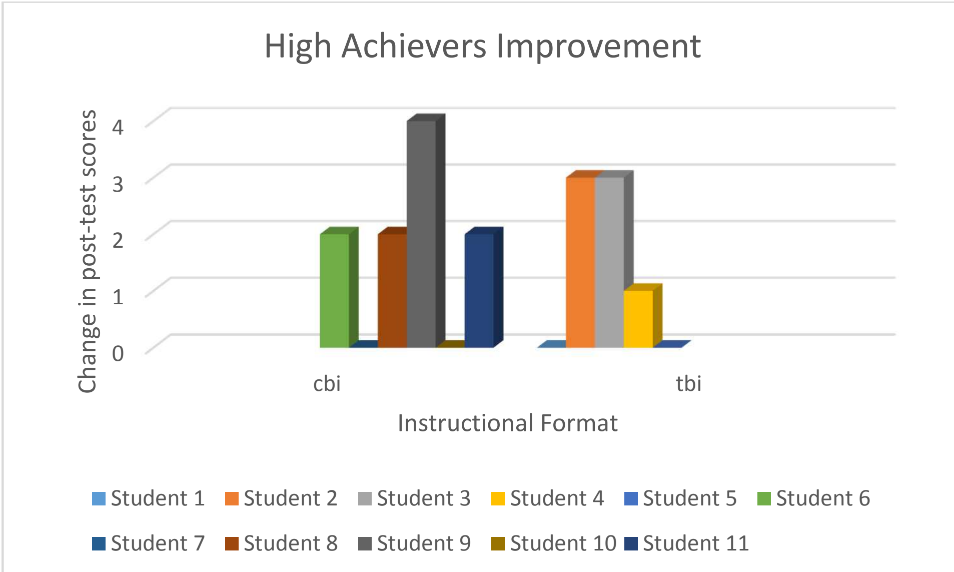
Data	
Hypothesized Difference	0
Level of Significance	0.05
Population 1 Sample	
Sample Size	11
Sample Mean	7.4
Sample Standard Deviation	1.429841
Population 2 Sample	
Sample Size	11
Sample Mean	8.909091
Sample Standard Deviation	1.375103
Two-Tail Test	
Lower Critical Value	-2.0930
Upper Critical Value	2.0930
p-Value	0.0234
Reject the null hypothesis	

Additionally, when the mean of deltas (average increase in number of questions correct) of 1.67 for high achievers that received CBI, was compared to the mean delta of those that received teacher-led instruction of 1.4, using t-test analysis, there was no statistical difference between groups found as shown in Table 7. This means that based on the data collected in this study, high academic achievers improved in content understanding equally from either CBI or teacher based instruction. Figure 1 presents the deltas of pre and post-test scores reported for high academic achievers receiving either instructional format in graph form.

Table 7. High Achievers that Received CBI Compared to Those That Received Teacher Led Instruction
(assumes equal population variances)

Data	
Hypothesized Difference	0
Level of Significance	0.05
Population 1 Sample	
Sample Size	5
Sample Mean	1.4
Sample Standard Deviation	1.516575
Population 2 Sample	
Sample Size	6
Sample Mean	1.666667
Sample Standard Deviation	1.505545
Two-Tail Test	
Lower Critical Value	-2.2281
Upper Critical Value	2.2281
p-Value	0.7661
Do not reject the null hypothesis	

Figure 1. High Achievers that Received CBI Compared to Those That Received Teacher Led instruction



Hypothesis #3. Low academic achievers will produce greater improvements in post-test scores from teacher-provided instruction. From the 4 sections of biology there were 32 students ranked as low academic achievers by their classroom teacher. The pre and post-test scores, deltas and gender are shown in Table 8.

Table 8. Pre and Post-Test scores and Deltas for Low-Achievers.

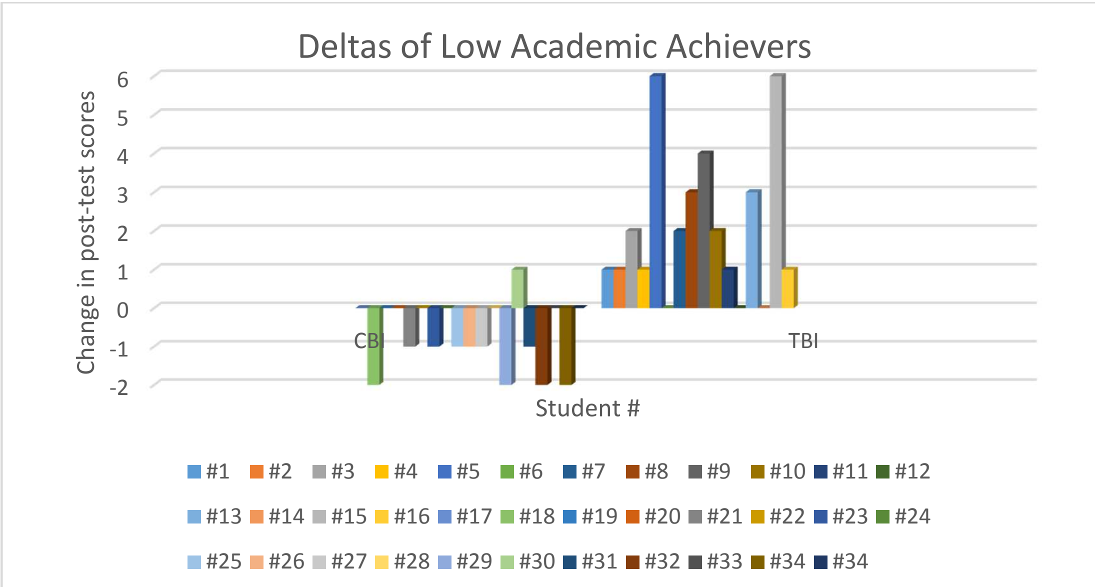
Identity	Pre-test	Post-test	Delta	CBI y/n	Gender
2g	4	5	1	n	m
2k	4	5	1	n	m
2n	3	5	2	n	m
2t	4	5	1	n	m
2w	3	9	6	n	f
3m	3	3	0	n	m
4i	4	6	2	n	f
4p	4	7	3	n	m
4q	3	7	4	n	f
4t	2	4	2	n	f
4v	2	3	1	n	f
6h	3	3	0	n	f
6x	2	5	3	n	m
6y	4	4	0	n	m
6k	5	11	6	n	m
6v	4	5	1	n	f
6n	1	1	0	y	m
6r	5	3	-2	y	m
6w	4	4	0	y	m
2q	3	3	0	y	f
2u	4	3	-1	y	f
2v	4	4	0	y	f
3k	5	4	-1	y	f
3s	4	4	0	y	f
4a	3	2	-1	y	f
4b	4	3	-1	y	m
4r	4	3	-1	y	m
4y	4	4	0	y	f
6aa	5	3	-2	y	m
6b	2	3	1	y	m
6c	3	2	-1	y	m
6f	6	4	-2	y	f
6n	1	1	0	y	m
6r	5	3	-2	y	m
6w	4	4	0	y	m

As shown in Table 9, of the 15 students ranked as low achievers who received teacher-led instruction, their average increase in number of questions answered correctly on the post-test was 2.13. Of the 19 students that received CBI, their average increase in correct answers was -.684. That is, the low academic achievement students actually got more questions *wrong* after receiving the computer-based lesson. Further, the p-value was highly significant at 0.00. A t-test analysis supports rejecting the null hypothesis, or the idea that this difference between groups is not due to random chance and the students ranked as low achievers in the teacher-led instructional group improved in post-test scores whereas the low achievers in the CBI group did not. Figure 3 shows low achiever deltas in graph form. It appears that this student group actually lost content understanding from CBI.

Table 9. T-test Results of Comparing Pre and Post-Test Deltas of Low Academic Achievers Receiving either CBI or Teacher-Led Instruction

Data	
Hypothesized Difference	0
Level of Significance	0.05
Population 1 Sample	
Sample Size	16
Sample Mean	2.133333333
Sample Standard Deviation	1.959105724
Population 2 Sample	
Sample Size	19
Sample Mean	-0.68421053
Sample Standard Deviation	0.885226373
Two-Tail Test	
Lower Critical Value	-2.0369
Upper Critical Value	2.0369
p-Value	0.0000
Reject the null hypothesis	

Figure 3. Low Achievers that Received CBI Compared to Those That Received Teacher Led Instruction



Although this study was intended to consider the academic performance of high academic achievers and low academic achievers specifically, the deltas of the mid-level achievers were assessed as well. Table 10 lists the pre and post-test scores of the mid-level ranked academic achievers. Figure 14 depicts graphically the change from pre to post-test scores of the 41 mid-level academic achievers in the study. From the t-test for statistical significance, Figure 4 shows that mid-level achievers did improve in content understanding as a group. Statistically there was no difference in improved content understanding between instructional formats, however there was a trend toward greater improvement with teacher based instruction. As would be expected, the higher academically rated students students scoring higher deltas were in the computer based instructional group suggesting their nearness to the higher academic achievement level group.

Table 10. Pre and Post-Test scores and Deltas for Mid level-Achievers.

Identity	Pre-test	Post-test	Delta	CBI y/n	Gender
2a	7		1	n	m
2c	5	8	3	n	m
2d	3	5	2	n	m
2e	4	6	2	n	f
2h	3	6	3	n	f
2j	4	5	1	n	m
2m	3	9	6	n	f
3a	3	5	2	n	m
3d	4	7	3	n	m
3g	3	3	0	n	f
3l	2	6	4	n	f
3r	3	5	2	n	m
4c	4	6	2	n	f
4d	4	7	3	n	m
4f	3	7	4	n	f
4h	2	4	2	n	f
4j	2	6	4	n	m
4s	2	3	1	n	f
4w	3	6	3	n	f
6a	3	3	0	n	f
6e	2	5	3	y	m
6g	4	4	0	y	m
6i	5	11	6	y	m
6k	4	7	3	y	f
6l	2	4	2	y	m
6m	5	6	1	y	m
6p	4	4	0	y	m
2l	3	6	3	y	f
2n	4	5	1	y	f
2o	4	4	0	y	f
3h	5	7	2	y	f
3i	3	5	2	y	f
4g	3	5	2	y	f
4k	4	6	2	y	m

4m	4	4	0	y	m
4o	4	4	0	y	f
6bb	5	6	1	y	m
6cc	2	3	1	y	m
6dd	3	3	0	y	m
6ee	5	7	2	y	f

Figure 4. Mid-Level Achievers that Received CBI Compared to Those That Received Teacher Led Instruction

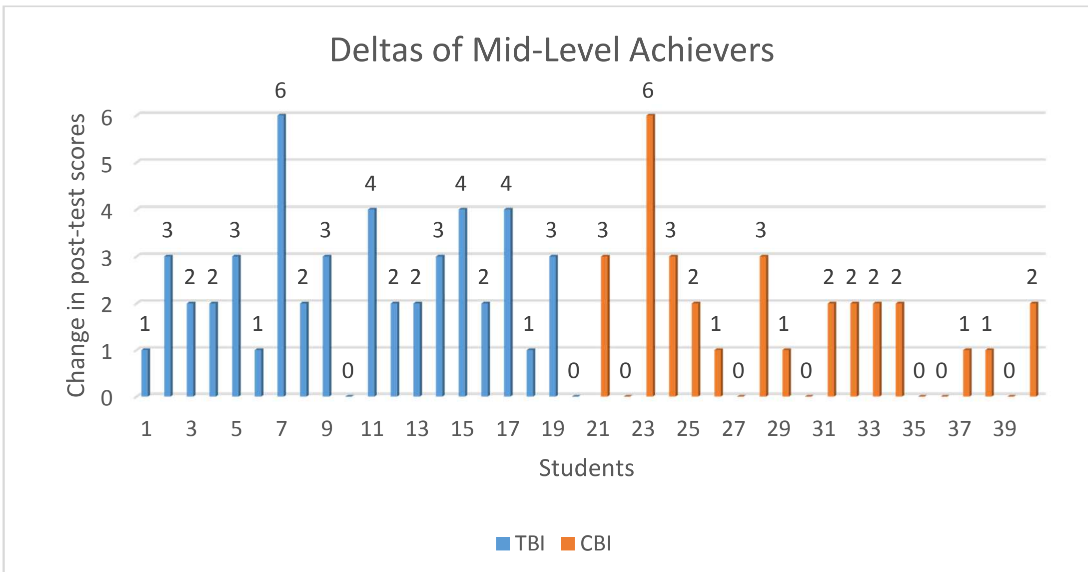


Table 11 is the statistical T-test results assessing the difference in learning between the two instructional formats for mid-level learners. Findings suggest that the improvement in pre and post-test scores for this group is not statistically different between instruction formats.

Figure11. Mid Achievers that Received CBI Compared to Those That Received Teacher Led Instruction
(assumes equal population variances)

Data	
Hypothesized Difference	0
Level of Significance	0.05
Population 1 Sample	
Sample Size	19
Sample Mean	7.4
Sample Standard Deviation	1.429841
Population 2 Sample	
Sample Size	21
Sample Mean	7.909091
Sample Standard Deviation	1.375103
Two-Tail Test	
Lower Critical Value	-2.0930
Upper Critical Value	2.0930
p-Value	0.0934
Do not reject the null hypothesis	

DISCUSSION

The data collected in the study contributes to the limited research on incorporating computer based instruction in to the high school science classroom. More specifically this study looks at the effect of using computer based instruction in a large classroom of over 27 students in a Title one, or low income based school in tandem with teacher instruction thereby creating smaller learning groups. Students from four pre-populated biology sections were administered a pre-test on the subject of cellular biology. After a 50 minute lesion provided by either a teacher or online, students took a post-test. The change in post-test scores from pre-test scores, or the deltas, were assessed to determine if whole classes improved in content understanding. Further, students were ranked by their teacher as high, mid, or low academic achievers and the deltas for each group were assessed.

Using a t-test electronic application to analyze the test scores, it was found that overall classroom content understanding did not significantly improve after one lesson. This was based on comparing all students that received the same lesson from a teacher to all the students the received the lesson online. These results however, do tell the complete story. When breaking out the results to consider the improvement in content understanding of each academic achievement level, there were clear suggestions as to the potential value of CBI in a large science classroom.

High academic achievers reported the highest increase in post-test scores. Statistically there was not a difference between their improved content understanding from CBI or from teacher based instruction. . This is in agreement with literature that shows that higher performing students are less affected by classroom dynamics (Blatchford, Bennett and Brown, 2011). There was a trend, however, towards higher total scores in the computer based instructional group of high academic achievers. This researches sees this as valuable insight as to which students to direct CBI in the classroom towards. In fact, given that advanced students should be provided differentiated instruction as well as challenged students, this seems an opportunity to do just that without demanding extensive additional teacher time.

Conversely, low academic achievers did not show a significant improvement in increased content understanding as a whole group. This gives explanation as to why the data that includes all students from all achievement levels did not show an improvement in learning. When low achiever deltas from each instructional group were analyzed, it was somewhat surprising to see that these students actually scored lower on the post-tests when receiving the content from a computer. This researcher finds this particularly poignant in light of the many 'credit recovery' programs offered to high school students that are exclusively online, the method of instruction that they most poorly learn from. When post-test results were separated out between instructional groups, the students who received instruction from the teacher, in a smaller group setting, did show statistically significant improvement in content understanding. This further emphasizes the importance of both the smaller learning group environment and the attention of a teacher to the more challenged student. This is also in agreement with the findings of Blatchford, Bennett and Brown, 2011.

A brief mention of the findings from analyzing the test scores from the mid-level academic achievers is warranted. These students did improve statistically in their content understanding over all, however not to the degree that the more advanced students did. In line with the findings for high and low achievers, the higher the mid-level students' scored on their post-test, the less difference there was between instructional formats. This suggests that there really isn't a middle group but that the nearer a student is to a high-achiever the less it matters where instruction comes from, and the higher still the student ranks in achievement level, the better they learn from CBI. The lower these students improved in content understanding, the better they performed as a result of teacher based instruction.

Limitations

There were a few limitations to this study. The first and most influential was the lack of personal computers for the participants. Even during the time this paper was started to the time is was submitted, the provision of personal computers for students by schools has increased incrementally, including in the school that this research was done in. Unfortunately this had a few consequences. The first was that the less could not be provided in the biology classroom that the students occupied daily. Although the intervention was done in one large common space, the school library, it was not ideal. The second was that the students were not familiar with the online process. They were not accustomed to logging on, and progressing through a computer based lesson. This required some extra time for these students to get started with the lesson, and certainly provided added frustration to a new practice. This effect may have been had greater negative effect of the lower achieving students.

The second limitation that effects the current and future success of online instruction in the classroom is the lack of engaging and creative lessons. At the time of this intervention all of the online lessons that this researcher reviewed were merely screen shots of text taken from text books and then enhance with pop-ups that may or may not offer helpful added text. In the researcher’s opinion and in light of the stimulation and engaging video software on the market that captures student attention endlessly, our educational system can and must do better in the arena. Not only are these bland and text heavy online lessons uninteresting, they rely primarily on reading, which a more challenged student will struggle with anyway. Further, because it is both uninteresting and laborious to absorb, the teacher is called upon to oversee student progress. This defeats the whole hope of created separate learning groups, one of which frees up the teacher to be available to the students her need her most.

A third limitation is the lack of a true control group. It was the intention of the investigator to use one full section of biology in this school as a control. This section was a large class of similar students learning the same content. However, after assimilating the data it was found that the control class had twice as many high academic achievers as any other section, and has significantly fewer low achievers. This made the class too dissimilar to qualify as a control.

This brings on an additional limitation in that the students in each class were pre-determined as assigned prior to the intervention. Students could choose the section of biology they wished to be assigned and such selection could be based on student schedule but could also be based on the other students also choosing that section. This reduced the level of pure randomization.

Conclusion

This research suggests that computer based instruction can be used within a large traditional science classroom for the purpose of offering both smaller learning groups and greater differentiated instruction to students, both of which have been found in the literature to increase student learning performance (Felner, Seitsinger, Brand, Burns, & Bolton, 2007). As was done in this intervention, students can be separated out to receive either teacher provided instruction or computer based instruction, thus creating smaller learning group environments.

These results however suggest that not all students benefit from either instructional format equally. Higher academic achieving students seem to learn equally well with both formats, and to a higher degree than other students. These higher achieving students also do somewhat better with computer based instruction. Conversely, lower academic achieving students increased in their content understanding significantly better in a small group setting with teacher provided instruction. In fact, in this study, the lowest achieving students performed worse in content understanding after a computer based lesson.

Technology has opened the door to limitless opportunities to exposed students to new ways to learn, to new ways to experience the world and to apply critical thinking. There is much to look forward to. At the same time, in light of this study, questioning both which students are best suited for various new instructional formats and improvement in the quality of online lessons is imperative.

Recommendations

First and foremost, better online lessons, particularly in science need to be discovered or created. Science in particular has traditionally carried with it a stigma of being non-essential, uninteresting, or too difficult for students. The importance that an understanding of the sciences brings to each individual is of such a great degree that it is well worth the time and investment necessary to make the learning experience exciting and engaging. It seems every day there are new web sites appearing that provide science learning. Finding better lessons with less plain text and more interactives with verbal instruction in combination may change future results of learning performance for all academic achievement levels.

Improved comfort level with online instruction should be a prerequisite for further study. Students should have a day of instruction on the online process and ideally have several opportunities to receive online instruction before their learning comprehension be compared to a different group of students receiving teacher based learning. In this low income school many students did not own their own lap tops and the school did not provide them so using a computer for any reason brought its own sense of novelty that may have distracted from the results.

For follow up research, I would like to see a study where a more engaging lesson could be used, and where students would use their own school provided personal computers. This would allow for the lessons to be provided in the same classroom that the students use every day. As an extension, I would like to see students receive a different lesson from each instructional format on one day and then flip formats on the second day to see if using both formats can improve learning to a greater degree.

REFERENCES

Astin, A. W. (1993). What matters in college?. Liberal Education, 79(4), 4

Balfanz, R. (2009). Can the American High School Become an Avenue of Advancement for All?. Future Of Children, 19(1), 17-36.

Berliner, D. (2001, January 28). Our schools vs. theirs: Averages that hide the true extremes. Washington Post, p. B3

Blatchford, P., Bassett, P., & Brown, P. (2011). Examining the effect of class size on classroom engagement and teacher–pupil interaction: Differences in relation to pupil prior attainment and primary vs. secondary schools. Learning and Instruction, 21(6), 715-730.

Blatchford, Bassett and Brown, 2008. Do low attaining and younger students benefit most from small classes? Results from a systematic observation study of class size effects on pupil classroom engagement and teacher pupil interaction. American Educational Research Association Annual Meeting 2008, New York.

CAMBURN, E. M., & SEONG WON, H. (2011). Two Decades of Generalizable Evidence on U.S. Instruction from National Surveys. Teachers College Record, 113(3), 561-610.

DREW DESILVER. Pew Research Center. Feb 15, 2017. http://www.pewresearch.org/fact-tank/2017/02/15/u-s-students-internationally-math-science/

Deutsch, F. M. (2003). Low-cost Ways to Shrink High-School Class Size. Education Digest, 69(2), 47-50

Felner, R. D., Seitsinger, A. S., Brand, S., Burns, A., & Bolton, N. (2007). Creating small learning communities: Lessons from the Project on High Performing Learning Communities about "what works" in creating productive, developmentally enhancing, learning contexts. Educational Psychologist ,42(4).

Gene V. Glass and Mary Lee Smith Educational Evaluation and Policy Analysis , Vol. 1, No. 1 (Jan. - Feb., 1979), pp. 2-16 Published by: American Educational Research Association Article Stable URL: http://www.jstor.org/stable/1164099

Gordon, Marshall. "Coleman Report." A Dictionary of Sociology. 1998.

Grigg, W., Lauko, M., & Brockway, D. (2006). The Nation's Report Card: Science 2005 (NCES 2006-466). U.S. Department of Education, National Center for Education Statistics. Washington, DC: U.S. Government Printing Office.

Grubb, M.(2011) PREDICTORS OF HIGH SCHOOL STUDENT SUCCESS IN ONLINE COURSES. A Doctoral Thesis Presented to the Faculty of the College of Education,University of Houston.

Irvin, M. J. (2012). Role of student engagement in the resilience of african american adolescents from low-income rural communities. Psychology In The Schools, 49(2), 176-193. doi:10.1002/pits.20626

Kuczynski-Brown, A. (2012). New York Class Size: Nearly Half Of Public Schools Have Overcrowded Classrooms, UFT Says. Huffingtonpost.com

Kulik, J. A. (2003). Instructional technology and school reform models. Ann Arbor, MI: Office of Evaluations & Examinations, University of Michigan. Retrieved from http://www.schooldata.com/mdrtechhilites.asp

Lee, O & Buxton, C (2008). Science Curriculum and Student Diversity: A Framework for Equitable Learning Opportunities. University of Miami, The Elementary School Journal Volume 109, Number 2 © The University of Chicago.

MacMahon, B. (2011). The Perpetuation of Risk: Organizational and Institutional Policies and Practices in a Title 1 School. Journal For Critical Education Policy Studies (JCEPS), 9(2), 199-215.

McGee, G. (2004): Closing the Achievement Gap: Lessons From Illinois' Golden Spike High-Poverty High-Performing Schools, Journal of Education for Students Placed at Risk (JESPAR), 9:2, 97-125

McKeachie, W. J., Pintrich, P. R., Lin, Y., Smith, D. A. F., & Sharma, R. (1986). Teaching and learning in the college classroom: A review of the research literature. Ann Arbor, MI: Regents of the University of Michigan.

MORGAN, H. (2012). POVERTY-STRICKEN SCHOOLS: WHAT WE CAN LEARN FROM THE REST OF THE WORLD AND FROM SUCCESSFUL SCHOOLS IN ECONOMICALLY DISADVANTAGED AREAS IN THE US. Education, 133(2), 291-297.

Panagiota Konstantinou-Katzi , Eleni Tsolaki , Maria Meletiou-Mavrotheris & Mary Koutselini (2013): Differentiation of teaching and learning mathematics: an action research

study in tertiary education, International Journal of Mathematical Education in Science and Technology, 44:3, 332-349
Polites, G. L., & Karahanna, E. (2012). SHACKLED TO THE STATUS QUO: THE INHIBITING EFFECTS OF INCUMBENT SYSTEM HABIT, SWITCHING COSTS, AND INERTIA ON NEW SYSTEM ACCEPTANCE. MIS Quarterly, 36(1), 21-A13.

Reardon, S. F. (2013). The Widening Income Achievement Gap. Educational Leadership, 70(8), 10-16.

Riffell, S & Sibley, D (2004).Using web-based instruction to improve large undergraduate biology courses: An evaluation of a hybrid course format. Department of Zoology, Michigan State University, East Lansing, MI 48824, USA, Center for Integrative Studies

Rouse, C., & Barrow, L. (2006). U.S. Elementary and Secondary Schools: Equalizing Opportunity or Replicating the Status Quo?. Future Of Children, 16(2), 99-123.

The New Normal: Doing More with Less -- Secretary Arne Duncan's Remarks at the American Enterprise Institute ,November 17, 2010. http://www.ed.gov/news/speeches/new-normal-doing-more-less-secretary-arne-duncans-remarks-american-enterprise-institut

Tomlinson, C., & Kalbfleisch, M.L. (1998). Teach me, teach my brain: A call
for differentiated classrooms. Educational Leadership, 52-55.

Truscott, D. M., & Truscott, S. D. (2005). Differing Circumstances, Shared Challenges: Finding Common Ground Between Urban and Rural Schools. Phi Delta Kappan, 87(2), 123-130.

Uekawa, K., Borman, K., & Lee, R. (2007). Student Engagement in U.S. Urban High School Mathematics and Science Classrooms: Findings on Social Organization, Race, and Ethnicity. Urban Review, 39(1), 1-43. doi:10.1007/s11256-006-0039-1

L.S. Vygotsky, L.S. (1978) Mind and Society: The Development of Higher Mental Processes, Harvard
University Press, Cambridge, MA

WATSON, S., & WATSON, W. R. (2011). The Role of Technology and Computer-Based Instruction in a Disadvantaged Alternative School's Culture of Learning. Computers In The Schools, 28(1), 39-55. doi:10.1080/07380569.2011.552042

Wojciechowski, A., & Palmer, L. B. (2005). Individual student characteristics: Can any be predictors of success in online classes? Online Journal of Distance Learning Administration, 8(2). Retrieved November 23, 2005, from http://www.westga.edu /~distance/ojdla/summer82/wojciechowski82.htm

Wu, H., & Pedersen, S. (2011). Integrating computer- and teacher-based scaffolds in science inquiry. Computers & Education, 57(4), 2352-2363. doi:10.1016/j.compedu.2011.05.011

Wyss, V. L., Tai, R. H., & Sadler, P. M. (2007). High school Class-size and College Performance in Science. High School Journal, 90(3), 45-53.

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